BLAST

User's Manual

the building loads analysis and system thermodynamics program

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Foreword

Installing the BLAST Program

Welcome to the BLAST family of building energy analysis programs. The program documentation is designed to assist you in installing and using BLAST and its related programs. If you have technical questions concerning the installation, use, or application of the BLAST program, please contact the Building Systems Laboratory.

Once you have successfully installed and tested the BLAST family programs, it is suggested that you read through the entire "GETTING STARTED" section of the manual. This section explains how the manual set should be used, how the BLAST program is structured, and how the BLAST program may be applied to building design applications. Short tutorials are also provided in the "GETTING STARTED" section to give you a feel for the BLAST program and how it should be used in conjunction with the user interface.

BLAST Overview

The BLAST Users' Manual is divided into several major sections. Each of these sections is briefly described below and can be accessed by clicking on the contents button displayed above.

Getting Started and BLAST Tutorial

The *Getting Started and BLAST Tutorial* sections should be reviewed, by new BLAST users, to gain important background knowledge vital to all users before proceeding with their first BLAST run. This section includes topics such as the Building Systems Laboratory services, overview of the BLAST family of programs, a detailed tutorial, and BLAST structure description.

Quick Reference

The *Quick Reference* section presents brief definitions of BLAST syntax and cross-references to encyclopedic listings of topics located in the *User Reference*.

User Reference

The *User Reference* is an encyclopedic listing of BLAST input file related topics. These listings consist of detailed descriptions, examples, and use instructions. Many topics in this section are cross-referenced to other entries in the *User Reference* as well as to entries in the *Technical Reference*.

The BLAST Libraries

The *BLAST Libraries* are all available through the HBLC interface and contains commonly used information. This information is stored under convenient names and may be specified by the user in the input language, which then automatically selects appropriate information from the BLAST library. When the user wants to select, for example, a location, occupancy schedule, or construction material they are available at the appropriate location in the HBLC interface.

Examples

This section contains sample BLAST input and output files.

Technical Reference

The *Technical Reference* section presents an encyclopedic listing of technical topics, such as mathematical descriptions of BLAST models, calculation procedures and advanced user topics.

Output Reports

A detail description of the BLAST Output Reports is presented in the *Output* section of the BLAST manual.

Auxiliary Programs

The *Auxiliary Programs* section includes user manuals for other programs in the BLAST family. The BLAST text input processor (BTEXT) is an automated technique to easily generate BLAST input files. The Chiller program is used to take manufacturer's catalog data and convert it into the chiller parameters used in BLAST. The Design Week Creation program can be used to generate a week of weather data for examining specific weather trends impact on the simulation. The Weather Information File Encoder (WIFE) program processes various weather data types to produce weather files in the form used by the BLAST program. The Report Writer program is used to obtain hourly values for various BLAST output variables.

Appendices

The *Appendices* include additional information related to the use of the BLAST program but not required in order to successfully use the program.

Historical Background

The BLAST program was developed by the U.S. Army Construction Engineering Research Laboratory (USACERL) under the sponsorship of the Department of the Air Force, Air Force Engineering and Services Center (AFESC), and the Department of the Army, Office of the Chief of Engineers (OCE). After the original release of BLAST, called BLAST Version 1.2, in December 1977, the program was extended and improved under the sponsorship of the General Services Administration, Office of Professional Services; BLAST Version 2.0 was released in June 1979. Under the sponsorship of the Department of the Air Force, Aeronautical System Division, and the Department of Energy, Conservation and Solar Energy Office, the program was further extended; BLAST Version 3.0 was released in September

1980. Since that time, BLAST has continually undergone improvements and defect fixing. For example, in 1989, a version with full capabilities of the mainframe version but geared to the PC platform was introduced. Following the popularity of the personal computer platform and Windows™, HBLC was introduced in several training courses and released in 1995.

In 1983, USACERL formed the BLAST Support Office at the University of Illinois. The two organizations have cooperated, since that time, to support, maintain and enhance the BLAST program and related software for the Army Corps of Engineers.

Entering a new era, the BLAST Support Office has now become more focused on research activities and development of the EnergyPlus© program. Thus, the staff that used to do mostly BLAST support activities has been renamed to the more general "Building Systems Laboratory".

License Agreement

This document was prepared by the Building Systems Laboratory, University of Illinois, under funding from the U. S. Army Construction Engineering Research Laboratory (USACERL). Portions of this document may have been taken directly from other USACERL publications.

The contents of this manual are not to be used for advertising, publication, or for promotional purposes. Citation of trade names does not constitute an official endorsement or approval of the use of such commercial products. This manual is not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

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The accuracy of these programs is entirely dependent on the user supplied input data. It is the user's responsibility to understand how the input data affects the program and to use the output data only as intended.

All documents and reports conveying information obtained as a result of the use of these programs by the recipient will acknowledge the Corps of Engineers, Department of the Army, as the origin of the program. All such documentation will state the name and version of these programs used by the recipient.

Building Systems Laboratory Services

Maintenance and Distribution

The Building Systems Laboratory is responsible for maintenance, distribution and support of the BLAST Family of Software and Documentation. Support will only provided to licensed users, therefore we require the user to have their serial number ready when contacting our office.

Hours

The Building Systems Laboratory provides support services Monday through Friday. Support questions can be e-mailed or faxed to the Building Systems Laboratory to be answered. A consultant will reply to these questions daily.

How to Contact the BSL

Telephone:

(217) 333-3977

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(217) 244-6534

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University of Illinois

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Training

Our experience has shown that new users may benefit tremendously from a formal introduction to the BLAST family of software. Accordingly, the Building Systems Laboratory offers individualized and group training courses that can be tailored to specific interests of the participants. For more information about scheduling a training course and the current fees, please contact the Building Systems Laboratory.

Special Services

When a user requires special services beyond what the Building Systems Laboratory can normally provide, the staff is occasionally available to take on special projects. These special services may include energy analyses, software development, documentation preparation, and training.

Getting Started

Overview of the BLAST Family of Programs

The BLAST Program

The Building Loads Analysis and System Thermodynamics (BLAST) program is a comprehensive program for predicting energy consumption and energy system performance in buildings. BLAST can be used to investigate the energy performance of new or retrofit building design options of almost any type and size. In addition to performing the peak load (design day) calculations necessary for mechanical equipment design, BLAST also estimates the annual energy performance of the facility, which is essential for the design of solar and total energy (cogeneration) systems and for determining compliance with design energy budgets. Since repeated use of BLAST is inexpensive, it can be used to evaluate, modify, and re-evaluate alternate designs on the basis of annual energy consumption and cost. In this way, efficient designs can be separated from the inefficient. Proper equipment type, size, and control can also be determined. Near-optimal designs for any new or retrofit project can be developed using this approach.

THE HEAT BALANCE LOADS CALCULATOR (HBLC)

Simplicity and accuracy are a necessary tradeoff in nearly all engineering applications. Most systems being analyzed by engineers are very complex. Time constraints do not allow every detail to be accounted for in the analysis. This is especially true when analyzing heating and cooling loads in buildings. Weather data, scheduled loads, and other thermal aspects of building design are usually approximated in order to complete the calculations in a reasonable amount of time.

The uniqueness and strength of the Heat Balance Loads Calculator (HBLC) is the fact that time constraints are satisfied by simplifying the input while retaining rigorous computational algorithms. HBLC provides a visually stimulating, easy-to-understand graphical interface to the Building Loads Analysis and System Thermodynamics computer simulation program. BLAST is a very powerful energy analysis program that calculates thermal loads using an implementation of the heat balance method. As a result, a simpler yet more accurate method of performing loads calculations is made available through the Heat Balance Loads Calculator.

HBLC will be described briefly in this section. It will be used in many of the examples in this entire document. It also comes with separate documentation as well as context sensitive helps from within the program. HBLC is also a general purpose interface to the entire family of BLAST software.

Objective of the Software

HBLC provides practicing mechanical engineers and architects with easy access to the complex BLAST heat balance load calculation algorithms. The software is intended to quickly calculate zone heating and cooling loads for most commercial building configurations. Hourly zone load profiles and block loads for design days and design years are computed and graphically displayed by the program.

The user interface has been developed to enhance the visual perception of the building and energy analysis to the engineer and architect.

Computational Algorithms

The heat balance method has long been recognized as a fundamentally sound approach to heating and cooling load calculations. Of the building simulation programs in the public domain, the BLAST program [BSO, 1993] contains an implementation of the heat balance procedure which is widely recognized and has been extensively validated [Herron, 1981, Yuill, G.K., Phillips, E.G., 1981].

The BLAST heat balance is formulated on the assumption of a "well stirred" zone, that is, the air temperature in a zone is assumed to be uniform. The inside surfaces of all building elements receive heat by various means. These include: conduction from the back, radiation exchange with a number of other surfaces in the zone (including other building elements, lights and equipment), solar beam radiation which may enter the zone through windows and finally convection heat transfer to the air mass. It is this latter heat flux which produces the heating or cooling load.

The temperature of the air mass reflects the balance between this convection heat transfer from the surfaces and the net energy transported into and out of the zone by the HVAC system. The zone air is assumed to have no capacitance, is always in steady state equilibrium, and it is transparent to radiative heat transfer between the walls. These assumptions are generally accepted as reasonable for normal circumstances.

Zone heat gains/losses, such as lights, equipment, people, and outside air are scheduled on an hourly basis. Weather data is either read from a weather file for each hour of the year (8760 hours), or specified as a 24 hour "design day". All zone loads are calculated on an hourly basis for either a single design day or an entire year.

Environment Selection

Selecting both a location and weather information from HBLC libraries specifies the outside environment. Over a hundred locations are available from the on-line locations library, and new locations may be defined by the user by inputting the latitude, longitude, time zone, and monthly ground temperatures of the site. Design day weather information is available for each of the library locations, and the user may define design days for other locations. Additionally, Weather files with hourly data in TMY and TRY formats are available separately for over 350 locations.

Building Geometry

Perhaps the most convenient feature of HBLC is the method of defining the building's walls, floors and roofs. An entire building with multiple zones may be defined through simple click-and-drag mouse operations. (See the figure below). A new zone, which appears as a simple rectangle on the screen may be reshaped in seconds into any orthogonal polygon. Up to one hundred simultaneous thermal zones at various elevations may be defined for a single building.

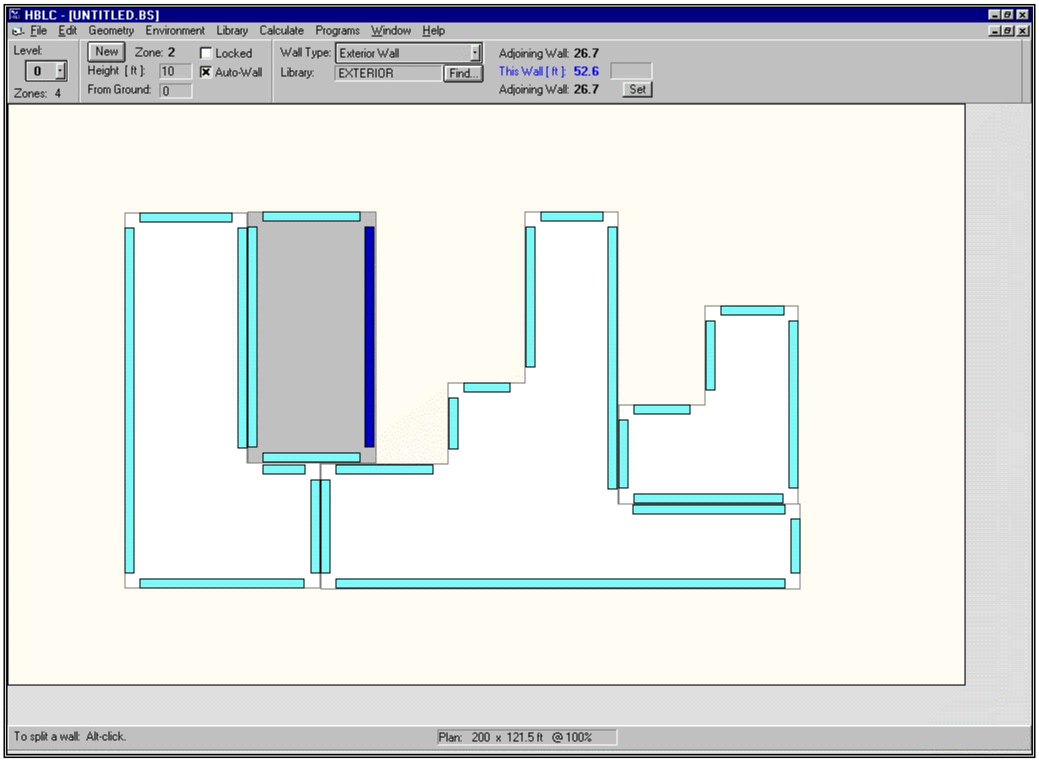


Figure 1. Plan View

When subsurfaces are added to a wall, an elevation view of that wall will appear. Windows and doors and overhangs are added by clicking screen buttons, and they are sized by clicking and dragging the surface's edge. (See the following figure).

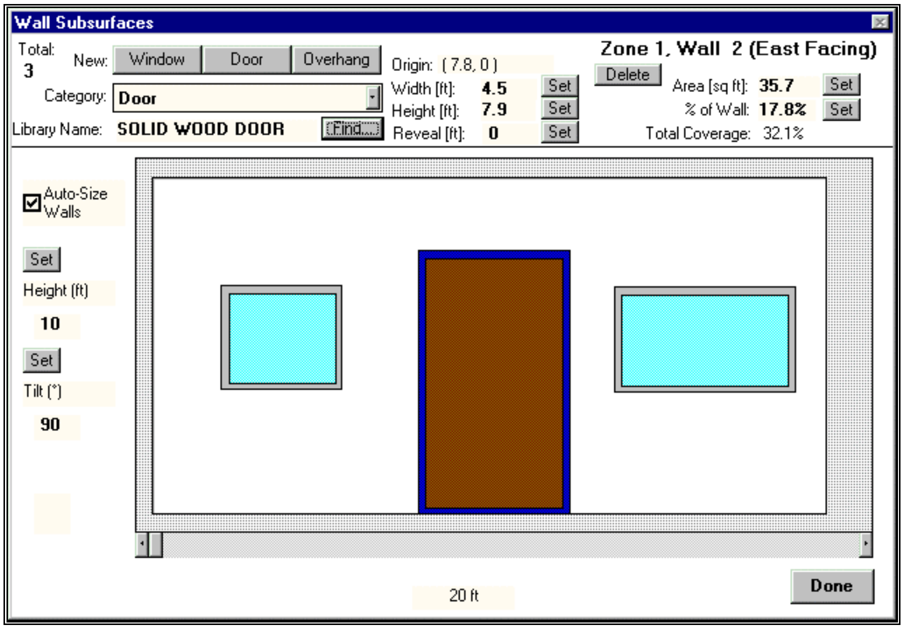


Figure 2. Elevation View of Wall

Surface constructions are easy to specify in HBLC. Each surface type (walls, roofs, floors, windows, and doors) has an easily accessible library from which pre-defined building elements can be selected. The library is actually a dynamic database containing layer-by-layer material information for each element. If the desired element is not in the library, the user may define the element by specifying its different material layers.

Scheduled Loads

HBLC allows scheduled load definitions for all load types, including people, lights, equipment, and outside air. Up to thirty-two loads may be scheduled for a given thermal zone. HBLC contains fifty library schedules available for application to these loads, most of which are ASHRAE standard schedules. If the desired schedule is not available, a user-defined schedule can be defined either graphically or numerically. Weekday, weekend, holiday, and special days all have maximum percentages for each hour of that day, and these percentages can be changed easily and viewed simultaneously in bar graph form. (See the following figure)

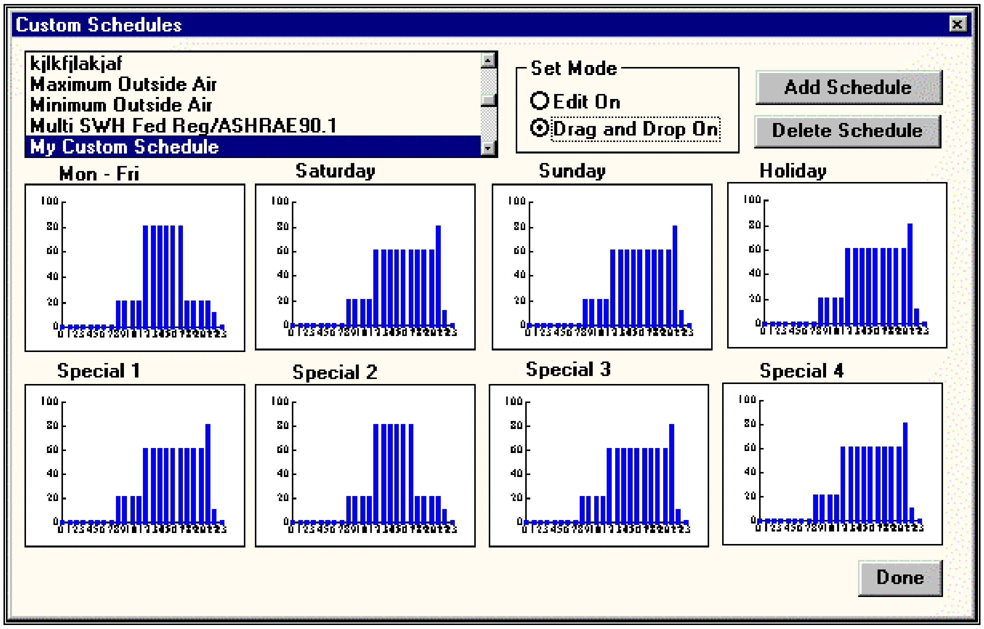


Figure 3. Editing Schedules

The figure shows that scheduled loads may be input in great detail if desired. For most applications, however, the user will find a suitable, pre-defined library schedule. The user may define the splits between latent or sensible loads and between the convective and radiative components of a load. All scheduled loads are presented in a table format with reasonable default parameters.

Systems and Plants

HBLC can access the BLAST Systems and Plants features and edit all of the their parameters. (*See the figures "Entering Fan Systems" and "Entering Central Plants"*) There are a total of twenty types of air handling systems and twenty-seven types of central plant equipment which can be entered using HBLC and then simulated using BLAST.

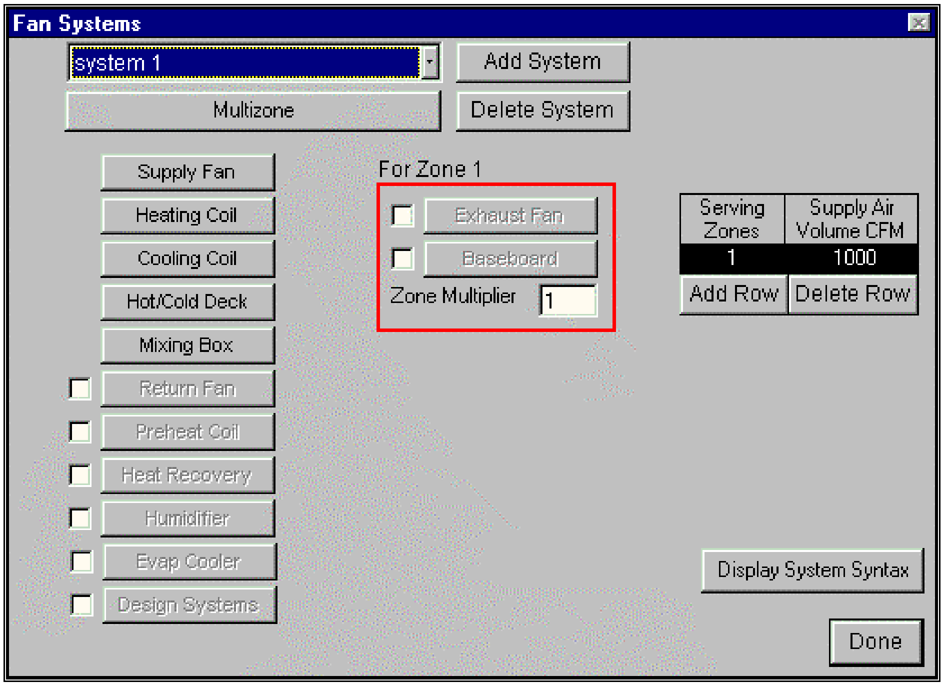


Figure 4. Entering Fan Systems

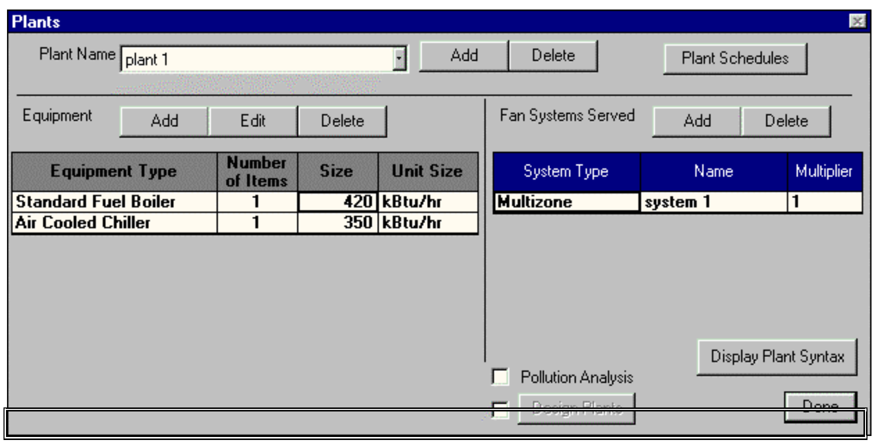


Figure 5. Entering Central Plants

Output Viewer

The Output Viewer allows users to plot and visually evaluate selected reports. The following figure illustrates the type of graphical output available in HBLC.

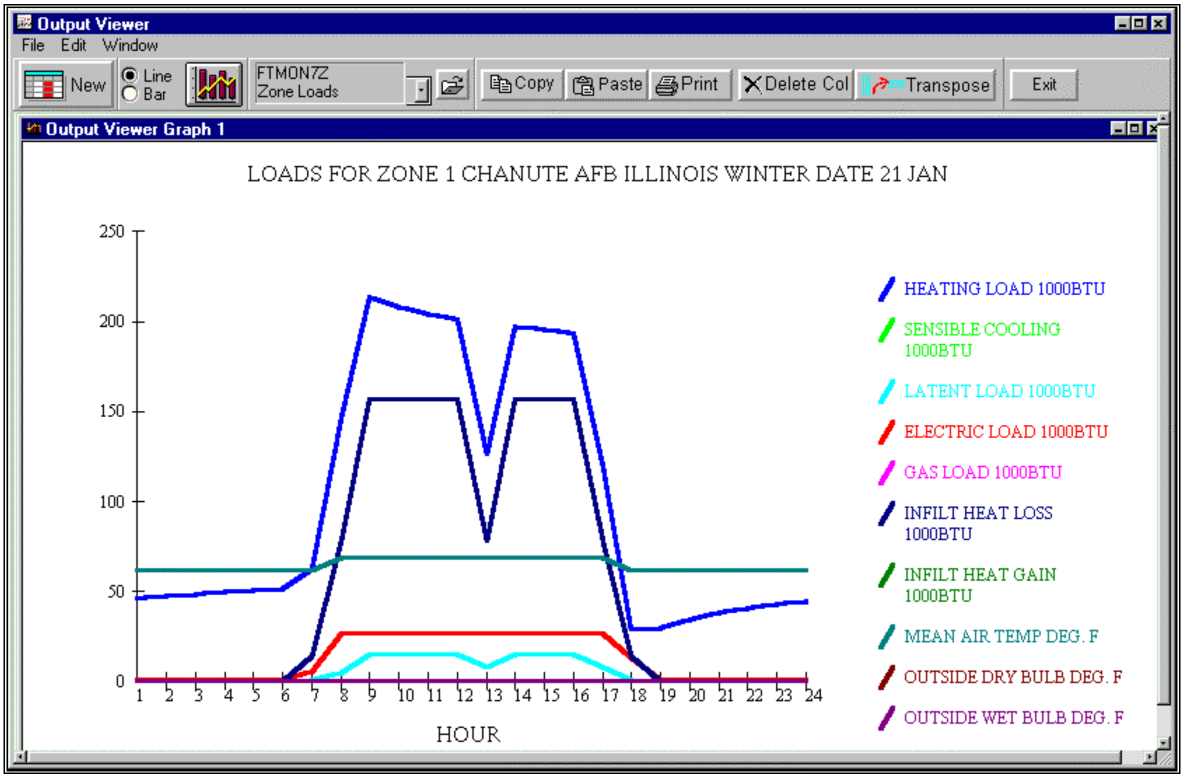


Figure 6. Output Viewer

BTEXT, The Textual Preprocessor to BLAST

The BLAST Text Preprocessor (BTEXT) is an interactive program for generating BLAST input files. BTEXT allows the user to create and modify databases from which BLAST input files can be generated. BTEXT virtually eliminates syntax errors in BLAST input files and is a text-based, menu-driven alternative to HBLC. The IBM PC version is especially helpful for users with limited access to the machine on which they are running BLAST. PC BTEXT provides the capability to prepare BLAST input files for BLAST execution.

Comparison of HBLC and BTEXT

HBLC and BTEXT are both capable tools that simplify the creation of BLAST input files. Each of them has certain limitations, which may make one preferable over the other for a specific situation.

HBLC is the interface of today – compatible with Windows™ operating systems, it allows users to modify nearly every aspect of their project on the fly, by using data forms and pop-up menus. Many options are provided to the user depending on previous selections. Building geometry is easy to manipulate by click and drag, and a geometric duplicate of a zone can be created in a one-step process. Selecting and creating library items is a snap with HBLC's library chooser system. For users who require assistance on their project, the HBLC and BLAST on-line manuals are available from the menu bar.

BTEXT is the text-based predecessor to HBLC. The menu structure is simple to navigate, although often in a more time consuming manner than the equivalent in HBLC. BTEXT is all text, so it will run on almost any PC in service today. BTEXT has user detail levels, which prevent more advanced options from being presented to a novice user. This will be of limited use to most users as they typically would be ready for the most detailed level after minimal BTEXT and BLAST exposure. BTEXT has the capability to copy and mirror zones, although it is cumbersome compared to HBLC's duplication. HBLC is able to specify overhangs, but BTEXT is able to specify wings and overhangs. A few other BTEXT options that are not currently available in HBLC are detached shading and radiant view factors. The largest advantage to using BTEXT over HBLC is that in BTEXT walls are not required to be orthogonal, and in fact are not required to be of rectangular profile.

Table 1. Features of BTEXT and HBLC

BTEXT	HBLC
not limited to orthogonal walls	graphical windows interface
same as	Duplicate zones
mirror	Forms
wings	library modifications
text based	Browsing all BLAST libraries
detached shading	on-line help
detail level	tailored system parameter values
radiant view factors	tailored plant parameter values
Limited online help	Use any BLAST library element as basis for new
	General BLAST Family of Programs interface
50 zones, 50 systems, 50 plants	100 zones, 50 systems, 50 plants
Not actively maintained	Maintained, may be enhanced
Limited temporary elements, schedules, controls	Unlimited new elements, schedules, controls
	Can share definitions between projects without rekeying

WIFE Program

The Weather Information File Encoder program of the BLAST system also accepts free-format, English-like user input. The program can automatically read several standard weather data tapes (TDF-14, TMY, TRY, SOLMET, SOLAR 280, ETAC-DATASAVE). Among the options to user input are holiday periods, type of units in output reports, monthly, daily and hourly reporting periods. The WIFE program will also allow previous BLAST weather files as input for the purposes of reporting or holiday selection.

CHILLER Program

BLAST simulates several types of compression and absorption chillers. The default chiller performance parameters may be used to model generic chillers. However, many users desire to simulate more specific chillers.

The CHILLER program is designed to take typical manufacturer's catalog data for compression chillers, convert it into the chiller parameters used in the EQUIPMENT PERFORMANCE PARAMETERS section in BLAST, and then test these parameters over a range of cooling loads and condenser temperatures. The program is simple to use and includes on-line help. Users are prompted for applicable chiller performance data that is used to calculate the chiller coefficients and part load statements for BLAST.

REPORT WRITER Program

The Report Writer program is an extremely useful engineering tool designed to be used in conjunction with output from the BLAST program. Its main function is to process hourly BLAST output into a form that can be manipulated in a spreadsheet environment. Report Writer has the ability to produce files that can be read directly into LOTUS and EXCEL. The user can then use these programs to manipulate the output, create reports and graphs, etc. Report Writer is also able to perform simple data reduction functions on output sets such as cut, slice, average, maximum, minimum, and frequency tabulation. Users of Report Writer will quickly notice two major benefits of the program: customization of reports and detailed hourly simulation results. With Report Writer, the transfer of data is automated, saving tremendous amounts of time, reducing error, and maximizing the potential utilization of the BLAST simulation in a more familiar environment.

WinLCCID Program

WinLCCID is a Windows™ based economic analysis computer program tailored to the needs of the Department of Defense (DOD). It is intended to be used as a tool in evaluating and ranking design alternatives for new and existing buildings. WinLCCID will calculate the life cycle costs, and other economic parameters, for a variety of energy conservation alternatives in DOD construction. It also has many general-purpose non-energy economic analysis applications for DOD work. It provides users some limited freedom to create their own economic criteria for non-DOD applications. WinLCCID incorporates the economic criteria of the Army, Navy, and Air Force for design studies and operates in a manner that requires little knowledge of these criteria by the program user. The basic algorithms and reports in WinLCCID are recognized as a standard for DOD. Since the DOD, and therefore WinLCCID, use the economic criteria of the Department of Energy (DOE) and the Office of Management and Budget (OMB) in these studies, the user may be able to use the program for economic studies for several other federal agencies. The WinLCCID program can be purchased separately from the Building Systems Laboratory.

WinLCCID comes with its own user manual and online context-sensitive help. It can import the BLAST produced LCC Report files.

Other Programs Supported by the Building Systems Laboratory

Weather Report, the Weather File Reporting Program, was developed as a supplemental program to WIFE. Weather Report reads processed BLAST weather files and produces a standard report showing monthly and daily weather data averages as well as design temperatures. The report is in a format that can readily be used by designers.

The Design Week Creation Program is intended for use with both the BLAST and WIFE programs. The need for Design Week stems from the design of some thermal energy storage systems on the basis of a week rather than a single day, allowing them to use an entire weekend to charge the storage system. Users wanted the ability to define an entire week based on their own experience rather than having to hunt down an appropriate week of weather data in a weather file.

As a result of the needs created by thermal energy storage models in BLAST and the wishes of the model users, Design Week was created. Design Week is a menu-driven program that allows the user to specify an entire week of weather data. The information required to run the program is the same type of information needed to create a design day. The user is given total control in the specification of the Design Week in that the seven consecutive days can be identical or different.

Other information

As noted in the Technical Reference, BLAST will interface with windows created by the Window 4.1 computer program. Window 4.1 is a readily available program for those users needing advanced window capabilities.

Description of the BLAST Program

BLAST can be used to investigate the energy performance of new or retrofit building design options of almost any type and size. In addition to performing peak load (design day) calculations necessary for mechanical equipment design, BLAST also estimates the annual energy performance of the facility, which is essential for the design of solar and total energy (cogeneration) systems and for determining compliance with design energy budgets. Since repeated use of BLAST is inexpensive, it can be used to evaluate, modify, and re-evaluate alternate designs on the basis of annual energy consumption and cost. In this way, efficient designs can be separated from the inefficient; proper equipment type, size, and control can also be determined. Near-optimal designs for any new or retrofit project can be developed using this approach.

Apart from its comprehensiveness, the BLAST system differs in four key respects from similar programs used in the past.

1. The BLAST program uses rigorous and detailed algorithms to compute loads, simulate fan systems, and simulate boiler and chiller plants.
2. The program has its own user-oriented input language and is accompanied by a library which contains the properties of all

materials, wall, roof, and floor sections listed in the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook of Fundamentals.

3. The program execution time is brief enough to allow many alternatives to be studied in a reasonable amount of time.

4. The program is not proprietary and is, therefore, open to inspection by its users and those who rely on its results.

BLAST consists of a "Lead Input" section, which defines the overall simulation parameters, and three major simulation sections. The purpose of each simulation is shown below. The relationship between these sections of the BLAST program is shown in the figure below.

1. The Space Load Predicting Simulation computes hourly space loads in a building based on weather data and user inputs detailing the building construction and operation.

2. The Air Distribution System Simulation uses the computed space loads, weather data, and user inputs describing the building air handling system to calculate hot water, steam, gas, chilled water, and electrical demands of the building and air-handling system.

3. The Central Plant Simulation uses weather data, results of the air distribution system simulation, and user input describing the central plant to simulate boilers, chillers, on site power generating equipment, and computes monthly and annual fuel and electrical power consumption.

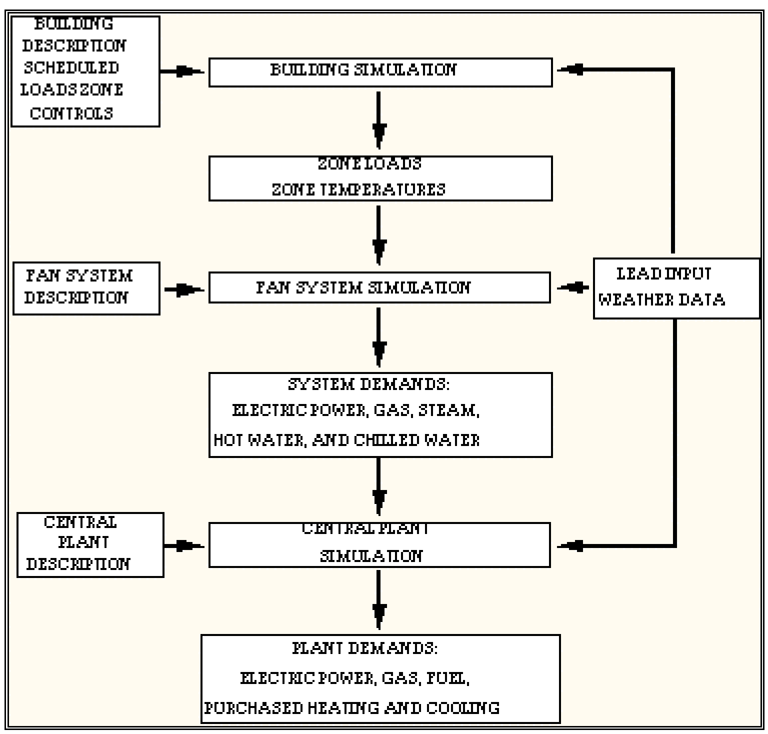


Figure 7. BLAST Program Structure

BLAST Building Simulation

The heart of space loads prediction is the room heat balance. For each hour simulated, BLAST performs a complete radiant, convective, and conductive heat balance for each surface of each zone described and a heat balance on the room air. This heat balance includes transmission loads, solar loads, internal heat gains, infiltration loads, and the temperature control strategy used to maintain the space temperature. Many of the important features of the loads predicting simulation are summarized below.

1. Calculates response factors and conduction transfer functions for all zone surfaces. (This permits the careful and complete analysis of transient heat conduction through walls and of heat storage in zones.)
2. Calculates the shaded and sunlit areas for all exterior surfaces shaded by attached or detached shadow casting surfaces (wings, overhangs, or other buildings). Also, the shading of windows caused by reveals is fully accounted for.
3. Calculates the solar flux transmitted through single and multi-pane windows, with or without interior shades, using either basic optical principles or "shading coefficients" specified by the user.
4. Determines the distribution of sunlight on interior surfaces. Allows the use of daylight to reduce loads.
5. Accounts for the effects of both inside and outside surface solar and infrared absorptivities.
6. Uses mean radiant temperature technique to calculate radiant heat transfer between zone surfaces as part of the room heat balance. Also calculates the radiant interchange between exterior surfaces (i.e., walls, roofs, windows) and the earth and sky.
7. Accounts for the effect of surface roughness and hourly variations in wind speed on outside wall convective heat transfer coefficients (air film resistance).
8. Adjusts the inside surface convective heat transfer coefficient (air film resistance) for ceilings, roofs, and floors based on whether the surfaces are hotter or colder than the room air.
9. Includes exact methods for the calculation of heat flow between adjacent zones of differing temperature. This is especially important for attics and crawl spaces.
10. Allows arbitrary (user-specified) room temperature control strategies. (Different control strategies can be specified for different hours during the day and different days during the week.)
11. Appropriately allocates radiant, convective, and latent fractions of the heat from people, lights, and equipment, and allows these internal gains to be scheduled differently for each hour of the day and each day of the week and for different seasons of the year.

Simulates the radiant and convective effects of outside air-controlled baseboard heating.

13. Accounts for the effects of wind speed, temperature differences, and time of day on zone infiltration.
14. Allows surfaces bounding a zone to be of arbitrary shape, three- and four-sided, and at any tilt or azimuth.
15. Allows controlled or scheduled ventilation for cooling or precooling the zone.
16. At the discretion of the user, allows calculated loads for each zone to be saved on disk for future used in examining many alternate fan system configurations (without recalculating space loads).
17. Simulates as may as 100 zones simultaneously and up to 100 zones per input file.

BLAST Fan System Simulation

Once zone loads are calculated, they must be translated into hot water, chilled water, steam, gas and electric power demands on a central plant or utility system. This is done by using basic heat and mass balance principles in the system simulation of BLAST. The major types of air distribution systems that BLAST can analyze are:

1. Multizone and dual duct systems
2. Three-deck multizone systems
3. Single-zone fan systems with sub-zone reheat
4. Unit ventilators with or without heating coils
5. Two-pipe fan coil systems
6. Four-pipe fan coil systems
7. Variable volume fan systems with optional reheat or thermostatically controlled baseboard heat.
8. Constant volume terminal reheat systems
9. Dual duct variable air-volume systems
10. Air- or water-cooled packaged direct-expansion systems
11. Single-zone draw through systems
12. Induction unit systems
13. Air to air heat packaged heat pumps
14. Evaporative coolers
15. Water Loop Source Heat Pumps

In addition, built-up direct-expansion cooling can be specified to serve the fan systems listed above, or chilled water can be the cooling source. Air-to-air heat recovery is also possible on most of the systems listed above. Default values are supplied for most of the pertinent fan system variables. All defaults can be overridden by the user. Many combinations of mixed-air and delivery-air control strategies are available for most of the air distribution systems.

The fan system simulation includes the following significant features:

1. The user may adjust the full-load efficiency and total fan pressure for supply, return, and exhaust fans, as well as the part-load performance characteristics of the supply and return fans.
2. Both cold and hot decks can be controlled (a) at a fixed temperature set point, (b) at a temperature varied with outdoor air temperature, or (c) based on the zone requiring the most heating or cooling.
3. The throttling range of the cold and hot deck controllers is fully accounted for and may be specified by the user.
4. Three different economy cycles can be used for most fan systems; the desired mixed-air temperature may be fixed or floating depending on the user specification.
5. Minimum and maximum outdoor air quantities can be scheduled for each hour of the day as well as seasonally.
6. Various preheat coil configurations can be simulated.
7. Humidifiers can be specified for most systems.
8. Fan, heating coil, preheat coil, cooling coil, and heat recovery operation can be scheduled on a daily and seasonal basis.
9. Users may elect to simulate any cooling coil by specifying cooling coil design parameters consisting of typical catalog data for one coil operating point.
10. At the discretion of the user, the results of fan system simulations may be saved on disk for future use in examining many alternate central plant configurations (without repeating the fan system simulations).
11. BLAST can simulate as many as 100 separate systems (many more than are usually required) at one time.

BLAST Central Plant Simulation

Once the hot water, chilled water, steam, gas, and electric demands of the building fan system are known, the central plant must be simulated to determine the building's final purchased electric power and/or fuel consumption. The central plant simulation of BLAST can simulate any thermodynamically feasible system consisting of any or all of the following central plant components:

1. Boilers
2. Centrifugal or reciprocating chillers
3. Absorption chillers (one or two stages)
4. Double-bundle chillers
5. Free cooling chillers
6. Direct drive chillers
7. Heat pumps (with or without solar assist)
8. Cooling towers

9. Evaporative and well-water condensers
10. Diesel engine generators
11. Gas turbine generators
12. Steam turbine generators
13. Heat recovery from generator prime movers
14. Process heat as a heat source
15. Purchased steam, electricity, gas, boiler fuel, and gas turbine fuel
16. Domestic hot water heater
17. Ice on coil (outside melt) ice storage
18. Ice harvester
19. Stratified Thermal Storage Tank
20. Encapsulated ice storage
21. Ice on coil (inside melt) ice storage

Some of the principal features of the central plant simulation program are:

1. Accounts for the effects of ambient temperature, chilled and hot water temperature, and other operating variables on plant performance and equipment capacity.
2. Accounts for the change in equipment COP or efficiency resulting from part-load operation.
3. Allows default equipment assignment strategies to be overridden, thereby permitting the user to select the operating strategy of his/her choice.
4. Allows the user may change equipment performance parameters to permit the exact modeling of available equipment.
5. Allows detailed energy accounting that permits accurate costing of energy, particularly of purchased electricity, which may have complicated block rate schedules.
6. Tabulates equipment-use statistics (hours of operation and average part-load ratio for each plant component) as well as energy consumption data, thereby permitting the BLAST output to be used as the basis for equipment selection.
7. Simulates as many as 100 central plants in one run.

BLAST Program Output

Standard BLAST Output Reports

BLAST produces many reports in standard formats. Default reports are generated automatically from within the space loads, air distribution, and central plant simulations. Other reports may be specified in the lead input section of the BLAST input file. Both default and specified reports are explained in detail in *BLAST OUTPUT*.

The BLAST Report Writer

The BLAST Report Writer system uses the results of a BLAST simulation to create customized output reports as well as standard input data files for graphics software. Both default and specified reports are explained in detail in the Report Writer guide. The Report Writer system consists of the two main parts explained below:

1. **Report File Generation**: While running HBLC a user has the ability to have specific output variables from the building loads, systems, and plants segments of the program written to a BLAST report file. To do this, the user simply chooses the variables that are desired from the Report Variables Form.
2. **Report Writer**: This program is run by selecting Report Writer from the Program menu in HBLC. This program uses information stored in the BLAST generated report files during a BLAST simulation to create detailed, user-specified output reports.

Inputs to the BLAST Program

The BLAST Library File

The BLAST program libraries are files that contain commonly used information. This information is stored under convenient names and may be specified by the user in the input language. The library is divided into eleven smaller sections.

l. The **Schedule Library** contains 24-hour profiles. This section is used when describing occupancy, lighting, equipment usage, infiltration, etc.

2. The **Locations Library** contains latitude, longitude, and time zone for named locations.
3. The **Design Days Library** contains weather data for design days.
4. The **Controls Library** contains space temperature control strategies.
5. The **Materials Library** contains the thermodynamic and/or optical properties of typical building materials.
6. The **Walls Library** contains typical wall section descriptions composed of materials from the Materials Library.
7. The **Roofs Library** contains typical roof and ceiling section descriptions composed of materials from the Materials Library.
8. The **Floors Library** contains typical floor section descriptions composed of materials from the Materials Library.
9. The **Doors Library** contains typical door section descriptions composed of materials from the Materials Library.

10. The **Windows Library** contains typical window section descriptions comprised of glass, air spaces, interior shades, and drapes from the Materials Library.

Materials, as well as, wall, roof, and floor sections found in the BLAST library are from the *ASHRAE Handbook of Fundamentals*. Entry names are keyed to the tables in the ASHRAE Handbook. Therefore, when preparing a building description for the BLAST Program, the user may specify short names that automatically select appropriate information from the library. The BLAST program language also provides the user with the capability to define additional entries in any of the library's subsets or to print the contents of the entire library.

Weather Files

Weather tapes come from various sources and can differ in format, information, and method of data compilation. The Weather Information File Encoder (WIFE) program processes weather data tapes to produce files containing surface and solar data in the form used by the BLAST program. Detailed information on the weather files and the WIFE program may be found in WIFE manual and Weather Report manual.

The BLAST Input File

The BLAST input file is a text file created by the user and read as input by the BLAST program. A special BLAST input language consisting of descriptive phrases was designed specifically for the BLAST program. The input language allows the user to create an input file which may be quickly read and understood by BLAST users.

The descriptive phrases of the BLAST input language may be located anywhere in the first 80 columns of a line. Very little of the BLAST input is order dependent. The amount of information on each line, the indentation scheme, or how blank lines are used is at the complete discretion of the user. Any formatting style, which makes the input readable, may be used. Any time two asterisks (**) appear together on a line, the remainder of that line is assumed to be a comment and is repeated when BLAST prints the input.

BLAST Input Language

The BLAST program uses a formatted, English-like input language that permits rapid inspection and easy interpretation of user-supplied input. Error detection and some automatic corrections assist in debugging the input file. The input is unformatted, but it does require proper syntax. Preprocessors have been developed to provide this syntax. In many cases the BLAST input language provides defaults which reduce the input required.

Heat Balance Loads Calculator (HBLC) Program

HBLC is a windows based, interactive program which helps the user create an input file for the building Loads Analysis and System Thermodynamics (BLAST) program. HBLC allows the user to graphically create the building structure and to easily input information for other portions of the systems and plants and creates an input file with correct BLAST syntax. The program maintains database files that may be changed as desired and then used to create BLAST input files.

Input File Format

There are four major sections to the BLAST input file:

1. Lead Input
2. Building Description
3. Fan System Description
4. Central Plant Description

A skeleton of an HBLC created BLAST input file showing the four main sections of the BLAST program is shown in following four figures.

```
RUN CONTROL:
        NEW ZONES,
        NEW AIR SYSTEMS,
        REPORTS(ZONE LOADS),
        UNITS(IN=ENGLISH, OUT=METRIC);
        DESIGN DAYS=CHANUTE SUMMER ,
                CHANUTE WINTER ;
        GROUND TEMPERATURES=(54, 55, 58, 62, 67, 74, 72, 68, 64, 62, 58, 55);
```

Figure 8. LEAD Input

```
BEGIN BUILDING DESCRIPTION;
        BUILDING="NONE ";
        NORTH AXIS=0.00;
        SOLAR DISTRIBUTION=-1;
        ZONE 1 "ONE ":
                ORIGIN:(0.00, 0.00, 0.00);
                NORTH AXIS=0.00;
        EXTERIOR WALLS :
                STARTING AT(0.00, 0.00, 0.00)
                FACING(180.00)
                TILTED(90.00)
                EXTERIOR (1000.00 BY 22.00);
        FLOORS :
                STARTING AT(0.00, 1000.00, 0.00)
                FACING(180.00)
                TILTED(180.00)
                FLOOR (1000.00 BY 1000.00);
        PEOPLE=45,CONSTANT ,
                AT ACTIVITY LEVEL 0.70, 70.00 PERCENT RADIANT,
                FROM 01JAN THRU 31DEC;
        END ZONE;
END BUILDING DESCRIPTION;
```

Figure 9. BUILDING DESCRIPTION.

```
BEGIN FAN SYSTEM DESCRIPTION;
VARIABLE VOLUME SYSTEM 1
        "FAN SYSTEM1" SERVING ZONES 1;
        FOR ZONE 1:
                SUPPLY AIR VOLUME=100;
                EXHAUST AIR VOLUME=0;
                ZONE MULTIPLIER=1;
        END ZONE;
        OTHER SYSTEM PARAMETERS:
                SUPPLY FAN PRESSURE=2.48914;
        END OTHER SYSTEM PARAMETERS;
        EQUIPMENT SCHEDULES:
        SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
        END EQUIPMENT SCHEDULES;
END SYSTEM;
END FAN SYSTEM DESCRIPTION;
```

Figure 10. FAN SYSTEM DESCRIPTION.

```
BEGIN CENTRAL PLANT DESCRIPTION;
        PLANT 1 "PLANT TT " SERVING ALL SYSTEMS;
                EQUIPMENT SELECTION:
                        CHILLER :
                        1 OF SIZE 199;
                END EQUIPMENT SELECTION;
        END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Figure 11. CENTRAL PLANT DESCRIPTION.

Tutorial

Using BLAST: A Short Tutorial

Recommended Uses for BLAST

BLAST is a powerful tool for HVAC design. Building design alternatives can be compared using the BLAST building simulation. The building simulation will also calculate peak loads for heating and cooling for design days that represent an extreme summer day and an extreme winter day. These peak loads can be used to determine supply air volumes for the individual zones. The fan system simulation can be used to compare different system alternatives and to determine chilled water, hot water, and steam demands for sizing central plant equipment. Then the central plant simulation can be used to compare different plant equipment alternatives.

The most powerful feature of BLAST is the annual simulation that will exercise the building, systems, and plant over the full range of conditions seen in a typical year. Different system alternatives may perform equally well under extreme design conditions, but there may be a big difference under the part load conditions that are typical throughout the year.

BLAST can be applied to a wide range of projects. For example:

1. BLAST can be used for new designs or retrofit projects and can simulate buildings and energy systems of almost any type and size, from residential to high-rise.

2. In addition to simulating the annual performance of buildings and their energy systems, BLAST can perform peak load (design day) calculations necessary for both heating and cooling coil selection and air distribution system and central plant design.

3. BLAST can evaluate building and energy system designs to determine if they comply with design energy budgets.

4. BLAST can estimate annual performance, which is essential for the design of solar and total energy (cogeneration) systems.

5. BLAST can be used for standards compliance including DOE Commercial Standard (10 CFR 435) and ASHRAE Commercial Standard 90.1.

6. Since repeated use of BLAST is inexpensive, it can be used to evaluate, modify, and re-evaluate alternate designs on the basis of annual energy consumption. In this way, efficient designs can be separated from the inefficient; proper equipment type, size, and control can also be determined. Near-optimal designs for any new or retrofit project can be developed using this approach.

Using the BLAST System

Overall, using BLAST consists of creating an input file with HBLC, fine-tuning the input file in an editor, and then executing BLAST. Auxiliary programs such as CHILLER and the Heat Pump Parameters Program may be used to calculate parameters for your BLAST input file. Weather information required by BLAST may be processed using the WIFE program. BLAST output may be used in the economics program WinLCCID 97 to associate a cost with the BLAST model. Finally, a pollution analysis of the information processed from the plant simulation may be performed to determine the pollutants generated annually. The mechanics of running the auxiliary programs are explained in the *AUXILIARY PROGRAMS* section.

A Methodology for Using BLAST

Because BLAST was developed as both a research and a design tool, it has the capabilities to model buildings in excruciating detail. This feature often becomes a trap for the uninitiated building modeler. This section provides a step by step outline that will help you avoid this trap as you construct your first BLAST input files. Using the HBLC, a simple BLAST model that captures the most significant features of your building can be constructed in a very short amount of time. The key concept is:

"*You always have time for a BLAST simulation, because the simplest BLAST model is more accurate and flexible than anything else you could do in the same amount of time.*"

The idea is to quickly construct a simple model. Next, estimate the importance of the input parameters used in the simple model. Finally, refine the most significant parameters in your simplified model. The methodology is explained in the following sections.

Step 1: Plan Ahead

Some preliminary steps will facilitate the construction of your BLAST input file. BLAST requires some modeling information in specified formats; other information may require some lead time to obtain. The following checklist should be completed before you start to construct your BLAST input file.

- √ Obtain a weather tape for the city in which your building is located if it was not included with your BLAST software package.
- √ Obtain sufficient *building construction* information to allow specification of overall building geometry and surface constructions (including exterior walls, interior walls, partitions, floors, ceilings, roofs, windows and doors).

- √ Obtain sufficient *building use* information to allow specification of the electric (and/or gas) equipment and the number of people in each area of the building.
- √ Obtain sufficient *building control* information to allow specification of the temperature control strategy for each area of the building.
- √ Obtain sufficient *air handling system operation* information to allow specification and scheduling of the fan systems.
- √ Obtain sufficient *central plant* information to allow specification and scheduling of the boilers, chillers and other plant equipment.

*Step 2: "*Zone" the Building

A building "surface" is the fundamental element in the BLAST building model. In the most general sense there are two types of "surfaces" in BLAST. These are:

1. heat transfer surfaces and
2. heat storage surfaces

The first rule of building modeling is, "*Always define a surface as a heat storage surface unless it must be defined as a heat transfer surface*". Any surface, which is expected to separate spaces of significantly different temperatures, must be defined as a *heat transfer surface.* Thus, exterior surfaces, such as outside walls, roofs and floors, are *heat transfer surfaces*. Interior surfaces (partitions) are *heat storage surfaces* if they separate spaces maintained at the same temperature and *heat transfer surfaces* if they separate spaces maintained at different temperatures. A discussion of how to define heat transfer and heat storage surfaces in BLAST will occur later in the tutorial. In order to correctly "zone" the building it is necessary only to distinguish between the two.

A BLAST "zone" is a *thermal* not a *geometric* concept. It is defined as an air volume at a uniform temperature plus all the heat transfer and heat storage surfaces bounding or inside of that air volume. BLAST calculates the energy required to maintain each zone at a specified temperature for each hour of the day. Since BLAST performs a zone heat balance, the first step in preparing a building description is to break the building into zones. The objective of this exercise is to define as *few* zones as possible without significantly compromising the integrity of the simulation.

Although defining building zones is somewhat of an art, a few general rules will keep the new BLAST user out of trouble. Consider the following figure, which shows the floor plan of the Ft. Monmouth Education Center.

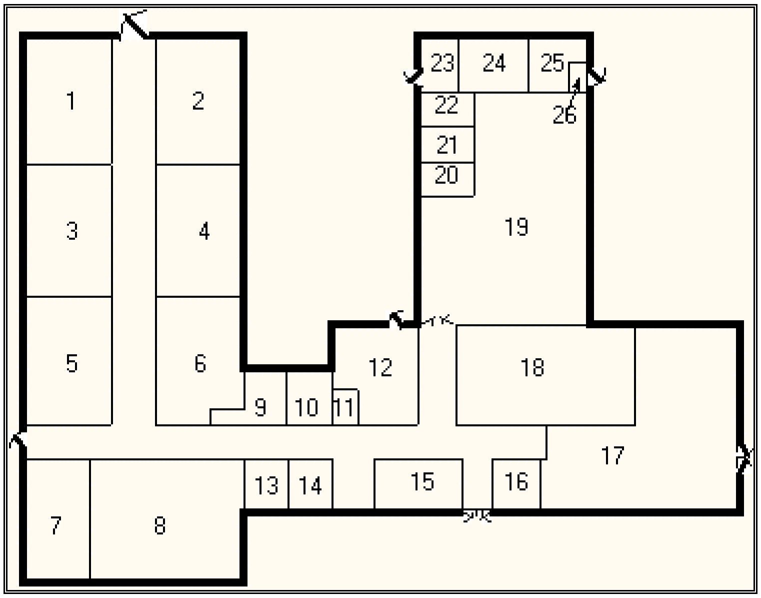


Figure 12. Fort Monmouth Education Center

The question is, "How many *thermal* zones should be used to model this building?" The inexperienced building modeler may be tempted to define each room in the building as a zone, but the thermal zone is defined as a volume of air at a uniform temperature. The general rule then is to *use the number of fan systems (and radiant systems) not the number of rooms to determine the number of zones in the building.* The minimum number of zones in a general simulation model will usually be equal to the number of systems serving the building. The collection of heat transfer and heat storage surfaces defined within each zone will include all surfaces bounding or inside of the space conditioned by the system.

Five systems were designed to serve the Ft. Monmouth Education Center. These systems with the thermal zones they serve are shown in the table below. The location of each zone is shown in accompanying figure.

System Number	System Name	CFM	Zone Served
1	Four Pipe Fan Coil	3900	Zone 1
1	Four Pipe Fan Coil	2500	Zone 2
2	Single Zone Draw Through	1400	Zone 3
3	Single Zone Draw Through	2250	Zone 5
4	Single Zone Draw Through	2450	Zone 6
5	Unit Heater	185	Zone 4
5	Unit Heater	41	Zone 7

Table 2. Zoning the Building by System Type

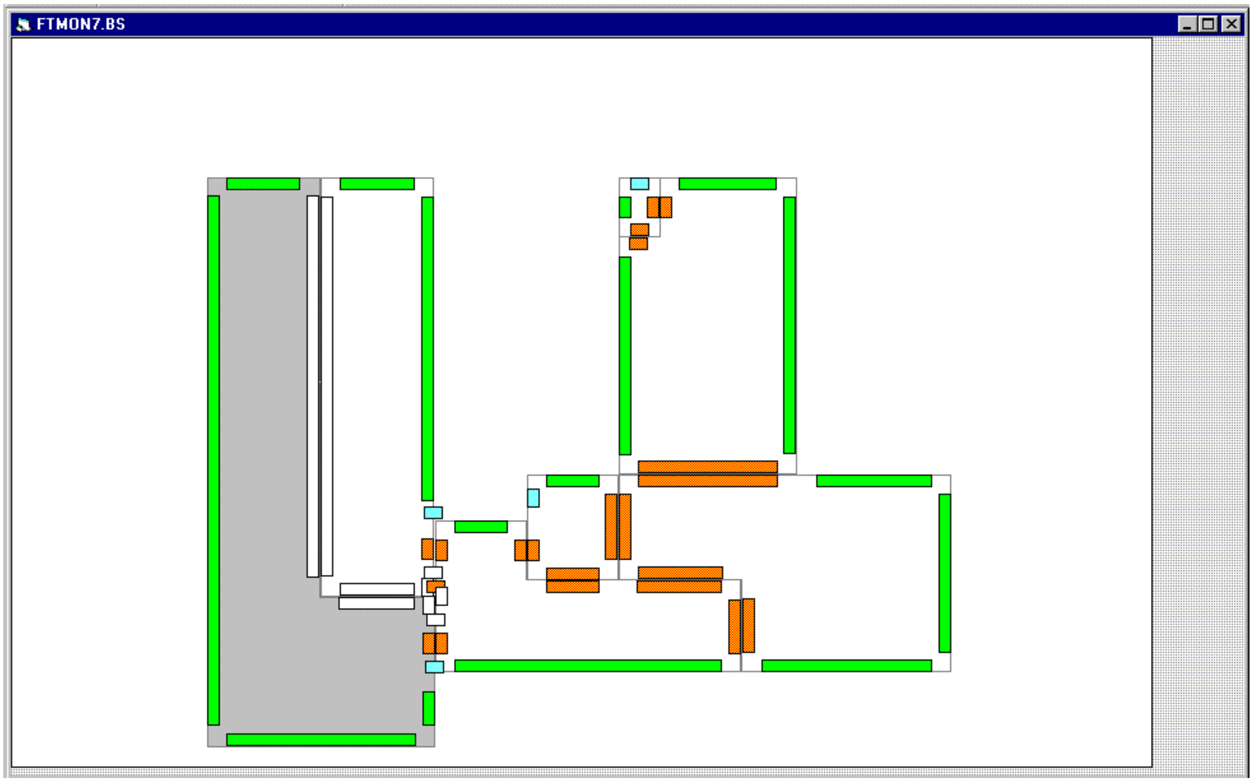


Figure 13. Plan View of Building Zones

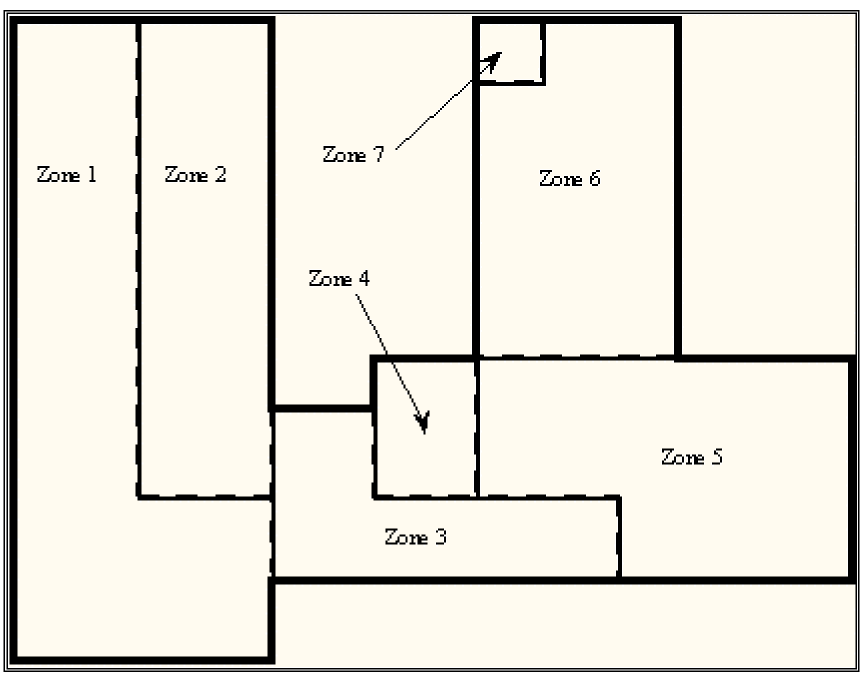


Figure 14. Zoning the Education Center for a General BLAST Simulation

Notice Zone 1, Zone 2, Zone 4, and Zone 7. The two important zoning concepts can be demonstrated with the zoning of the Ft. Monmouth Education

Center to reinforce the idea of a thermal zone and encourage the use of simplified models.

1. Notice that Zones 4 and 7 include two rooms that are not adjacent to one another but are served by the same system. Because the air temperature in the two spaces is maintained at the same uniform temperature, the two spaces, though separated spatially, may be defined as a single zone. But for our purposes we will define them as separate zones.

2. Notice that Zone 1 and Zone 2 are served by the same fan system and could be defined as a single zone with 7650 cfm of conditioned air supplied to the space. The space was split into two zones because the designer expected higher solar loads on the South and West sides of the wing and wanted to examine the *distribution* as well as the *magnitude* of the load in the space.

Zoning concept number 2 (above) leads to an important final point concerning the zoning of a building for a BLAST simulation. Complete estimates of the total building load (magnitude only) may be obtained with very simple models. For example the total building load calculated using a one-zone model of the Ft. Monmouth Education Center (Figure below) will **NOT** be significantly different from the total building load calculated using a more detailed model. The *distribution* of the load within the building cannot be estimated with the simplified building model, but its *magnitude* (such as would be used in sizing the central plant equipment) can be quickly estimated using a very simple model.

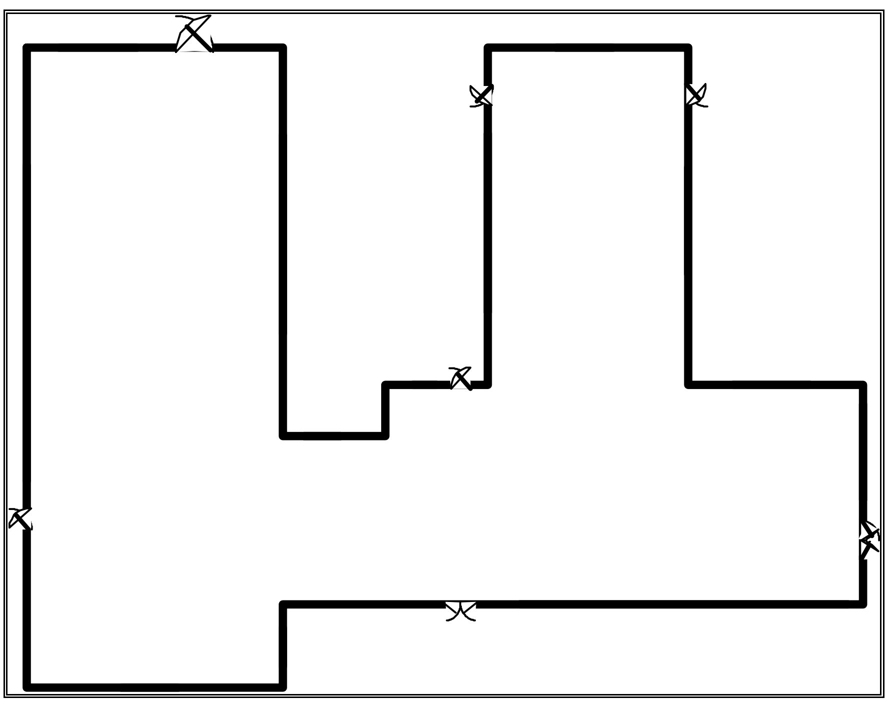


Figure 15. Single Zone Model of the Ft. Monmouth Education Center.

Step 3: Prepare to Construct the Building Model

Working from blueprints or sketches and following the guidelines in Step 2, the building zones were determined. It is recommended that the engineer sketch the building with its zones. Surface dimensions should be included in the sketch. Additional geometric and surface information is required before a BLAST input file describing the building can be constructed. Specifically the building model must:

1. Determine *heat transfer* and *heat storage* surfaces.
2. Define equivalent surfaces.
3. Specify surfaces and subsurfaces (windows, doors, etc.) not found in the BLAST Library.
4. Compile surface and subsurface information.

At this point it is appropriate to begin to introduce the structure of the BLAST input file. The next figure shows a section of a BLAST input file created by HBLC. This file is used by the BLAST program to perform the building analysis. The entire building is described between the BEGIN BUILDING DESCRIPTION statement and the END BUILDING DESCRIPTION statement as shown in the previous description on BLAST Input File.

```
BEGIN BUILDING DESCRIPTION;
  BUILDING="FORT MONMOUTH EDUCATION CENTER ";
    NORTH AXIS=165.00;
    SOLAR DISTRIBUTION=-1;
    ZONE 1 "ZONE 1 ":
      ORIGIN:(0.00, 0.00, 0.00);
      NORTH AXIS=0.00;
      EXTERIOR WALLS :
        STARTING AT(0.00, 0.00, 0.00)
        FACING(180.00)
        TILTED(90.00)
        CONST1 (50.00 BY 10.00),
        STARTING AT(25.00, 124.66, 0.00)
        FACING(0.00)
        TILTED(90.00)
        CONST1 (25.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DPW (6.97 BY 6.00)
            REVEAL(0.00)
            AT (0.01, 0.01)
          WITH DOORS OF TYPE
          ALD (3.50 BY 3.00)
            AT (0.01, 0.01),
                .
         (more exterior walls)
                .
      PARTITIONS :
        STARTING AT(50.00, 29.00, 0.00)
        FACING(90.00)
        TILTED(90.00)
        CONST3 (3.66 BY 10.00),
        STARTING AT(50.00, 32.66, 0.00)
        FACING(0.00)
        TILTED(90.00)
        CONST3 (25.00 BY 10.00),
                .
        (more partitions)
                .
      INTERZONE PARTITIONS :
        STARTING AT(50.00, 16.00, 0.00)
        FACING(90.00)
        TILTED(90.00)
        CONST2 (13.00 BY 10.00)
        ADJACENT TO ZONE (2);
      SLAB ON GRADE FLOORS :
        STARTING AT(0.00, 0.00, 0.00)
        FACING(0.00)
        TILTED(180.00)
        CONST6 (157.33 BY 25.00);
      ROOFS :
        STARTING AT(0.00, 0.00, 10.00)
        FACING(0.00)
        TILTED(0.00)
        CONST5 (157.33 BY 25.00);
      INTERNAL MASS: CONST3
        ( 238.00 BY 10.00);
    END ZONE;
          .
    (additional zones)
          .
END BUILDING DESCRIPTION;
```

Figure 16. Building Description Portion of BLAST Input File.

1. Determine *heat transfer* and *heat storage* surfaces.

Between the **BEGIN** and **END** statements, each zone is described separately surface by surface. Notice that the zone surfaces are grouped in categories ("exterior walls", "partitions", etc.). As the building model is constructed in HBLC, it will be necessary to identify the category in addition to surface construction information. In the simulation, BLAST treats each category differently. Therefore, it is important to designate all surfaces correctly as either *heat transfer* or *heat storage* surfaces according to the following list:

Heat Storage Surfaces

PARTITIONS:

CEILING:

FLOOR:

Heat Transfer Surfaces Exposed to the Outside Environment

EXTERIOR WALLS:

ROOF:

WALLS TO UNCOOLED SPACES:

EXPOSED FLOOR:

Heat Transfer Surfaces in Contact with the Ground

BASEMENT WALL:

SLAB ON GRADE FLOOR:

Heat Transfer Surfaces Exposed to Another Zone

INTERZONE PARTITION:

INTERZONE CEILING:

INTERZONE FLOOR:

CEILINGS, FLOORS, and PARTITIONS are assumed to divide temperature-controlled spaces. The program assumes that the surface temperatures on both sides of the surface are the same. This means that even though heat may be stored in a partition, ceiling, or floor, no heat flows *through* it.

EXTERIOR WALLS, ROOFS, WALLS TO UNCOOLED SPACES, and EXPOSED FLOORS divide the temperature controlled space from the outside environment. EXTERIOR WALLS, EXPOSED FLOORS, and ROOFS feel the full effect of both solar radiation and outside temperature, and the outside air film resistance for these surfaces changes with wind speed and wind direction. WALLS TO UNCOOLED SPACES are not affected by solar radiation, wind speed or direction and have a constant outside convective air film resistance.

BASEMENT WALLS and SLAB ON GRADE FLOORS separate the space from the earth surrounding the surfaces. Therefore, the outside surface temperatures become the ground temperatures.

INTERZONE PARTITIONS, INTERZONE CEILINGS and INTERZONE FLOORS separate zones that may be at different temperatures. These surface types allow heat transfer (by conduction through the walls) from a zone at a higher temperature to a zone at a lower temperature. The location of the heat storage surface in the zone is not important except in specialized solar studies.

2. Define equivalent surfaces.

When the building was zoned our objective was to define as *few* zones as possible. Now we would like to extend this objective to include defining as *few* surfaces as possible without significantly compromising the integrity of the simulation. We reduce the number and complexity of surfaces in our BLAST input file by defining *equivalent* surfaces.

Before dealing with equivalent surfaces, it is appropriate to take the concept of a thermal zone one step further. BLAST performs heat balances on individual zone surfaces and on the zone air. For purposes of the heat transfer calculations in BLAST, a *geometrically* correct rendering of the zone surfaces is not required. The surfaces do not even have to be connected. As long as BLAST knows to which thermal zone (mass of air) each surface transfers heat, it will calculate all heat balances correctly. For example, all heat storage surfaces of the same construction within a zone may be defined as a single rectangular surface. The size of this *equivalent* surface will equal the sum of all the areas of all the heat storage surfaces in the zone. A few simple rules will further explain what we mean by *equivalent* surfaces and where these surfaces should be used.

1. *Define all roofs and floors as rectangles regardless of the shape of the zone.* Each zone should have one rectangular roof and one rectangular floor of a given construction.
2. *Define all heat storage surfaces of the same construction within a zone as a single surface*. The size of the single surface is obtained by summing the individual surface areas exposed to the zone. Thus if a partition is completely within a zone (both sides of the partition are exposed to the zone), the area of each side must be added to the area of the equivalent surface. On the other hand, if the partition separates two zones, the area of only one side should be added to the equivalent surface.
3. *Combine all windows on a given exterior surface into a single window*. Usually each exterior surface should have only one window of each type. Overhangs or other shading devices may require that more windows be specified or combined together. Note that glass doors are specified as "windows" in BLAST.

The following figure shows the surfaces and subsurfaces required for a one-zone model, i.e., the Fort Monmouth education center. Since there were two types of partitions in the building, two heat storage surfaces ("internal mass") of different constructions were defined.

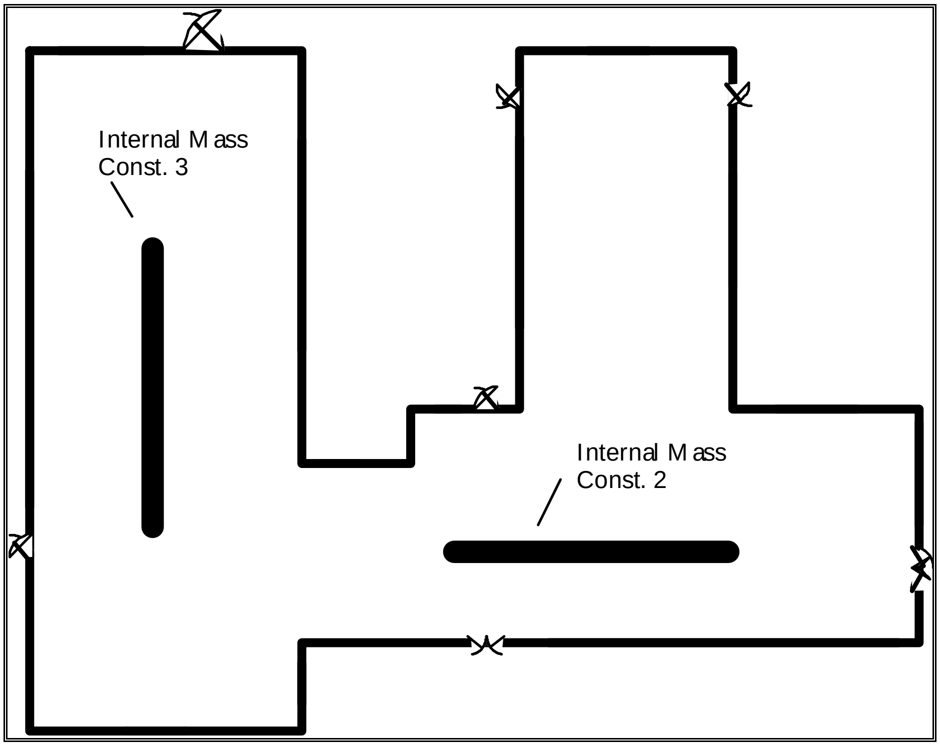


Figure 17. Simplifications Using Equivalent Surfaces

3. Specify surfaces not found in BLAST Library

When creating a BLAST input file, the desired surface constructions may not be available in the BLAST Libraries. In these cases, "temporary" constructions, which are applicable to a single BLAST input file, may be defined using standard BLAST library materials ("Temporary" materials may also be defined; see *Temporary Materials* in *User Reference*). The table below illustrates the use of standard BLAST materials to create custom surfaces. When defining building elements, BLAST requires the materials to be listed from the outside to the inside of the zone. The information compiled in the table will be required when using HBLC to create a BLAST input file for the workshop listed below.

Number	Type (1)	Name (2)	Abbr. (3)	Material (4)
1	Wall	const1	A2	4 IN DENSE FACE BRICK
			C8	8 IN HW CONCRETE BLOCK
			IN3	MINERAL FIBER FIBROUS 6 IN
			PL4	GYPSUM LWA 5 / 8 IN
2	Partition	const2	PL4	GYPSUM LWA 5 / 8 IN
			A2	4 IN DENSE FACE BRICK
			C8	8 IN HW CONCRETE BLOCK

			PL4	GYPSUM LWA 5 / 8 IN
3	Partition	const3	PL4	GYPSUM LWA 5 / 8 IN
			B1	AIRSPACE RESISTANCE
			PL4	GYPSUM LWA 5 / 8 IN
4	Wall	const4	PL4	GYPSUM LWA 5 / 8 IN
			C8	8 IN HW CONCRETE BLOCK
			A2	4 IN DENSE FACE BRICK
			PL4	GYPSUM LWA 5 / 8 IN
5	Roof	const5	RF4	BUILT UP ROOFING 3 / 8 IN
			IN71	EXPANDED EXT POLYSTYRENE R12 2 IN
			E4	CEILING AIRSPACE
			BB17	ACOUSTIC TILE 3 / 4 IN
6	Floor	const6	DIRT 12 IN	DIRT 12 IN
			CO17	CONCRETE DRIED SAND AND GRAVEL 4 IN
			FF5	FINISH FLOORING TILE 1 / 16 IN

Table 3. Temporary Building Elements

Notes:

(1) The surface type is either a wall, floor, roof, window or door.

(2) User supplies name for the element.

(3) Abbreviate as found in the BLAST Standard libraries.

(4) Material's full name is as found in the BLAST Standard libraries.

4. Compile surface and subsurface information.

As you use HBLC to construct your BLAST input file, you will need to input information for each surface into HBLC. Time can be saved in constructing your BLAST input file by knowing ahead of time what information HBLC requires.

Building information:

1. *Building North Axis:* This syntax simplifies building geometry specification by designating one wall of the building as the building's north pointing axis. The building model North axis is measured from true (compass) North. Surface facing angles (see surface information below) are then specified relative to the building north axis. The *North Axis* entry in the *BLAST User Reference* illustrates specification of the building north axis.

Zone information:

1. *Wall height*: This is entered once. All walls are assumed to be the same height. If the height for a given wall differs from the specified height, the wall length should be adjusted by the user to give the correct equivalent area. In certain conditions this may not be possible and you will need to resize each wall accordingly.

Surface information:

1. *Surface Type:* Surfaces may be of the following types: wall, floor, roof, internal mass, or subsurface

WALLS

Exterior Wall

Partition

Wall to Uncooled Space

Basement Wall

Interzone Partition

ROOFS/CEILINGS

Roof

Ceiling

Interzone Ceiling

FLOORS

Floor

Slab on Grade Floor

Exposed Floor

Interzone Floor

2. *Construction:* The type of construction of the surface may either be a library surface or a temporary (user defined) building element.

Subsurface information:

1. Surface Type:

SUBSURFACES

Window

Door

Wing

Overhang

2. *Area:* Area of the subsurface.
3. *Reveal:* For windows only, the distance it is inset from the outside surface of a wall.

It is recommended that the surface data be compiled prior to running HBLC. For example, consider the single zone model. The following figure is a schematic representation of a one zone representation. The figure shows the location of the "zone origin", the length of all "base" surfaces and the areas of all "subsurfaces" (windows and doors). The surfaces are numbered counter-clockwise around the zone beginning at the zone origin as shown the table below, the table of required zone information compiled by the user prior to running HBLC. A few simple conventions should be followed to facilitate the construction of zone information tables:

1. Number all surfaces in order counter-clockwise around the zone.
2. Keep the subsurfaces with the base surface on which they are located.
3. Specify *lengths* for base surfaces and areas for subsurfaces and internal mass.
4. Specify the roof and floor as rectangles of the correct size.

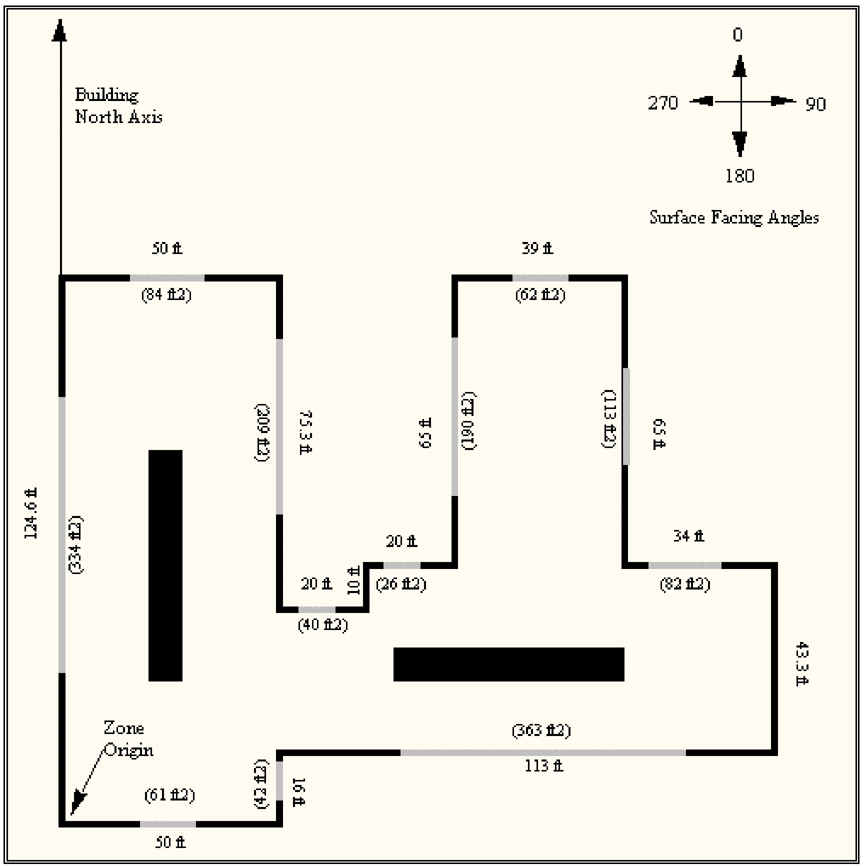


Figure 18. Schematic of One Zone Model with Surface Information.

Zone 1

Surface	type	const.	length	area
1	exterior wall	const1	50	
2	window	dpw		61
3	exterior wall	const1	16	
4	window	dpw		42
5	exterior wall	const1	113	
6	window	dpw		363
7	exterior wall	const1	43.33	

8	window	dpw		101
9	exterior wall	const1	34	
10	window	dpw		82
11	exterior wall	const1	65	
12	window	dpw		113
13	exterior wall	const1	39	
14	window	dpw		62
15	exterior wall	const1	65	
16	window	dpw		190
17	exterior wall	const1	20	
18	window	dpw		26
19	exterior wall	const1	10	
20	exterior wall	const1	20	
21	window	dpw		40
22	exterior wall	const1	75.33	
23	window	dpw		209
24	exterior wall	const1	50	
25	window	dpw		84
26	exterior wall	const1	124.66	
27	window	dpw		334
28	roof	const5	116 X 116	13450
29	floor	const6	116 X 116	13450
30	internal mass	const2		10300
31	internal mass	const3		18920

Table 4. Compilation of Surface Information for the One Zone Model

The column headings in the previous table have the following meanings:

Type: The surface code used by BLAST to differentiate between heat storage surfaces and various types of heat transfer surfaces.

Const: The standard BLAST Library or user defined "temporary" description of the surface construction.

Length: The length of base surfaces. An equivalent size of roofs and floors is also included.

Area: The area of subsurfaces.

Step 4: Compile Scheduled Loads Data

People, lights, equipment, outside air infiltration and ventilation all constitute "scheduled loads" for the thermal zone. In HBLC these loads are specified as a *peak* level with a *schedule* that specifies a fraction of the peak for each hour. An appropriate schedule should be selected from the BLAST library. The peak level is calculated by the user. The following table shows the internal loads for a single zone model of Ft. Monmouth and the BLAST library schedule selected to specify the hourly load.

				Other Information
1	people	205	Office Occupancy	Defaults
	lights	90	Office Lighting	Defaults
	infiltration	1570	Constant	Defaults
	controls	defaults	nws2	convective

*Table 5. Scheduled Loads Data **NWs2=Setback with Dual Throttling Ranges*

The column headings in the table have the following meanings:

Load Type: The scheduled load code used by BLAST to differentiate between various types of internal loads.

Size: The peak load. This is the actual size of the load for every hour that the schedule specifies "100%".

Schedule: The hourly schedule which specifies the percentage of peak load for each hour of the day.

Other Info.:: Specifies recommended changes in the HBLC defaults.

Step 5: Run HBLC: Input Building Model

Input the building model using the information compiled in the previous tables. Step by step instructions on using HBLC to input the building model are provided in the workshop which follows. Once the BLAST input file containing the building model has been constructed by HBLC, run the BLAST program using "Design Days" (24 hour simulations) to verify the correctness of the building model.

Compare the heating loads to the ASHRAE Heating Load calculation, if desired, by selecting that Report.

Step 6: Run HBLC: Add Fan Systems

The Fan Systems can be added in HBLC from the environment menu. HBLC initially assigns default values to all the system parameters. However, you can through various forms relating to the particular fan system modify virtually all applicable parameters. Run the BLAST program using "Design Days" and the “Design System” option to size the fan system and validate its performance.

Use the information from that run to enter into the "supply air volumes" for each zone in the system.

Step 7: Add Central Plant Syntax Using HBLC

The next step is to add the information for central plants using HBLC. Plants must be sized after running a simulation with fan systems, but the central plant information can be added in this step. Run the BLAST program using "Design Days" and the “Design Plant” option to size the plant and verify its operation.

Use the information from that run to enter the proper equipment sizes for each equipment on your plant.

Step 8: Perform Annual Simulation

Make final adjustments and perform a final annual run.

Comparison of Simple and Complex BLAST Models

For the Ft. Monmouth Education Center, the simple (one zone) model provides the user with an excellent estimate of total building loads. More complex models such as the seven zone model shown in the figure "Complex seven zone model" provide the user with additional information and more accurate fan system and central plant models, but for buildings with uniformly controlled interior spaces these models do not significantly improve the results calculated by simple models. Buildings with basements and/or significantly different control schemes throughout the building (such as large unconditioned spaces) cannot be modeled as a single zone but may be accurately modeled with just a few zones.

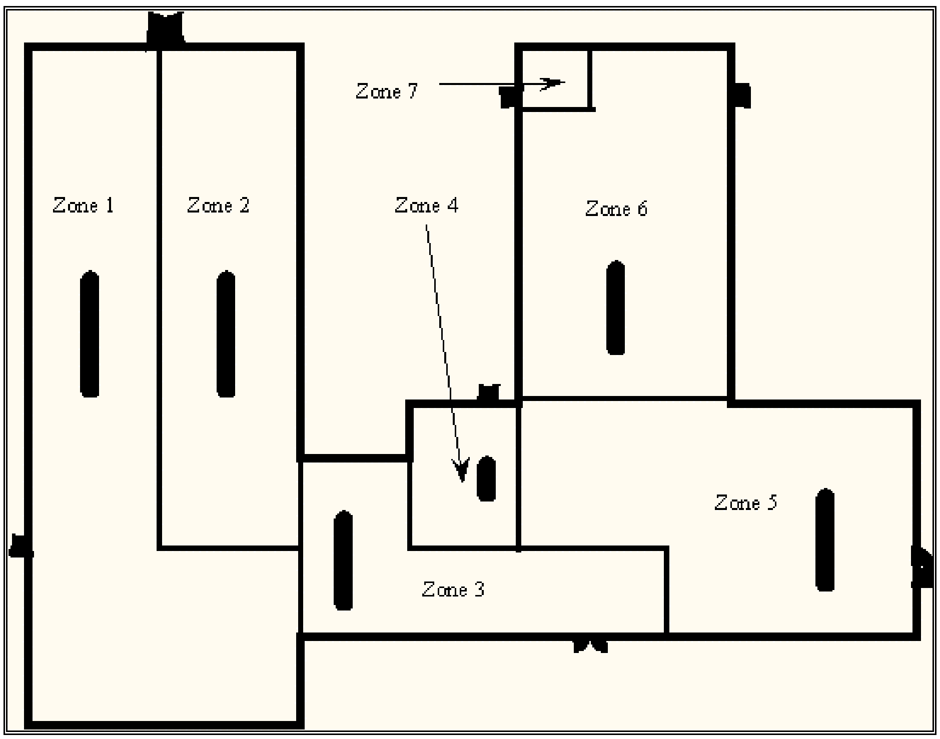


Figure 19. Complex seven zone model

The "compilation of surface information" tables below show the information required by the 7-zone model. The user must input nearly three times the number of surfaces and six times the number of scheduled loads required by the simple model. For his efforts, he realizes an improvement of less than 10% in the total cooling load and an improvement of less than .3% in the total heating load! The comparisons of the results (total, heating and cooling) are shown below.

	1 Zone	7 Zone	% Deviation
Heating Loads [kBtu]	7211.75	7226.62	0.21%
Cooling Loads [kBtu]	2554.12	2325.89	9.81%

Table 6. Comparison of 1 Zone and 7 Zone Results

The simple model captures the same building physics as the complex model.

1. The solar load was exactly the same for both models.
2. The internal loads were exactly the same.
3. The building exterior was exactly the same.
4. The same weather file was used for both runs.
5. The internal mass of the building was accurately approximated for the simple model.

The only significant difference between the two models was the fact that the complex model accounted for the effects of the uncontrolled mechanical rooms. Complex models yield additional valuable information, but if only overall building loads are required of the simulation, the user should always use simple models.

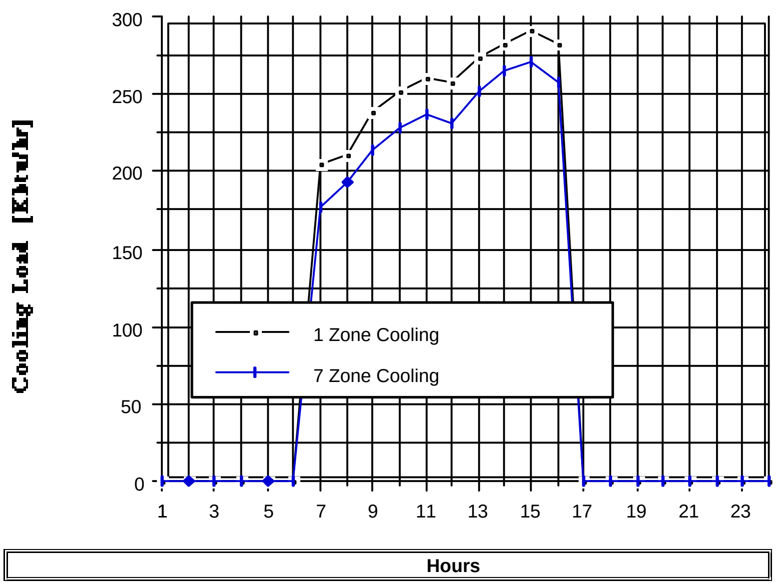


Figure 20. Comparison of 1 zone and 7 zone models for Ft. Monmouth for Cooling

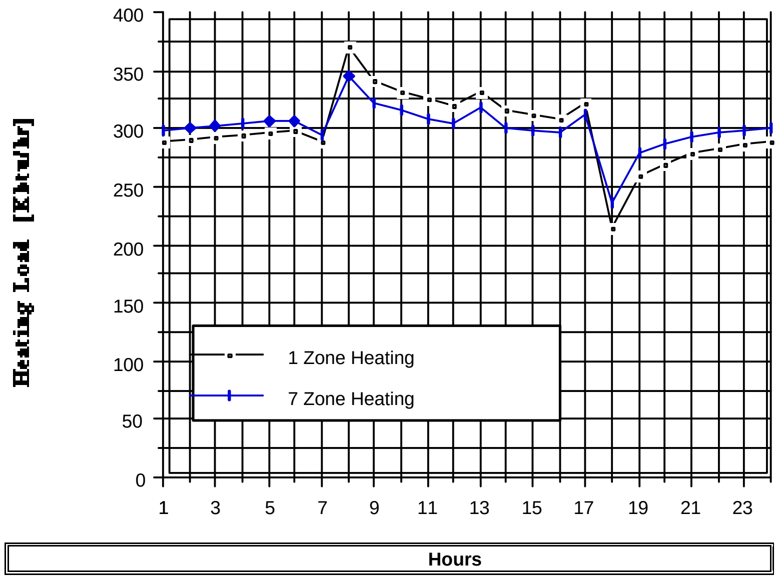


Figure 21. Comparison of 1 zone and 7 zone models for Ft. Monmouth for Heating

Zone 1

Surface	type	const	length	area
1	exterior wall	const1	50	
2	window	dpw		60.9
3	exterior wall	const1	16	
4	window	dpw		41.8
5	intz. pt (w/zn 3)	const2	13	
6	partition	const3	3.66	
7	partition	const3	25	
8	partition	const3	92	
9	exterior wall	const1	25	
10	window	dpw		41.8
11	door	ald		10.5
12	exterior wall	const1	124.66	
13	window	dpw		334
14	door	ald		16.3
15	roof	const5	157.3 X 25.0	
16	floor	const6	157.3 X 25.0	
17	internal mass	const3		2380

Zone 2

Surface	type	const	length	area
18	partition	const3	25	
19	partition	const3	3.67	60.9
20	intz. part. (w/zn3)	const2	13	
21	exterior wall	const1	75.33	41.8
22	window	dpw		208.8
23	exterior wall	const1	25	

24	window	dpw		41.8
25	door	ald		10.5
26	partition	const3	92	
27	roof	const5	92.0 X 25.0	
28	floor	const6	92.0 X 25.0	
29	internal mass	const3		880

Table 7. Compilation of Surface Information for Zones One and Two

Zone 3

Surface	type	const	length	area
30	exterior wall	const1	67	
31	window	dpw		179.4
32	door	ald		35
33	intz. part. (w/zn5)	const3	20.33	
34	intz. part. (w/zn5)	const3	27	
35	intz. part. (w/zn4)	const3	20	
36	intz. part. (w/zn4)	const3	13	
37	exterior wall	const1	20	
38	window	dpw		39.7
39	intz. part. (w/zn2)	const2	13	
40	partition	const3	7.33	
41	intz. part. (w/zn1)	const2	13	
42	roof	const5	33.3 X 48.7	
43	floor	const6	33.3 X 48.7	
44	internal mass	const3		3220

Zone 4

Surface	type	const	length	area
45	intz. part. (w/zn3)	const3	20	
46	intz. part. (w/zn5)	const3	23	
47	exterior wall	const1	20	
48	window	dpw		26.2
49	door	ald		21
50	exterior wall	const1	10	
51	intz. part. (w/zn3)	const3	13	
52	roof	const5	20.0 X 23.0	
53	floor	const6	20.0 X 23.0	
54	internal mass	const3		280

Table 8. Compilation of Surface Information for Zones Three and Four

Zone 5

Surface	Type	const	length	area
55	exterior wall	const1	46	
56	Window	dpw		184
57	exterior wall	const1	43.33	
58	window	dpw		102
59	door	ald		35

60	exterior wall	const1	34	
61	window	dpw		81.7
62	intz. part. (w/zn6)	const2	39	
63	intz. part. (w/zn4)	const3	23	
64	intz. part. (w/zn3)	const3	27	
65	intz. part. (w/zn3)	const3	20.33	
66	roof	const5	40.3 X 60.3	
67	floor	const6	40.3 X 60.3	
68	internal mass	const3		1240

Zone 6

Surface	type	const	length	area
69	intz. part. (w/zn5)	const2	39	
70	exterior wall	const1	65	
71	window	dpw		113.8
72	door	ald		21
73	exterior wall	const1	30	
74	window	dpw		62.3
75	intz. part (w/zn4)	const3	13	
76	intz. part. (w/zn4)	const3	9	
77	exterior wall	const1	52	
78	window	dpw		189.6
79	roof	const5	31.0 X 78.0	
80	floor	const6	31.0 X 78.0	
81	internal mass	const3		2380

Table 9. Compilation of Surface Information for Zones Five and Six

Zone 7

Surface	type	const	length	area
82	intz. part. (w/zn6)	const3	9	
83	intz. part. (w/zn6)	const3	13	
84	exterior wall	const1	9	
85	exterior wall	const1	13	
86	door	ald		21
87	roof	const5	13.0 X 9.0	
88	floor	const6	13.0 X 9.0	

Table 10. Compilation of Surface information for zone seven

Zone	Load	Size	Schedule	Other Information
1	people	100	Office Occupancy	defaults
	lights	26.9	Office Lighting	defaults
	infiltration	470	constant	defaults
	controls	defaults	nws2	convective

Zone	Load	Size	Schedule	Other Information
2	People	55	Office Occupancy	defaults
	Lights	15	Office Lighting	defaults
	Infiltration	262	constant	defaults
	Controls	defaults	nws2	convective

Zone	Load	Size	Schedule	Other Information
3	People	10	Office Occupancy	defaults
	Lights	9.9	Office Lighting	defaults
	Infiltration	172	constant	defaults
	Controls	defaults	nws2	convective

Zone	Load	Size	Schedule	Other Information
4	People	none	Office Occupancy	defaults
	Lights	3.3	Office Lighting	defaults
	Infiltration	58	constant	defaults
	Controls	default heating	nws2	convective
		cooling = 0		

Zone	Load	Size	Schedule	Other Information
5	People	20	Office Occupancy	defaults
	Lights	17.6	Office Lighting	defaults
	Infiltration	307	constant	defaults
	Controls	defaults	nws2	convective

Zone	Load	Size	Schedule	Other Information
6	People	20	Office Occupancy	defaults
	Lights	16.5	Office Lighting	defaults
	Infiltration	287	constant	defaults
	Controls	defaults	nws2	convective

Zone	Load	Size	Schedule	Other Information
7	People	none	Office Occupancy	defaults
	Lights	0.8	Office Lighting	defaults
	Infiltration	14	constant	defaults
	Controls	default heating	nws2	convective
		cooling = 0		

Table 11. Scheduled loads data for the seven zones

HBLC Workshop: One-Zone Model: Loads Calculation

Introduction

In the following workshop, you will generate the BLAST input file for a one-zone model of the Fort Monmouth Education Center using the data compiled in tables in previous section. The methodology used in the workshops will consist of a brief explanation of how HBLC will be used to accomplish the next step followed by a screen shot showing the user how the entered information should appear. A detailed guide to HBLC is found within the HBLC User's Guide included with the software. You can access it through the help menu in HBLC.

Starting HBLC/Project Information

Start the HBLC program. After HBLC finishes loading, select "New" from the file menu. Executing this command will load a new project with one initial zone and will display a window titled "Project Information." In this window you should enter the input units, output units, building north axis, building name, project title, and the shading and solar options. For the building name input "Ft Monmouth Education Center" and type in 195 for true north axis. This will set your building north axis to 165 degrees. The building north axis is 360 degrees minus the true north axis. Choose English for both the input and output units. Then click the "OK" button.

Next, in order to view your project at the appropriate scale it is necessary to resize the plan view. From the geometry menu select "Resize Plan View." A subscreen will appear containing the default plan view information. Enter 200 X 200 and click the "OK" button.

Entering Basic Geometry

The next step will be to enter the geometrical information from "Diagram and Description of the One Zone Model" below. The first step is changing the wall heights to 10ft. This can be accomplished by editing the height text box at the top of your screen. The square in the lower left of the screen represents a plan view of your zone. The thin, colored rectangles around the edge of the zone represent the zone walls. You can click on any wall and drag it in or out to resize the zone. Click and drag in the center of the zone to move the entire zone. The square zone can be turned into the irregular shaped zone shown in the diagram as follows:

1. Resize the irregular zone to the overall dimensions of the irregular shaped zone (124.6 X 163 ft.) by either dragging the walls out to the size or by using the set button, located at the upper right portion of the plan view screen.

2. Split the top wall in four places and split the bottom wall in one place. This can be accomplished by selecting the wall you wish to split by clicking on it with your mouse. Then choose "Split Wall" from the geometry menu or by hitting alt-click. You will then be able to pull sections of a wall either out or in from other sections. (For more information see "Building Geometry" under HBLC help.)

3. Reshape the rectangular zone into the irregular shaped zone by dragging the new wall pieces in or out. The wall lengths can also be typed in the box at the top right just below the menu bar. After entering the desired size of a wall, the "set" button must be clicked for the change to take effect. Resize the walls in order, starting at any point and moving counter-clockwise around the building.

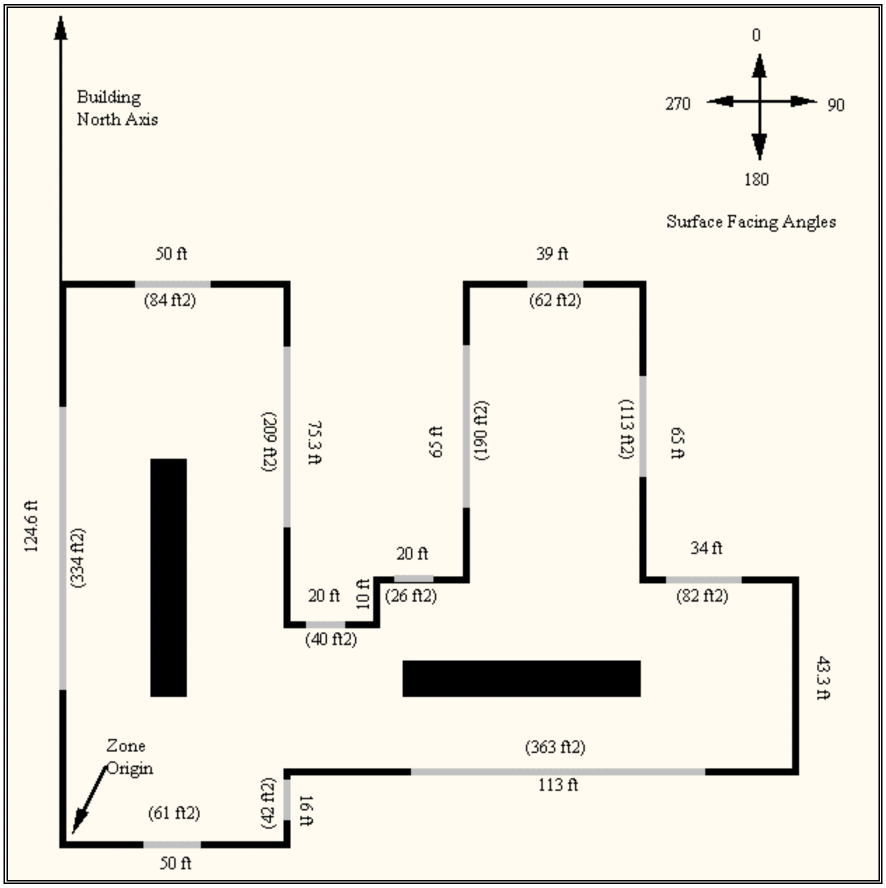


Figure 22. Diagram and Description of one zone model

After splitting the walls, pulling the wall sections in or out and entering wall lengths your zone should look like the figure below.

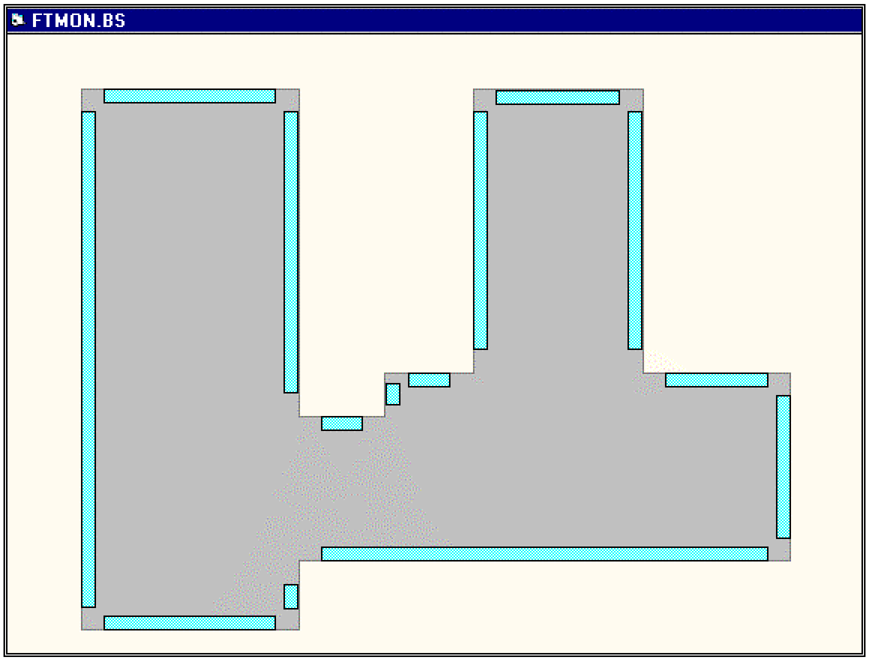


Figure 23. One zone model entered into HBLC

Saving Your File

At this point it is advised to save your file. To do this select “Save As...” from the file menu. This will bring up a Save As screen in which you should enter the name of the file and the directory. We recommend naming the file FtMon.bs and saving in the C:\blastsys\workdir\ directory. (For more information regarding saving files in HBLC, see File Operations in the HBLC User’s Guide.)

Entering Temporary Building Elements

After you have successfully saved your file, you will need to enter all of the temporary building elements from the table below.

Number	Type	Name	Abbr.	Material
1	Wall	const1	A2	4 IN DENSE FACE BRICK
			C8	8 IN HW CONCRETE BLOCK
			IN3	MINERAL FIBER FIBROUS 6 IN
			PL4	GYPSUM LWA 5 / 8 IN
2	Partition	const2	PL4	GYPSUM LWA 5 / 8 IN

			A2	4 IN DENSE FACE BRICK
			C8	8 IN HW CONCRETE BLOCK
			PL4	GYPSUM LWA 5 / 8 IN
3	Partition	const3	PL4	GYPSUM LWA 5 / 8 IN
			B1	AIRSPACE RESISTANCE
			PL4	GYPSUM LWA 5 / 8 IN
4	Wall	const4	PL4	GYPSUM LWA 5 / 8 IN
			C8	8 IN HW CONCRETE BLOCK
			A2	4 IN DENSE FACE BRICK
			PL4	GYPSUM LWA 5 / 8 IN
5	Roof	const5	RF4	BUILT UP ROOFING 3 / 8 IN
			IN71	EXPANDED EXT POLYSTYRENE R12 2 IN
			E4	CEILING AIRSPACE
			BB17	ACOUSTIC TILE 3 / 4 IN
6	Floor	const6	DIRT 12 IN	DIRT 12 IN
			CO17	CONCRETE DRIED SAND AND GRAVEL 4 IN
			FF5	FINISH FLOORING TILE 1 / 16 IN

Table 12. Temporary Building Elements

In order to enter the temporary building elements you will need to select "Custom Building Elements" from the Library Menu. This will load the Building Element Editor. First, select the type of element you will be creating. Since our first new element is a wall we will select "walls" from the Building Elements text box. (See figure below.) Next, click on the "New Element" button to begin building your custom building element. This will prompt you for a name for the new temporary building element that you should enter as "const1", our first temporary building element. Next, find the first material composing your new building element in the material list at the bottom of the screen. For this example we are looking, first, for "A2 - 4IN DENSE FACE BRICK." Select it by clicking on it, then hold down on your left mouse and drag it up to the first blank in your new building element, "const1." Repeat this procedure for each element in "const1." When you are finished with your new temporary building element, it should look like the one shown below.

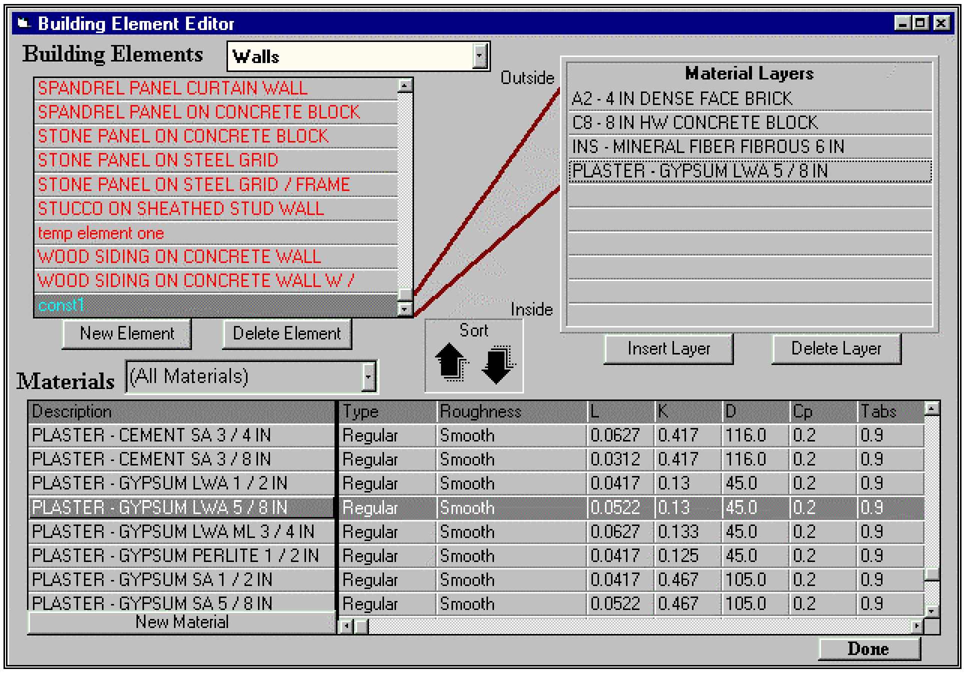


Figure 24. Building Element Editor

In this way, create all six temporary building elements that need to be defined. (For more information regarding entering in temporary elements, see Custom Library Entries in the HBLC User's Guide.)

Subsurfaces and Building Constructs

Next, you will need to assign the temporary building elements to specific walls, roofs and floors and define each individual subsurface. We will begin at the origin, the south-west corner of the building and work our way counter-clockwise around the zone. Therefore, starting with the 50ft. wall, we will first define its construction type. To accomplish this, first click on the wall once with the mouse to highlight the wall. Next click "Find..." by the library text box at the top of the screen. Choose the library element titled "const1" and click the "Select" button. After you have chosen the construction type, you will need to define the subsurfaces. In order to accomplish this, just double-click on the wall. This will bring up the wall subsurface screen as shown below. (For this wall, click the new window button at the upper left-hand corner.) Next, change the area of the window by either dragging its edges or by typing in the appropriate area and clicking the "Set" button. Next, you will need to select the construction of the window you just added. Click on the "Find..." button next to the Library Name text box. Choose Double Pane Window and click the

"Select" button. You have finished entering the subsurface information for this wall, so click the "Done" button at the lower right-hand corner.

Continue entering the information for the walls from the table shown below. The surfaces are numbered counter-clockwise around the zone beginning at the zone origin.

Zone 1

origin: (0.00, 0.00, 0.00)

Surface	type	const.	length	area
1	exterior wall	const1	50	
2	window	dpw		61
3	exterior wall	const1	16	
4	window	dpw		42
5	exterior wall	const1	113	
6	window	dpw		363
7	exterior wall	const1	43.33	
8	window	dpw		101
9	exterior wall	const1	34	
10	window	dpw		82
11	exterior wall	const1	65	
12	window	dpw		113
13	exterior wall	const1	39	
14	window	dpw		62
15	exterior wall	const1	65	
16	window	dpw		190
17	exterior wall	const1	20	
18	window	dpw		26
19	exterior wall	const1	10	
20	exterior wall	const1	20	
21	window	dpw		40
22	exterior wall	const1	75.33	
23	window	dpw		209
24	exterior wall	const1	50	
25	window	dpw		84
26	exterior wall	const1	124.66	
27	window	dpw		334
28	roof	const5	116 X 116	13450
29	floor	const6	116 X 116	13450
30	internal mass	const2		10300
31	internal mass	const3		18920

Table 13. Compilation of Surface Information for the One Zone Model

Once you have completed entering the wall information you will now need to enter the roof, floor, and internal mass information. To accomplish this just double-click anywhere within the center of the zone. HBLC will display a screen similar to the one shown in the figure below.

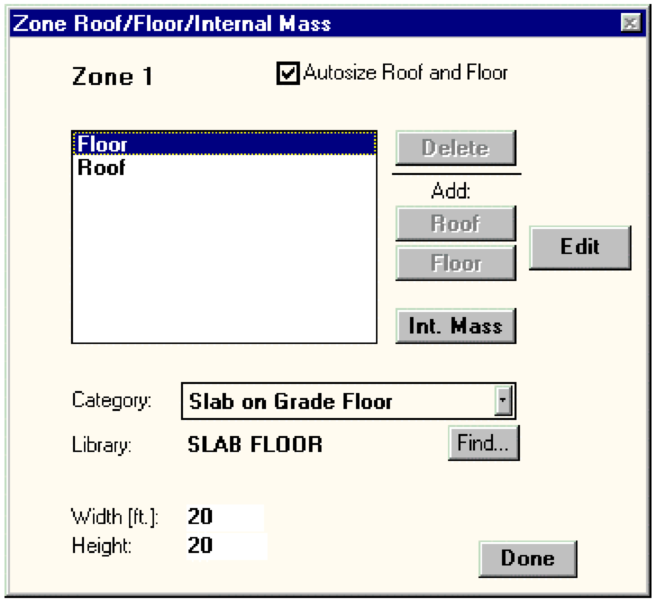


Figure 25. Zone Roof/Floor/Internal Mass Screen

Highlight the word "Floor" within the large textbox in the center of the screen. Select the category “Slab on Grade Floor” from the drop down menu. Then, click the “find” button and choose "const6". Next, highlight the word roof by clicking on it once. Click the “find” button and choose "const5" for the roof. You will notice that HBLC automatically sized your roof and floor to cover the appropriate area. Now, you will need to enter internal mass. To do this, click the “Int. Mass” button. For the first internal mass you will need to click on the “find” button and choose "const2". Then set the width and height mass to equal the area of 10300. I chose a width of 5 and a height of 2060. Similarly, enter a second internal mass except choose const3 for the construction and enter a width of 5 and a height of 3784. Then click the "Done" button.

Scheduled Loads

Finally, you will need to enter the scheduled loads. The information for our scheduled loads can be found in the table below.

				Other Information
1	people	205	Office Occupancy	Defaults
	lights	90	Office Lighting	Defaults
	infiltration	1570	Constant	Defaults
	controls	defaults	nws2	convective

*Table 14. Scheduled Loads Data **NWS2=Setback With Dual Throttling Ranges*

To enter this information into HBLC you will need to select “Scheduled Loads” from the environment menu. HBLC will display a screen similar to the one shown below in the figure below.

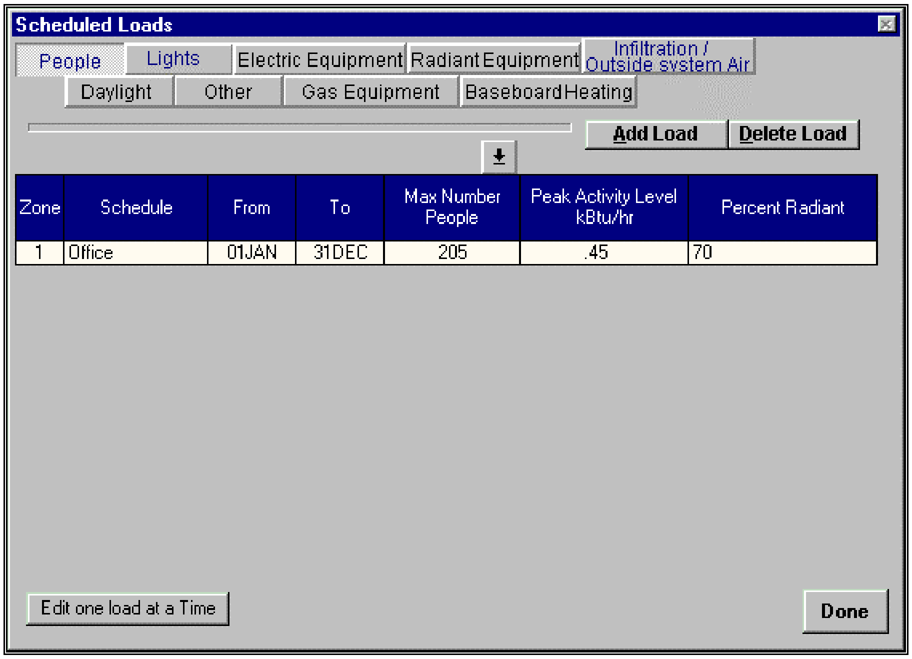


Figure 26. Scheduled Loads Screen

To enter the first load, people, click on the “People” button at the top of the screen and click the "add load" button. Change the Max Number of People to 205 and select Office Occupancy for the schedule. Then click the “Lights” button at the top of the screen. Change the Peak to 90(Kbtu/hr) and the schedule to Office Lighting. Then click the “Infiltration/ Outside System Air” button. Change the peak volume flow rate to 1570(cfm) and the schedule to constant. You have finished entering schedule loads. Conclude by clicking the “Done” button.

Controls

To begin entering controls, select “Controls” from the Environment menu. The figure below displays the screen that will appear.

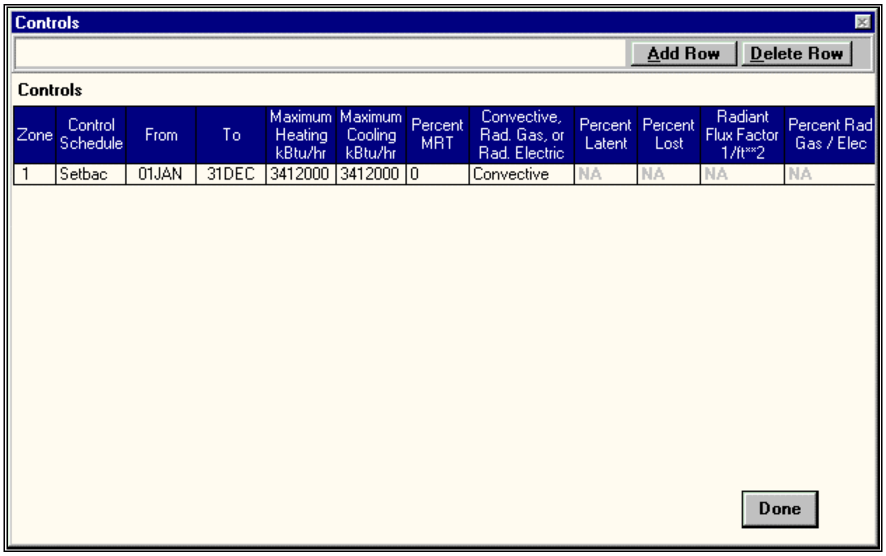


Figure 27. Controls Screen

Change the Control Schedule to Setback with Dual Throttling range. Then change the “Convective, Rad. Gas, or Rad. Electric” to Convective. Click the “Done” button at the right-hand corner. Now, all three scheduled loads and the zone controls have been entered. Note that default parameters are accepted unless the designer has detailed information indicating that a change is required. The syntax is explained in detail in the “Quick Reference” section of the manual.

Finishing the Data and Running BLAST

There are just a few things left to enter before creating the input file and running BLAST. Note that Fan Systems and Central Plants are not being simulated, so these can be ignored.

Next, choose “Location” from the environment menu. Find and highlight New York City, then click the “Done” button.

Next, select “Design Days” form the Environment menu. Locate “New York City New York Summer", highlight it by clicking on it and then click the “Add to Selection” button. Similarly locate “New York City New York Winter,” highlight it by clicking on it, and then click the “Add to Selection” button.

Now select “Reports” from the Environment menu. From this screen, you select the reports that you would like BLAST to output. For further information regarding BLAST reports see “BLAST Output” from the BLAST User’s Guide. We will turn on several reports, “Zone Loads,” “Hourly Profiles,” “Zone Summary,” and “Zone Group,” in addition to the default reports.

Finally, we are ready to run BLAST. To do this first choose “Create Input File” from the Calculate menu. You will be prompted to save your *.bs file (The data file where HBLC stores all of its information); click the “Save” button. Next, a “Create Input File” screen will appear. We will be doing just a design day simulation, therefore, you just need to check the box next to Design

Day Simulation then click the “Create” button. It will prompt you to save the input file; click “OK.” Now you are ready to run BLAST. Select “Calculate Loads” from the Calculate menu. Make sure the input file designated is FtMon.bin and the Output file designated is “FtMon.bot” and click the “Run BLAST” button. The output for this run can either be viewed through the Output Viewer in HBLC (Located under the Programs menu) or it can be manually read by viewing FtMon.bot in an editor. The output for this specific run is located in the *Examples* section. The *.bs files, input files (*.bin), and the output files (*.bot) for both a one-zone model and a seven-zone model are copied into the blastsys\examples directory after installation of the software.

Quick Reference

Introduction

For ease of reference, BLAST program information is presented under four separate tabs:

1. The *Quick Reference* defines BLAST syntax.
2. The *User Reference* is an encyclopedic listing of user information.
3. The *Output* section explains all BLAST output reports.
4. The *Technical Reference* contains engineering, modeling and advanced user information.

The *Quick Reference* is the first level of BLAST detail as presented in the BLAST manual set. It contains a complete listing of BLAST syntax with brief definitions and explanations. The *Quick Reference*, which extensively references other sections of the manual, is designed to give experienced users a minimal amount of information and to point inexperienced users to additional information in other sections of the manual

The *Quick Reference* is organized around the BLAST input file, and as such is presented in four sections: "Lead Input", "Building Loads", "Fan Systems" and "Central Plants".

Lead Input Syntax

The first major section of the BLAST input file is the Lead Input. The following table is an example of the Lead Input section of a BLAST input file. All of the syntax shown in the table can be created using HBLC or BTEXT. All but a few advanced options can be created more easily with HBLC. Each significant phrase of the Lead Input is explained in the following paragraphs in the order in which it appears in the BLAST input file. Cross-references to more detailed explanations in the encyclopedic listings of topics are also provided.

```
BEGIN INPUT;
    RUN CONTROL:
        NEW ZONES,
        NEW AIR SYSTEMS,
        PLANTS,
        DESIGN SYSTEMS,
```

```
        DESIGN PLANTS,
        UNITS(IN=ENGLISH, OUT=ENGLISH),
        REPORTS(SYSTEM,SHADE),
        PRINT LIBRARY(WALLS);
    TEMPORARY LOCATION:
        COLUMBIA=(LAT=38.09,LONG=92.30,TZ=6);
    END;
    TEMPORARY DESIGN DAYS:
        COLUMBIA SUMMER=(HIGH=95.00,LOW=73.00,WB=78.00,
        DATE=24JUL,PRES=405.0,WS=210.0,DIR=235.0,
        CLEARNESS=0.95,WEEKDAY);
        COLUMBIA WINTER=(HIGH=6.00,LOW=6.00,WB=6.00,
        DATE=24JAN,PRES=405.0,WS=110.0,DIR=0.0,
        CLEARNESS=0.0,WEEKDAY);
    END;
    TEMPORARY MATERIALS:
      LOW EMISSIVITY COATING=(R=0.01,ABS=0.75,TABS=0.01,MEDIUM
SMOOTH);
    END;
    TEMPORARY FLOORS:
        SLAB=(DIRT 12 IN, CONCRETE - SAND AND GRAVEL 4 IN,FINISH
FLOORING - CARPET RUBBER PAD);
    END;
    TEMPORARY SCHEDULE(MYSCHEDULE):
        MONDAY THRU
FRIDAY=(0.0,0.0,0.1,0.1,0.2,0.2,0.3,0.3,0.4,0.4,0.5,0.5,
        0.7,0.8,1.0,1.0,0.7,0.5,0.3,0.1,0.0,0.0,0.0,0.0),
        SATURDAY THRU SUNDAY=(00 TO 24 - 0.05),
        HOLIDAY=SUNDAY;
    END SCHEDULE;
    TEMPORARY CONTROLS(DEADBAND2):
        PROFILES:
            PROFILE1=(1.0 AT 70,0.0 AT 70,0.0 AT 75,-1.0 AT 75);
        SCHEDULES:
            MONDAY THRU SUNDAY=(00 TO 24 - PROFILE1),
            HOLIDAY=SUNDAY;
    END CONTROLS;
    PROJECT="SAMPLE LEAD INPUT";
    LOCATION=COLUMBIA;
    DESIGN DAYS=COLUMBIA SUMMER,
             COLUMBIA WINTER;
    WEATHER TAPE FROM 01JAN THRU 31DEC;
    REPORT FILE FROM 01MAY THRU 31MAY;
    GROUNDTEMPERATURES=(40,42,48,55,62,65,60,58,56,51,47,44);
    MAKE UP WATER
TEMPERATURES=(50,51,53,54,56,58,57,55,54,53,52,51);
```

Figure 28. Lead Input Syntax

Run Control

RUN CONTROL: This command, which is normally present, must appear immediately following BEGIN INPUT and includes the following optional parameters in any order.

New Zones

NEW ZONES specifies simulation of the zones described in the building description input block. If *NEW ZONES* is not specified, BLAST will not perform a loads simulation.

Add Zones

ADD ZONES specifies that:

1) The user has saved previously calculated loads data for one or more zones and now wishes to add calculated loads for new zones

to the same load data file. Additional information can be found in the *BLAST Technical Reference* under "BLDFL and AHLDFL Files."

2) The zones to be added, and only these zones, are described in the building description input block. Interzone partitions can not be specified since interaction between zones can not be taken into account.

3) Every zone has a zone number assigned by the user, and the added zones must be assigned different numbers from any zone numbers previously used.

4) The loads that are to be calculated for the described zones and the hourly results are added to the loads data file.

Replace Zones

REPLACE ZONES specifies that:

1) The user has saved previously calculated loads data for one or more zones, but one or more of these zones have changed. Additional information can be found in the *BLAST Technical Reference* under "BLDFL and AHLDFL Files."

2) Only zones for which loads are to be recalculated are described in the building description input block. Interzone partitions can not be specified since interaction between zones can not be taken into account.

3) The replaced zones must have the same zone number as one of the previously simulated zones.

4) The loads are to be recalculated for the described zones and the hourly results are to replace the previously calculated results on the loads data file. (Hourly results for previously calculated zone loads for zones not described in the building description block are not changed.)

New Air Systems

NEW AIR SYSTEMS specifies simulation of the fan systems described in the fan system description input block. If *NEW AIR SYSTEMS* is not specified, no fan system simulation will be performed. Any fan system simulation requires that zone loads data be available. This requires that *NEW ZONES* be specified or that a BLDFL file be available for BLAST to read.

Add Air Systems

ADD AIR SYSTEMS specifies that:

1) The user has saved previously calculated fan systems data for one or more systems and now wishes to add fan systems to the same fan systems data file. Additional information can be found in the *BLAST Technical Reference* under "BLDFL and AHLDFL Files."

2) The fan systems to be added, and only these fan systems, are described in the fan systems description input block.

3) Every fan system has a fan system number assigned by the user, the added fan systems must be assigned different numbers from any fan system's number previously used.

4) The loads that are to be calculated for the described fan systems and the hourly results are added to the fan systems data file.

Replace Air Systems

REPLACE AIR SYSTEMS specifies that:

1) The user has saved previously calculated fan systems data for one or more systems, but one or more of these fans systems have changed. Additional information can be found in the *BLAST Technical Reference* under "BLDFL and AHLDFL Files."

2) Only fan systems for which loads are to be recalculated are described in the fan systems description input block.

3) The replaced fan systems must have the same fan systems number as one of the previously simulated fan systems.

4) The loads are to be recalculated for the described fan systems and the hourly results are to replace the previously calculated results on the loads data file. (Hourly results for previously calculated loads for fan systems not described in the fan systems description block are not changed.)

Plants

PLANTS specifies simulation of plant loads for the plants described in the central plant description input block. If *PLANT* is not specified, no central plant simulation will be performed. Any central plant simulation requires that fan system loads be available. This requires that *NEW AIR SYSTEMS* be specified or that an AHLDFL file be available for BLAST to read.

Design Systems*

*Refer to encyclopedic listing in BLAST User Reference for more information.

DESIGN SYSTEMS specifies automatic calculation of the air volume flow rate to each zone. The flow rates are based on the peak sensible heating and cooling loads calculated during the building simulation for the specified design days. Please note that the Water Loop Heat Pump System cannot be sized using the Design Systems. Please see Water Loop Heat Pump in the BLAST Technical Reference.

Design Plants*

*Refer to encyclopedic listing in BLAST User Reference for more information.

DESIGN PLANTS specifies calculation of the central plant component sizes. The sizes are based on the peak system demands for the specified design days. Please note that the Ice Storage Plants and the Thermally Stratified Tank Plant cannot be sized using Design Plants. Please see the appropriate section(s) in the BLAST Technical Reference.

*Units**

∗Refer to encyclopedic listing in BLAST User Reference for more information.

<u>*UNITS*</u> indicates whether input and output are to be in English or metric units. If this parameter is omitted, BLAST will expect English units as input and will print reports in English units.

*Reports**

∗Refer to encyclopedic listing in BLAST User Reference for more information.

<u>*REPORTS*</u> specifies the non-default reports which should be printed during any BLAST run. Detailed descriptions of the available reports may be found in *BLAST OUTPUT*.

Print Library

<u>*PRINT LIBRARY (secname1,secname2,...)*</u> causes specific sections of the BLAST library to be printed. Omitting the *secname* parameters causes the entire BLAST library to be printed alphabetically by section. The following library sections may be specified:

SCHEDULE	CONTROLS	ROOFS	DESIGN DAYS
LOCATION	MATERIALS	FLOORS	
WALLS	DOORS	WINDOWS	

Temporary Location*

∗Refer to encyclopedic listing in BLAST User Reference for more information.

<u>*TEMPORARY LOCATION: usname=(LAT=usn1,LONG=usn2,TZ=usn3); END;*</u> creates a temporary location which is only valid for the current BLAST run. This statement allows the use of usname in the LOCATION statement described below. See *Library Modification* in the *BLAST User Reference*.

Appendix B gives latitude and longitude for 50 major U.S. cities with each state represented.

Temporary Design Days*

∗Refer to encyclopedic listing in BLAST User Reference for more information.

<u>*TEMPORARY DESIGN DAYS: usname=(HIGH=usn1,LOW=usn2, ...); END;*</u> creates a temporary design day which is valid only for the current BLAST run. This statement allows the use of usname in the DESIGN DAYS statement below. See *Library Modification* in the *BLAST User Reference*.

Temporary Materials*

∗Refer to encyclopedic listing in BLAST User Reference for more information.

<u>*TEMPORARY MATERIALS: usname=(L=usn1,K=usn2,CP=usn3,D=usn4,...); END;*</u> creates a temporary material which can be used in conjunction with other

temporary materials and BLAST Library materials to define TEMPORARY SURFACES. See *Library Modification* in the *BLAST User Reference*.

Appendix A presents absorptivity data of common materials to solar radiation.

Temporary Surfaces*

*Refer to encyclopedic listing in BLAST User Reference for more information.

TEMPORARY surftype: usname=(layer1,layer2, ... layer10); END; creates a temporary surface of type surftype. There can be up to ten layers defined. These definitions can be used later in the zone descriptions. See *Library Modification* in the *BLAST User Reference*.

Temporary Schedules*

*Refer to encyclopedic listing in BLAST User Reference for more information.

TEMPORARY SCHEDULE (schname): daytype=(24-hour profile); ... END SCHEDULE; creates a temporary schedule based upon the day type and the 24-hour profile data. The temporary schedules can be used later in the input file in place of BLAST Library schedules. See *Library Modification* in the *BLAST User Reference*.

Temporary Controls*

*Refer to encyclopedic listing in BLAST User Reference for more information.

TEMPORARY CONTROLS (ctlname): PROFILES: prfname=(profile description); ... ; SCHEDULES: schname=(schedule description), ... ; END CONTROLS; creates a temporary control profile which can be implemented in the CONTROLS statement of the zone description. See *Library Modification* in the *BLAST User Reference*.

Project

PROJECT = projname; shows the project title which will be reproduced periodically throughout BLAST printed reports.

Location

LOCATION = locname; specifies the weather location for design day simulations when weather tapes are not being used. Any time weather data tapes are used, the location data are taken from the weather tapes and the location command is ignored.

The location name must correspond to either the name in the location subset of the BLAST library or the name of a *TEMPORARY LOCATION* defined in the same BLAST input file.

Design Days

DESIGN DAYS = usname1, usname2, ... last name; species one or more 24 hour, single day simulations. The words "usname1, usname2, ..." are the names of design days stored in the DESIGN DAYS library or specified as Temporary Design Days. The DESIGN DAYS command is ignored for any simulation using previously saved loads (i.e., ADD or REPLACE ZONES); instead, design day data from the saved loads file are used.

Weather Tape

WEATHER TAPE FROM usdate THRU usdate; tells BLAST to read actual weather data from the weather tape or file for the simulation. A weather file must be attached at the time the BLAST program is run as explained in the BLAST program installation guide for your computer. Only one sequence of weather days can be specified in any one run. Both DESIGN DAYS and WEATHER TAPE can be used in the same BLAST run.

Report File

REPORT FILE FROM usdate THRU usdate; specifies starting and ending dates for Report Writer data based on a weather tape simulation. Data for all design days are printed by default. The dates for the Report File line must fall within the dates specified by the Weather Tape line. More information on Report Writer can be found in *BLAST OUTPUT*

Ground Temperatures

GROUND TEMPERATURES = (usn1, usn2, ... usn12); specifies monthly ground temperatures required for simulation of slab-on-grade floors or basement walls. The number "usn1" is the temperature in degrees Fahrenheit or Celsius for January; usn2 is the temperature for February, and so on. Twelve months should be specified. If GROUND TEMPERATURES are not specified, the program supplies default values of 55°F (12.78°C).

Appendix C gives typical ground temperature for many locations in the United States.

Make Up Water Temperatures

MAKE UP WATER TEMPERATURES = (usn1, usn2, ... usn12); specifies the monthly temperature of makeup water to the building, system, and plant. The format of the command is similar to the *GROUND TEMPERATURES* command. The default water temperature, if *MAKE UP WATER TEMPERATURES* are not specified, is 55°F (12.78 °C) for each month.

Building Description Syntax

The second major section of the BLAST input file is the Building Description. The figure below is an example of the Building Description section of a BLAST input file. Most of the syntax shown in the figure can be created using HBLC (“Same As” is only available manually or through BTEXT). Each significant phrase of the Building Description is explained in the following paragraphs in the order in which it appears in the BLAST input file. Cross-references to more detailed explanations in the encyclopedic listing of topics are also provided.

Because of BLAST array dimension limits, the user should simulate no more than 100 zones, define no more than 1000 total heat transfer surfaces, use no more than 200 different materials from the library, and have no more than 50 different construction types in any one *building description.* The user should describe multiple buildings with a maximum of 20 zones per BUILDING DESCRIPTION or use ADD ZONES runs when it is necessary to have a larger building loads file. More than one BEGIN BUILDING DESCRIPTION: ... END BUILDING DESCRIPTION; sequence may be entered in any one run.

```
BEGIN INPUT;
   RUN CONTROL:
     NEW ZONES,
     NEW AIR SYSTEMS,
     PLANT,
     REPORTS(WALLS,SHADE,DESIGN DAYS,EQUIPMENT PARAMETERS,ZONE
LOADS,
             SYSTEM LOADS,PLANT LOADS,COIL LOADS,ZONE,SYSTEM,ICE
STORAGE REPORT,
             ASHRAE HEATING LOAD CALCULATION,KSU,FANGER,PIERCE),
     UNITS(IN=ENGLISH, OUT=ENGLISH);
     TEMPORARY LOCATION:
       SOUTH
         = (LAT=-40.00,LONG=-20.00,TZ=2);
     END;
     TEMPORARY DESIGN DAYS:
       ANY DAY
         = (HIGH=95.00,LOW=52.00,WB=55.00,DATE=21JUL,PRES=405.00,
           WS=660.00,DIR=270.00,CLEARNESS=0.89,WEEKDAY);
     END;
     PROJECT="SAMPLE OUTPUT ";
     LOCATION=SOUTH ;
     DESIGN DAYS=ANY DAY ;
     WEATHER TAPE FROM O1JAN TO 31DEC;
     GROUND TEMPERATURES=(55, 55, 55, 55, 55, 55, 55, 55, 55, 55,
55, 55);
   BEGIN BUILDING DESCRIPTION;
     BUILDING="SAMPLE ";
       NORTH AXIS=0.00;
       SOLAR DISTRIBUTION=-1;
       ASHRAE HEATING OUTDOOR TEMPERATURE=10.00;
       ASHRAE HEATING INDOOR TEMPERATURE=70.00;
       ASHRAE HEATING INFILTRATION=100.00;
       ASHRAE HEATING GROUND TEMPERATURE=55.00;
       ZONE 1 "ZONE 1 ":
         ORIGIN:(0.00, 0.00, 0.00);
         NORTH AXIS=0.00;
         EXTERIOR WALLS :
           STARTING AT(0.00, 0.00, 0.00)
           FACING(180.00)
           TILTED(90.00)
           EXTERIOR (10.00 BY 10.00)
             WITH WINDOWS OF TYPE
             SPHW (4.00 BY 4.00)
               REVEAL(0.00)
               AT (2.00, 2.00)
             WITH OVERHANGS (10.00 BY 3.00)
               AT (0.00, 10.00),
           STARTING AT(10.00, 0.00, 0.00)
           FACING(90.00)
           TILTED(90.00)
           EXTERIOR (10.00 BY 10.00)
             WITH DOORS OF TYPE
             SWD (2.00 BY 6.00)
               AT (5.00, 1.00),
           STARTING AT(0.00, 10.00, 0.00)
           FACING(270.00)
           TILTED(90.00)
           EXTERIOR (10.00 BY 10.00);
         SLAB ON GRADE FLOORS :
           STARTING AT(0.00, 10.00, 0.00)
           FACING(180.00)
           TILTED(180.00)
```

```
          SLAB FLOOR (10.00 BY 10.00);
        ROOFS :
          STARTING AT(0.00, 0.00, 10.00)
          FACING(180.00)
          TILTED(0.00)
          ROOF31 (10.00 BY 10.00);
        OTHER=-100.00,CONSTANT ,
           30.00 PERCENT RADIANT, 0.00 PERCENT LATENT,
          FROM 01JAN THRU 31DEC;
        CONTROLS=DEAD BAND ,
               3412000.0 HEATING, 3412000.0 COOLING,
              0.00000 PERCENT MRT,
              0.00000 PERCENT RADIANT GAS HEAT,
              0.00000 RADIANT FLUX FACTOR,
              0.00000 PERCENT LATENT, 0.00000 PERCENT LOST,
          FROM 01JAN THRU 31DEC;
        INFILTRATION=1.00,CONSTANT ,
          WITH COEFFICIENTS (0.000000, 0.000000, 0.000000,
0.000000),
          FROM 01JAN THRU 31DEC;
        LIGHTS=100.00,CONSTANT ,
            0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
           20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
          FROM 01JAN THRU 31DEC;
        PEOPLE=41,DORMITORY OCCUPANCY ,
          AT ACTIVITY LEVEL 0.45, 70.00 PERCENT RADIANT,
          FROM 01JAN THRU 31DEC;
      END ZONE;
      ZONE 2 "ZONE 2 ":
        ORIGIN:(10.00, 0.00, 0.00);
        NORTH AXIS=0.00;
        SAME AS ZONE 1 EXCEPT:
          MIRROR Y;
      END ZONE;
  END BUILDING DESCRIPTION;
```

Building

BUILDING = "building name"; An optional building title which will appear on reports summarizing zone loads. The building name may consist of 40 or less alpha-numeric characters and must be enclosed in double quotes.

Dimensions

DIMENSIONS: variable = num, variable = num; A global dimension statement must appear before any zone description and establishes names of dummy values which can later be used to describe dimensions within any or all of the zones of the current building.

North Axis*

*Refer to encyclopedic listing in BLAST User Reference for more information.

NORTH AXIS = degrees; rotates the entire building the specified number of degrees (clockwise is positive); i.e., it establishes a new north axis which will usually correspond to a long line of the building. Its default value is 0. The NORTH AXIS statement is used because buildings frequently do not line up with true north.

Solar Distribution*

*Refer to encyclopedic listing in BLAST User Reference for more information.

<u>*SOLAR DISTRIBUTION = soldistnum;*</u> determines the level of detail which BLAST utilizes in the calculation of incident solar energy. The parameter soldistnum must be equal to -1, 0, or 1.

Detached Shading*

*Refer to encyclopedic listing in BLAST User Reference for more information.

Detached Shading describes adjacent buildings or other shadow casting geometries that are not part of the building model.

ASHRAE Heating Outdoor Temperature

ASHRAE heating outdoor temperature is used to perform ASHRAE heating loads calculations. These calculations can be used to compare values with actual BLAST output.

BEGIN BUILDING DESCRIPTION:

ASHRAE HEATING OUTDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INDOOR TEMPERATURE = (none); (°F,

ASHRAE HEATING INFILTRATION= 0.0; (ft³/min, m³/s)

ASHRAE HEATING GROUND TEMPERATURE = 55; (°F, °C)

ZONE 1 ...

For more information see "Heating Loads" in the ASHRAE fundamentals volume.

ASHRAE Heating Indoor Temperature

ASHRAE heating indoor temperature is used to perform ASHRAE heating loads calculations. These calculations can be used to compare values with actual BLAST output.

BEGIN BUILDING DESCRIPTION:

ASHRAE HEATING OUTDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INFILTRATION= 0.0; (ft³/min, m³/s)

ASHRAE HEATING GROUND TEMPERATURE = 55; (°F, °C)

ZONE 1 ...

For more information see "Heating Loads" in the ASHRAE fundamentals volume.

ASHRAE Heating Infiltration

ASHRAE heating infiltration is used to perform ASHRAE heating loads calculations. These calculations can be used to compare values with actual BLAST output.

BEGIN BUILDING DESCRIPTION:

ASHRAE HEATING OUTDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INDOOR TEMPERATURE = (none); (°F,

ASHRAE HEATING INFILTRATION= 0.0; (ft^3/min, m^3/s)

ASHRAE HEATING GROUND TEMPERATURE = 55; (°F, °C)

ZONE 1 ...

For more information see "Heating Loads" in the ASHRAE fundamentals volume.

ASHRAE Heating Ground Temperature

ASHRAE heating ground temperature is used to perform ASHRAE heating loads calculations. These calculations can be used to compare values with actual BLAST output

BEGIN BUILDING DESCRIPTION:

ASHRAE HEATING OUTDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INDOOR TEMPERATURE = (none); (°F,

ASHRAE HEATING INFILTRATION= 0.0; (ft^3/min, m^3/s)

ASHRAE HEATING GROUND TEMPERATURE = 55; (°F, °C)

ZONE 1 ...

.

For more information see "Heating Loads" in the ASHRAE fundamentals volume.

Zone

<u>*ZONE zonenum "zone name":*</u> identifies a zone. All zones must be uniquely numbered (unique *zonenum)* but do not necessarily have to be numbered sequentially or in any particular order. HBLC will automatically number zones sequentially in order of creation. The zone name is a user supplied title that may be up to 40 characters in length.

Origin

ORIGIN: (usn1, usn2, usn3); gives the (x,y,z) location of the zone origin (usually the lower southwest corner of the zone) relative to the designated building origin (usually the lower southwest corner of the building).

*North Axis**

*Refer to encyclopedic listing in BLAST User Reference for more information.

NORTH AXIS = degrees; rotates the entire zone the specified number of degrees (clockwise is positive); i.e., it establishes a new zone north axis relative to the building north axis. Its default value is 0.

Dimensions

DIMENSIONS: variable = num, variable = num; A zone dimension statement establishes names of dummy values which can only be used to describe dimensions within the current zone.

Exterior Walls

EXTERIOR WALLS: is a category of heat transfer surfaces exposed on one side to the outside environment. Vertical surface heat transfer coefficients are applied to these surfaces. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT *(usn1, usn2, usn3)* indicates the (x,y,z) location of the lower-left corner of the wall relative to the zone's origin. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING *(usn4)* indicates the direction towards which the surface faces; i.e., the direction of the outward pointing normal to the surface. The angle towards which a surface faces is the same one that would usually be used to describe the room, i.e., the north wall is the wall which faces northward. The BLAST convention is: North=0, East=90, South=180, West=270. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED *(usn5)* HBLC assumes that all walls are vertical and specifies *Tilted= 90°*. To specify non-vertical walls, tilt must be specified in the wall subsurfaces form. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) The usname is a wall section from the wall subset of the library or a temporary wall defined in the Lead Input section. This phrase describes the construction and size of the exterior wall.

VIEW FROM PERSON *(usn6)* specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE *(usn7)* specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

WITH specification allows subsurfaces such as windows, doors, wings, and overhangs to be described. WINDOWS are the *only* subsurfaces that can transmit sunlight. Hence, glass doors should be described as windows.

WINDOWS *OF TYPE usname (width BY height)* The usname is a window section from the window subset of the library or a temporary window defined in the Lead Input section.

REVEAL *(usn)* The distance a window is inset from the outside surface of the wall.

AT (usn, usn) The (x,y) coordinate location of the subsurface origin relative to the surface origin.

AND allows duplicate subsurfaces to be described by indicating only the location of their lower-left corner relative to the lower-left corner of the surface.

DOORS *OF TYPE usname (width BY height)* The usname (user-supplied names) above is a door from the door subset of the library or a temporary door defined in the Lead Input section. The width and height of the door are given immediately following their usname. Note that doors cannot transmit sunlight. Hence, glass doors should be described as windows.

REVEAL *(usn)* The distance a door is inset from the outside surface of the wall.

AT (usn, usn) The location of the subsurface origin relative to the surface origin.

WINGS *(width BY height)* specifies the size of the shading surface. See *Wings and Overhangs* in the *BLAST User Reference*.

AT (usn, usn) The (x,y) coordinate location of the bottom left corner of the subsurface origin relative to the surface origin.

TRANS *(usn)* The transmittance of the overhang or wing. The default is zero, which is opaque. Total transparency is 1.

FROM date1 THRU date2 The dates allow seasonal scheduling of these shading features.

OVERHANGS *(width BY height)* specifies the size of the shading surface. See *Wings and Overhangs* in the *BLAST User Reference*.

AT (usn, usn) same as wings.

TRANS *(usn)* same as wings.

FROM date1 THRU date2 same as wings.

Partitions, Ceiling, Floor

PARTITIONS: , *CEILING:* , *FLOOR:* are categories of heat storage surfaces. Appropriate heat transfer coefficients are applied to these surfaces. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) Since these are heat storage surfaces only, their location within the zone is only important in passive solar applications. For solar applications, the advanced user option, "BTEXT Level 5", must be used to generate the geometry. (Or the syntax must be placed into the input file with a text editor.) For all other applications, HBLC default settings will simulate accurately. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) The facing angle of heat storage surfaces is only important for passive solar studies. BLAST automatically assigns appropriate convective heat transfer coefficients to ceilings, floors, and partitions. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) specifies the angle from the Z axis (the upward pointing axis) to the outward pointing normal of the surface. HBLC automatically specifies flat roofs and ceilings and vertical walls with the following defaults: roofs and ceilings = 0°, walls = 90°, and floors = 180°. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) The usname is a partition, ceiling, or floor sections from the wall, roof, or floor subsets of the library or a temporary surface defined in the Lead Input section. This phrase describes the construction and size of the partition, ceiling, or floor.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

Walls to Uncooled Spaces

WALLS TO UNCOOLED SPACES: are the same as exterior walls except that they do not receive solar beam radiation or a wind speed and direction. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) same as *Exterior Walls.* See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) same as *Exterior Walls.* See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) same as *Exterior Walls*. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) same as *Exterior Walls*.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

DOORS *OF TYPE usname (width BY height)* The usname (user-supplied names) above is a door from the door subset of the library or a temporary door defined in the Lead Input section. The width and height of the door are given immediately following their usname. Note that doors cannot transmit sunlight. Hence, glass doors should be described as windows.

REVEAL *(usn)* The distance a door is inset from the outside surface of the wall.

AT (usn, usn) The location of the subsurface origin relative to the surface origin.

Interzone Partition, Interzone Ceiling, Interzone Floor

INTERZONE PARTITION:, *INTERZONE CEILING:*, *INTERZONE FLOOR:* are categories of heat transfer surfaces. These surfaces transfer heat between zones. Appropriate heat transfer coefficients are applied to these surfaces. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) indicates the lower-left corner of the surface being described relative to the zone's origin. If this specification is omitted, the default value is 0,0,0. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) indicates the direction towards which the surface faces; i.e., the direction of the outward pointing normal to the surface. The angle towards which a surface faces is the same one that would usually be used to describe the room, i.e., the north wall is the wall which faces northward. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) same as *Partition, Ceiling, Floor*. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) same as *Partition, Ceiling, Floor*.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

ADJACENT TO ZONE *(usn8)* specifies the zone number *(usn8)* with which the surface transfers heat.

Exposed Floor

EXPOSED FLOOR: are the same as exterior walls except they use a heat transfer coefficient appropriate for floors and do not receive any beam solar radiation. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) same as *Interzone Floor*. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) same as *Interzone Floor*. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) same as *Interzone Floor*. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) same as *Interzone Floor*.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

WITH specification allows subsurfaces such as windows, doors, wings, and overhangs to be described. WINDOWS are the *only* subsurfaces that can transmit sunlight. Hence, glass doors should be described as windows.

WINDOWS *OF TYPE usname (width BY height)* The usname is a window section from the window subset of the library or a temporary window defined in the Lead Input section.

REVEAL *(usn)* The distance a window is inset from the outside surface of the wall.

AT (usn, usn) The (x,y) coordinate location of the subsurface origin relative to the surface origin.

AND allows duplicate subsurfaces to be described by indicating only the location of their lower-left corner relative to the lower-left corner of the surface.

DOORS *OF TYPE usname (width BY height)* The usname (user-supplied names) above is a door from the door subset of the library or a temporary door defined in the Lead Input section. The width and height of the door are given immediately following their usname. Note that doors cannot transmit sunlight. Hence, glass doors should be described as windows.

REVEAL *(usn) The* distance a door is inset from the outside surface of the wall.

AT (usn, usn) The location of the subsurface origin relative to the surface origin.

WINGS *(width BY height)* specifies the size of the shading surface. See *Wings and Overhangs* in the *BLAST User Reference*.

AT (usn, usn) The (x,y) coordinate location of the bottom left corner of the subsurface origin relative to the surface origin.

TRANS *(usn)* The transmittance of the overhang or wing. The default is zero, which is opaque. Total transparency is 1.

FROM date1 THRU date2 The dates allow seasonal scheduling of these shading features.

OVERHANGS *(width BY height)* specifies the size of the shading surface. See *Wings and Overhangs* in the *BLAST User Reference*.

AT (usn, usn) same as wings.

TRANS *(usn)* same as wings.

FROM date1 THRU date2 same as wings.

Basement Wall

BASEMENT WALLS: is a category of heat transfer surfaces in contact with the ground. See *Surface Types*, in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) same as *Exterior Walls*. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) same as *Exterior Walls*. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) same as *Exterior Walls*. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) same as *Exterior Walls*.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

DOORS *OF TYPE usname (width BY height)* The usname (user-supplied names) above is a door from the door subset of the library or a temporary door defined in the Lead Input section. The width and height of the door are given immediately following their usname. Note that doors cannot transmit sunlight. Hence, glass doors should be described as windows.

REVEAL *(usn)* The distance a door is inset from the outside surface of the wall.

AT (usn, usn) The location of the subsurface origin relative to the surface origin.

Slab on Grade Floor

SLAB ON GRADE FLOOR: is a category of heat transfer surfaces in contact with the ground. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) same as *Interzone Floor*. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) same as *Interzone Floor*. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) same as *Interzone Floor*. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) same as *Interzone Floor*.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

DOORS *OF TYPE usname (width BY height)* The usname (user-supplied names) above is a door from the door subset of the library or a temporary door defined in the Lead Input section. The width and height of the door are given immediately following their usname. Note that doors cannot transmit sunlight. Hence, glass doors should be described as windows.

REVEAL *(usn)* The distance a door is inset from the outside surface of the wall.

AT (usn, usn) The location of the subsurface origin relative to the surface origin.

Roof

ROOF: is the same as exterior walls with appropriate heat transfer coefficients. See *Surface Types* in the *BLAST User Reference* for additional information.

STARTING AT (usn1, usn2, usn3) indicates the lower-left corner of the surface being described relative to the zone's origin. If this specification is omitted, the default value is 0,0,0. See *Detailed Geometry* in the *BLAST Technical Reference* for additional information.

FACING (usn4) HBLC specifies an appropriate default value for flat roofs. Sloped roofs must be specified using the "Zone Roof/Floor/Internal Mass…" form. See *Facing Angle* in the *BLAST Technical Reference* for additional information.

TILTED (usn5) HBLC automatically specifies a flat roof with *Tilted= 0°*. See *Tilt Angle* in the *BLAST User Reference* for additional information.

usname (width BY height) The usname is a roof section from the roof subset of the library or a temporary roof defined in the Lead Input section. This phrase describes the construction and size of the roof.

VIEW FROM PERSON (usn6) specifies the direct view factor from the person (temperature controller) to the surface. See *View From Person/Source* in the *BLAST User Reference* for more information.

VIEW FROM RADIANT SOURCE (usn7) specifies the percent of direct radiant energy that is incident on the surface from the radiant source. See *View From Person/Source* in the *BLAST User Reference* for more information.

WITH specification allows subsurfaces such as windows, doors, wings, and overhangs to be described. WINDOWS are the *only* subsurfaces that can transmit sunlight. Hence, glass doors should be described as windows.

WINDOWS *OF TYPE usname (width BY height)* The usname is a window section from the window subset of the library or a temporary window defined in the Lead Input section.

REVEAL *(usn)* The distance a window is inset from the outside surface of the wall.

AT (usn, usn) The (x,y) coordinate location of the subsurface origin relative to the surface origin.

AND allows duplicate subsurfaces to be described by indicating only the location of their lower-left corner relative to the lower-left corner of the surface.

DOORS *OF TYPE usname (width BY height)* The usname (user-supplied names) above is a door from the door subset of the library or a temporary door defined in the Lead Input section. The width and height of the door are given immediately following their usname. Note that doors cannot transmit sunlight. Hence, glass doors should be described as windows.

REVEAL *(usn)* The distance a door is inset from the outside surface of the wall.

AT (usn, usn) The location of the subsurface origin relative to the surface origin.

WINGS *(width BY height)* specifies the size of the shading surface. See *Wings and Overhangs* in the *BLAST User Reference*.

AT (usn, usn) The (x,y) coordinate location of the bottom left corner of the subsurface origin relative to the surface origin.

TRANS *(usn)* The transmittance of the overhang or wing. The default is zero, which is opaque. Total transparency is 1.

FROM date1 THRU date2 The dates allow seasonal scheduling of these shading features.

OVERHANGS *(width BY height)* specifies the size of the shading surface. See *Wings and Overhangs* in the *BLAST User Reference*.

AT (usn, usn) same as wings.

TRANS *(usn)* same as wings.

FROM date1 THRU date2 same as wings.

*Other Side Coefficients**

*Refer to encyclopedic listing in BLAST User Reference for more information.

OTHER SIDE COEFFICIENTS: allows specification of temperatures on the "other side" of a heat transfer surface, thus providing the means by which a user may control the simulation of temperatures and heat flow between the zone being described and its neighbor(s).

*View to Ground**

*Refer to encyclopedic listing in BLAST User Reference for more information.

VIEW TO GROUND (usn) The amount of diffuse solar radiation incident on building surfaces depends on the intensity of radiation and on the view factor between the surface and the radiation source. BLAST sets default view factors according to the tilt of the surface.

*View to Sky**

*Refer to encyclopedic listing in BLAST User Reference for more information.

VIEW TO SKY (usn) The amount of diffuse solar radiation incident on building surfaces depends on the intensity of radiation and on the view factor between the surface and the radiation source. BLAST sets default view factors according to the tilt of the surface.

Controls - convective*

*Refer to encyclopedic listing in BLAST User Reference for more information.

CONTROLS = profname, specifies the temperature control profile name. The profname is either a library or temporary control profile.

usn1 HEATING, usn2 COOLING, specifies the maximum heating capacity of the air handling system in kBtu/hr (kW) and the maximum cooling capacity of the air handling system in kBtu/hr (kW).

usn3 PERCENT MRT, determines how BLAST calculates the Effective Temperature (ET) of the zone. The Effective Temperature is defined by the following equation:

$$ET = usn3*MRT/100 + (1-usn3)*MAT/100$$

MRT is the Mean Radiant Temperature; MAT is the zone Mean Air Temperature. A value of 45 for usn3 is a reasonable estimate of normal indoor conditions.

FROM date1 THRU date2; dates between which the control schedule is in effect. If controls overlap, the last one parsed takes priority for the dates it is effective.

Controls - radiant*

*Refer to encyclopedic listing in BLAST User Reference for more information.

CONTROLS = profname, specifies the temperature control profile name. The profname is either a library or temporary control profile. See *Controlled Radiant Heater* in the *BLAST User Reference* for additional information on temperature controlled high temperature radiant heaters.

usn1 HEATING, usn2 COOLING, specifies the maximum heating capacity of the radiant heater in kBtu/hr (kW) and the maximum cooling capacity of the air handling system in kBtu/hr (kW) (convective only; no radiant cooling is currently allowed).

usn3 PERCENT MRT determines how BLAST calculates the Effective Temperature (ET) of the zone. The Effective Temperature is defined by the following equation:

$$ET = usn3*CMRT/100 + (1-usn3)*MAT/100$$

CMRT, the Comfort Mean Radiant Temperature, is a modified version of the Mean Radiant Temperature. MAT is the zone Mean Air Temperature. A value of 45 for usn3 is a reasonable estimate of normal indoor conditions.

usn4 PERCENT RADIANT GAS/ELECTRIC HEAT specifies the percent of the total heating capacity that is radiated as heat. This percentage is a characteristic of the radiant heater being modelled and is defined as the product of the radiation generation ratio and the fixture efficiency. The radiation generation ratio, which depends on the type of radiant heater being used, is the ratio of radiant output from the heating element to the total input. Fixture efficiencies typically range from 80% to 95%. The user should consult the engineering specifications of the particular radiant heater being used or the ASHRAE Equipment Handbook for more precise radiation generation ratio values, fixture efficiencies, and other information.

usn5 RADIANT FLUX FACTOR specifies the Radiant Flux Factor (RFF) defined by the following equation: $RFF = \alpha_p * F_{rh-p} / A_{eff}$. α_p is the absorptivity of human skin to thermal radiation; a typical value is 0.85. F_{rh-p} is the view factor from the radiant heater to a person in the zone. A_{eff} is the effective surface area of the person. A good starting estimate for RFF is 0.0005.

usn6 PERCENT LATENT specifies the percent of the total heating capacity (defined by usn1) that is added to the zone as a latent load.

usn7 PERCENT LOST specifies the percent of the total heating capacity (defined by usn1) that is lost. This is equivalent to an overall loss for the heater. The amount lost does not enter into the zone loads calculation.

FROM date1 THRU date2; specifies the dates between which the control schedule is in effect. If controls overlap, the last one parsed takes priority for the dates it is effective.

Radiant Equipment*

*Refer to encyclopedic listing in BLAST User Reference for more information.

RADIANT EQUIPMENT = usn1, schedname, specifies the maximum total heating capacity of the radiant heater in kBtu/hr (kW). This would be equal to the peak electrical input to an electric radiant heater or the peak rate of gas energy input to a gas-fired radiant heater. The schedule is either a library or temporary schedule, which apportions the peak load for each hour.

usn2 PERCENT RADIANT GAS/ELECTRIC HEAT, specifies the percent of the total capacity (defined by usn1) that is actually radiated as heat. This is calculated in the same way as PERCENT RADIANT GAS/ELECTRIC HEAT in the radiant CONTROLS statement. To reiterate: This percentage is a characteristic of the radiant heater being modelled and is defined as the product of the radiation generation ratio and the fixture efficiency. The radiation generation ratio, which depends on the type of radiant heater being used, is the ratio of radiant output from the heating element to the total input. Fixture efficiencies typically range from 80% to 95%. The user should consult the engineering specifications of the particular radiant heater being used or the ASHRAE Equipment Handbook for more precise radiation generation ratio values, fixture efficiencies, and other information.

usn3 PERCENT LATENT, specifies the percent of the total heating capacity (defined by usn1) that is added to the zone as a latent load.

usn4 PERCENT LOST specifies the percent of the total heating capacity (defined by usn1) that is lost. This is equivalent to an overall loss for the heater. This portion does not enter into the zone loads calculation.

usn5 RADIANT FLUX FACTOR specifies the Radiant Flux Factor as defined in the radiant CONTROLS statement.

FROM date1 THRU date2 specifies the dates between which the radiant heater is in operation. If radiant equipment schedules overlap, they are additive.

People*

*Refer to encyclopedic listing in BLAST User Reference for more information.

PEOPLE = usn1, schedname, specifies the maximum number of people (usn1) expected to occupy the zone being described and a schedule (from the schedule library or a temporary schedule) which apportions the maximum PEOPLE value for each hour of the day.

AT ACTIVITY LEVEL *usn2*, specifies the amount of heat given off per person per hour in kBtu/hr (kW). The default is 0.450 kBtu/hr (0.13 kW) or the value for light office work.

usn3 PERCENT RADIANT, specifies what percent of the sensible heat is radiant; if the percent is not specified, a default value of 70 percent radiant is used.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. More PEOPLE statements may be used as long as the time periods do not overlap. If people schedules overlap, the last one parsed takes priority for the dates it is effective.

*Lights**

*Refer to encyclopedic listing in BLAST User Reference for more information.

LIGHTS = usn1, schedname, specifies the peak lighting level in kBtu/hr (or kW) and a schedule (from the schedule library or a temporary schedule) which apportions the peak lighting level for each hour of the day.

usn2 PERCENT RETURN AIR, specifies percentage of hourly total that is added to the return air duct as heat.

usn3 PERCENT RADIANT, specifies percentage of hourly total radiated to zone as heat.

usn4 PERCENT VISIBLE, specifies percentage of hourly total radiated to zone as light.

usn5 PERCENT REPLACEABLE, specifies the percent of electric lighting which can be replaced by natural light (see *DAYLIGHT* syntax below).

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. If light schedules overlap, they are additive.

Electric Equipment

ELECTRIC EQUIPMENT = usn1, schedname, specifies the peak electric equipment level in kBtu/hr (or kW) and a schedule (from the schedule library or a temporary schedule) which apportions the peak lighting level for each hour of the day.

usn2 PERCENT RADIANT, specifies percentage of hourly total radiated to zone as heat.

usn3 PERCENT LATENT specifies percentage of equipment power which enters the zone as moisture.

usn4 PERCENT LOST specifies the percent of equipment power which is not added to the zone.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods may overlap. Overlapping statements are additive.

Gas Equipment

GAS EQUIPMENT = usn1, schedname, specifies the peak gas equipment level in kBtu/hr (or kW) and a schedule (from the schedule library or a temporary schedule) which apportions the peak lighting level for each hour of the day. Gas equipment energy is part of the gas load of the zone.

usn2 PERCENT RADIANT, specifies percentage of hourly total radiated to zone as heat.

usn3 PERCENT LATENT specifies percentage of equipment power which enters the zone as moisture.

usn4 PERCENT LOST specifies the percent of equipment power which is not added to the zone.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods may overlap. Overlapping statements are additive.

Other

OTHER = usn1, schedname, specifies the peak other equipment level in kBtu/hr (or kW) and a schedule (from the schedule library or a temporary schedule) which apportions the peak lighting level for each hour of the day. The OTHER statement allows a load to be put on the zone without adding to the zone electric or gas load. A negative peak power could be used to describe equipment that has a cooling effect on the zone.

usn2 PERCENT RADIANT, specifies percentage of hourly total radiated to zone as heat.

usn3 PERCENT LATENT specifies percentage of equipment power which enters the zone as moisture.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods may overlap. Overlapping statements are additive.

*Infiltration**

*Refer to encyclopedic listing in BLAST User Reference for more information.

INFILTRATION = usn1, schedname, specifies the peak infiltration in ft³/min (or m³/s) and a schedule (from the schedule library or a temporary schedule) which apportions the peak infiltration for each hour of the day.

WITH COEFFICIENTS (usn1, usn2, usn3, usn4), specifies the dependence of infiltration on wind speed and temperature.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods of multiple ventilation statements may not overlap.

*Ventilation**

*Refer to encyclopedic listing in BLAST User Reference for more information.

VENTILATION = usn1, schedname, specifies the peak forced or natural ventilation in ft³/min (or m³/s) and an optional schedule (from the schedule library or a temporary schedule) which permits hourly variation of the maximum ventilation rate.

usn2 MIN TEMP, specifies the desired zone temperature.

usn3 DEL TEMP, specifies that the outside air must be *"del temp"* °F (°C) cooler than the zone air before ventilation occurs.

usn4 INTAKE FAN PRESSURE, specifies pressure rise across a forced ventilation intake fan (in. water or Pa). User should specify either intake or exhaust fan.

usn5 EXHAUST FAN PRESSURE, specifies pressure rise across a forced ventilation exhaust fan (in. water or Pa). User should specify either intake or exhaust fan.

usn6 FAN EFFICIENCY, specifies the efficiency of the ventilation fan.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods of multiple ventilation statements may not overlap.

*Mixing**

*Refer to encyclopedic listing in BLAST User Reference for more information.

MIXING = usn1, schedname, specifies an amount of air to be supplied to the zone from another zone in ft³/min (or m³/s) and a schedule (from the schedule library or a temporary schedule) which permits hourly variation of the maximum mixing rate. MIXING affects only the receiving zone. *The air lost by the source zone must be accounted for by the user* with an INFILTRATION, VENTILATION, or MIXING statement in the source zone's description.

FROM ZONE *usn2,* specifies the zone from which air is being drawn.

usn3 DEL TEMP, When *"del temp"* is negative, it specifies that the source zone air must be *"del temp"* °F (°C) cooler than the zone air before mixing will occur. When *"del temp"* is positive, it specifies that the source zone air must be *"del temp"* °F (°C) warmer than the zone air before mixing will occur.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods of multiple mixing statements with the same source zone may not overlap. There may be mixing from several different source zones simultaneously.

*Cross Mixing**

*Refer to encyclopedic listing in BLAST User Reference for more information.

CROSS MIXING = usn1, schedname, specifies an amount of air that will be exchanged between two zones in ft³/min (or m³/s) and a schedule (from the schedule library or a temporary schedule) which permits hourly variation of the maximum mixing rate.

FROM ZONE *usn2,* specifies the other zone for air exchange.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods of multiple mixing statements with the same source zone may not overlap. There may be mixing from several different source zones simultaneously.

Baseboard Heating

BASEBOARD HEATING = (usn1 AT usn2, usn3 AT usn4), schedname, specifies outside temperature-controlled baseboard heating (thermostatically controlled baseboard heat is specified in the Fan System simulation). Here, *usn1* and *usn3* are baseboard heating capacities in kBtu/hr (kW) at the temperatures given by the terms usn2 and usn4. The optional schedule allows both capacities to change hourly on a proportional basis.

usn5 PERCENT RADIANT, specifies percentage of hourly total radiated to zone as heat.

FROM date1 THRU date2; The dates allow this scheduled load to be applied to only part of a year. Time periods of multiple statements may overlap. Overlapping statements are additive.

*Daylight**

*Refer to encyclopedic listing in BLAST User Reference for more information.

DAYLIGHT = schedname The *schedname* is a schedule chosen from the BLAST library or one defined by the user in the Lead Input section of the input deck. The schedule acts as a multiplier on *"Percent Beam Usable"* to account for hourly variations as sunlight patterns created by internal zone obstructions move across the room. The electric lighting energy will be reduced by the amount of usable beam plus the amount of usable diffuse radiation entering the zone up to the amount "replaceable" (see LIGHTS).

usn1 PERCENT BEAM USABLE specifies the percent of beam solar radiation entering the room which can reduce electric lighting.

usn2 PERCENT DIFFUSE USABLE specifies the percent of diffuse solar radiation (from the sky and reflected from the ground) entering the room which can reduce electric lighting.

FROM date1 THRU date2 specifies the dates between which daylighting is in effect. The time periods of multiple daylight statements may not overlap.

*Internal Mass**

*Refer to encyclopedic listing in BLAST User Reference for more information.

INTERNAL MASS: wall name (width BY height); specifies a simplified heat storage surface (i.e. a simplified partition) in the zone. The wall type should be selected to represent the average conductive properties of the internal partitions and zone contents. The expression "(width BY height)" should be selected to give an area equal to the total surface area exposed to the zone (e.g., both sides of internal partitions). When significantly different materials are present, it may be necessary to use more than one INTERNAL MASS statement.

Relative Velocity

RELATIVE VELOCITY = usn, schedname; A thermal comfort parameter that specifies the maximum air velocity that will be present in the zone in ft/min (m/s). The maximum air velocity of a zone will depend upon the ventilation rate, the infiltration rate, natural convection, and air movement due to a forced air conditioning system. This value must be defined by the user and will not be calculated by BLAST. The default value is 0.137 m/s. An appropriate library or temporary schedule should be selected. The default schedule is CONSTANT. For additional information, see *Thermal Comfort* in the *BLAST User Reference*.

Relative Humidity

RELATIVE HUMIDITY = usn, schedname; A thermal comfort parameter that specifies the zone maximum relative humidity (expressed as a fraction). This is not to be confused with any humidity control or dehumidification process. It is only used for the Thermal Comfort models. The default value is 0.35. If the humidity ratio for the interior is nearly equal to the exterior humidity ratio (e.g. natural ventilation is used to condition an interior space), the thermal comfort algorithm will use exterior humidity ratio if the default value is changed from 0.35 to -999. An appropriate library or temporary schedule should be selected. The default schedule is CONSTANT. For additional information, see *Thermal Comfort* in the *BLAST User Reference*.

*Metabolic Rate**

*Refer to encyclopedic listing in BLAST User Reference for more information.

METABOLIC RATE = usn, schedname; A thermal comfort parameter that specifies the maximum metabolic rate in mets (1 met = 58.2 W/m²). An appropriate library or temporary schedule should be selected. The default schedule is CONSTANT. For additional information, see *Thermal Comfort* in the *BLAST User Reference*.

Work Efficiency

WORK EFFICIENCY = usn, schedname; A thermal comfort parameter that specifies the maximum work efficiency expressed as a fraction. The work efficiency is defined as the percentage of the metabolic rate that is converted directly into mechanical work. A work efficiency of zero would correspond to all of the internal energy (metabolic rate) being converted into heat. The default value for work efficiency is 0.0. An appropriate library or temporary schedule should be selected. The default schedule is CONSTANT. For additional information, see *Thermal Comfort* in the *BLAST User Reference*.

*Clothing Insulation**

*Refer to encyclopedic listing in BLAST User Reference for more information.

CLOTHING INSULATION = usn, schedname; A thermal comfort parameter that specifies the maximum clothing insulation expressed in units of clos. An appropriate library or temporary schedule should be selected. The default schedule is CONSTANT. For additional information, see *Thermal Comfort* in the *BLAST User Reference*.

Report Variables

REPORT VARIABLES=(usn1, ..., usnn); is used to specify zone variables and surface temperatures that can be reported on an hourly basis. These are then processed throught the auxiliary program Report Writer. For a list of Report Writer zone variables currently available, see the *Zone Report Writer Variable List* under *Report Writer*. For additional information, see the *Report Writer* section of the manual.

*Same As**

*Refer to encyclopedic listing in BLAST User Reference for more information.

SAME AS (zone number) EXCEPT: specifies that the current zone is identical to a previously described zone except for any surface, non-geometric factors, or other differences between the two zones.

Mirror

It is quite common for similar zones to be identical except that they are mirror images of each other. Most mirror image zones cannot be made from each other by any combination of rotations and translations. Therefore, two imaging commands have been added to let the user better describe similar zones:

MIRROR X;

MIRROR Y;

The MIRROR X command causes the X-coordinates of all surfaces of the zone to be replaced by -X values. The MIRROR Y command operates on the Y-coordinates. As with rotation, these commands do not move the origin of the zone.

MIRROR must be used in conjunction with SAME AS.

Fan System Syntax

In the following sections, the HBLC or BTEXT generated fan system syntax is briefly explained. The fan system section of the input file (located between the *BEGIN FAN SYSTEM DESCRIPTION* and *END FAN SYSTEM DESCRIPTION* phrases) is organized into blocks of information called data blocks. The data blocks serve to organize the fan system syntax as shown below.

1. The ***Zone Data Block*** contains data on each zone such as air flow rate, reheat capacity, minimum air fractions, and exhaust air fractions.
2. The ***Other System Parameters Data Block*** contains data on other system variables such as hot deck and cold deck temperatures, control strategies, and fan pressure and efficiency.
3. The ***Cooling Coil Design Parameters Data Block*** contains data on a single coil operating point such as entering and leaving water, air temperatures, and flow rates.
4. The ***Heat Recovery Parameters Data Block*** contains air-to-air heat recovery parameters.
5. The ***Equipment Schedules Data Block*** specifies when fans and coils are allowed to operate (daily and seasonally).
6. The ***DX Condensing Unit Parameters Data Block*** contains performance parameters used to simulate condensing units.
7. The ***Heat Pump Cooling Data Block*** contains heat pump cooling parameters.
8. The ***Heat Pump Heating Data Block*** contains heat pump heating parameters.

The following figure is an example of the fan system section of a BLAST input file. The data for all parameters in all input data blocks have default values, which may or may not be adjusted at the user's discretion. Only in rare cases, however, will all defaults be appropriate for the simulation of a particular fan system. The eight data blocks are described in detail in the following paragraphs. Cross-references to more detailed explanations in the encyclopedic listing of topics are also provided.

BEGIN FAN SYSTEM DESCRIPTION;

TWO PIPE FAN COIL SYSTEM 1

"EXAMPLE SYSTEM " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .       (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=0.49783;
    .   .   .   .   OTHER SYSTEM PARAMETER DATA BLOCK
    .   .   .   .    (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
    .   .   .   .   COOLING COIL DATA BLOCK
    .   .   .   .   (Optional expert user input)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
    .   .   .   .   HEAT RECOVERY DATA BLOCK
    .   .   .   .       (Only applicable to some systems)
    HEAT RECOVERY CAPACITY=3412000;
END HEAT RECOVERY PARAMETERS;
WATER  SOURCE HEAT PUMP PARAMETERS:
    HHCP(-3.6975,4.3774,0.0745);
    .   .   .   .   .   WATER LOOP HEAT PUMP DATA BLOCK
    .   .   .   .   .   (Optional expert user input)
    WLPT(0.0,1.0,0.0);
END WATER SOURCE HEAT PARAMETERS;
HEAT PUMP COOLING PARAMETERS:
    COPC=(11,34.09,-0.087);
    .   .   .   .       AIR TO AIR HEAT PUMP DATA BLOCK
        .   .   .   .   (Only applicable to some systems)
    END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
    COPH2=(22,-3.9,0.022);
    .   .   .   .   AIR TO AIR HEAT PUMP DATA BLOCK
    .   .   .   .   (Only applicable to some systems)
                    .   .   .   .
END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Only applicable to some systems)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .               SCHEDULES DATA BLOCK
        .   .   .   .               (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

Fan System List

system type SYSTEM system num " system name" SERVING ZONES zone num, zone num, zone num ; The system number and name are arbitrarily chosen by the user. the zones served by the system (*zone num*) are the zone numbers assigned to the zones in the Building Description section of the input file. The system types can be any one of the following. Each system type is explained in detail in the *BLAST User Reference.*

TERMINAL REHEAT	TWO PIPE INDUCTION
SUBZONE REHEAT	FOUR PIPE INDUCTION

VARIABLE VOLUME	MULTIZONE
UNIT VENTILATOR	DUAL DUCT VARIABLE VOLUME
TWO PIPE FAN COIL	DUAL DUCT
FOUR PIPE FAN COIL	SINGLE ZONE DRAW THROUGH
DX PACKAGED UNIT	WATER LOOP HEAT PUMP
UNIT HEATER	THREE DECK MULTIZONE
EVAPORATIVE COOLER	HEAT PUMP PACKAGED UNIT

(Note: The Heat Pump Packaged Unit can be found under *Air to Air Heat Pump* in the *BLAST User Reference*.)

For Zone

FOR ZONE zone num: This statement begins the Zone Data Block (See *Zone Data Block* in the *BLAST User Reference*). A Zone Data Block must be included for each zone served by the system.

Supply Air Volume

SUPPLY AIR VOLUME=usn; is the airflow rate of the zone under peak conditions in ft^3/min (m^3/s). It is the only required syntax in the zone data block.

Minimum Air Fraction

MINIMUM AIR FRACTION=usn; applies only to variable volume systems and is the minimum fraction of the zone's design supply volume which will be delivered to the space any time the fan system is running. The minimum air fraction specified in the zone data block takes precedence over any minimum air fraction later specified in the OTHER SYSTEM PARAMETERS block. If not specified, the minimum air fraction defaults to the minimum air fraction specified in OTHER SYSTEM PARAMETERS.

Exhaust Air Volume

EXHAUST AIR VOLUME=usn; is the amount of air which will be removed from the zone any time the fan system is in operation (ft^3/min [m^3/s]) and which will be exhausted directly (without heat recovery) from the zone. BLAST will always verify that the supply air volume, whether in a fixed or variable volume system, is equal to or greater than the exhaust air volume.

Reheat Capacity

REHEAT CAPACITY=usn; is input in kBtu/hr (kW) and applies only to terminal reheat systems, variable volume systems with reheat, subzone reheat systems, unit ventilator systems and unit heater systems. The default capacity is 0.

Reheat Energy Supply

REHEAT ENERGY SUPPLY=supply type; specifies the type of reheat coil. *Supply type* is one of HOT WATER, STEAM, ELECTRIC, or GAS. HOT WATER is the default.

Baseboard Heat Capacity

BASEBOARD HEAT CAPACITY=usn; specified in kBtu/hr (kW), is thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. See *Thermostatic Baseboard* in the *BLAST User Reference.*

Baseboard Heat Energy Supply

BASEBOARD HEAT ENERGY SUPPLY=supply type; specifies the type of baseboard heater. *Supply type* is one of HOT WATER, STEAM, ELECTRIC or GAS. HOT WATER is the default. See *Thermostatic Baseboard* in the *BLAST User Reference.*

Recool Capacity

RECOOL CAPACITY=usn; specifies the design capacity of the recooling coils. Currently, recooling coils are allowed only for induction systems and are assumed to be chilled water coils that accomplish sensible cooling only.

Induced Air Fraction

INDUCED AIR FRACTION=usn; is the ratio of induced room air flow to supply air flow. This applies only to induction systems.

Zone Multiplier

ZONE MULTIPLIER=usn; is used to simulate identical or nearly identical spaces. It would be pointless to calculate loads and perform simulations for two identical zones (same orientation, dimensions, construction, schedules, etc.), since if these zones are truly identical, the hourly load profiles and impact on the air distribution system will also be identical. The ZONE MULTIPLIER avoids the need for redundant load calculation by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier. In practice, zones which are nearly identical (very similar) can be treated as identical to simplify input and avoid calculation expense.

Report Variables

REPORT VARIABLES=(usn1, ..., usnn); is used to specify zone in system variables to be reported on an hourly basis. These are processed by the auxiliary program Report Writer. For a list of Report Writer zone variables currently available, see the *Zone in System Report Writer Variable List* under *Report Writer*. For additional information, see the *Report Writer* section of the manual.

End Zone

END ZONE; This statement ends the Zone Data Block.

Other System Parameters

This statement begins the Other System Parameters Data Block. *Other System Parameters* affect the different fan systems as shown in the following chart.

Each fan system entry in the *BLAST User Reference* defines the other system parameters that pertain to that system. The *Other System Parameters Data Block* entry in the *BLAST User Reference* lists all parameters with their defaults and references additional information on specific parameters. The following table contains all of the *Other System Parameters* and their applicability to each fan system.

	MULTIZONE	DUAL DUCT(2)	THREE DECK MULTIZONE	DUAL DUCT VARIABLE VOLUME	VARIABLE VOLUME	TERMINAL REHEAT	SUBZONE REHEAT	TWO PIPE FAN COIL (1)	FOUR PIPE FAN COIL (1)	SINGLE ZONE DRAW THRU	DX PACKAGED UNIT	UNIT VENTILATOR	UNIT HEATER	TWO PIPE INDUCTION UNIT (1)	FOUR PIPE INDUCTION UNIT (1)	WATER LOOP HEAT PUMP (1)
SUPPLY FAN PRESSURE & EFFICIENCY	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
RETURN FAN PRESSURE & EFFICIENCY	●	●	●	●	●	●	●			●	●	●		●	●	●
EXHAUST FAN PRESSURE & EFFICIENCY	●	●	●	●	●	●	●	●	●	●		●		●	●	●
COLD DECK CONTROL/TEMPERATURE	●	●	●	●	●	●		●	●					●	●	●
COLD DECK THROTTLING RANGE	●	●	●	●	●	●								●	●	●
COLD DECK CONTROL SCHEDULE	●	●	●	●	●	●		●	●					●	●	●
HEATING COIL ENERGY/CAPACITY	●	●	●	●				●	●	●	●		●			●
HOT DECK CONTROL/TEMPERATURE	●	●	●	●				●	●					●	●	●
HOT DECK THROTTLING RANGE	●	●	●	●												●
HOT DECK CONTROL SCHEDULE	●	●	●	●				●	●					●	●	●
REHEAT TEMPERATURE CONTROL					●	●	●					●	●			
REHEAT TEMPERATURE LIMIT					●	●	●					●	●			
REHEAT CONTROL SCHEDULE					●	●	●					●	●			
MIXED AIR CONTROL	●	●	●	●	●	●	●			●	●	●		●	●	●
DESIRED MIXED AIR TEMPERATURE	●	●	●	●	●	●	●			●	●	●		●	●	●
OUTSIDE AIR VOLUME	●	●	●	●	●	●	●			●	●	●		●	●	●
PREHEAT COIL LOCATION	●	●	●	●	●	●	●			●		●		●	●	
PREHEAT TEMPERATURE	●	●	●	●	●	●	●			●		●		●	●	
PREHEAT ENERGY/CAPACITY	●	●	●	●	●	●	●			●		●		●	●	
GAS BURNER EFFICIENCY	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
VAV MINIMUM AIR FRACTION				●	●											
VAV VOLUME CONTROL				●	●											
FAN POWER COEFFICIENTS				●	●											
HUMIDIFIER TYPE	●	●	●	●	●	●	●			●		●		●	●	
HUMIDISTAT LOCATION	●	●	●	●	●	●	●			●		●		●	●	
HUMIDISTAT SET POINT	●	●	●	●	●	●	●			●		●		●	●	
SYSTEM ELECTRICAL DEMAND	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
COOLING SAT DIFFERENCE	●	●	●	●	●	●	●	●	●	●	●			●	●	●
HEATING SAT DIFFERENCE	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
AIR VOLUME COEFFICIENT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Notes:

1.) Hot deck temperature sets upper limit on reheat or heating coil temperature.

2.) Dual deck is the same as multizone in BLAST.

Supply Fan Pressure

SUPPLY FAN PRESSURE=usn; is used to specify the pressure drop across the supply fan in units of inches H20 or N/m².

Supply Fan Efficiency

SUPPLY FAN EFFICIENCY=usn; is used to specify the efficiency of the supply fan. This parameter must be specified as a decimal fraction between 0.0 and 1.0.

Return Fan Pressure

RETURN FAN PRESSURE=usn; is used to specify the pressure drop across the return fan in units of inches H20 or N/m².

Return Fan Efficiency

RETURN FAN EFFICIENCY=usn; is used to specify the efficiency of the return fan. This parameter must be specified as a decimal fraction between 0.0 and 1.0.

Exhaust Fan Pressure

EXHAUST FAN PRESSURE=usn; is used to specify the pressure drop across the exhaust fan in units of inches H20 or N/m².

Exhaust Fan Efficiency

EXHAUST FAN EFFICIENCY=usn; is used to specify the efficiency of the exhaust fan. This parameter must be specified as a decimal fraction between 0.0 and 1.0.

Cold Deck Control

COLD DECK CONTROL=controltype; is used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Cold Deck Throttling Range

COLD DECK THROTTLING RANGE=usn; is used to specify the cold deck temperature in units of °F or °C based on the previous hour’s cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Cold Deck Temperature

COLD DECK TEMPERATURE=usn; is used to specify the fixed set point temperature of the cold deck in units of °F or °C. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Cold Deck Control Schedule

COLD DECK CONTROL SCHEDULE=(usn1 AT usn2, usn3 AT usn4); is used to specify the cold deck temperature if the deck is OUTSIDE AIR CONTROLLED or ZONE CONTROLLED. The usn paramters define a piecewise linear profile in units of °F or °C. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Hot Deck Control

HOT DECK CONTROL=controltype; is used to specify how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Hot Deck Throttling Range

HOT DECK THROTTLING RANGE=usn; is used to specify the hot deck temperature in units of °F or °C based on the previous hour's heating load. The deck temperature is adjusted somewhere between the hot deck set point and the set point plus the throttling range. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Hot Deck Temperature

HOT DECK TEMPERATURE=usn; is used to specify the fixed set point temperature of the hot deck in units of °F or °C. See *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Hot Deck Control Schedule

HOT DECK CONTROL SCHEDULE=(usn1 AT usn2, usn3 AT usn4); is used to specify the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED or ZONE CONTROLLED. The usn paramters define a piecewise linear profile in units of °F or °CSee *Cold and Hot Deck Control* in the *BLAST User Reference* for more information.

Heating Coil Energy Supply

HEATING COIL ENERGY SUPPLY=energytype; is used to specify the heating coil energy type. The options are HOT WATER, GAS, STEAM, and ELECTRIC. HOT WATER is the default.

Heating Coil Capacity

HEATING COIL CAPACITY=usn; is used to specify the capacity of the heating coil in units of kBtu/hr or kW.

Reheat Temperature Control

REHEAT TEMPERATURE CONTROL=controltype; is used to specify how the hot deck is controlled. The options are FIXED SET POINT and OUTSIDE AIR CONTROLLED. See *Reheat Coil* in the *BLAST User Reference* for more information.

Reheat Temperature Limit

REHEAT TEMPERATURE LIMIT=usn; is used to specify the maximum temperature of the reheat coil in units of °F or °C. See *Reheat Coil* in the *BLAST User Reference* for more information.

Reheat Control Schedule

REHEAT CONTROL SCHEDULE=(usn1 AT usn2, usn3 AT usn4); is used to specify the reheat deck temperature in units of °F or °C if the deck is OUTSIDE AIR CONTROLLED. See *Reheat Coil* in the *BLAST User Reference* for more information.

Gas Burner Efficiency

GAS BURNER EFFICIENCY=usn; is used to specify the efficiency of the gas burner as a decimal fraction between 0.0 and 1.0. This syntax is only valid for a heating coil that uses GAS as the energy source.

Mixed Air Control

MIXED AIR CONTROL=controltype; is used to specify the method for controlling the mixed air box of the fan system. FIXED PERCENT is the default mixed air control which allows hourly control of the fraction of outside air based on the MINIMUM VENTILATION SCHEDULE (see *Equipment Schedules*). FIXED AMOUNT allows the amount of outside air to be specified on a fixed volume basis (see *Outside Air Volume*) and is also modified by the MINIMUM VENTILATION SCHEDULE. Three economy cycles, including the TEMPERATURE ECONOMY CYCLE, the RETURN AIR ECONOMY CYCLE, and the ENTHALPY ECONOMY CYCLE are also valid. See *Mixed Air Control* in the *BLAST User Reference* for more information.

Desired Mixed Air Temperature

DESIRED MIXED AIR TEMPERATURE=controltype/usn; is used to specify the desired temperature for the mixed air economy cycles. There are two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the COLD DECK TEMPERATURE. The other option is specify an arbitrary fixed value in units of °F or °C. See *Mixed Air Control* in the *BLAST User Reference* for more information.

Outside Air Volume

OUTSIDE AIR VOLUME=usn; is used to specify the amount of maximum outside air in units of ft^3/min or m^3/s that is taken through the system. This syntax is only valid for the FIXED AMOUNT mixed air control option. The maximum value is multiplied by the MINIMUM VENTILATION SCHEDULE (see *Equipment Schedules*). See *Mixed Air Control* in the *BLAST User Reference* for more information.

Preheat Coil Location

PREHEAT COIL LOCATION=option; is used to sspecify the location in the air duct of the preheat coil. The options are NONE (default), OUTSIDE AIR DUCT, or MIXED AIR DUCT. See *Preheat Coil* in the *BLAST User Reference* for more information.

Preheat Coil Capacity

PREHEAT COIL CAPACITY=option; is used to specify the capacity of the preheat coil in units of kBtu/hr or kW. See *Preheat Coil* in the *BLAST User Reference* for more information.

Preheat Energy Supply

PREHEAT ENERGY SUPPLY=energytype; is used to specify the heating coil energy type. The options are HOT WATER, GAS, STEAM, and ELECTRIC. HOT WATER is the default. See *Preheat Coil* in the *BLAST User Reference* for more information.

VAV Minimum Air Fraction

VAV MINIMUM AIR FRACTION=usn; is used to specify the percentage of the supply air that passes through the VAV box when the damper is closed. This parameter is employed only if no minimum fraction is specified in the ZONE data block. The minimum fraction specified in the ZONE data block has precedence over the minimum fraction specified with this statement in the OTHER SYSTEM PARAMETERS data block. See *Minimum Air Fraction* in the *BLAST Quick Reference* for more information.

VAV Volume Control Type

VAV VOLUME CONTROL TYPE=controltype; is used to specify the type of fan used in a VAV system. The options are INLET VANES (default), VARIABLE FAN SPEED, and DISCHARGE DAMPERS. All three options have associated default fan power coefficients, but fan performance can also be characterized using the FAN POWER COEFFICIENTS. Either a VAV Volume Control Type or a set of Fan Power Coefficients may not be specified. Specification of both a control type and coefficients is not allowed. See *Fan Power Coefficients* in the *BLAST Technical Reference* for more information.

Fan Power Coefficients

FAN POWER COEFFICIENTS=(usn1,usn2,usn3,usn4,usn5); is used to specify the fan power consumption at part-load conditions for variable volume systems. This may be defined alternatively through the use of a VAV VOLUME CONTROL TYPE. See *Fan Power Coefficients* in the *BLAST Technical Reference* for more information.

Humidifier Type

HUMIDIFIER TYPE=energytype; is used to specify what type of energy is used by the humidifier. The options are NONE (default), HOT WATER, STEAM, and ELECTRIC. See *Humidistat Set Point* in the *BLAST Quick Reference* for more information.

Humidistat Location

HUMIDISTAT LOCATION=zonenumber is used to specify the zone where the humidistat is located. Only one zone per fan system may be specified. See *Humidistat Set Point* in the *BLAST Quick Reference* for more information.

Humidistat Set Point

HUMIDISTAT SET POINT=usn; is used to specify the relative humidity percentage above which humidification is employed. If the relative humidity of the zone defined by the HUMIDISTAT LOCATION syntax drop below the set point, then a humidifer is used to add moisture to the air stream. Dehumidification is not controlled by this syntax.

System Electrical Demand

SYSTEM ELECTRICAL DEMAND=usn; is used to specify the maximum parasitic electric consumption of the fan system in units of kBtu/hr or kW. This parameter is multiplied by the hourly fraction defined by the SYSTEM ELECTRICAL DEMAND SCHEDULE. See *Equipment Schedules* for more information.

Cooling SAT Difference

COOLING SAT DIFFERENCE=usn; is used to specify the temperature difference in units of °F or °C between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. See *Design Systems* in the *BLAST User Reference* for more information.

Heating SAT Difference

HEATING SAT DIFFERENCE=usn; is used to specify the temperature difference in units of °F or °C between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. See *Design Systems* in the *BLAST User Reference* for more information.

Air Volume Coefficient

AIR VOLUME COEFFICIENT=usn; is used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume. See *Design Systems* in the *BLAST User Reference* for more information.

Evaporative Cooler Type

EVAPORATIVE COOLER TYPE=type; is used to specify the type of evaporative cooler configuration that is being employed with the fan system. The options are DIRECT, DRY COIL INDIRECT, WET COIL INDIRECT, DRY COIL TWO STAGE (default), and WET COIL TWO STAGE. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Indirect Fan Size

INDIRECT FAN SIZE=usn; is used to specify the secondary flow rate of the indirect evaporative cooler in units of ft^3/min or m^3/s. This syntax is applicable to all evaporative coolers except the direct stage evaporative coolers. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Indirect Fan Efficiency

INDIRECT FAN EFFICIENCY=usn; is used to specify the efficiency of the indirect fan of an evaporative cooler as a decimal fraction. This syntax is applicable to all evaporative coolers except the direct stage evaporative coolers. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Sec Fan Pressure Drop

SEC FAN PRESSURE DROP=usn; is used to specify the pressure drop across the secondary fan of an evaporative cooler in units of inches H20 or N/m². This syntax is applicable to all evaporative coolers except the direct stage evaporative coolers. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Effectiveness Indirect HX

EFFECTIVENESS INDIRECT HX=usn; is used to specify the effectiveness of the indirect air-to-air heat exchanger in an evaporative cooler as a decimal fraction. This syntax is applicable only to systems that include a dry coil indirect stage cooler. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Direct Pad Area

DIRECT PAD AREA=usn; is used to specify the pad area of direct stage evaporative coolers in units of ft² or m². See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Direct Pad Depth

DIRECT PAD DEPTH=usn; is used to specify the pad depth of direct stage evaporative coolers in units of ft or m. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Indirect Pad Area

INDIRECT PAD AREA=usn; is used to specify the pad area of indirect stage evaporative coolers in units of ft² or m². See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Indirect Pad Depth

INDIRECT PAD DEPTH=usn; is used to specify the pad depth of indirect stage evaporative coolers in units of ft or m. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Wet Coil Max Eff

WET COIL MAX EFF=usn; is used to specify the maximum efficiency for the heat exchanger in wet coil indirect stage evaporative coolers as a decimal fraction. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Wet Coil Flow Ratio

WET COIL FLOW RATIO=usn; is used to specify the flow efficiency ratio for the heat exchanger in wet coil indirect stage evaporative coolers as a decimal fraction. See *Evaporative Cooler* in the *BLAST Technical Reference* for more information.

Loop Mass

LOOP MASS=usn; is used to specify the total mass in the loop in units of kg or lb for a Water Loop Heat Pump System. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Loop Mass Ratio

LOOP MASS RATIO=usn; is used to define the division of the total loop mass between the central plant and the heat pump network inlet for a Water Loop Heat Pump System. This parameter is dimensionless. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

System Pressure Head

SYSTEM PRESSURE HEAD=usn; is used to specify the pressure head of the water loop excluding the heat pump units in units of inches H20 or N/m^2 for a Water Loop Heat Pump System. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Loop Pump Efficiency

LOOP PUMP EFFICIENCY=usn; is used to specify the efficiency of the water loop pump for a Water Loop Heat Pump System. This parameter is dimensionless. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Tank Temperature

TANK TEMPERATURE=usn; is used to specify the initial temperature of the storage tank in units of °F or °C for a Water Loop Heat Pump System. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Loop Control

LOOP CONTROL=controltype; is used to select the control option for a Water Loop Heat Pump System. The three options are FIXED TEMPERATURE (default), DEAD BAND, and HOURLY SCHEDULE. FIXED TEMPERATURE control regulates the water loop to a single temperature defined by the FIXED LOOP TEMPERATURE statement. DEAD BAND control allows the water loop to float between the limits established by the MAXIMUM and MINIMUM LOOP TEMPERATURE statements. HOURLY SCHEDULE control is defined by an Equipment Schedule. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Fixed Loop Temperature

FIXED LOOP TEMPERATURE=usn; is used to specify the fixed loop temperature for a FIXED TEMPERATURE controlled Water Loop Heat Pump System in units of °F or °C. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Maximum Loop Temperature

MAXIMUM LOOP TEMPERATURE=usn; is used to specify the maximum loop temperature for a DEAD BAND controlled Water Loop Heat Pump System in units of °F or °C. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Minimum Loop Temperature

MINIMUM LOOP TEMPERATURE=usn; is used to specify the minimum loop temperature for a DEAD BAND controlled Water Loop Heat Pump System in units of °F or °C. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Storage Volume

STORAGE VOLUME=usn; is used to specify the volume of the water storage tank in units of ft^3 or m^3 for a Water Loop Heat Pump System. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Supplemental Heat Type

SUPPLEMENTAL HEAT TYPE=type; is used to specify the central plant heating unit source for a Water Loop Heat Pump System. The options are HOT WATER (default), GAS, STEAM, and ELECTRIC. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Supplemental Cool Type

SUPPLEMENTAL COOL TYPE=type; is used to specify the central plant cooling unit type for a Water Loop Heat Pump System. The options are COMPRESSION (default) and TOWER. COMPRESSION selects any of the central plant units in BLAST while TOWER employs an integrated closed loop cooling tower in the fan system simulation. If COMPRESSION is selected, the cooling loads required by the water loop are passed to the central plant simulation. If TOWER is selected, the cooling loads are handled by a cooling tower in the fan system simulation, and the cooling tower electric consumption is passed to the central plant simulation. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Nominal Flow Rate

NOMINAL FLOW RATE=usn; is used to specify the nominal flow rate of the water loop in units of lbm/kBtu or kg/kJ for a Water Loop Heat Pump System. This value is the design flow rate of the heat pump divided by the design capacity and is assumed constant for all units. See *Water Loop Heat Pump System* in the *BLAST Technical Reference* for more information.

Nominal Pressure Drop

NOMINAL PRESSURE DROP=usn; is used to specify the nominal or base rated pressure drop across the heat pumps in units of inches H20 or N/m² for a Water Loop Heat Pump System. See *Water Loop Heat Pump System* in the *BLAST Technical Reference* for more information.

Tower Capacity

TOWER CAPACITY=usn; is used to specify the capacity of the integrated cooling tower in units of kBtu/hr or kW for a Water Loop Heat Pump System where the SUPPLEMENTAL COOL TYPE is set to TOWER. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Tower Electric Coefficient

TOWER ELECTRIC COEFFICIENT=usn; is used to specify the amount of energy used by the fans in the integrated cooling tower for a Water Loop Heat Pump System where the SUPPLEMENTAL COOL TYPE is set to TOWER. This parameter is dimensionless. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Tower Pump Coefficient

TOWER PUMP COEFFICIENT=usn; is used to specify the amount of energy consumed by the integrated cooling tower pump for a Water Loop Heat Pump System where the SUPPLEMENTAL COOL TYPE is set to TOWER. This parameter is dimensionless. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Pump Type

PUMP TYPE=type; is used to specify the type of pump used by a Water Loop Heat Pump System where the SUPPLEMENTAL COOL TYPE is set to TOWER. The options are CONSTANT FLOW (default) and VARIABLE FLOW. See *Water Loop Heat Pump System* in the *BLAST User Reference* for more information.

Report Variables

REPORT VARIABLES=(usn1, ..., usnn); is used to specify fan system variables to be reported on an hourly basis. These are processed by the auxiliary program Report Writer. For a list of Report Writer zone variables currently available, see the *System Report Writer Variable List* under *Report Writer*. For additional information, see the *Report Writer* section of the manual.

End Other System Parameters

END OTHER SYSTEM PARAMETERS; This statement ends the Other System Parameters Data Block

Cooling Coil Design Parameters*

*Refer to encyclopedic listing in BLAST User Reference for more information.

COOLING COIL DESIGN PARAMETERS: This statement begins the Cooling Coil Design Parameters Data Block. Parameters in this block may not be changed arbitrarily. Users are advised to use complete sets of manufacturers data when changing these parameters. Changing these parameters does not affect the coil capacity for simulation purposes since BLAST assumes all coils have infinite capacity.

Coil Type

COIL TYPE=type; is used to define the type of cooling coil that is utilized by the system. The options are DIRECT EXPANSION (DX) or CHILLED WATER.

Entering Water Temperature

ENTERING WATER TEMPERATURE=usn; is used to specify the design entering water temperature for chilled water coils in units of °F or °C.

Entering Air Dry Bulb Temperature

ENTERING AIR DRY BULB TEMPERATURE=usn; is used to specify the design entering air dry bulb temperature in units of °F or °C.

Entering Air Wet Dry Bulb Temperature

ENTERING AIR WET BULB TEMPERATURE=usn; is used to specify the design entering air wet bulb temperature in units of °F or °C.

Leaving Water Temperature

LEAVING WATER TEMPERATURE=usn; is used to specify the design leaving water temperature for chilled water coils in units of °F or °C.

Leaving Air Dry Bulb Temperature

LEAVING AIR DRY BULB TEMPERATURE=usn; is used to specify the design leaving air dry bulb temperature in units of °F or °C.

Leaving Air Wet Dry Bulb Temperature

LEAVING AIR WET BULB TEMPERATURE=usn; is used to specify the design leaving air wet bulb temperature in units of °F or °C.

Water Velocity

WATER VELOCITY=usn; is used to specify the design velocity of the chilled water through the cooling coil in units of ft/min or m/s.

Water Volume Flow Rate

WATER VOLUME FLOW RATE=usn; is used to specify the design volumetric flow rate of the chilled water through the cooling coil in units of ft^3/min or

Air Face Velocity

AIR FACE VELOCITY=usn; is used to specify the design velocity of the air over the cooling coil in units of ft/min or m/s.

Air Volume Flow Rate

AIR VOLUME FLOW RATE=usn; is used to specify the design volumetric flow rate of the air over the cooling coil or the sum of the supply air flow rates for all of the zones served by the system in units of ft^3/min or m^3/s.

Barometric Pressure

BAROMETRIC PRESSURE=usn; is used to specify the barometric pressure of the air in units of inches H20 or N/m^2.

Entering Refrigerant Temperature

ENTERING REFRIGERANT TEMPERATURE=usn; is used to specify the entering refrigerant temperature of a DX coil in units of °F or °C.

Leaving Refrigerant Temperature

LEAVING REFRIGERANT TEMPERATURE=usn; is used to specify the leaving refrigerant temperature of a DX coil in units of °F or °C.

Total Cooling Load

TOTAL COOLING LOAD=usn; is used to specify the design cooling load of a DX coil in units of kBtu/hr or kW.

Number of Tube Circuits

NUMBER OF TUBE CIRCUITS=usn; is used to specify the number of circuits of a DX coil.

DXCOIL1, DXCOIL2, DXCOIL3

DXCOIL1(usn1,usn2,usn3);

DXCOIL2(usn1,usn2,usn3);

DXCOIL3(usn1,usn2,usn3); are used to specify the performance of the DX coil of a DX Packaged Unit system. See *Packaged DX Coil* under *Coiling Coil Design Parameters* in the *BLAST Technical Reference* for more information.

End Cooling Coil Design Parameters

END COOLING COIL DESIGN PARAMETERS; This statement ends the Cooling Coil Design Parameters Data Block.

Heat Recovery Parameters*

*Refer to encyclopedic listing in BLAST User Reference for more information.

HEAT RECOVERY PARAMETERS: This statement begins the Heat Recovery Parameters Data Block. Specifying Air to Air Heat Recovery parameters is explained in the *BLAST Technical Reference*.

HTREC1, HTREC2, HTREC3

HTREC1(usn1,usn2,usn3);

HTREC2(usn1,usn2,usn3);

HTREC3(usn1,usn2,usn3); are used to specify the effectiveness of sensible heat recovery in the fan system.

HTREC4, HTREC5, HTREC6

HTREC4(usn1,usn2,usn3);

HTREC5(usn1,usn2,usn3);

HTREC6(usn1,usn2,usn3); are used to specify the effectiveness of latent heat recovery in the fan system.

HTPWR

HTPWR(usn1,usn2,usn3); is used to specify the power consumption of the heat recovery unit in the fan system.

Heat Recovery Capacity

HEAT RECOVERY CAPACITY=usn; specifies the capacity of the heat recovery unit in kBtu/hr or kW.

End Heat Recovery Parameters

END HEAT RECOVERY PARAMETERS; This statement ends the Heat Recovery Parameters Data Block

DX Condensing Unit Parameters*

*Refer to encyclopedic listing in BLAST User Reference for more information.

DX CONDENSING UNIT PARAMETERS: This statement begins the DX Condensing Unit Parameters Data Block. The DX Condensing Unit operates in conjunction with the DX Packaged unit or the DX coil.

DX Condensing Unit Capacity

DX CONDENSING UNIT CAPACITY=usn; specifies the capacity of the DX packaged unit in kBtu/hr or kW.

Design Saturated Suction Temperature

DESIGN SATURATED SUCTION TEMPERATURE=usn; is used to specify the design compressor suction temperature of the DX package unit in °F or °C.

Design Saturated Condensing Temperature

DESIGN SATURATED SUCTION TEMPERATURE=usn; is used to specify the design condenser suction temperature of the DX package unit in °F or °C.

Minimum Saturated Condensing Temperature

MINIMUM SATURATED SUCTION TEMPERATURE=usn; is used to specify the minimum condenser suction temperature of the DX package unit in °F or

Unloader Throttling Range

UNLOADER THROTTLING RANGE=usn; is used to specify the temperature throttling range for the unloader on the DX package unit in °F or °C.

Condenser UA

CONDENSER UA=usn; is used to specify the value of the overall heat transfer coefficient for the DX packaged unit condenser in units of kBtu/hr/°F or

SCT Temperature Rise Coefficient

SCT TEMPERATURE RISE COEFFICIENT=usn; is used to specify the actual suction temperature rise of the DX packaged unit. The “usn” parameter in this statement is dimensionless.

Design Full Load Power Ratio

DESIGN FULL LOAD POWER RATIO=usn; is used to specify the compressor full load power ratio at design conditions for the DX packaged unit. The “usn” parameter in this statement is dimensionless.

RCAVCD

RCAVCD(usn1,usn2,usn3); is used to specify the available capacity of the DX package unit.

RPWRCD

RPWRCD(usn1,usn2,usn3); is used to specify the fraction of full load power for the DX package unit.

ADJECD

ADJECD(usn1,usn2,usn3); is used to specify the full load power ratio of the DX package unit.

End DX Condensing Unit Parameters

END DX CONDENSING UNIT PARAMETERS; This statement ends the DX Condensing Unit Parameters Data Block.

Heat Pump Cooling Parameters

HEAT PUMP COOLING PARAMETERS: This statement begins the Heat Pump Cooling Parameters Data Block. Please note that all of the parameters in this data block are in SI units. Moreover, if any of these parameters are changed, the rest must be changed accordingly. See *Heat Pump: Air Source* in the *BLAST Technical Reference* for more information.

EWBDC

EWBDC=usn; is used to specify the entering coil wet bulb temperature for an air to air heat pump in cooling mode at design conditions in units of °C.

ODBDC

ODBDC=usn; is used to specify the outdoor dry bulb temperature for an air to air heat pump in cooling mode at design conditions in units of °C.

ETDCC

ETDCC=usn; is used to determine the temperature difference based on design conditions for the outside temperature and entering wet bulb temperature of an air to air heat pump in cooling mode. The “usn” parameter in this statement is dimensionless.

FOMCC

FOMCC=usn; is used to determine the the figure of merit for an air to air heat pump in cooling mode. The “usn” parameter in this statement is dimensionless.

COPDC

COPDC=usn; is used to determine the coefficient of performance for an air to air heat pump in cooling mode at design conditions. The “usn” parameter in this statement is dimensionless.

QHPDC

QHPDC=usn; is used to determine the maximum heat transfer rate in kW for an air to air heat pump in cooling mode at design conditions.

HPCOIL1, HPCOIL2, HPCOIL3

HPCOIL1(usn1,usn2,usn3);

HPCOIL2(usn1,usn2,usn3);

HPCOIL3(usn1,usn2,usn3); is used to determine the ratio between the sensible and the wet coil total heat transfer rate as a function of entering wet bulb temperature, entering dry bulb temperature, and the outdoor dry bulb temperature.

COPC

COPC=usn; is used to specify the coefficient of performance for an air to air heat pump in cooling mode at off design conditions. The “usn” parameter in this statement is dimensionless.

QHPC

QHPC=usn; is used to determine heat transfer rate of the coil for an air to air heat pump in cooling mode at off design conditions. The “usn” parameter in this statement is dimensionless.

End Heat Pump Cooling Parameters

END HEAT PUMP COOLING PARAMETERS: This statement ends the Heat Pump Cooling Parameters Data Block.

Heat Pump Heating Parameters

HEAT PUMP HEATING PARAMETERS: This statement begins the Heat Pump Heating Parameters Data Block. Please note that all of the parameters in this data block are in SI units. Moreover, if any of these parameters are changed, the rest must be changed accordingly. See *Heat Pump: Air Source* in the *BLAST Technical Reference* for more information.

EWBDH

EWBDH=usn; is used to specify the entering coil wet bulb temperature for an air to air heat pump in heating mode at design conditions in units of °C.

ODBDH

ODBDH=usn; is used to specify the outdoor dry bulb temperature for an air to air heat pump in heating mode at design conditions in units of °C.

ETDCH

ETDCH=usn; is used to determine the temperature difference based on design conditions for the outside temperature and entering wet bulb temperature of an air to air heat pump in heating mode. The "usn" parameter in this statement is dimensionless.

FOMCH

FOMCH=usn; is used to determine the figure of merit for an air to air heat pump in heating mode. The "usn" parameter in this statement is dimensionless.

COPDH

COPDH=usn; is used to determine the coefficient of performance for an air to air heat pump in heating mode at design conditions. The "usn" parameter in this statement is dimensionless.

QHPDH

QHPDH=usn; is used to determine the maximum heat transfer rate in kW for an air to air heat pump in heating mode at design conditions.

HPTT

HPTT=usn; is used to specify the turning temperature in °C for an air to air heat pump.

QHPH1

QHPH1(usn1,usn2,usn3); is used to determine the heat transfer rate of the coil at off design conditions when the outside dry bulb is less than the turning temperature (HPTT) of an air to air heat pump.

QHPH2

QHPH2(usn1,usn2,usn3); is used to determine the heat transfer rate of the coil at off design conditions when the outside dry bulb is greater than or equal to the turning temperature (HPTT) of an air to air heat pump.

COPH1

COPH1(usn1,usn2,usn3); is used to specify the coefficient of performance of the heat pump at off design conditions when the outside dry bulb is less than the turning temperature (HPTT) of an air to air heat pump.

COPH2

COPH2(usn1,usn2,usn3); is used to specify the coefficient of performance of the heat pump at off design conditions when the outside dry bulb is greater than or equal to the turning temperature (HPTT) of an air to air heat pump.

End Heat Pump Heating Parameters

END HEAT PUMP HEATING PARAMETERS: This statement ends the Heat Pump Heating Parameters Data Block.

Water Source Heat Pump Parameters

WATER SOURCE HEAT PUMP PARAMETERS: This statement begins the Water Source Heat Pump Parameters Data Block. These parameters are only valid for the Water Loop Heat Pump fan system. See *Water Loop Heat Pump System* in the *BLAST Technical Reference* for more information.

HHCP

HHCP(usn1,usn2,usn3); is used to calculate the water loop heat pump heating capacity.

HCCP

HCCP*(usn1,usn2,usn3);* is used to calculate the water loop heat pump cooling capacity.

HCOP

HCOP*(usn1,usn2,usn3);* is used to calculate the water loop heat pump coefficient of performance.

HEER

HEER*(usn1,usn2,usn3);* is used to calculate the water loop heat pump energy efficiency rating.

PRSURE

PRSURE*(usn1,usn2,usn3);* is used to calculate the water loop heat pump pressure drop. Note that the third parameter in this statement, usn3, is not used by the program.

WLPT

WLPT*(usn1,usn2,usn3);* is used to calculate the cooling tower pump energy usage for a water loop heat pump system.

End Water Source Heat Pump Parameters

END WATER SOURCE HEAT PUMP PARAMETERS: This statement ends the Water Source Heat Pump Parameters Data Block.

Equipment Schedules*

*Refer to encyclopedic listing in BLAST User Reference for more information.

EQUIPMENT SCHEDULES: controls the operation of all system components.

NOTE 1: Component schedules must be consistent with specified control profiles. See Interaction of Loads and Systems in the BLAST Technical Reference for additional information.

NOTE 2: Because equipment schedules are defaulted "ON", all "OFF" periods must be defined in the Equipment Schedules Data Block. Any time period not specified in the data block will default to the "ON" mode of operation. The following is an example of scheduling a component "ON" and "OFF".

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 02JUN;
EXHAUST FAN OPERATION=OFF,FROM 03JUN THRU 31DEC;
```

component name = sched name, FROM date1 THRU date2, specifies the component (from the list below), either a library or a temporary schedule, and the time period that the schedule is in effect.

usn1 MAXIMUM TEMPERATURE optional syntax which specifies the outdoor air dry-bulb temperature above which this schedule does not apply; i.e., equipment will be turned off.

usn2 MINIMUM TEMPERATURE, optional syntax which specifies the outdoor air dry-bulb temperature below which this schedule does not apply; i.e., equipment will be turned off.

component name =

RECOOL COIL OPERATION	FANCOIL HEATING OPERATION

EXHAUST FAN OPERATION	FANCOIL COOLING OPERATION
PREHEAT COIL OPERATION	TSTAT BASEBOARD HEAT OPERATION
HEATING COIL OPERATION	HEAT PUMP COOLING OPERATION
COOLING COIL OPERATION	MINIMUM VENTILATION SCHEDULE
HUMIDIFIER OPERATION	MAXIMUM VENTILATION SCHEDULE
REHEAT COIL OPERATION	SYSTEM ELEC. DEMAND SCHEDULE
SYSTEM OPERATION	WLHPS STORAGE TANK OPERATION
HEAT RECOVERY OPERATION	WLHPS VENTILATION SYSTEM OPER.
EVAP COOLER OPERATION	WLHPS LOOP CONTROL SCHEDULE
HEAT PUMP BACKUP HEAT OPER.	VAV MINIMUM AIR FRACTION
HEAT PUMP HEATING OPERATION	

End Equipment Schedules

<u>*END EQUIPMENT SCHEDULES;*</u> This statement ends the Equipment schedules Data Block.

Central Plant Syntax

In the following sections, the HBLC or BTEXT generated central plant syntax is briefly explained. The central plant section of the input file (located between the *BEGIN CENTRAL PLANT DESCRIPTION* and *END CENTRAL PLANT DESCRIPTION* phrases) is organized into blocks of information called data blocks. The data blocks serve to organize the central plant syntax as shown below.

1. The ***Equipment Selection Data Block*** supplies information on the type, number, size, and availability of plant components.
2. The ***Equipment Assignment Data Block*** defines the number and size of each type of equipment that will operate in each specified load range.
3. The ***Part Load Ratios Data Block*** establishes minimum, maximum, and best part load ratios for each type of equipment and the ratio of electrical energy input per unit output.
4. The ***Schedule Data Block*** provides information on scheduling of domestic hot water and plant electrical demands, and process waste heat availability.
5. The *Special* **Parameters Data Block** provides information on temperatures, pressures, flow rates, and other parameters.
6. The ***Equipment Performance Data Block*** supplies coefficients describing the performance of actual equipment to be specified.
7. The ***For System Data Block*** supplies information on system multipliers for duplicate fan systems.

The following figure is an example of the central plant section of a BLAST input file. Each syntax data block in this section of the BLAST input file is explained in the following paragraphs in the order in which it appears in the input file. Cross-references to more detailed explanations in the encyclopedic listing of topics are also provided.

With the exception of the type, number and size of equipment, all other parameters have default values that need not be changed to successfully simulate a central plant. The seven data blocks are described in detail in the following paragraphs.

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "ICE STORAGET" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE STORAGE:
1 OF SIZE 400;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(0.88768,-0.029155,0.0114526);
.   .   .   .   .
.   .   .   .   .
STORE9(-2.45402,0.422024,3.12814);
END EQUIPMENT PERFORMACE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
.   .   .   .   .
.   .   .   .   .
PSHAVE=0.0;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Plant

PLANT plant num " plant name" SERVING SYSTEMS sys num, sys num, sys num; The plant number and name are arbitrarily chosen by the user. The systems served by the plant (*sys num*) are the system numbers assigned to the systems in the Fan System section of the input file.

Equipment Selection

EQUIPMENT SELECTION: This statement begins the Equipment Selection Data Block. Central plant equipment currently available in BLAST is shown in the list below. Syntax information is shown in the *BLAST User Reference* listed under the equipment type name. For chillers and boilers utilizing cold or hot water, the pump's performance can be modified by Equipment Performance and Special Parameters as described in *Pumps* in the *BLAST User Reference*.

Information on how the specified equipment will operate may be found in the *Default Operating Rules* entry of the *BLAST User Reference*.

Boiler	Ice Storage: Ice Harvester
Electric Boiler	Ice Storage: Ice on Coil
Simple Fuel Boiler	Ice Storage: Ice Container
Air Cooled Chiller	Ice Storage: Ice Tank
Chiller	Stratified Thermal Storage Tank
Diesel Chiller	Evaporative Condenser
Double Bundle Chiller	Well Water Condenser
Free Cooling Chiller	Cooling Tower
Gas Turbine Chiller	Direct Cooling Tower
Open Chiller	Fuel Domestic Hot Water Heater
Reciprocating Chiller	Elec. Domestic Hot Water Heater
Simple Chiller	Purchased Heating
One Stage Absorber	Purchased Cooling
Two Stage Absorber	Diesel Generator
Two Stage Absorber W/Econ	Gas Turbine Generator
Heat Pump (water to water)	Steam Turbine Generator

End Equipment Selection

END EQUIPMENT SELECTION; This statement ends the Equipment Selection Data Block.

Equipment Assignment*

*Refer to encyclopedic listing in BLAST User Reference for more information.

EQUIPMENT ASSIGNMENT: This statement begins the Equipment Assignment Data Block which allows users to override all or some of the default operating rules for equipment selected in the Equipment Selection Data Block. Syntax and examples may be found in the *Equipment Assignment* entry of the *BLAST User Reference*.

End Equipment Assignment

END EQUIPMENT ASSIGNMENT: This statement ends the Equipment Assignment Data Block.

Part Load Ratios

PART LOAD RATIOS: This statement begins the Part Load Ratios Data Block which allows users to specify whether, and at what level, each type of equipment will operate. Syntax and examples may be found in the *Part Load Ratios* entry of the *BLAST User Reference*.

End Part Load Ratios

END PART LOAD RATIOS: This statement ends the Part Load Ratios Data Block.

Schedule

SCHEDULE: This statement begins the Schedule Data Block which allows users to schedule domestic hot water demand, plant electrical demand, and availability of process waste heat (see *Default Operating Rules* in the *Blast User Reference*). Syntax and examples may be found in the *Schedule* entry of the *BLAST User Reference*.

End Schedule

END SCHEDULE : This statement ends the Schedule Data Block.

Special Parameters

SPECIAL PARAMETERS: This statement begins the Special Parameters Data Block which allows users to specify constants (such as boiler and chiller operating temperatures, heat content of fuels, and system pressures and flow rates) needed to simulate central energy plants. Syntax and examples may be found in the *Special Parameters* entry of the *BLAST User Reference*.

End Special Parameters

END SPECIAL PARAMETERS: This statement ends the Special Parameters Data Block.

Equipment Performance Parameters

EQUIPMENT PERFORMANCE PARAMETERS: This statement begins the Equipment Performance Parameters Data Block. The coefficients and constants required to model the performance of the various types of equipment are shown in this block. Default performance parameters are listed under the name of each type of equipment in the *BLAST User Reference*. Specific information on the model itself may be found (listed under the equipment type) in the *BLAST Technical Reference*. Generic syntax and use are shown under *Equipment Performance Parameters* in the *BLAST User Reference*.

End Equipment Performance Parameters

END EQUIPMENT PERFORMANCE PARAMETERS: This statement ends the Equipment Performance Parameters Data Block.

For System

FOR SYSTEM sysnum: This statement begins the For System Data Block. This data block provides accounting for duplicate fan system loads in the plant simulation. The system number (*sysnum*) is the system served by the central plant whose load will be duplicated by the system multiplier. The default for the system multiplier is 1. The block format is as below:

System Multiplier

SYSTEM MULTIPLIER = usn; The loads from fan system *sysnum* are multiplied by *usn*. If this block is seen by considering a case in which many fan systems are identical, e.g., middle stories of a skyscraper. This could be done by setting the system multiplier = 3, for system number 15. An equivalent, but cumbersome way to do this would be:

CENTRAL PLANT1 "MIDDLE SKYSCRAPER" SERVING SYSTEMS 10,15,15,15,4;

End for System

END : This statement ends the For System Data Block.

Other Plant Parameters

OTHER PLANT PARAMETERS: This statement begins the Other Plant Parameters Data Block. The only valid statements for this data block is the REPORT VARIABLE statement which is used to select Report Writer central plant variables and the Well Water Temperatures used by the Well Water Condenser.

Report Variables

REPORT VARIABLES=(usn1, ..., usnn); is used to specify central plant variables to be reported on an hourly basis. These are processed by the auxiliary program Report Writer. For a list of Report Writer central plant variables currently available, see the *Plant Report Writer Variable List* under *Report Writer*. For additional information on Report Writer, see the *Report Writer* section of the manual.

End Other Plant Parameters

END: This statement ends the Other Plant Parameters Data Block.

User Reference

User Reference Introduction

For ease of reference, BLAST program information is presented under four separate tabs:

1. The *Quick Reference* defines BLAST syntax.
2. The *User Reference* is an encyclopedic listing of user information.
3. The *Output* section explains all BLAST output reports.
4. The *Technical Reference* contains engineering, modeling and advanced user information.

The *User Reference* is the second level of BLAST detail as presented in the BLAST manual set. It contains an encyclopedic listing of BLAST input file related topics. This section present descriptions, definitions and syntax information about items used in BLAST models. Examples and use instructions guide the user in constructing BLAST input for the "Lead Input" section, which defines the overall simulation, and the three main simulation sections; "Building Loads", "Fan Systems" and "Central Plants".

Each listing starts with a general description and definitions and then examples of the subject use in BLAST is presented. Information about HBLC procedures is given for each listing when relevant. Many topics in this section are cross referenced to *Getting Started* and *The Technical Reference* for more detailed information on that subject.

The primary header (in bold type) on each page shows the topic presented in that section of the manual. The secondary header shows the section of the BLAST simulation ("Building Loads", "Fan Systems" and "Central Plants") to which the topic is related.

BLAST User Reference.

Note: A weather tape will have “built in” latitude and longitude that BLAST will use during annual simulations.

Design Days

Design days must be specified by the user if a design day simulation is to be attempted. An extensive library of design day profiles exists, however a temporary design day can easily be created with HBLC. Please see Temporary Design Days in the *BLAST User Reference* for more information

Geometry

Before HBLC will allow specification of loads and controls for a simulation, the zones need to be defined. Creation of zones is done graphically in HBLC, using the point and click technology of Microsoft Windows.™ For a detailed lesson on how to create building geometry with HBLC, please see the *HBLC User’s Manual*.

Building Loads

The HBLC interface allows quick and easy scheduling of building loads. Selecting “Scheduled Loads” from under the “Environment” tab of the menu bar will open the Scheduled Loads dialog box. The steps in scheduling loads are:

1. Click on the type of load that you would like to add or modify.

2. Click on the “Add Load” button to add a load. To modify a load, click on the box for the data you would like to change. “Delete

3. Enter the zone that the load is to be scheduled for.

4. Select the load schedule from the drop down menu. If the desired schedule is not among the choices, it may have to be created with the Custom Schedules menu.

5. Enter the size of the load. For some options there will be a drop down menu available to select choices from. Different load types will have different parameters to specify their size.

6. Peak load data can be entered in a variety of units. Click on the arrow above the column to select non-default units.

7. Click on “Edit one load at a time” to enter each load form by form instead of a table.

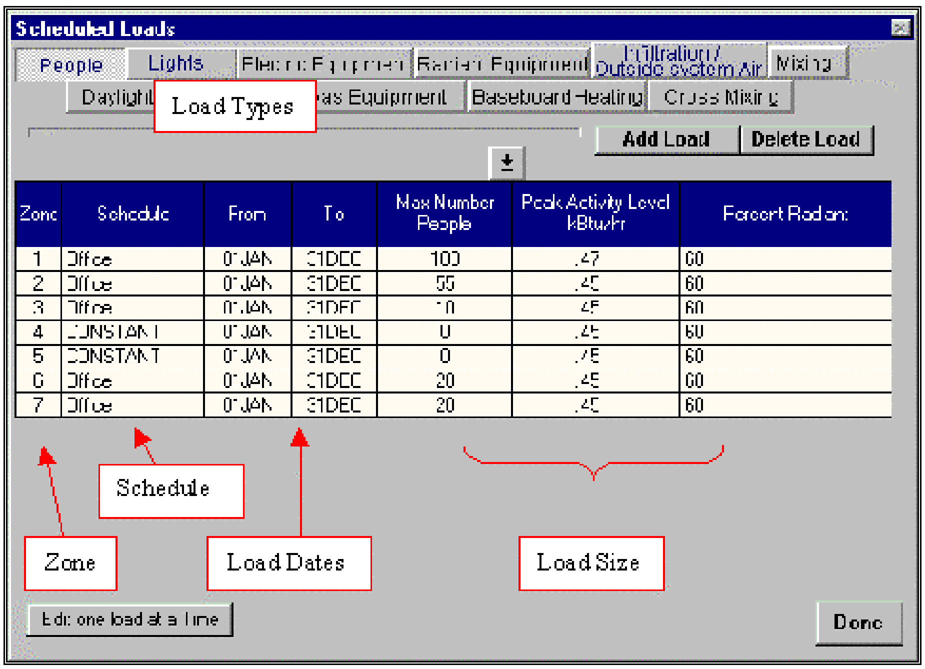


Figure 29. Scheduled Loads form

Controls

Controls can be specified for zones by following the methods outlined in “Specifying Controls in HBLC.” For more information on Controls, please see *Controls* in the *BLAST User Reference*.

Fan Systems

Creating and Editing Fan Systems with HBLC

HBLC provides a simple, intuitive way to create, edit, and delete fan systems in a BLAST simulation.

Going to the menu bar and selecting “Environment” and then choosing “Systems” from the list will open up the Systems dialog box. The steps involved in adding any fan system are:

1. Click on the “Add System” button. To modify an existing system, select it from the pull down menu.
2. The user will be asked to select a system type from a list of pre-defined system types.
3. Next, a name must be chosen for the system.
4. There will be several boxes and data cells that will appear. The user must fill out highlighted items. Optional items can be chosen by marking the check box in front of the button.
5. The buttons on the left of the box represent system specific parameters – many systems will have the same types of parameters. Each system will also have a button underneath the system name that will have system parameters to input.
6. The boxes in the middle and on the right must be filled out with information relating the system to the zones that it serves.
7. The user is advised to click on all available buttons and fill in his or her own data. Default entries are provided which will allow BLAST to run, but simulation accuracy will be improved by entering user specific data.

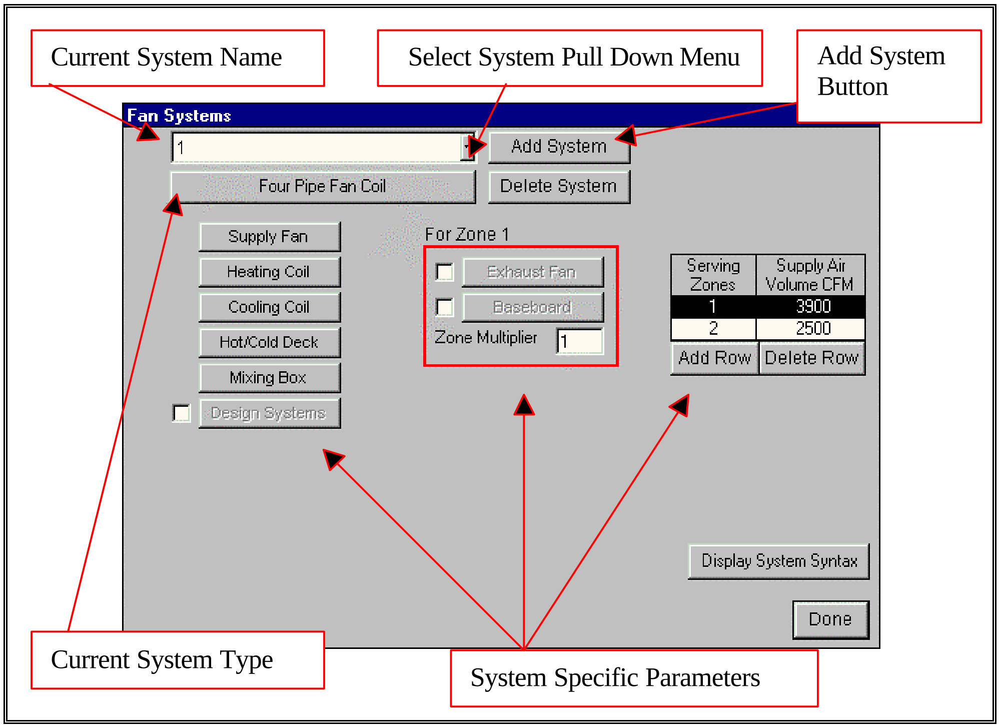


Figure 30. Fan Systems form

Central Plants

Creating and Editing Central Plants with HBLC

The HBLC interface allows easy creation and modification of central plants. Typically plant creation would occur after having completed all zoning and system creation. Selecting “Plants” from under the “Environment” tab of the menu bar will open the Plants dialog box. The steps in creating a central plant are:

1. Click on the “Add” button at the top of the box to create a new plant. HBLC will prompt the user for a plant name. To modify an existing plant, select it from the pull down menu.
2. Adjust the plant control schedule by clicking on the “Plant Schedule” button.
3. Equipment can be added to the plant by clicking on the “Add” button in the plant equipment section of the dialog box. A drop down menu will appear listing all the equipment available for simulation.
4. Enter the quantity of the equipment
5. Enter the size of the equipment in appropriate English or SI units.
6. Adjust the equipment parameters. The parameter data can be called up by either selecting the equipment and clicking the “Edit” button, or double clicking on the equipment.
7. Assign fan systems to be served by the plant. Clicking on the “Add” button will open a drop down menu with systems available to be served by the current plant. To delete a system from a plant’s service list, first select the system, then click on “Delete.”

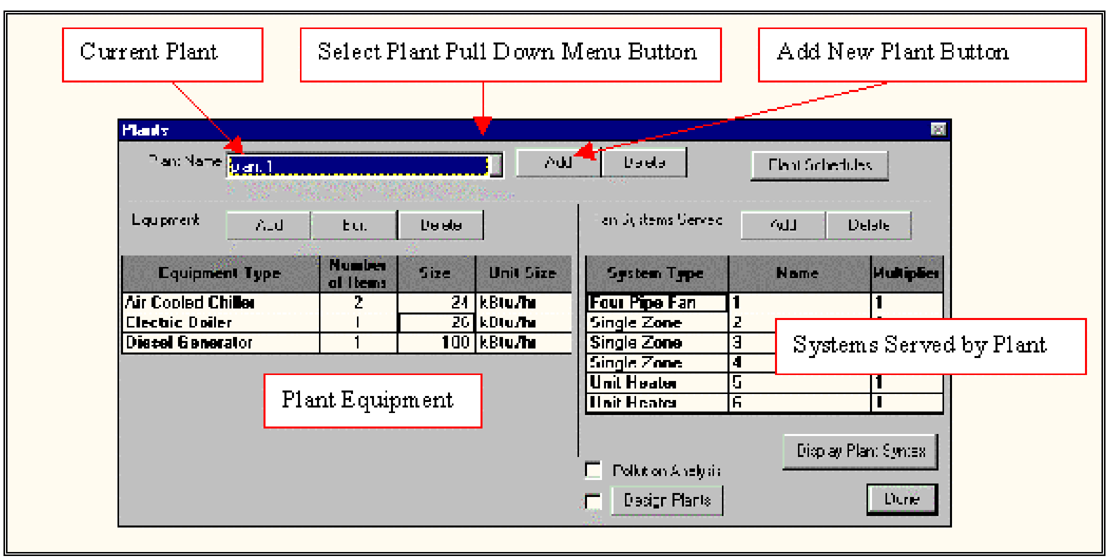


Figure 31. Plants form

Air Cooled Chiller

Equipment Description:

The BLAST model of an air cooled chiller is simulated as a standard vapor compression refrigeration cycle with an air cooled condenser and a hermetic centrifugal compressor. The hermetic centrifugal compressor is a sealed unit that contains the motor and the compressor. The closed housing is then immune to leakage that often occurs in open type compressors. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to air condenser. The heat from the condenser is rejected to the atmosphere by an exhaust fan. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

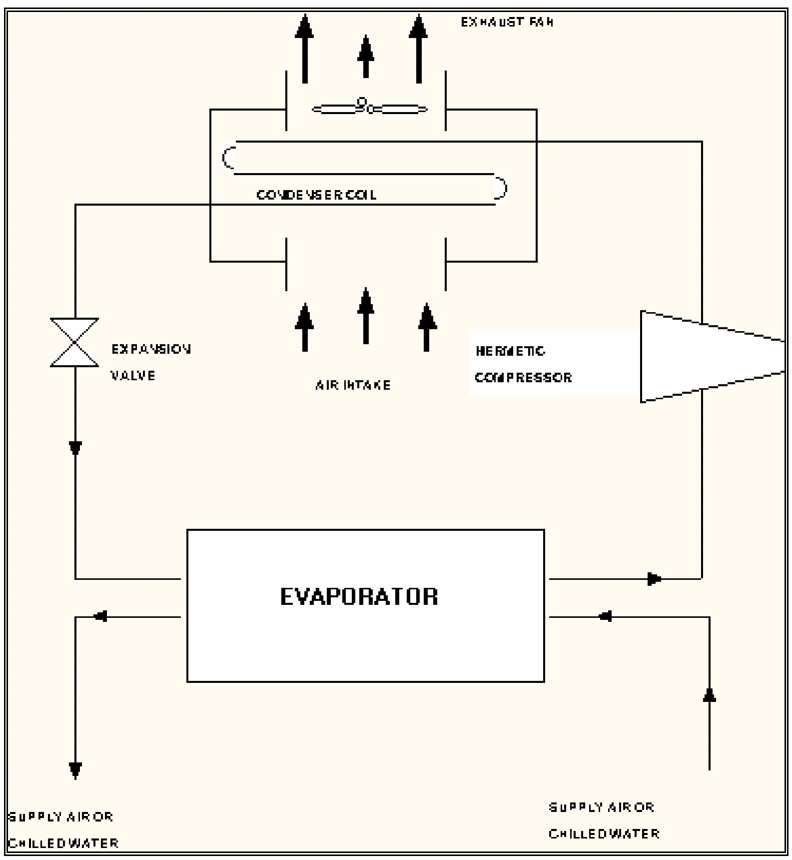


Figure 32. Diagram of a BLAST air cooled chiller

USING THE BLAST AIR COOLED CHILLER:

Specifying an Air Cooled Chiller in HBLC

To specify an air cooled chiller as one of the operating components in the central energy plant, the user must follow the instructions contained in Central Plants.

Adjusting the Performance Parameters of the Air Cooled Chiller

Once the air cooled chiller has been added, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters will allow a valid simulation for an air cooled chiller that has the following operating parameters:

Evaporator temperature	= 40 to 48 °F
Condenser temperature	= 70 to 100 °F
Capacity	= 920 to 1000 Tons

If your air cooled chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program.

To edit the current parameters, select the chiller and click on the edit button, or alternatively double click on the chiller.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJTAC- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAVAC- Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJEAC- Used to adjust the full load power consumption of the chiller.

RPWRAC- Used to determine the fraction of full load power.

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the air cooled chiller syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the air cooled chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

AIR COOLED CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ACC" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
AIR COOLED CHILLER:
1 OF SIZE 100;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
AIR COOLED CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.398);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTAC(95,2.778,45);
RCAVAC(0.994,-0.02553,-0.000418);
ADJEAC(2.33,-1.975,0.6121);
RPWRAC(0.03303,0.6852,0.2818);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

AIR COOLED CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ACC" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
AIR COOLED CHILLER:
1 OF SIZE 24;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
AIR COOLED CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTAC(35,2.778,7.22);
RCAVAC(0.9949,-0.045945,-0.001534);
ADJEAC(2.33,-1.975,0.6121);
RPWRAC(0.03303,0.6852,0.2818);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
```

```
SPECIAL PARAMETERS:
TCOOL=6.667;
.    .    .
.    .    .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Air to Air Heat Pump

EQUIPMENT DESCRIPTION:

One of the most common types of heat pump is the reversible packaged type. The reversible heat pump can operate in a cooling and a heating mode. During heating operation a four way valve positions itself so that the high pressure discharge gas from the compressor flows first to the heat exchanger in the conditioned air stream. To convert form heating to cooling operation the four way valve shifts to its opposite position so that discharge gas from the compressor first flows to the outdoor coil. Packaged units are usually categorized by mounting position and capacity, such as a "10 ton roof top unit". Most units are purchased as a single component and installed with a relatively small amount of labor.

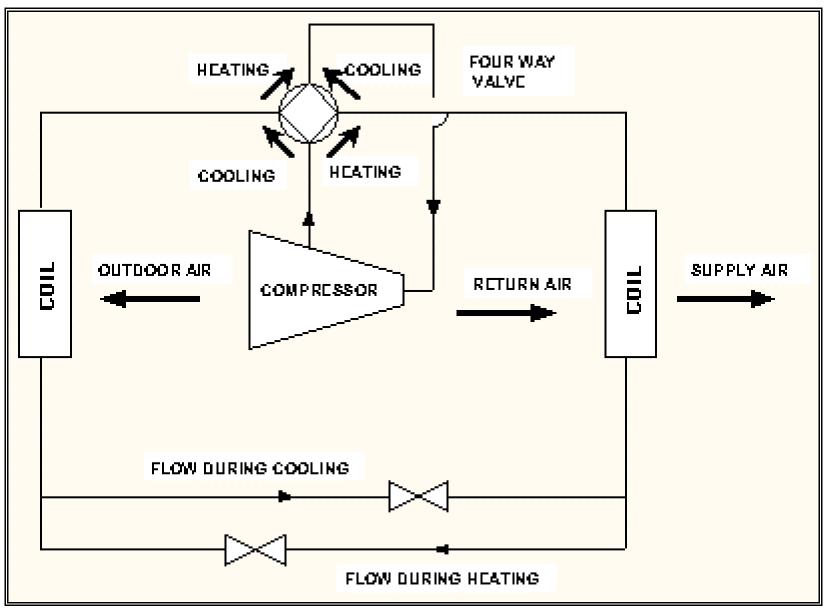


Figure 33. Diagram of a BLAST air to air heat pump

USING THE HEAT PUMP UNIT:

Specifying a Heat Pump Unit in HBLC

To specify a heat pump unit as one of the fan systems in the building simulation, the user must first select the component using the “Systems” dialog box under the “Environment” pull down menu. For reference, see Fan Systems.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the Heat pump unit. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

HEAT PUMP PACKAGED UNIT SYSTEM 1

"HEAT PUMP " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .      (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
   SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .      OTHER SYSTEM DATA BLOCK
      .   .   .   .      (Required user input)
   COOLING SAT DIFFERENCE=20 (11.1);
   HEATING SAT DIFFERENCE=70 (38.8);
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .      COOLING COIL DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .      HEAT RECOVERY DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
   COPC=(11,34.09,-0.087);
      .   .   .   .      HEAT PUMP DATA BLOCK
      .   .   .   .      (Optional expert user input)
.   .   .   .
END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
   COPH2=(22,-3.9,0.022);
                      HEAT PUMP DATA BLOCK
.   .   .             (Optional expert user input)
.   .   .   .
END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
      .   .   .   .      DX UNIT DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      .   .   .   .      SCHEDULES DATA BLOCK
      .   .   .   .      (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the heat pump unit syntax is shown in the context of a complete fan system description with English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The fan system syntax shown in these figures is sufficient to completely model the heat pump unit system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the heat pump unit system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the heat pump unit system are listed in bold and all options as well as Metric (SI) units are italicized. Please note that all default values given below are for the ten ton model only.

HEAT PUMP ZONE DATA BLOCK

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100 (.0473);
   EXHAUST AIR VOLUME=0 (0);
   MINIMUM AIR FRACTION=0.19 (0.1);
   BASEBOARD HEAT CAPACITY=0.0 (0);
   BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                      =STEAM;
                      =ELECTRIC;
                      =GAS;
   REHEAT CAPACITY=0.0 (0);
   REHEAT ENERGY SUPPLY=HOT WATER;
                      =STEAM;
                      =ELECTRIC;
                      =GAS;
   RECOOL CAPACITY=0.0 (0);
   INDUCED AIR FRACTION=2.0 (2);
   ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

HEAT PUMP OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
            =OUTSIDE AIR CONTROLLED;
            =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
            =GAS;
            =ELECTRIC;
            =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
            =OUTSIDE AIR CONTROLLED
            =ZONE CONTROLLED;
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    TRPEN=0.016;
    HEATING COIL TYPE=HEAT PUMP COIL;
    COOLING COIL TYPE=HEAT PUMP COIL;
    BACKUP HEAT CAPACITY=34120 (10000);
    HEAT PUMP BACKUP HEAT TYPE=ELECTRIC;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft³/min or m³/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

HUMIDIFIER TYPE- Used to specify the type of energy that is used by the humidifier. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

TRPEN- Used to specify the transient nature of the heat pump. According to the formula:

$$Q_{COIL} = Q_{SS}(t - TA)$$

Where:

Q_{SS} = The steady state heat transfer rate

t = The time the pump is in operation

Q_{COIL} = Amount of energy transferred from the coil.

TA = A constant which is equal to **TRPEN.**

HEATING COIL TYPE- Used to specify the type of heating coil that is used by the system. The only option for the packaged heat pump is HEAT PUMP COIL.

COOLING COIL TYPE- Used to specify the type of cooling coil that is used by the system. The only option for the packaged heat pump is HEAT PUMP COIL.

BACKUP HEAT CAPACITY- Used to specify the capacity of the backup heat used with the packaged heat pump. Units: kBtu/hr or kW

HEAT PUMP BACKUP HEAT TYPE- Used to specify the type of backup heat used with the packaged heat pump. Options include hot water, electric, steam, and gas.

HEAT PUMP COOLING PARAMETERS DATA BLOCK

```
HEAT PUMP COOLING PARAMETERS:
    EWBDC=21.6667;
    ODBDC=46.1111;
    ETDCC=0.34387;
    FOMCC=12.28344;
    QHPDC=33.70317;
    COPDC=2.3535;
    HPCOIL1 (-0.063508488,0.0046417,0.000024671);
    HPCOIL2 (0.015555,0.00002695,0.00000024777);
    HPCOIL3 (-0.00011997,-0.00000027022,0.00312);
    QHPC (1.0058399,0.01053023,0.00003394931);
    COPC (-0.053957574,0.168795005,-0.00414629);
END HEAT PUMP COOLING PARAMETERS;
```

***NOTE**: All heat pump parameters are always input in SI units and if any parameters are changed, the rest need to be changed accordingly. See the technical reference section to customize heat pump parameters.

EWBDC- Used to specify the entering coil wet bulb design temperature. Units: °C

ODBDC- Used to specify the outdoor dry bulb design temperature. Units: °C

ETDCC- Used to determine the temperature difference based on design conditions for the outside temperature and entering wet bulb temperature according to the following formula:

$$\Delta T = \frac{(Tewb - Tewbd)}{ETDCC} - (Todb - Todbd)$$

Tewb **-** Entering wet bulb temperature.

Tewbd **-** Entering wet bulb design temperature.

Todb **-** Outside dry bulb temperature.

Todbd **-** Outside dry bulb design temperature.

FOMCC- Used to specify the figure of merit for the heat pump.

COPDC- Used to specify the coefficient of performance at design conditions.

QHPDC- Used to specify the maximum heat transfer rate of the cooling coil at design conditions. Units: kW

HPCOIL1- Used to determine the ratio between the sensible and the wet coil total heat transfer rate as a function of entering wet bulb temperature, entering dry bulb temperature and the outdoor dry bulb temperature.

HPCOIL2- Used to determine the ratio between the sensible and the wet coil total heat transfer rate as a function of entering wet bulb temperature, entering dry bulb temperature and the outdoor dry bulb temperature.

HPCOIL3- Used to determine the ratio between the sensible and the wet coil total heat transfer rate as a function of entering wet bulb temperature, entering dry bulb temperature and the outdoor dry bulb temperature.

COPC- Used to determine the coefficient of performance of the heat pump at off design conditions.

QHPC- Used to determine heat transfer rate of the coil at off design conditions.

HEAT PUMP HEATING PARAMETERS DATA BLOCK

```
HEAT PUMP HEATING PARAMETERS:
    EWBDH=21.6667;
    ODBDH=22.222;
    ETDCH=8.2067;
    FOMCH=82.4122;
    QHPDH=47.18443;
    COPDH=3.0835;
    HPTT=4.16667;
    QHPH1 (0.90339,-0.02004084,0.00009646011);
    QHPH2 (1.00520777,-0.019170755,-0.00015469510);
    COPH1 (-4.05738268362,2.9100227356,-0.42249909043);
    COPH2 (-0.89820170403,0.82049518824,-0.07453066856);
END HEAT PUMP COOLING PARAMETERS;
```

***NOTE**: All heat pump parameters are always input in SI units and if any parameters are changed, the rest need to be changed accordingly. See the technical reference section to customize heat pump parameters.

EWBDH- Used to specify the entering coil wet bulb design temperature. Units: °C

ODBDH- Used to specify the outdoor dry bulb design temperature. Units: °C

ETDCH- Used to determine the temperature difference based on design conditions for the outside temperature and entering wet bulb temperature according to the following formula:

$$\Delta T = \frac{(Tewb - Tewbd)}{ETDCH} - (Todb - Todbd)$$

Tewb **-** Entering wet bulb temperature.

Tewbd **-** Entering wet bulb design temperature.

Todb **-** Outside dry bulb temperature.

Todbd **-** Outside dry bulb design temperature.

FOMCH- Used to specify the figure of merit for the heat pump.

COPDH- Used to specify the coefficient of performance at design conditions.

QHPDH- Used to specify the maximum heat transfer rate of the heating coil at design conditions. Units: kW

HPTT- Used to specify the turning temperature for the heat pump. Units: °C

QHPH1- Used to determine heat transfer rate of the coil at off design conditions when the outside dry bulb is less than the turning temperature (HPTT) of the last pump.

QHPH2- Used to determine heat transfer rate of the coil at off design conditions when the outside dry bulb is greater than or equal to the turning temperature (HPTT) of the heat pump.

COPH1- Used to determine the coefficient of performance of the heat pump at off design conditions when the outside dry bulb is less than the turning temperature (HPTT) of the heat pump.

COPH2- Used to determine the coefficient of performance of the heat pump at off design conditions when the outside dry bulb is greater than or equal to the turning temperature (HTPP) of the heat pump.

HEAT PUMP EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEAT PUMP COOLING OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEAT PUMP HEATING OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEAT PUMP BACKUP HEAT OPERATION=MINOA,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,
       392 MAXIMUM TEMPERATURE,
       -328 MINIMUM TEMPERATURE;
```

PREHEAT COIL OPERATION- Used to schedule preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT PUMP HEATING OPERATION- Used to schedule the heating operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT PUMP COOLING OPERATION- Used to schedule the cooling operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT PUMP BACKUP HEAT OPERATION- Used to schedule the backup heating operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Boiler**

**Refer to encyclopedic listing in BLAST Technical Reference for more information.

EQUIPMENT DESCRIPTION:

The BLAST model of a Boiler is simulated as a standard fuel fired boiler. The performance of the boiler is based on the air to fuel ratio, fuel heating value, boiler stack temperature and ambient air temperature.

USING THE BLAST BOILER:

Specifying a Boiler in HBLC

To specify a boiler as one of the operating components in the central energy plant, the user must follow the procedure outlined in Central Plants.

Adjusting the Performance Parameters of the Boiler

Once the boiler has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these parameters, default parameters will be used. The default parameters will allow a valid simulation for a boiler that has the following operating characteristic:

Ratio of actual efficiency to theoretical = 0.7 to 1.0

If your boiler does not fall within this range, a new set of parameters must be generated from manufacturers or test data.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

RFUELB- Used to calculate the theoretical fuel consumption divided by the actual fuel consumption or the actual efficiency divided by the theoretical efficiency.

HPUMP- Used to adjust the electric consumption of the hot water pump based on the installed boiler capacity.

HFUELB- Heat content of boiler fuel. Affects the boiler efficiency and should be consistent with SRATB. Units: Btu/lb or kJ/kg

PSTEAM- Gauges boiler steam pressure, unless steam turbines are selected (equivalent saturation pressure for hot water boilers). Units: in. water gauge (Pascals gauge), 1 psi =27.71 in water gauge.

RFLASH- The boiler flash water or blow down rate (pounds of steam discharged per pound of steam produced). For water boilers, this parameter should probably be set to zero. Units: Dimensionless

RHFLASH- Fraction of heat in boiler flash(blow down) which is recovered in feed water preheater. Units: Dimensionless

SRATB- Air-to-fuel stoichiometric ratio (pounds of air per pound of fuel) for boilers. Affect the boiler efficiency and should be consistent with HFUELB. Units: Dimensionless

STEAM- Enthalpy of steam from boiler or heat recovery. If not given, calculated as the saturation enthalpy at PSTEAM AND TSATUR. Units: Btu/lb or kJ/kg

TLEAVE- Temperature of flue gas leaving the boiler stack. Affects the boiler efficiency and should be the same as the stack temperature used to compute the RFUELB equipment performance parameter set. Units: °F or °C

TSATUR- Steam saturation temperature or boiler hot water temperature. If not specified, TSATUR will be calculated from PSTEAM. Units: °F or °C

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the boiler syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the boiler. Extraneous parameters need not be removed from the BLAST input file. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

BOILER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "BOILER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
BOILER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
BOILER(MIN=0.01,MAX=1.05,BEST=.87,ELECTRICAL=0.0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
RFUELB(0.6,0.889,-0.4935);
RCAVDC(1,0,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
HFUELB=20013.384;
PSTEAM=284.409;
RHFLASH=0.5;
RFLASH=0.071;
SRATB=17;
STEAM=1168.67;
TLEAVE=550.04;
TSATUR=241.53;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

BOILER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "BOILER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
BOILER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
BOILER(MIN=0.01,MAX=1.05,BEST=.87,ELECTRICAL=0.0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
RFUELB(0.6,0.889,-0.4935);
RCAVDC(1,0,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
HFUELB=46580;
PSTEAM=70841.4;
RFLASH=0.5;
```

```
SRATB=17;
STEAM=2716.528;
TLEAVE=278.8;
TSATUR=116.405;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Chiller (Hermetic Centrifugal Compression)

EQUIPMENT DESCRIPTION:

The BLAST model of a chiller is simulated as a standard vapor compression refrigeration cycle with a water cooled condenser and a hermetic centrifugal compressor. The hermetic centrifugal compressor is a sealed unit that contains the motor and the compressor. The closed housing is immune to leakage that often occurs in open type compressors. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The heat from the condenser is rejected to a cooling tower, evaporative condenser, or well water condenser depending which one is selected by the user based on the physical parameters of the plant. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

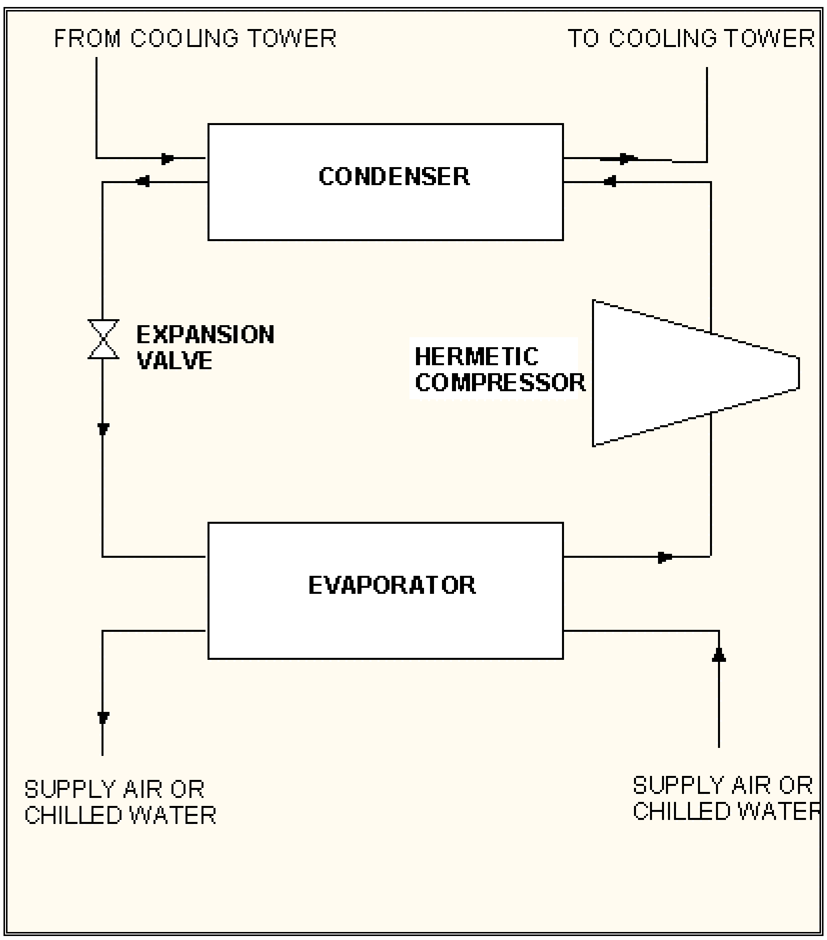


Figure 34. Diagram of a BLAST chiller

USING THE BLAST CHILLER:

Specifying a Chiller in HBLC

To specify a chiller as one of the operating components in the central energy plant, please reference Central Plants.

Adjusting the Performance Parameters of the Chiller

Once the chiller has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default will allow a valid simulation for a chiller that has the following operating parameters:

Evaporator temperature	= 40 to 48 °F
Condenser temperature	= 70 to 100 °F
Capacity	= 920 to 1000 Tons

If your chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for a chiller are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJT1C- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAV1C- Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJE1C- Used to adjust the full load power consumption of the chiller.

RPWR1C- Used to determine the fraction of full load power.

CPUMP- Used to determine the electric consumption of the chilled water pumps.

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the chiller syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJT1C(95,2.5,44);
RCAV1C(1.01836,-0.03075,-0.0001442);
ADJE1C(2.3201,-1.4617,0.181487);
RPWR1C(0.18717,0.122387,0.67436);
CPUMP(1,0,0);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 24;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJT1C(35,2.5,6.667);
RCAV1C(1.01836,-0.05535,-0.0004673);
```

```
ADJE1C(2.3201,-1.4617,0.181487);
RPWR1C(0.18717,0.122387,0.67436);
CPUMP(1,0,0);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Cold and Hot Deck Control

Cold Deck Control

Fixed Set-Point

If the fixed set-point option (default) is specified, the specified deck temperature becomes the set point of the deck temperature controller. The cold deck set point is set to a constant temperature under all conditions. The value of this temperature is entered under:

COLD DECK TEMPERATURE = usn.

Outside Air Controlled

If OUTSIDE AIR CONTROLLED is specified, the cold deck set point is adjusted according to outside air temperature. The user must also specify two points which become control limits, as shown below:

COLD DECK CONTROL = OUTSIDE AIR CONTROLLED;

COLD DECK CONTROL SCHEDULE = (55 AT 90, 65 AT 70);

In the above example, when outside air is at 90°F or above, the cold deck temperature is set at 55°F. When the outside air temperature is at 70°F or below, the cold deck set point is 65°F. For outside air temperatures between 70°F and 90°F a linear interpolation is performed to determine the cold deck set point, as shown in the figure below.

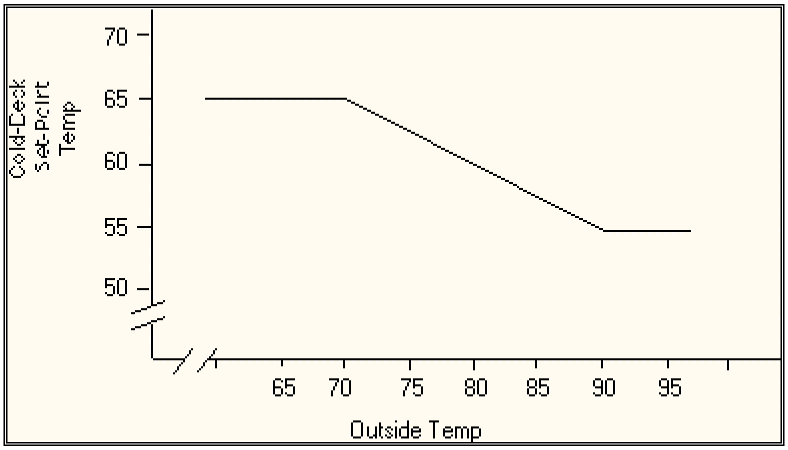


Figure 35. Cold Deck Set-Point Temp vs Outside Temp

Zone Controlled

If the cold deck strategy is ZONE CONTROLLED, then the zone requiring the coldest air is used to establish the cold deck set point. The following example serves to illustrate how this is affected.

COLD DECK CONTROL = ZONE CONTROLLED;

COLD DECK CONTROL SCHEDULE = (45 AT 55, 65 AT 65);

In the above example, if the zone requiring the coldest air must be supplied with air at a temperature of 55°F (this air temperature is calculated by BLAST for each hour of the simulation), the cold deck set point is 45°F. If the zone requiring the coldest air needs air at a temperature of 65°F, then the cold deck set point is 65°F. For any temperatures between 55°F and 65°F, linear interpolation is performed to establish the cold deck set point, as shown in the figure below. One can see that as the zone with the greatest thermal requirements needs colder air, the deck set point is lowered to provide this colder air.

In the above example, gain has been added to the cold deck control strategy. Air at 55°F is required but 45°F air is supplied in an attempt to provide the necessary cooling at a faster rate. The user may add gain or not, depending upon the actual situation. The default for the cold deck control schedule is:

COLD DECK CONTROL SCHEDULE = (32 AT 32, 212 AT 212);

Which simply sets the cold deck temperature equal to the temperature of the air required by the zone needing the coldest air for all possible situations.

Note that the zone requiring the coldest air is not necessarily the zone requiring the most cooling.

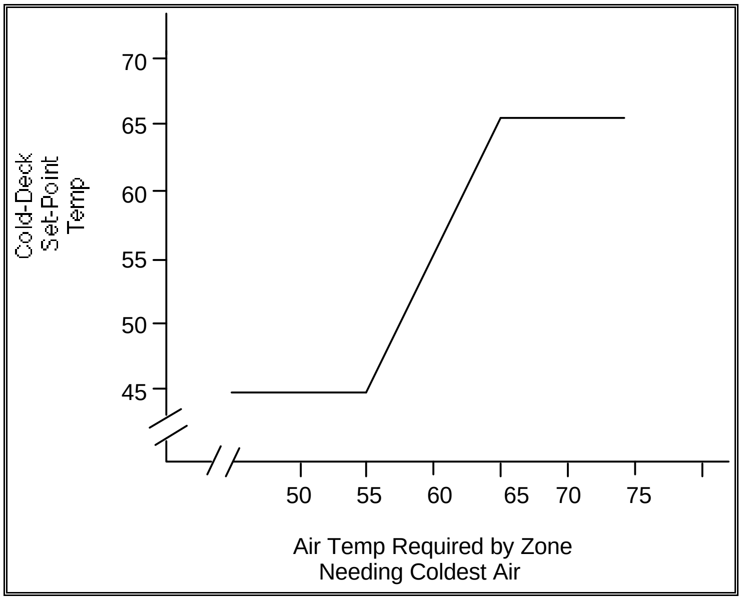


Figure 36. Cold Deck Setpoint in Zone Controlled use

Throttling Range

Although only the deck *set point* temperature has been referred to, the *actual* deck temperature is also influenced by the deck throttling range. It may also be influenced in the simulation by the ability of the coils to maintain the desired deck temperature.

Regardless of which deck control strategy is chosen, the deck throttling range is used in conjunction with the specified deck control strategy to determine the actual delivery temperature of the air. The above explanations of the three deck control strategies described how the deck *set point* was established. However, the deck set point is not necessarily the actual temperature of the air delivered by the deck. In all three cases one must specify a cold deck throttling range which is used in conjunction with the cold deck set point to determine the actual cold deck air delivery temperature. If the cooling coil load from the previous hour was 100 percent of capacity, the cold deck set point is also the actual cold air delivery temperature. If, however, the cooling coil load was not 100 percent of capacity, then the actual cold deck temperature is calculated as follows: based on the last hour's cooling coil load ratio, the desired cold deck temperature is proportioned to a value between the set point and the set point minus the throttling range. The exact inverse applies to hot decks; i.e., the deck temperature increases above the set point with decreasing coil load.

Example: Throttling Range

The user specified the cold deck throttling range as 50°F in the BLAST input. The cold deck set point has been calculated to be 55°F for the present hour in the BLAST simulation. The cooling coil load from the previous hour was 80 percent of capacity. Hence, the actual delivery temperature of the cold deck air is modulated down from the cold deck set point by 20 percent, to 54°F (see the figurebelow).

NOTE: "Coil operates at 100%" means that the coil operates with 100% of the maximum possible flow rate of chilled water.

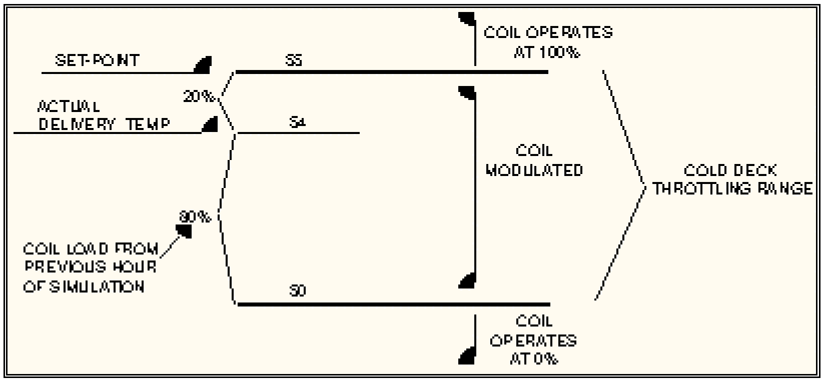


Figure 37. Cold Deck Throttling Range Example

For deck control schemes where any room thermostat is in direct control of the hot or cold deck, the deck throttling range should be set to zero. For schemes where an air temperature sensor in the hot or cold deck controls the deck temperature (whether or not it is reset by one or more room thermostats), a finite throttling range should be specified since the actual deck temperature must deviate from the deck set point before any control action takes place.

Deck Temperatures

Hot and cold deck temperatures have different meanings depending on the type of fan system being used. For multizone, dual-duct, and dual-duct variable volume systems, hot and cold deck temperatures are the actual desired air temperatures. These temperatures will be maintained if at all possible. For fan coil and unit ventilator and unit heater systems, the hot and cold deck temperatures set the maximum and minimum air temperatures leaving the unit. (Note that unit ventilators are heating only.) For example, a hot deck temperature of 120°F for a fan coil system means that the air leaving the unit

Variable volume, terminal reheat, subzone reheat and induction units are a combination of the above cases. For these systems, the cold deck temperature is the desired air temperature leaving the main cooling coil, but the hot deck temperature is just a limit on the air temperature leaving the reheat coil.

For DX packaged units and single-zone draw through systems, hot and cold deck temperatures have no meaning. For these systems, the desired supply air temperature is provided if at all possible. The desired supply air temperature is the temperature necessary to meet the load for a given hour.

The cold- and hot-deck temperature control options, applicable regardless of the system type, are (1) fixed set point, (2) outside air controlled, and (3) zone controlled.

Hot Deck Controls

Hot deck control works in the inverse manner; the deck temperature increases with the decreasing coil load.

VAV, terminal reheat, and subzone reheat systems use the hot deck parameters differently than explained above. Since there is no hot deck, the entry "HOT DECK TEMPERATURE = " is used to determine the maximum allowable temperature of the air leaving the reheat coils. The entry "HOT DECK CONTROL =" may be set to "OUTSIDE AIR CONTROLLED" or "FIXED SET POINT" (but *not* to "ZONE CONTROLLED").

Outside Air Controlled

The first available option, HOT DECK CONTROL = OUTSIDE AIR CONTROLLED, is used if the boiler delivers hot water to the reheat coil and the temperature of this water is adjusted according to outside air temperature. In this case the user must also specify the appropriate HOT DECK CONTROL SCHEDULE, which is taken from actual operating conditions of the boiler.

Outside Air Controlled Example

A VAV system is used in which the temperature of the water provided by the boiler to the reheat coil equals 120°F for outdoor air temperatures less than or equal to 10°F, and the water temperature equals 80°F for outdoor air temperatures greater than or equal to 70°F. This is graphically presented in the figure below.

BLAST entries to model the above are:

HOT DECK CONTROL = OUTSIDE AIR CONTROLLED;

HOT DECK CONTROL SCHEDULE = (120 AT 10, 80 AT 70);

If the boiler always delivers water to the reheat coil at a constant temperature, or if the heating coil is supplied by a source other than hot water, then the user should specify:

HOT DECK CONTROL = FIXED SET POINT;

HOT DECK TEMPERATURE = usn;

The entry HOT DECK CONTROL SCHEDULE does not apply in this case.

Note that the entry HOT DECK THROTTLING RANGE is *never* used in any simulation of VAV, terminal reheat or subzone reheat systems.

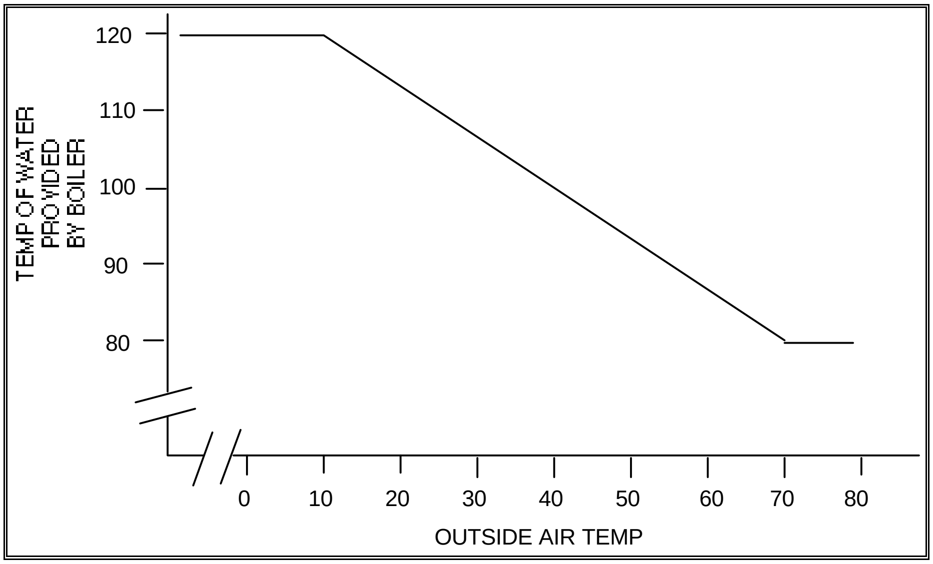


Figure 38. Water Temp vs Outside Air Temp

Controlled Radiant Heater

High Temperature Radiant Heaters in BLAST

High Temperature Radiant Heaters are the implementation of Phase I of the BLAST Radiant Heat Enhancements. This type of radiant heater includes high temperature gas or electric heaters that give off a directional component of infrared radiant heat. This type of radiant heater is not to be confused with Low Temperature Radiant Heaters that include heated floor slabs and radiant ceiling panels. The following sections will describe the syntax necessary to simulate High Temperature Radiant Heaters within BLAST.

Specifying and Controlling Radiant Heaters in BLAST

High Temperature Radiant Heaters in BLAST can be described as either **scheduled** or **temperature controlled**. The RADIANT EQUIPMENT statement defines a **scheduled** radiant heater. For more information, see *Radiant Equipment* in the *BLAST Quick Reference*. A CONTROLS statement may be used to specify a **temperature controlled** radiant heater. It is similar to the heating load that is determined in the BLAST Loads simulation for a convection heater. The difference between the convection heating profile and the radiant heating profile is that the radiant heater disperses direct and/or diffuse radiant energy to the zone occupants and surfaces. For more general information, see *High Temperature Radiant Heaters* in the *BLAST Technical Reference*.

Specifying Temperature Controlled Radiant Heaters in HBLC

Enter the Controls dialog box under the Environment tab on the menu bar. Add the High Temperature Radiant Heater by filling in the data boxes with the heater parameters.

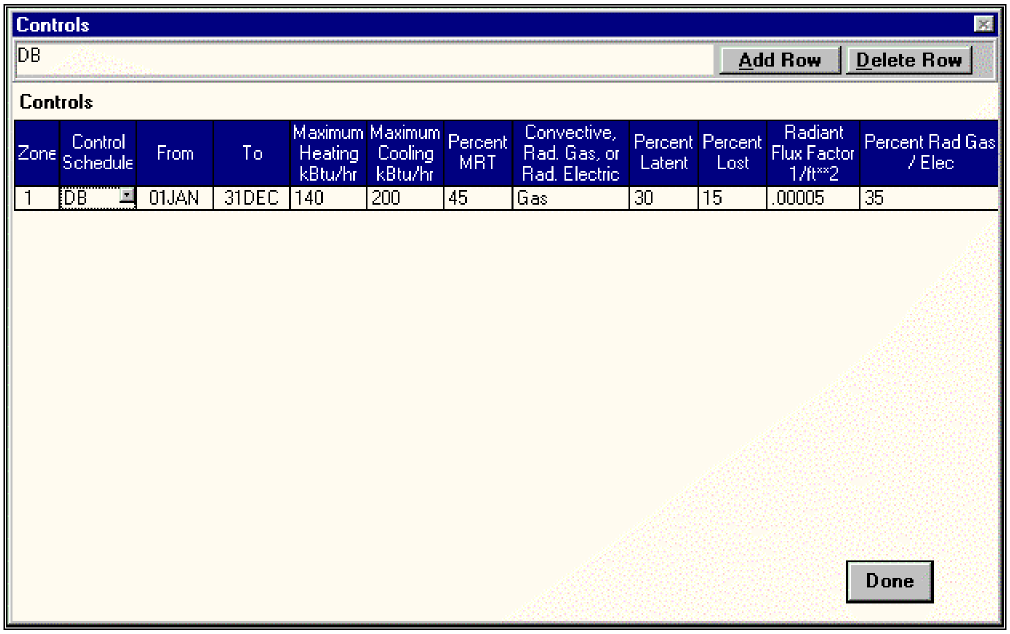


Figure 39. Controls form with a High Temperature Radiant Heater

Example of a Temperature Controlled Radiant Heater

```
CONTROLS = TEMPDB, 140.00 HEATING, 200.00 COOLING, 45 PERCENT MRT,
  35 PERCENT RADIANT GAS HEAT, 0.0005 RADIANT FLUX FACTOR,
  30 PERCENT LATENT, 15 PERCENT LOST, FROM 01JAN THRU 31DEC;
```

The CONTROLS statement specifies a gas fired temperature controlled radiant heater with a temporary control schedule named TEMPDB. The radiant heating capacity and convective cooling capacity are defined as 140 kBtu/hr and 200 kBtu/hr, respectively. BLAST assumes that an air handler will supply cooling to the zone. 55 percent of the Effective Temperature for the zone is made up of the Mean Air Temperature of the zone. 35 percent of the total heating capacity is radiant energy; 30 percent of the total heating capacity is latent; 15 percent of the total heating capacity is lost. The remaining 30 percent of the energy input is added to the zone heat balance as convective heat. The Radiant Flux Factor is 0.0005/ft^2. The CONTROL schedule remains in effect the entire year.

Controls**

**Refer to encyclopedic listing in BLAST Technical Reference for more information.

The Function of a Control Profile

A control profile is a piecewise linear function that specifies the amount of heating or cooling delivered by the system to a zone. A user specifies a control profile by giving the end points of the segments of the function. Control profiles are defined by specifying the fraction of full heating or cooling available at a specified room temperature. All fractions must be between + 1 and **-** 1 inclusive; + 1 is full heating, **-** 1 is full cooling. 0 is no heating or cooling. BLAST constructs linear throttling ranges or dead bands between user-specified control points. The syntax used to describe control profiles will be detailed below.

In order to understand control profiles, it is important to understand how the building loads section and fan system section of BLAST interact. The loads simulation is performed first and calculates space temperatures and building loads based on environmental conditions, different types of internal loads, interactions between zones, infiltration, ventilation and what the air handling system is doing. This calculation is basically an energy balance performed in an iterative manner. Its goal is to find the space temperature at which the zone load balances with the heating or cooling provided by the system. To successfully find this balance point, the user must describe to BLAST how the heating or cooling provided by the system varies with zone temperature. The mechanism for doing this is the control profile. When combined with the cooling and heating capacities specified by the user, the control profile specifies heating or cooling provided by the system as a function of zone temperature.

The Control Profile's Relationship to the Fan System

It is important to note that the control profile specifies the amount of heating or cooling *provided* by the system, **not** the amount of heating or cooling energy *consumed* by the system. It is possible that a system may either provide heating or cooling to the zone without consuming any energy (really, only consuming fan energy) or provide no heating or cooling to the zone while consuming massive amounts of energy.

An example of the former is a system with an economy cycle that brings in outdoor air to meet a deck set-point temperature. For a zone that needs cooling, the system can provide cooling equivalent to

$$q = \dot{m} C_r \Delta T$$

while only consuming fan energy.

Conversely, a system such as a multizone system can provide no heating or cooling while consuming significant amounts of energy. How is this possible? If there is no load on a zone, a multizone system can mix hot air and cold air together to create zone temperature air. When zone temperature air is provided to a zone, no heating or cooling is provided, although certainly energy was consumed to heat and cool air and then mix it together.

Selecting Control Profiles for Zones

HBLC provides an easy way to select a control profile from available libraries. If none of the standard library entries describe a situation adequately, a custom control library entry can be easily produced.

In the BLAST input file, control strategies are defined for a zone by the following syntax:

```
CONTROLS = schedule, usn1 HEATING, usn2 COOLING,
  usn3 PERCENT RADIANT, FROM date1 THRU date2;
```

The minimum specification for room temperature control is the schedule name from the control schedules library. The default heating and cooling capacities are 3,412,000 Btu/hr (1000MW). These large default capacities are helpful when a building is being run for the first time in BLAST; i.e., before the user knows what capacities should be used. This first run will indicate the peak heating and cooling required to maintain the room at a temperature very close to the desired set point; a check of BLAST's output will permit a determination of the required capacity. Once the required capacity is known, it can be used by BLAST in its annual calculations or in subsequent design day runs. The PERCENT RADIANT term is the percent of the zone mean radiant temperature used to determine the effective temperature necessary to compute the zone load.

The following equation allows an approximation of the comfort effect of radiant temperature on the zone load:

$$ET = \frac{usn3}{100} * CMRT + \frac{(1 - usn3)}{100} * MAT$$

where:

ET = effective temperature

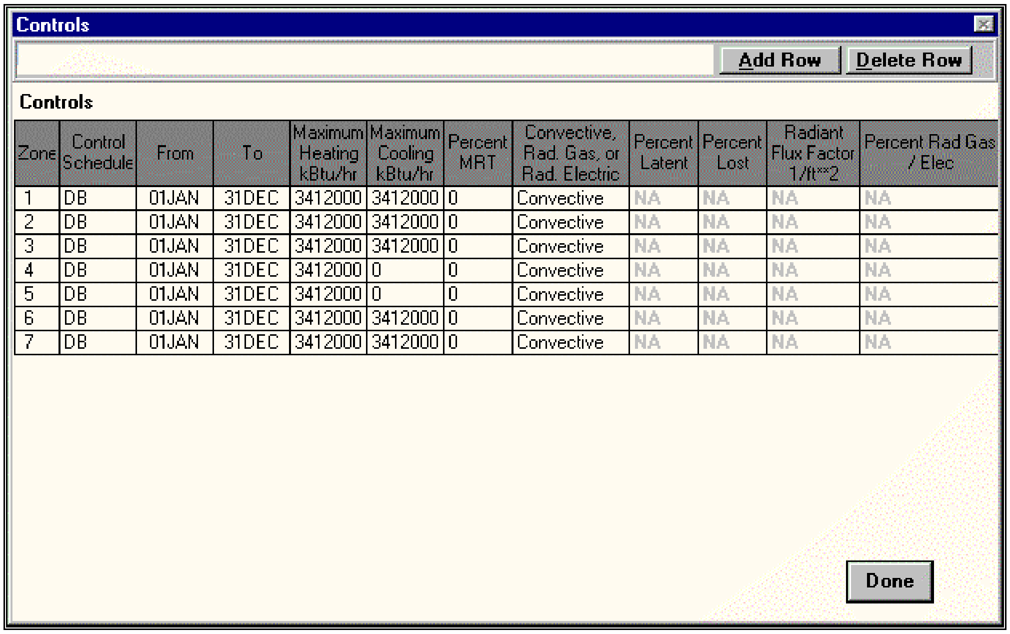
CMRT = comfort mean radiant temperature

MAT = mean air temperature

The usn3's default is 0. A good wintertime comfort index is usn3 = 0.45. Summer conditions are complicated by the effect of humidity. BLAST does not compute the moisture balance in the building loads section. If the heating or cooling capacity is off for part of the year, the fact must be expressed by the start and stop dates. (Note that time periods may not overlap.) If both heating and cooling capacities should be zero, as is common in attics, the user should not use any control statement.

Specifying Controls in HBLC

Controls can be specified in HBLC using the Controls form. To access this form, select “Controls” under the “Environment” tab of the menu bar.



Controls

Add Row | Delete Row

Controls

Zone	Control Schedule	From	To	Maximum Heating kBtu/hr	Maximum Cooling kBtu/hr	Percent MRT	Convective, Rad. Gas, or Rad. Electric	Percent Latent	Percent Lost	Radiant Flux Factor 1/ft**2	Percent Rad Gas / Elec
1	DB	01JAN	31DEC	3412000	3412000	0	Convective	NA	NA	NA	NA
2	DB	01JAN	31DEC	3412000	3412000	0	Convective	NA	NA	NA	NA
3	DB	01JAN	31DEC	3412000	3412000	0	Convective	NA	NA	NA	NA
4	DB	01JAN	31DEC	3412000	0	0	Convective	NA	NA	NA	NA
5	DB	01JAN	31DEC	3412000	0	0	Convective	NA	NA	NA	NA
6	DB	01JAN	31DEC	3412000	3412000	0	Convective	NA	NA	NA	NA
7	DB	01JAN	31DEC	3412000	3412000	0	Convective	NA	NA	NA	NA

Done

Figure 40. Controls Form in HBLC.

Data boxes can be edited by clicking on them and then changing the values. Pull down menus are available to select control schedules and device types. A custom schedule can be created using the “Custom Schedules “Library” tab of the menu bar. The options in the last four columns only apply when the device type is set to Radiant Gas or Radiant Electric.

Example Based on the Temporary Control Profile

For example, to specify controls in a zone description, HBLC might create input syntax:

```
CONTROLS = NIGHT AND WEEKEND SETBACK WITH DUAL THROTTLING RANGES,
  80 HEATING, 100 COOLING, FROM 01JAN THRU 31DEC;
```

This causes BLAST to use the control profiles shown in the figure below to add 80 kBtu/hr [23.4 kW] of heat to the room when full heating is required, or to remove 100 kBtu/hr [29.9 kW] of sensible heat from the room when full cooling is required. The heat balance point calculated by BLAST occurs at the temperature where the heat gains or losses to the *room air* exactly equal the cooling or heating capacity available *at that temperature*.

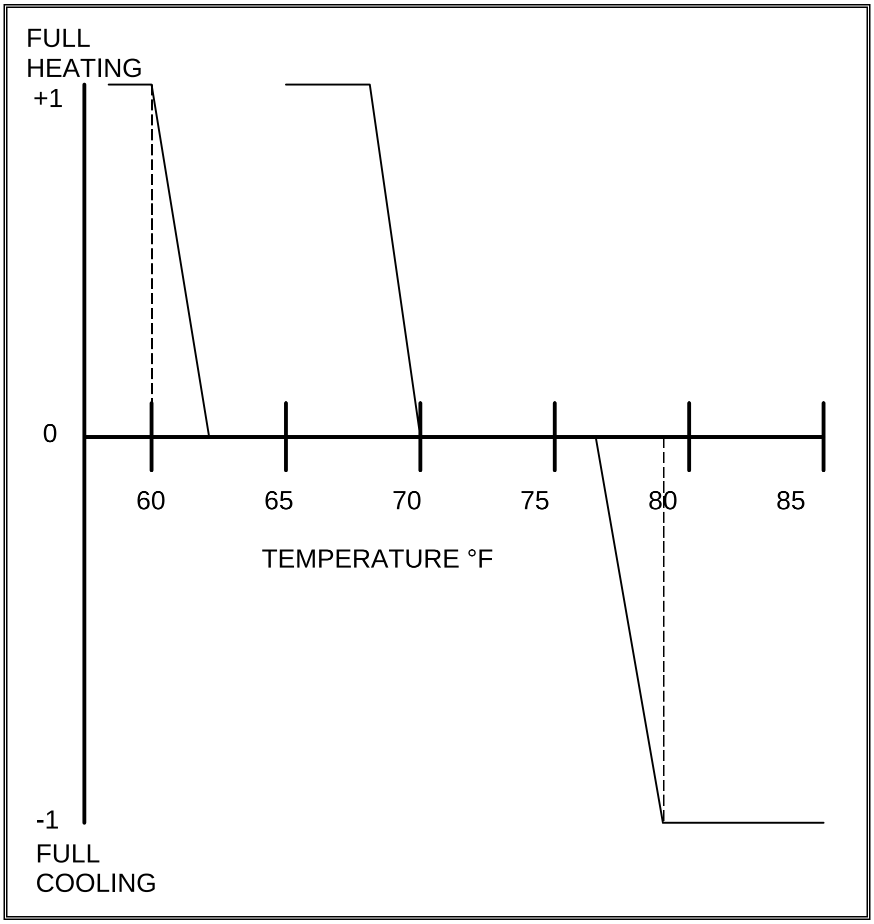


Figure 41. Control Profile

Observations and Comments

Heat Balance Points

The figure below is the same as the HEATANDCOOL profile from the figure above, except that the Y axis now shows zone capacities (+1 from above is now 80 kBtu/hr [23.4 kW] and -1 is now -100 kBtu/hr [29.3 kW]). The following heat balance points are also shown:

Point 1 might occur on a winter day. At Point 1, the room is at 68°F [20.0°C] and the heat loss from the room air exactly equals the room heating capacity available at 68°F [20.0°C]. In this example, the room heating load (heat delivered to the zone) is 40 kBtu/hr [11.7 kW].

Point 2 might occur on a mild day in the spring or fall. At this point (73°F [22.8°C]), no room heating or cooling is accomplished by the building fan system (although heating or cooling energy may be consumed to heat or cool outdoor air). For the heat balance to occur at Point 2, room air convective heat gains caused by factors such as lights or occupancy must be balanced by convective heat losses to the walls or other room surfaces, or by infiltration losses. (Except for infiltration, convection is the only mechanism by which heat is transferred to the room air; radiant energy must first be absorbed by surfaces in the room before some or all of it is convected into the room air.) If there are heat gains to the room air, some or all of the surfaces surrounding the room air must be colder than 73°F [22.8°C] to allow the heat to escape by convection. The load at Point 2 is zero.

Point 3 shows a cooling condition. Here, heat gains to the room air are balanced by the cooling capacity available at the balance point temperature.

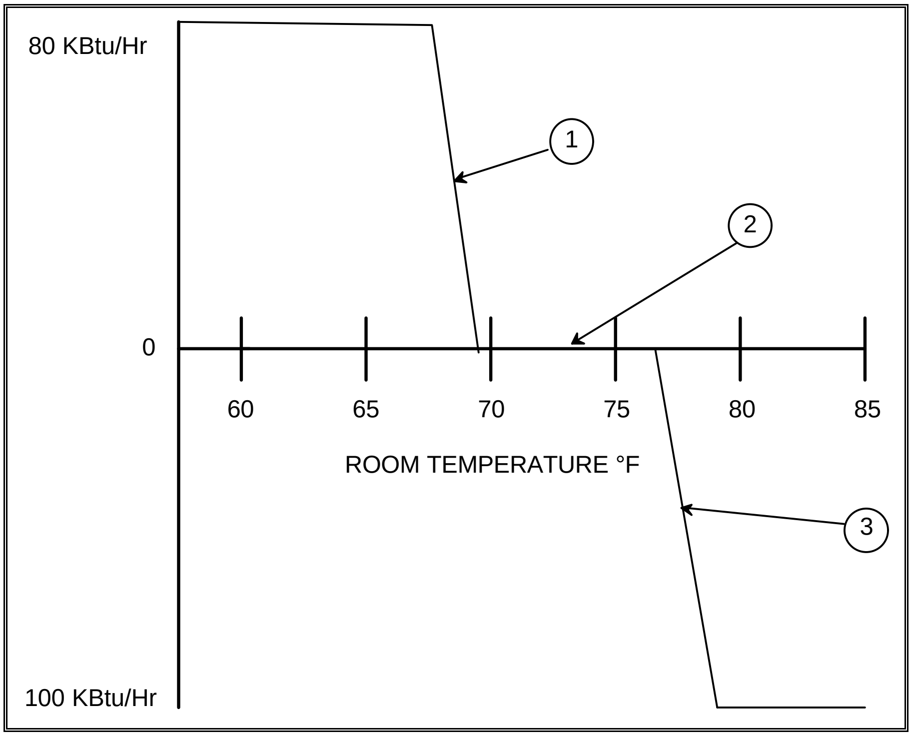


Figure 42. Control Profile

Variation between System Types

Space temperature control is somewhat dependent on the type of system serving the space. The type of control strategy shown in the previous figures approximates a single-zone drawthrough, package DX, or fan coil system. It does not apply to typical multizone, dual duct, or reheat systems, since a deadband is not possible with these types of systems. For more information, see *CONTROLS* in the *BLAST Technical Reference Manual*. It contains exact descriptions of how to create fan system specific control strategies.

Cooling Tower**

**Refer to encyclopedic listing in BLAST Technical Reference for more information.

EQUIPMENT DESCRIPTION:

The BLAST cooling tower cools water by contacting it with air through a closed loop heat exchanger. In most cooling towers serving refrigeration chillers, one or more propeller or centrifugal fans move air vertically up or horizontally through the tower.

USING THE BLAST COOLING TOWER:

Specifying a Cooling Tower in HBLC

To specify a cooling tower as one of the operating components in the central energy plant, the user must first select any chiller using the Central Plants input form. Double click on the chiller or select the chiller and press the “edit” button to open the chiller parameters dialog box. Open the “Condenser Tower” pull down menu and the form below will appear.

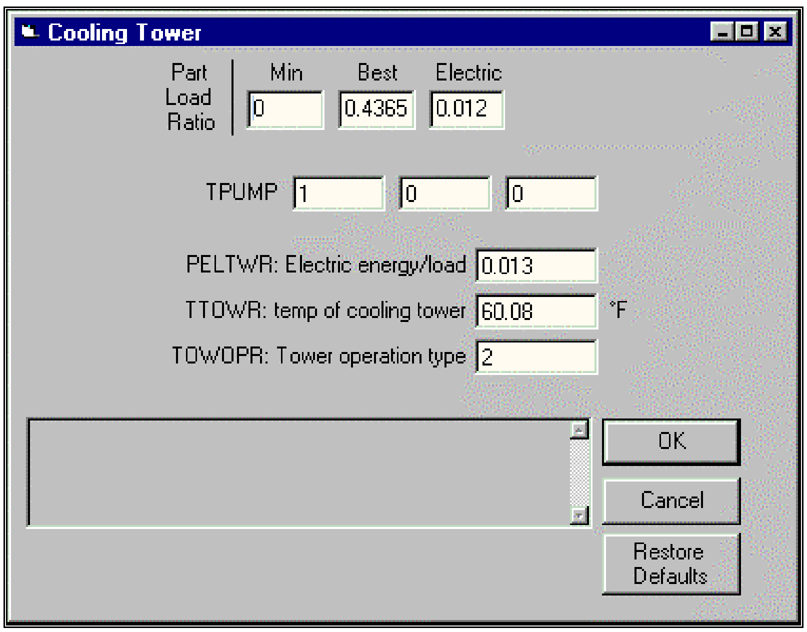


Figure 43. Cooling Tower Screen in HBLC

Adjusting the Performance Parameters of the Cooling Tower

Once the cooling tower has been added using HBLC, the user must specify operating rules and parameters. If the user does not specify these values, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a cooling tower that has the following operating parameters:

Flow Rate	= FIXED
Minimum tower temperature	= 60 °F

The default parameters have been devised so that the default cooling tower operates independently of the capacity.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

TPUMP- Used to determine the power of the cooling tower pump.

PELTWR-If cooling towers are specified in the input, PELTWR is the ratio of pump electrical energy required to cooling tower load. If cooling towers are not specified in the input, PELTWR is the ratio of tower pump electrical energy required to cooling tower load. If no tower is specified, the total electrical demand for towers and pumps is (PELTWR + ELECTRICAL)*(Tower Load) where ELECTRICAL is the power consumption per unit load for towers from PART LOAD RATIOS.

TOWOPR- Tower operation type. 1**-**variable water flow rate or 2**-**fixed water flow rate.

TTOWR-Minimum allowable temperature for water leaving the cooling tower. Also, the initial temperature of water leaving the cooling tower. Units: °F or °C

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND-Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the cooling tower syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the cooling tower. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

COOLING TOWER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "COOLING TOWER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH COOLING TOWER:
1 OF SIZE 100;
COOLING TOWER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
COOLING TOWER(MIN=0.0,MAX=1.00,BEST=.4365,ELECTRICAL=0.0125);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
TPUMP(0,1,0);
ADJT1C(1,0,0);
RCAV1C(1.006,-0.019,0.002);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PELTWR=0.013;
TOWOPR=2;
TTOWR=60.08;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

COOLING TOWER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "COOLING TOWER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH COOLING TOWER:
1 OF SIZE 26;
COOLING TOWER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
COOLING TOWER(MIN=0.0,MAX=1.00,BEST=.4365,ELECTRICAL=0.0125);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
TPUMP(0,1,0);
ADJT1C(1,0,0);
RCAV1C(1.006,-0.0342,0.007);
ADJE1C(3.158,-3.313,1.540);
```

```
RPWR1C(0.1607,0.3164,0.5198);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
PELTWR=0.013;
TOWOPR=2;
TTOWR=15.6;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Cross Mixing

The CROSS MIXING statement causes some amount of air to be supplied between zones. An example of where CROSS MIXING might be used is when two zones have a large opening between them. This would then try to simulate the natural convection between the two rooms. Again, the difficulty that arises is determining the amount of air being exchanged. The syntax for describing CROSS MIXING in BLAST is:

```
CROSS MIXING = usn1, schedule, FROM ZONE usn2, usn3 DEL TEMP,
  FROM date1 THRU date2;
```

An equal amount of air is mixed between zones. The minimum specification is the peak mixing (usn1) in ft^3/min (m^3/s) and the zone (usn2) from which air is being drawn. The default schedule is constant for all hours. When usn3 is positive, the temperature of the zone from which air is being drawn must be usn3 °F (°C) warmer than the zone air or no mixing occurs. When usn3 is zero (default), mixing occurs regardless of the relative air temperatures. Negative usn3 is not permitted. The time periods of multiple mixing statements may not overlap. When two zones are cross mixing, they may not cross mix with a third zone.

Specifying Cross Mixing in HBLC

CROSS MIXING must be defined in both zones. It can be specified in HBLC under the “Cross-Mixing” tab in the Scheduled Loads dialog box (shown below). For more information on specifying load, please see Building Loads in the User Reference.

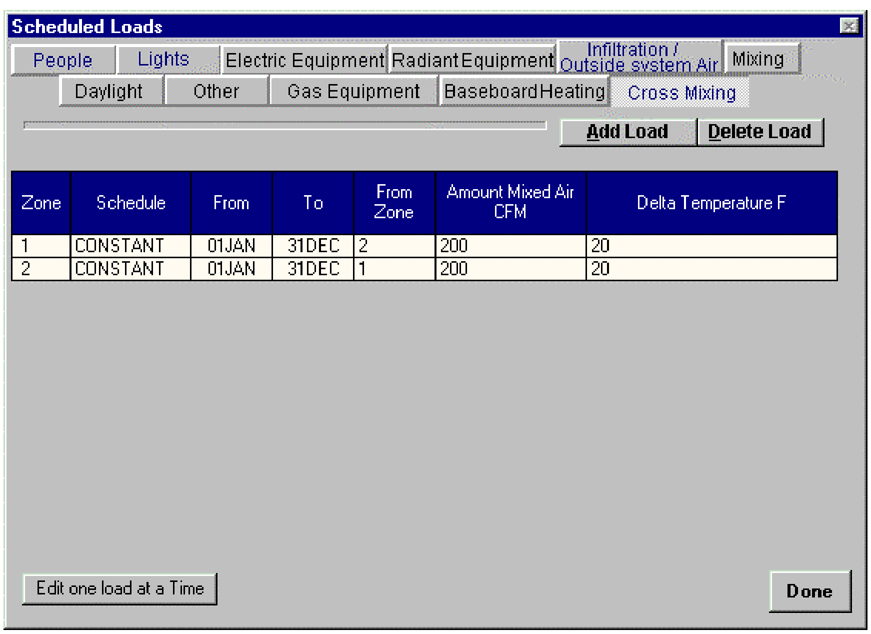


Figure 44. Scheduled Loads Screen in HBLC

Fill in the data boxes where the zone number is for the zone receiving the air, dates do not overlap, and the Delta Temperature is a positive value. The schedule may be accessed through a pull down menu. An identical load must be entered for the second zone to match the amount of air exchanged between the two zones.

CROSS MIXING allows the user to exchange equal amounts of air between two different zones. In this situation, BLAST knows how much air leaves one zone and enters the other and therefore calculates the appropriate energy balances for both zones. BLAST calculates the energy balance for only the receiving zone when MIXING is used.

Within a description block, the time periods of multiple CROSS MIXING statements may not overlap. Also, when two zones are CROSS MIXING, they may not cross mix with a third zone.

For example:

Zone 1:

```
CROSS MIXING = 100, CONSTANT 1, FROM ZONE 2, FROM 01JAN THRU 01FEB
CROSS MIXING = 100, CONSTANT 2, FROM ZONE 2, FROM 09JAN THRU 09FEB
```

Zone 2:

```
CROSS MIXING = 100, FROM ZONE 3, FROM 01JAN THRU 01FEB
```

This example is not allowed because:

1. Zone 1 tries to CROSS MIX with Zone 2 with two different schedules at the same time (overlapping)
2. Zone 2 is trying to CROSS MIX with Zone 3 as well as with Zone 1 (cannot CROSS MIX with a third zone).

Comparison of Mixing and Cross Mixing

There is a distinct difference between MIXING and CROSS MIXING. MIXING assumes that the source zone is unaffected by the loss of air. CROSS MIXING, which was described above, assumes that an equal amount of air is exchanged between two zones and that the energy balance of both zones is affected. The figure below illustrates the effects of a CROSS MIXING statement in BLAST.

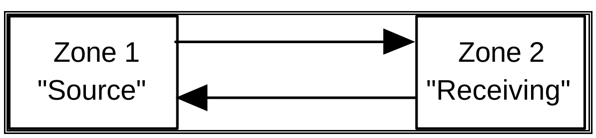


Figure 45. Cross Mixing Effects

Note that if a temperature difference exists between zones 1 and 2, the introduction of zone 1 air into zone 2 will affect the loads calculation of zone 2. The same is true of the energy balance of zone 1. It will be affected by the introduction of zone 2 air. The energy balance of both zones will be altered by a factor which is directly proportional to the peak CROSS MIXING volume, the CROSS MIXING schedule, and the temperature difference.

MIXING allows an amount of air to move from one zone to another. In this case, the energy balance of only the receiving zone is affected. For more information, see *MIXING* in the *BLAST User Reference*.

Default Operating Rules (Plant Equipment)

Default Equipment Operating Rules

The user may specify operating rules for allocating each type of equipment to meet different load ranges. If *not* specified, default rules will assign equipment in a fashion designed to approach the optimum operating point for each component type. In addition, default or user-specified "best" operating points are given for each component. These values are used to determine the near-optimum equipment loading. If this default load allocation strategy will *not* be used, then the *specific* control strategy to be used should be specified in the EQUIPMENT ASSIGNMENT block.

The following example shows how gas turbine equipment is allocated by the default operating rules to meet an electrical demand of 3750 kBtu/hr. The equipment selection block is:

```
EQUIPMENT SELECTION:
    GAS TURBINE:
        3 of size 1000 (2 Available),
        1 of size 5000;
END EQUIPMENT SELECTION;
```

Assume that gas turbine generators operate BEST (most efficiently) at 60 percent of full load and that 1000- and 5000-kBtu/hr units will be used. The allocation algorithm first computes the best capacity to apply if units of the appropriate size are available, i.e., 3750/.6 or 6250 kBtu/hr. The total available capacity is 7000, which is +750 from the optimum. The algorithm next subtracts one unit of the *first size* specified from the available capacity (i.e., one 1000 kBtu/hr unit), leaving 6000 available. This available capacity is -250 from the optimum, which is closer to the optimum than the availability of 7000 kBtu/hr. Therefore (providing the demand does not overload the equipment as it does not in this case), 6000 kBtu/hr capacity will be made available to meet the 3750 kBtu/hr load with one 5000 kBtu/hr unit and one 1000 kBtu/hr unit sharing the load in proportion to their individual capacities. The operating load ratio will be 0.625.

If the user had specified a 5000 kBtu/hr unit first and then the two 1000 kBtu/hr units, the default operating rule would allocate 7000 kBtu/hr of capacity at an operating ratio of 0.536 (not only would subtraction of the first specified 5000 kBtu/hr unit result in an overload, but 2000 is clearly further from the optimum of 6250 than is 7000). This illustrates the importance of the order in which unit sizes are specified.

If computed results are to have meaning, actual systems either being designed or which presently exist must be capable of being controlled in the same fashion as simulated.

Waste Heat Utilization

A few other default operating rules pertaining to sequence of equipment types are also part of central plant simulation. The heat energy demands and supplies in the plant are divided into five categories according to the "level" of energy required (see the following table). Level 5 is the highest quantity required.

Energy "Levels" and Corresponding Demand and Supply

Level	Demand
5	Two-stage absorber
4	One-stage absorber
3	Space heating
2	Domestic hot water heating
1	Make up water preheat

Table 15. Energy Levels and Corresponding Demand

Level	Supply (from Waste Heat)
5	Exhaust heat from diesel, gas turbine, and steam turbine
4	Diesel jacket heat and solar heat for cooling (above TMINC)
3	Recovered heat from double bundle and heat pump and solar heat for heating (above TMINH)
2	Lube heat and solar heat for domestic hot water (below TMINH)
1	None

Table 16. Energy Level and Corresponding Supply

The waste heat supplies are used to meet demands at their level or any lower lever. Any heating demands that cannot be met by waste heat become loads on the boiler. If, for example, Level 3 energy is demanded, it can be supplied only by Levels 3, 4, and 5, successively.

If the amount of Level 5 waste heat supply exceeds the amount of the Level 5 demand, and if all other lower level demands are satisfied, heat can be stored for that hour if a hot storage tank is specified. (Only Level 5 heat will be stored in a HOT STORAGE TANK specified under EQUIPMENT SELECTION.)

If the hot storage tank becomes charged to capacity, or is not specified, then cold storage can occur from the surplus Level 5 heat. To allow the cold storage, the user must specify a cold storage tank and an absorption chiller. (Only excess level 5 heat can be used for cold storage.) The hot and cold stored energy are then used to offset the space heating and cooling loads, respectively, in later hours.

In addition to the energy level rules above, BLAST generally allocates the most efficient devices to meet demands. Thus, diesel generators (if specified) are allocated before steam turbines (if steam turbines are selected) which are allocated before gas turbines (if any gas turbines are selected).

Heat pumps are always allocated before double-bundle chillers and double-bundle chillers are always used before simple compression chillers whenever there is a demand for heat (otherwise they are not). Unless waste heat is available, compression chillers are always used before absorbers, if both are selected. If waste heat (from engines) is available, absorbers are allocated first up to a capacity corresponding to the amount of waste heat available or the total absorber capacity available, whichever is smaller. Compression chilling is used to meet the remaining load, if any. Note that if engine generators are used, more waste heat is available as the compression chiller load increases. Thus, chilled water demands are automatically divided between compression and absorption chillers so that as much of the waste heat as possible is used to accomplish "free" cooling. This strategy corresponds to a series piping arrangement where absorbers are used to precool the chilled water before it enters the compression chiller. If no waste heat is available, compression chillers are used up to their installed capacity and then absorbers, if installed, are used with heat produced by a boiler. If the generating capacity of a plant is exceeded, purchased power is used.

Design Plants

If DESIGN PLANTS is specified, BLAST will automatically calculate the central plant component sizes. The sizes are based on the peak system demands for the specified design days. The most useful feature of the design plant calculation is that it will find the actual simultaneous peak of multiple systems and not assume that all the individual peaks occur at the same time.

By entering "DESIGN PLANTS" in the run control block, BLAST will determine the peak loads on the central plant and use these loads to size all equipment except solar collectors and storage. The equipment size is computed from the number of each type specified, the size and plant design multipliers.

Any or all of the allowable central plant components may be sized in this manner. A summary report is produced indicating number and size of each component. Note that the size parameter takes on special significance because it determines the fraction of the peak component load to size the individual components.

Using Design Plants

Specify the central plant equipment for the simulation in HBLC. For more information on setting up a central plant reference the Central Plants.

The first step is to check the “Design Plants” box at the bottom of the Central Plants form. The equipment sizing data cell will now be entered as a fraction of peak load (i.e. 1 = exact capacity). Specify the number of items for each type of equipment. Lastly, click on the “Design Plants” button to enter multipliers for Boiler Capacity, Chiller Capacity, and Electrical Generator multipliers. The multiplier defaults are 1, but could be set higher to allow for a factor of safety.

Design Plants Algorithm

The equations for determining the size of each central plant component are:

Boiler size = (ESFPL for boiler component) * (PDPBCM) * (peak heating load)

Chiller size = (ESFPL for chiller component) * (PDPCCM) * (peak cooling load)

Electrical generator size = (ESFPL for electrical generator component) * (PDPECM) * (peak electrical load)

where ESFPL is the equipment size as a function of peak load for each particular central plant component as specified in the Plants form and PDPBCM, PDPCCM, and PDPEGM are the capacity multipliers specified in the Design Plants form. As mentioned above, the defaults for PDPCCM, PDPEGM, and PDPBCM are 1.

For example, the user would like two boilers each to account for half of the load. The user would then specify 2 for “Number of Items” and 0.5 for “Size”.

Design Plant Notes

Design Plants is useful for determining approximate equipment sizes. However, the user should always remove this option and replace the calculated equipment sizes with the desired values before performing the final simulation. The values calculated by BLAST should always be evaluated by the user and adjusted as needed.

The Ice Storage Plants and the Thermally Stratified Tank Plant cannot be sized using the Design Plants. Please see the appropriate section(s) in the BLAST Technical Reference.

Design Systems

If DESIGN SYSTEMS is specified, BLAST will automatically calculate the air volume flow rate to each zone. The flow rates are based on the peak heating and cooling demands for the specified design days. The DESIGN SYSTEMS option calculates a supply air volume for each zone, based on the peak sensible heating and cooling loads calculated during the building simulation. Please note that the Water Loop Heat Pump System cannot be sized using Design Systems. Please see Water Loop Heat Pump in the BLAST Technical Reference.

Using Design Systems

1. Specify type of fan system in the “Fan Systems” form located under the “Environment” tab on the menu bar. For more information about editing and creating fan systems, see the Fan Systems section of the User Reference.

2. Specify a reasonable CFM for supply air volume.

3. Check the “Design Systems” check box at the bottom of the left hand column on the form.

4. Click on the “Design Systems” button (which should become highlighted after checking it’s box) and fill in the OTHER SYSTEM PARAMETERS of the Fan System:

   COOLING SAT DIFFERENCE (SAT = supply air temperature),

   HEATING SAT DIFFERENCE,

   AIR VOLUME COEFFICIENT.

Design Systems Algorithm

The air volume flow rates (CFM) are calculated simply as the peak load (Q) divided by density (ρ), specific heat (C_p), and temperature difference (ΔT):

The equation for determining the supply air is:

$$CFM = (\text{air volume coeff}) * (\text{peak load})/(1.08 * \Delta T)$$

ΔT is controlled by the variables HEATING SAT DIFFERENCE and COOLING SAT DIFFERENCE.

For winter:

ΔT= HEATING SAT DIFFERENCE = (supply temp - zone temp)

For summer:

ΔT= COOLING SAT DIFFERENCE = (zone temp - supply temp)

The default values for ΔT are 70° and 20°F, respectively.

A cooling volume and a heating volume are calculated, and the maximum volume is used. An AIR VOLUME COEFFICIENT may also be specified. The calculated supply air volumes are all multiplied by the AIR VOLUME

COEFFICIENT. This allows the user to increase or decrease the volumes if desired. The default value for the air volume coefficient is 1.

Other Design System Features

For each design day, BLAST will also calculate the supply air CFM required for the "opposite" day. For example, if the design day was a weekday BLAST would also simulate the same conditions for a weekend and the maximum required supply air CFM would be specified.

The type of condition for which the air handling system was sized is also reported. The system's design volumetric flow rate (CFM) may be calculated under any of the following conditions:

1. No Load
2. Heating Load
3. Cooling Load
4. Cooling Load with Baseboard specified for Heating

BLAST now checks for baseboard heat while calculating the CFM requirements. If baseboard heat is present, it will size the supply air CFM based on the cooling load. Furthermore, if reheat is specified with a VAV system and the minimum air flow is not adequate to supply heat to the zone, a warning message is printed. In BLAST, since VAV systems are typically used for cooling, they are sized for cooling regardless of the heating load.

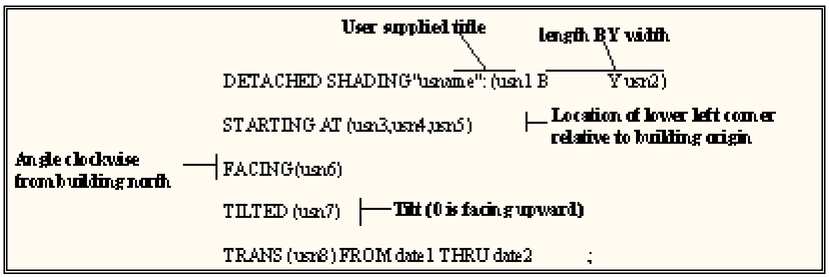
Design System Notes

Design Systems is useful for determining approximate air flow rates. However, the user should always remove this option and replace the calculated supply air volumes with the desired values before performing the final simulation. The values calculated by BLAST should always be evaluated by the user and adjusted as needed.

Detached Shading

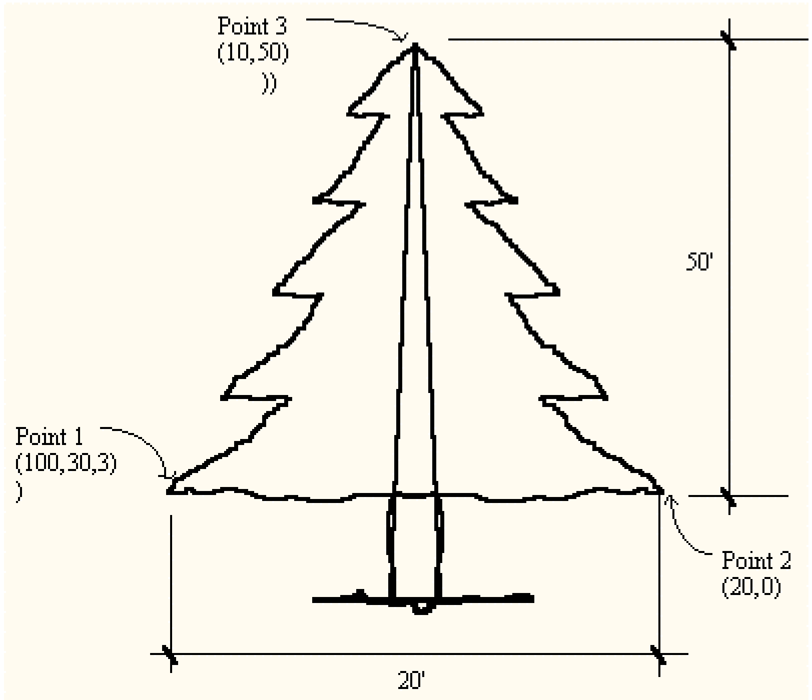
Surfaces of a zone that cast shadows onto other surfaces are handled automatically by BLAST. In addition, users may describe adjacent buildings or other significant shadow casting features not attached to a particular zone and which can shade more than one zone or more than one zone surface. A detached shading device **-** regardless of type **-** casts a shadow only in the hemisphere toward which it faces.

The syntax for describing detached shading is:



The term usn8 is the fractional transmittance (from 0.0 to 1.0) of the shading surface. The default value is 0.0, which is opaque. The transmittance and the optional dates allow the description of seasonal shading features such as trees. Dates should be chosen from the list given with overhangs and wings. Detached shading surfaces are described in much the same way as zone surfaces. However, all detached shading surfaces start at a point relative to the general building origin and have a facing angle relative to the *building's north axis*. (If tilt is not specified, a default tilt angle of 90 degrees is used.)

Since detached shading is not part of the zone description, it must appear outside any zone description, i.e., before or between the zone descriptions. While "detached" implies that shading surfaces are not part of the building, the detached shading sequence can be used to describe attached shading surfaces which may shade more than one zone. For example, one wing of a building might shade several zones of another wing. Detached shading surfaces cast shadows only when the sun is behind them (as determined by their facing angle); therefore, a wall described as a detached shading surface will not shade itself. For this reason, detached objects which cast shadows in an arc of more than 180 degrees when viewed from above should be described as several detached shading surfaces with different facing angles and origins.



Syntax for Describing Detached Shading: "Starting at" coordinates (Point 1) are with respect to the building)

STARTING AT (100,30,3) FACING (90)

((20,0), (10,50)) TRANS (.7) FROM 01JAN THRU 31DEC;

Specifying Detached Shading in HBLC

Detached shading cannot be specified in HBLC. IF detached shading is required, the user can place it into the BLAST input file any text editor.

Detailed Geometry**

See Also:

Technical Reference

**Refer to encyclopedic listing in BLAST Technical Reference for more information

BLAST can accept virtually any three or four sided geometry (must be a convex shape – see non-rectangular shapes) the user wishes to specify. Windows, doors, overhangs, and wings are limited to rectangular shapes.

Both BTEXT and HBLC are more simplified in approach to describing the building's geometry. In both, all surfaces are rectangular. In HBLC, zones must be orthogonal shapes; however, BTEXT has the capability of producing more complex zone shapes.

Detailed Geometry in BTEXT

In BTEXT, it is possible to choose between 5 different levels of zone description. Levels 1 and 2 are the simple levels and are thus limited in complexity. Levels 2 and 3 are the intermediate levels which allow the user to describe a more complex zone. Level 5 is the most detailed level. Level 5 allows the user to describe a zone in great detail, thus allowing for a more complex zone description. A BLAST user with even a small amount of experience should have no problem learning to use level 5. Level 5 is the default and is recommended because of its versatility, however, the first 4 levels will always be available and may be preferred by some users in describing certain zones.

The detail level in BTEXT can be changed at any time by entering the following series of commands:

- Choose **B** (Building and Zone Descriptions) from the Main Menu
- Choose **L** (Detail Level) from the Building and Zone Choices Menu
- Enter the **Level Number** corresponding to the level of detail desired

Detail Level Descriptions

Levels 1 and 2 are restricted to describing rectangular zones. The user is always prompted for a zone height. Next, the user is prompted for four vertical surfaces (walls, partitions, etc.), one at a time, in a 360 degree rotation. STARTING ATS for the surfaces are calculated by BTEXT using previous inputs. Subsurfaces can be attached to a surface but will be positioned on the surface's origin (relative to the building origin). Next, a floor then, a ceiling/roof is requested. It should be noted that the positioning of a window on a wall has no effect on BLAST calculations if -1 is used for solar distribution unless overhangs are also input. Overhangs must retain relative positioning even when solar distribution is -1. The only difference in level 1 and level 2 is that surface length is used for input of each vertical surface in level 1 while surface area is used for input in level 2. In each case, the area of the floor and the area of the ceiling/roof are calculated by BTEXT.

Levels 3 and 4 allow a more complex zone layout. SAME AS may be used in describing zones as well as zone mirroring. The user is prompted for a zone height before describing surfaces. STARTING ATs are again calculated by previous inputs but may be overridden. BTEXT does not automatically request any surface. It is up to the user to supply all surfaces. The difference in levels 3 and 4 is identical to the difference in levels 1 and 2. In level 3, length is an input for describing vertical surfaces whereas in level 4 area is used. As in levels 1 and 2, subsurfaces are attached to surfaces at the surface origin; therefore, -1 should be used for solar distribution.

Level 5 allows the most detail in describing zones and requires more information from the user. Again, SAME AS and zone mirroring are allowed, and the user describes surfaces in any order. STARTING ATS are supplied by the user along with surface dimensions (there is no one set zone height). Tilted surfaces are allowed and subsurfaces will be positioned on surfaces exactly where the user wants (i.e., the user positions subsurfaces-only in level 5).

Detailed Geometry in HBLC

HBLC has taken a pretty simple approach to describing a building. Zones are limited to orthogonal shapes (walls must be at 90° angles to each other). Windows, doors, and overhangs can be entered and are rectangular shapes. Wings cannot be entered in HBLC. Walls can be tilted at virtually any angle and the subsurfaces follow those tilts.

You can accept the equivalent area formula that HBLC uses for determining roofs and floors (recalculated on each save of the .BS file) or you can choose to enter more complex floors and roofs/ceilings. Thermally, it is more important to have the correct area than the actual placing of the floor/roof/ceiling coordinates.

Diesel Chiller

EQUIPMENT DESCRIPTION:

The diesel-driven chiller is an open centrifugal chiller driven directly by a diesel engine. The BLAST model of an open centrifugal chiller is modeled as standard vapor compression refrigeration cycle with a centrifugal compressor driven by shaft power from an engine. The centrifugal compressor has the incoming fluid entering at the eye of a spinning impeller that throws the fluid by centrifugal force to the periphery of the impeller. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The heat from the condenser is rejected to a cooling tower, evaporative condenser, or well water condenser depending on the user selected physical parameters of the plant. The refrigerant pressure is then dropped passing through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

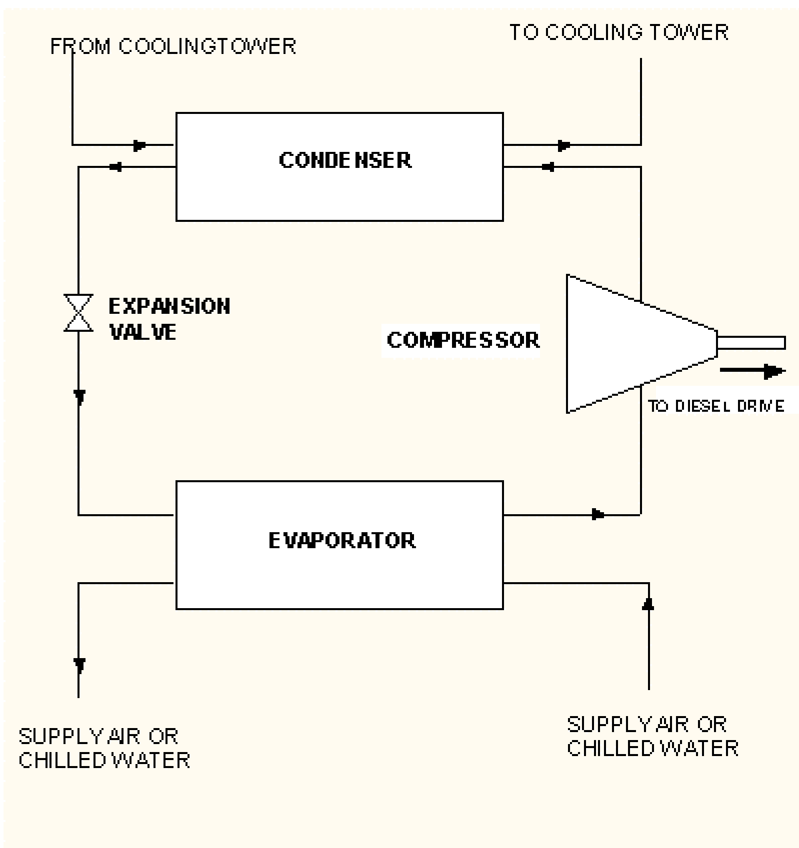


Figure 46. Diagram of a BLAST diesel chiller

USING THE BLAST DIESEL-DRIVEN CHILLER:

Specifying a Diesel-Driven Chiller in HBLC

To specify a diesel-driven chiller as one of the operating components in the central energy plant, the user must follow the steps outlined in the Central Plants section of the User Reference.

Create a new plant if necessary, otherwise modify an existing one. Once the plant has been created, click on “Add” equipment and select “Chillers” from the drop down menu. Choose “Diesel” from the list of available chillers.

Fill in the Number of Diesel Chillers and their size in the data cells. Click on “Edit” equipment to adjust the performance parameters of the chiller.

Adjusting the Performance Parameters of the Diesel-Driven Chiller

Once the diesel-driven chiller has been added, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a diesel-driven chiller that has the following operating parameters:

Evaporator temperature	= 40 to 48 °F
Condenser temperature	= 70 to 100 °F
Capacity	= 920 to 1000 Tons

If your diesel-driven chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for a diesel-driven chiller are:

Cooling tower

Direct cooling Tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJTDC- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAVDC- Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJEDC- Used to adjust the full load power consumption of the chiller.

RPWRDC- Used to determine the fraction of full load power.

RELDC- Used to compute the ratio of fuel energy input to shaft energy output.

UACDC- Used to define heat recovery for the diesel engine.

RJACDC- Used to calculate the recoverable jacket heat to fuel energy ratio for the diesel engine.

RLUBDC- Used to determine the ratio of recoverable lube oil heat to fuel energy input for the diesel engine.

TEXDC- Used to calculate the exhaust gas temperature to fuel energy ratio for the diesel engine

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

RWCDC- Ratio of condenser flow rate to diesel driven chiller capacity. Units: Dimensionless

RMXKWDC- Maximum exhaust flow per unit capacity for diesel-driven chillers. The parameter sets an upper limit on exhaust gas flow, and therefore exhaust gas heat recovery for diesel turbines. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW capacity

REXDC- Parameters set to determine the ratio of total exhaust heat to fuel energy input for the diesel engine.

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the diesel driven chiller syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the diesel driven chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

DIESEL DRIVEN CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "SAMPLE PLANT" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
DIESEL DRIVEN CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
DIESEL DRIVEN CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.25);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTDC(95,2.5,44);
RCAVDC(1.018,-0.0307,-0.0001442);
ADJEDC(2.3201,-1.46175,1.154);
RPWRDC(0.239,-0.04045,0.18148);
RELDC(0.09755.0.6318,0);
RJACDC(9.41,-9.48,4.32);
RLUBDC(0.883,-0.1371,0.09726);
TEXDC(1179.4,60,0);
REXDC(0.3114,-0.1353,0.09726);
UACDC(0.009523,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44;
RWCDC=124.822;
RMXKWDC=1.467;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

DIESEL DRIVEN CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DIESEL DRIVEN CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
DIESEL DRIVEN CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 24;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
DIESEL DRIVEN CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.25);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTDC(35,2.5,6.67);
```

```
RCAVDC(1.018,-0.05535,-0.000467030);
ADJEDC(2.3201,-1.46175,1.154);
RPWRDC(0.239,-0.04045,0.18148);
RELDC(0.09775,0.06318,0);
RJACDC(0.3993,-0.04372,0.2776);
RLUBDC(0.833,-0.833,-0.153,0.0803);
TEXDC(655.22,33.333,0);
REXDC(0.3144,-0.1353,0.09726);
UACDC(0.015161,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.667;
RWCDC=0.0537;
TMXKWDC=0.00063;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Diesel Generator

EQUIPMENT DESCRIPTION:

The basic cycle for a diesel generator is the Diesel cycle, which is a slight modification of the standard Otto cycle.

USING THE BLAST DIESEL GENERATOR:

Specifying a Diesel Generator in HBLC

To specify a diesel generator as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Diesel” from the “Generators” sub-menu. Fill in the number of generators and their individual capacity.

Adjusting the Performance Parameters of the Diesel Generator

Once the diesel generator has been added in HBLC, the user must specify operating rules and parameters for the component by selecting the generator and clicking the “Edit” equipment button. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a diesel generator that has the following operating parameters:

Exhaust flow per capacity = 0.00063 kg/sec per kW capacity

If your diesel generator does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

RELD- Used to calculate the electric energy output divided by the fuel energy consumption as a function of part-load ratio.

RJACD- Used to calculate the recoverable jacket heat as a function of part-load ratio.

RLUBD- Used to calculate the recoverable lube oil heat as a function of part-load ratio.

REXD- Used to calculate the total exhaust heat as a function of part-load ratio.

TEXD- Used to determine the exhaust gas temperature as a function of part-load ratio.

UACD- Used to determine amount of heat recovery using the UA product.

RMXKWD- Maximum exhaust flow per unit capacity for diesel engines. The parameter sets an upper limit on exhaust gas flow and exhaust gas heat recovery for diesel engines. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW capacity

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the diesel generator syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the diesel generator. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

DIESEL GENERATOR BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DIESEL GENERATOR" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
DIESEL GENERATOR:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100 CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
DIESEL GENERATOR(MIN=0.02,MAX=1.05,BEST=0.6,ELECTRICAL=0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
RELD=(0.09755,0.6318,-0.4165);
RJACD=(0.3922,-0.4367,0.27796);
RLUBD=(0.0803,-0.1371,0.0803);
REXD=(0.3144,-0.1353,0.09726);
TEXD=(1179.4,59.999,0);
UACD=(0.009523,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
RMXKWG=1.41644;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

DIESEL GENERATOR BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DIESEL GENERATOR " SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
DIESEL GENERATOR:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26,CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
DIESEL GENERATOR(MIN=0.02,MAX=1.05,BEST=0.6,ELECTRICAL=0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
RELD=(0.09755,0.6318,-0.4165);
RJACD=(0.3922,-0.4367,0.27796);
RLUBD=(0.0803,-0.1371,0.0803);
REXD=(0.3144,-0.1353,0.09726);
TEXD=(655.55,33.333,0);
UACD=(0.01516,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
RMXKWG=0.00063;
.   .   .
END SPECIAL PARAMETERS;
```

```
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER SYSTEM PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Direct Cooling Tower

EQUIPMENT DESCRIPTION:

The BLAST direct cooling tower cools water by contacting it with air and evaporating some of the water. In most cooling towers serving refrigeration chillers, one or more propeller or centrifugal fans move air vertically up or horizontally through the tower. A large surface area of water is provided by spraying the water through nozzles or splashing the water down the tower from one baffle to another.

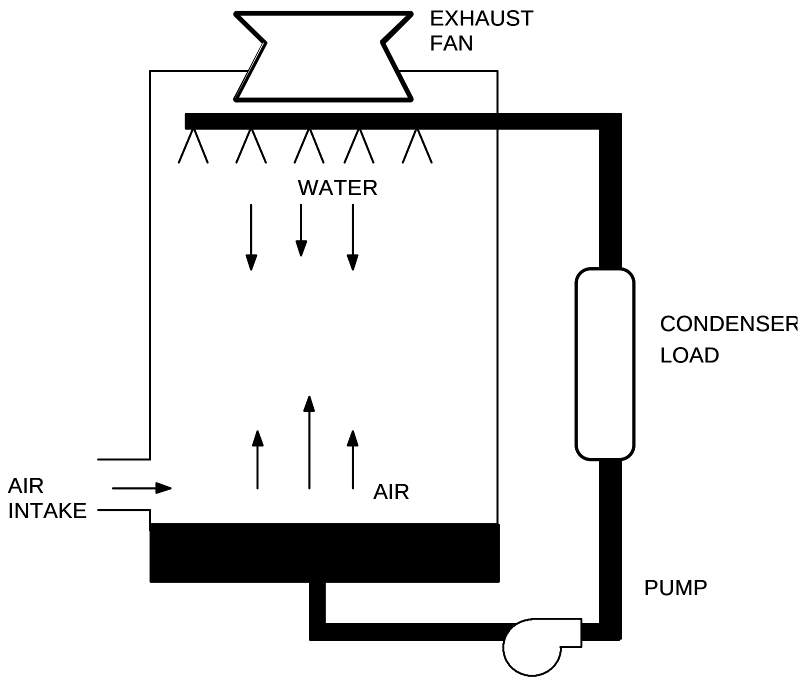


Figure 47. Diagram of a DirectCooling Tower

USING THE BLAST COOLING TOWER:

Specifying a Direct Cooling Tower in HBLC

To specify a cooling tower as one of the operating components in the central energy plant, the user must first select any chiller using the methods outlined in Central Plants. When it is appropriate to choose a Direct Cooling Tower, the choice will be available in a pull down menu in the chiller parameters form.

Cooling Tower parameters can be edited from the chiller parameter form, or once the Cooling Tower has been added to the plant it may be edited as with any piece of plant equipment.

Adjusting the Performance Parameters of the Direct Cooling Tower

Once the chiller has been added using HBLC, the user must specify operating rules and parameters for the cooling tower. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a cooling tower that has the following operating parameters:

Flow Rate	= FIXED
Minimum tower temperature	= 60 °F

The default parameters have been devised so that the default cooling tower operates independently of the capacity.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

DTPUMP- Used to determine the power of the cooling tower pump.

PELDTWR- If cooling towers are specified in the input, PELTWR is the ratio of pump electrical energy required to cooling tower load. If cooling towers are not specified in the input, PELTWR is the ratio of tower pump electrical energy required to cooling tower load. If no tower is specified, the total electrical demand for towers and pumps is (PELTWR + ELECTRICAL)*(Tower Load) where ELECTRICAL is the power consumption per unit load for towers from PART LOAD RATIOS.

TOWOPR- Tower operation type. 1-variable water flow rate or 2-fixed water flow rate.

TCOOL- Temperature of water leaving the Tower. Units: °F or °C

TDCTWR- Minimum allowable temperature for water leaving the cooling tower. Also, the initial temperature of water leaving the cooling tower. Units: °F or °C

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the cooling tower syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the cooling tower. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

DIRECT COOLING TOWER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "COOLING TOWER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH COOLING TOWER:
1 OF SIZE 100;
DIRECT COOLING TOWER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
DIRECT COOLING
TOWER(MIN=0.0,MAX=1.00,BEST=.4365,ELECTRICAL=0.0125);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
DTPUMP(0,1,0);
ADJT1C(1,0,0);
RCAV1C(1.006,-0.019,0.002);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PELDTWR=0.013;
TOWOPR=2;
TDCTWR=60.08;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

DIRECT COOLING TOWER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "COOLING TOWER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH COOLING TOWER:
1 OF SIZE 26;
DIRECT COOLING TOWER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
DIRECT COOLING
TOWER(MIN=0.0,MAX=1.00,BEST=.4365,ELECTRICAL=0.0125);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
DTPUMP(0,1,0);
ADJT1C(1,0,0);
```

```
RCAV1C(1.006,-0.0342,0.007);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
PELDTWR=0.013;
TOWOPR=2;
TDCTWR=15.6;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Domestic Hot Water Heater

EQUIPMENT DESCRIPTION:

The domestic hot water heater is simulated similar to the simple boiler simulation with an added loss factor. The loss factor is the amount of energy that is lost to the surroundings for a given hour. The losses of the domestic hot water heater can be accounted for by an equivalent efficiency or by a loss factor. In most applications, an equivalent efficiency will accurately model the domestic hot water energy consumption. It should be noted that the energy consumption is reported when a hot water demand exists and not when the hot water is actually produced. However, the amount of loss for a given hour will be accounted for in the hour that the loss occurs. In the past domestic hot water demands were met by whatever equipment type was available for a given hour. The code has been changed such that the domestic hot water demand can only be met by what is specified as the energy source in the Schedule Data Block under hot water consumption. The fuel consumption for the fuel domestic hot water heater is reported in the BUILDING / FAN / PLANT ENERGY UTILIZATION SUMMARY report under boiler fuel column for the amount of fuel used and under the appropriate electric consumption column for the parasitic electric consumption. In addition, the consumption is reported in the PLANT EQUIPMENT ENERGY INPUT BREAKDOWN report under Fuel Boiler and Fuel Boiler Electric for the fuel and electricity consumed, respectively. The electricity consumption for the electric domestic hot water heater is reported in the BUILDING / FAN / PLANT ENERGY UTILIZATION SUMMARY report under the appropriate electric consumption column.

USING BLAST DOMESTIC HOT WATER:

Specifying Domestic Hot Water in HBLC

To specify a Domestic Hot Water heater as one of the operating components in the central energy plant, the user must select it using the methods outlined in Central Plants. Two types of Domestic Hot Water are available, electric and fuel. Both Fuel and Electric Domestic Hot Water heaters are located on the “Other” menu under the “Add Equipment” drop down menu.

Adjusting the Performance Parameters of Fuel Domestic Hot Water

Once the Fuel Domestic Hot Water has been added using HBLC, the user must specify operating rules and parameters for the heater. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a fuel water heater that has the following operating parameters:

Constant Efficiency = .75

Loss Factor = 0

The user must specify supply temperature and peak demand based upon the current simulation. Default values are 125 °F and 0 kBtu/hr. The default fuel type is natural gas. Other fuel types available from the drop down menu are distillate oil, residual oil, or coal.

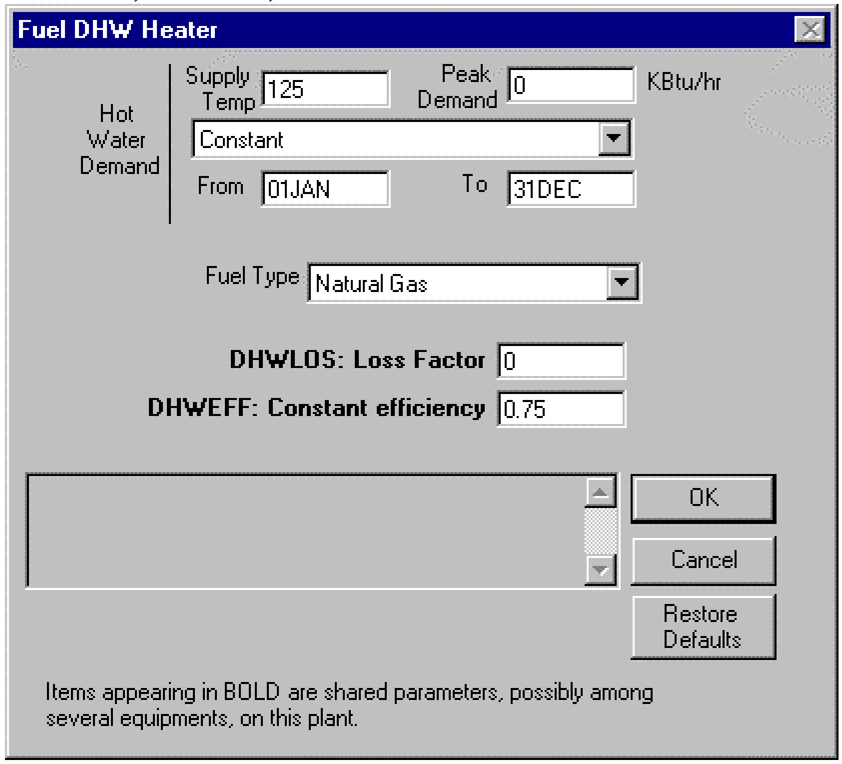


Figure 48. Fuel Domestic Hot Water Heater form

Adjusting the Performance Parameters of Electric Domestic Hot Water

Once the Electric Domestic Hot Water has been added using HBLC, the user must specify operating rules and parameters for the heater. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for an electric water heater that has the following operating parameters:

Constant Efficiency = .75

Loss Factor = 0

The user must specify supply temperature and peak demand based upon the current simulation. Default values are 125 °F and 0 kBtu/hr

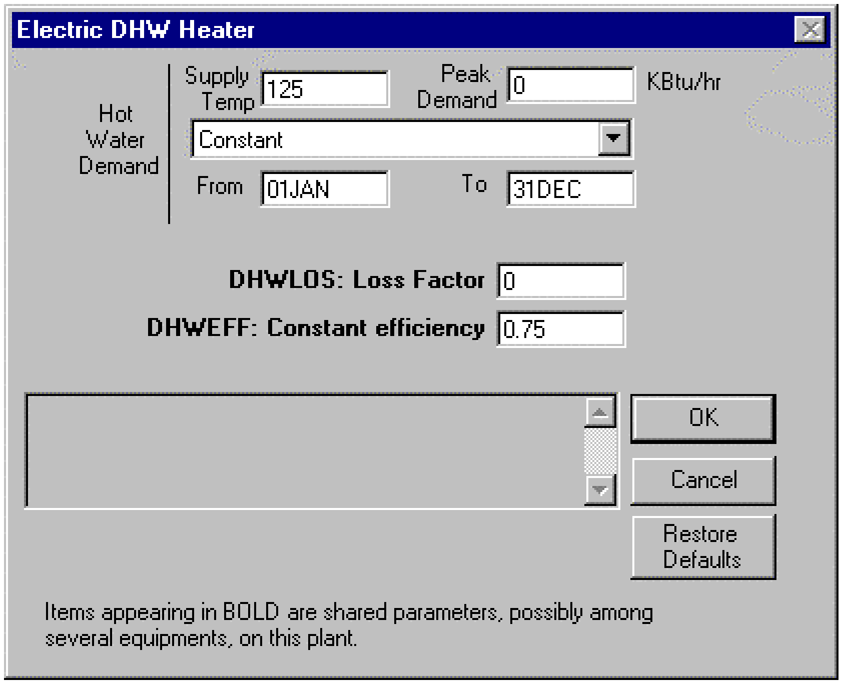


Figure 49. Electric Domestic Hot Water Heater form

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

DHWLOS- Used to specify a loss factor that will account for any heat lost to surroundings.

DHWEFF- Used to adjust the efficiency of the domestic hot water heater. EFUEL = EDHW/DHWEFF + OCAP*DHWLOS/DHWEFF where EFUEL is the energy consumed in a given hour. This energy consumed may be electrical or fuel. EDHW is the demanded hot water for a given hour and OCAP is the capacity of the domestic hot water heater.

Syntax Descriptions: (BLAST Input File Syntax given for Fuel Heater with Electric Heater syntax given in italics)

EQUIPMENT SELECTION- Type and capacity of plant selected.

HOT WATER- Specifies Hot Water Demand (in kBTU/hr)

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the domestic hot water syntax is shown in the context of a complete central plant description with English and Metric default values.

The central plant syntax shown in these figures is sufficient to completely model the domestic hot water equipments. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

DOMESTIC HOT WATER HEATER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DOMESTIC HOT WATER HEATER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
FUEL DOMESTIC HOT WATER HEATER:
1 OF SIZE 100;
ELECTRIC DOMESTIC HOT WATER HEATER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
HOT WATER=100, CONSTANT, FROM 01JAN THRU 31 DEC AT 125.0 SUPPLIED
BY FUEL DOMESTIC HOT WATER HEATER;
HOT WATER=100, CONSTANT, FROM 01JAN THRU 31 DEC AT 125.0 SUPPLIED
BY ELECTRIC DOMESTIC HOT WATER HEATER;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
DHWLOS=0.0;  ** Used in both Fuel and Electric
DHWEFF=0.75; ** Used in both Fuel and Electric
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

DOMESTIC HOT WATER HEATER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DOMESTIC HOT WATER HEATER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
FUEL DOMESTIC HOT WATER HEATER:
1 OF SIZE 26;
ELECTRIC DOMESTIC HOT WATER HEATER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
HOT WATER=100, CONSTANT, FROM 01JAN THRU 31 DEC AT 52 SUPPLIED BY
FUEL DOMESTIC HOT WATER HEATER;
HOT WATER=100, CONSTANT, FROM 01JAN THRU 31 DEC AT 52 SUPPLIED BY
ELECTRIC DOMESTIC HOT WATER HEATER;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
DHWLOS=0.0;  ** Used in both Fuel and Electric
DHWEFF=0.75; ** Used in both Fuel and Electric
.   .   .
.   .   .
END SPECIAL PARAMETERS;
```

```
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Double Bundle Chiller**

**Refer to encyclopedic listing in BLAST Technical Reference for more information.

EQUIPMENT DESCRIPTION:

The BLAST model of a double bundle chiller is simulated as a standard vapor compression refrigeration cycle with a double bundled condenser and a hermetic centrifugal compressor. The hermetic centrifugal compressor is a sealed unit that contains the motor and the compressor. The closed housing is immune to leakage that often occurs in open type compressors. A double bundle condenser involves two separate flow paths through the condenser. One of these paths is to a standard cooling tower, evaporative condenser, or well water condenser depending on which one is selected by the user based on the physical parameters of the plant. The other path is to heating coils located in perimeter zones. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

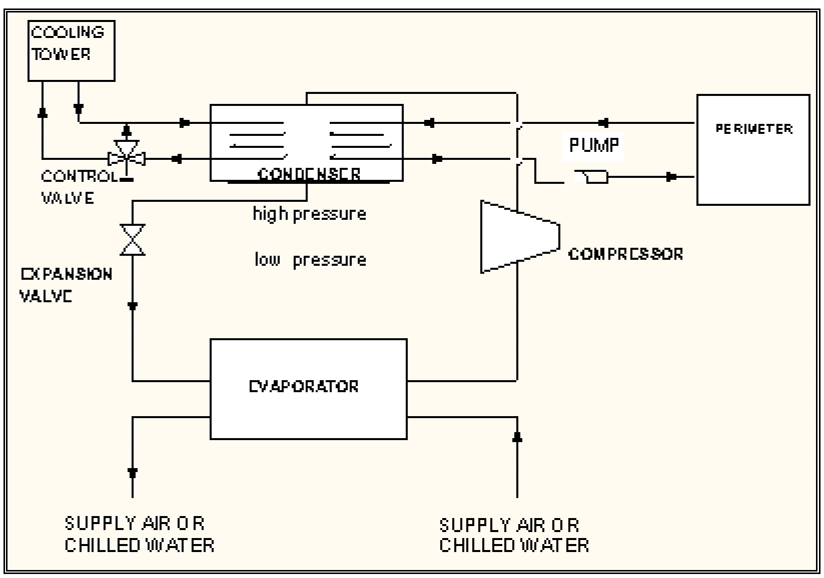


Figure 50. Diagram of Double Bundle Chiller

USING THE BLAST DOUBLE BUNDLE CHILLER:

Specifying a Double Bundle Chiller in HBLC

To specify a double bundle chiller as one of the operating components in the central energy plant, the user must first select the component using the methods outlined in Central Plants.

Select “Double Bundled” from the “Chiller” sub menu after creating the plant and clicking on “Add” equipment. Fill in the number of chillers and their unit capacity.

Adjusting the Performance Parameters of the Double Bundle Chiller

Once the double bundle chiller has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a double bundle chiller that has the following operating parameters:

Evaporator temperature = 40 to 48 °F

Condenser temperature = 70 to 100 °F

Capacity = 920 to 1000 Tons

If your double bundle chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for a double bundle chiller are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJTDB- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAVDB- Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJEDB- Used to adjust the full load power consumption of the chiller.

RPWRDB- Used to determine the fraction of full load power.

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

RWCDB- Ratio of condenser flow rate to double bundle chiller capacity. Units: Dimensionless

TCW- Temperature of the water leaving the condenser. Units: °F or °C

RAVRHDB- Fraction of Double Bundle Chiller heat that is recoverable. Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the double bundle chiller syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the double bundle chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

DOUBLE BUNDLE CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DOUBLE BUNDLE CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION;
DOUBLE BUNDLE CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
DOUBLE BUNDLE CHILLER
(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTDB(95,2.5,44);
RCAVDB(1.01846,-0.03075,0.0001442);
ADJEDB(2.3201,-1.1467,0.181487);
RPWRDB(0.16017,0.31644,0.51894);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
RWCDB=124.8834;
TCW=110.0;
RAVRHDB=0.95;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

DOUBLE BUNDLE CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "DOUBLE BUNDLE CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
DOUBLE BUNDLE CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 23.6;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=23.6, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
DOUBLE BUNDLE
CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTDB(35,2.5,6.667);
RCAVDB(1.01846,-0.05535,0.0004673);
ADJEDB(2.3201,-1.1467,0.181487);
RPWRDB(0.16017,0.31644,0.51894);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.667;
RWCDB=0.0537;
TCW=43.44;
RAVRHDB=0.95;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Dual Duct System

EQUIPMENT DESCRIPTION:

Dual duct systems condition all the air in a central apparatus and distribute it to the conditioned zones through two parallel ducts. One duct carries cold air and the other warm air, providing air sources for both heating and cooling at all times. In each conditioned zone, a mixing valve responsive to a room thermostat mixes the warm and cold air in proper proportions to satisfy the prevailing heating or cooling load of the space. In BLAST, a dual duct system is identical to a multizone system.

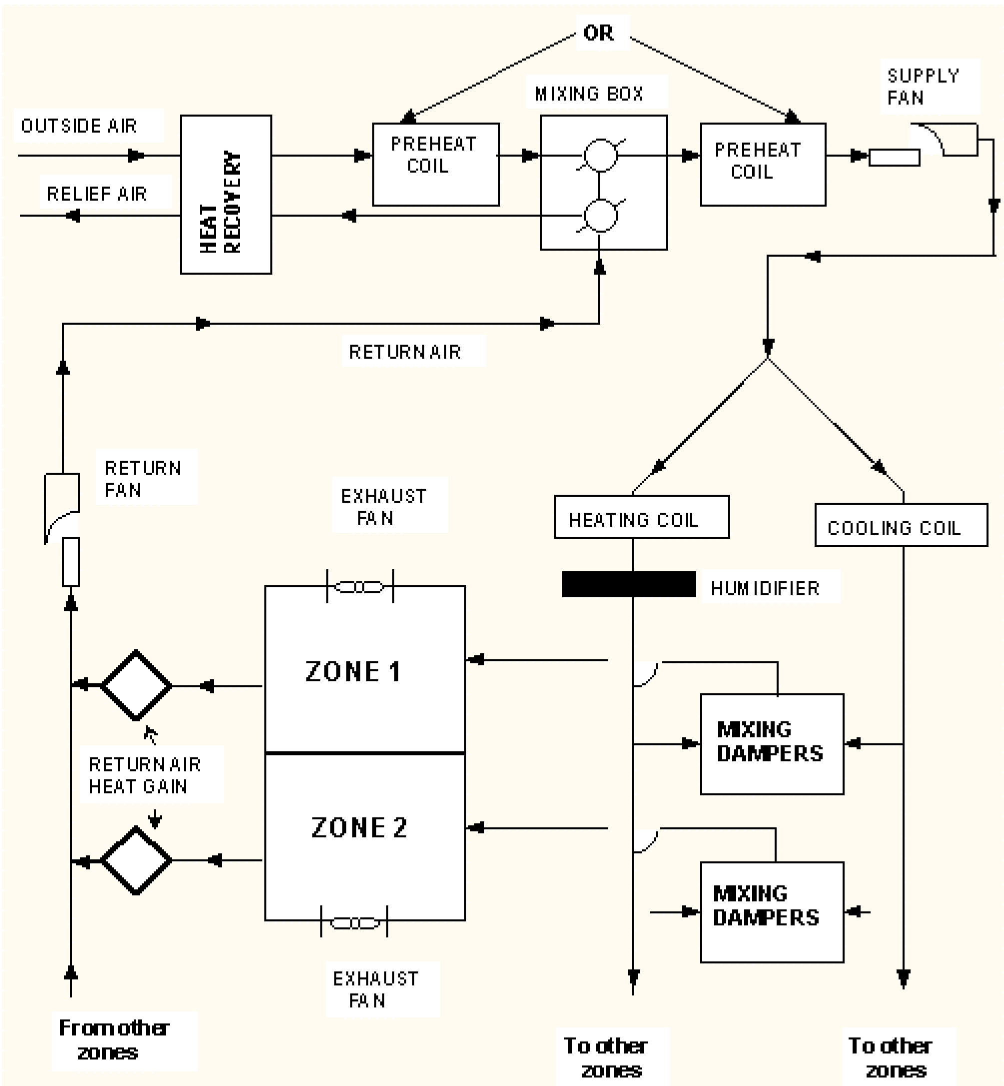


Figure 51. Dual Duct System Schematici

USING THE BLAST DUAL DUCT SYSTEM:

Specifying a Dual Duct System in HBLC

To specify a multizone system as one of the fan systems in the building simulation, the user must first select the component using the methods outlined in Fan Systems. Select “Multizone” from the list of systems provided in the pop up menu after clicking the “Add System” button in the “Systems” form.

Once a multizone system has been created, the user should input simulation specific data for zone numbers served and their corresponding supply air volume.

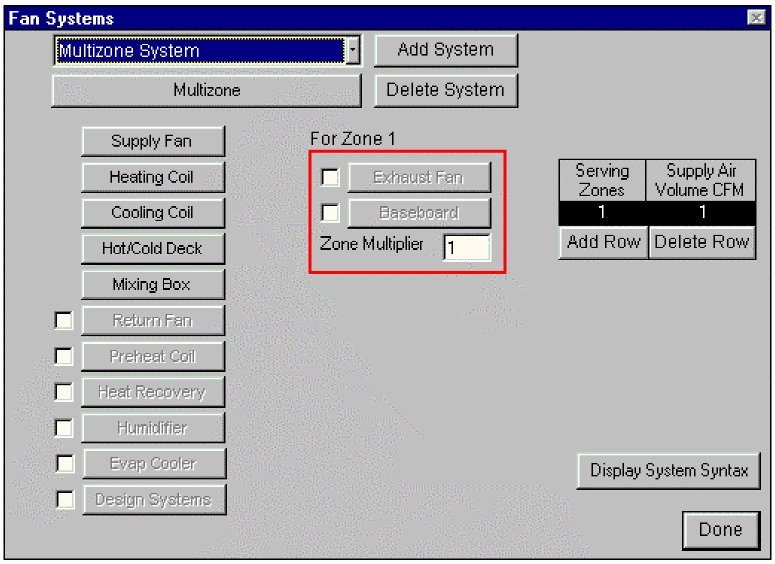


Figure 52. Multizone Fan System form

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the dual duct system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;
MULTIZONE SYSTEM 1
"MULTIZONE " SERVING ZONES 1;

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100;
        .   .   .   .       ZONE DATA BLOCK
        .   .   .   .        (Required user input)
    ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783;
        .   .   .   .       OTHER SYSTEM DATA BLOCK
        .   .   .   .       (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
        .   .   .   .       COOLING COIL DATA BLOCK
        .   .   .   .       (Optional expert user input)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
            .   .   .   .       (Optional user input)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
    COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)
END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
    COPH2=(22,-3.9,0.022);
                            HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)
        .   .   .   .
END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION
        =ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the multizone system syntax is shown in the context of a complete fan system description with English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The fan system syntax shown in these figures is sufficient to completely model the multizone system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the multizone system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the multizone system listed in bold and all options as well as Metric (SI) units are italicized.

DUAL DUCT ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    INDUCED AIR FRACTION=2.0 (2);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

DUAL DUCT OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                    =OUTSIDE AIR CONTROLLED;
                    =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT 
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                        =GAS;
                        =ELECTRIC;
                        =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                        =OUTSIDE AIR CONTROLLED
                        =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT 
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT 
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                    =FIXED AMOUNT;
                    =TEMPERATURE ECONOMY CYCLE;
                    =RETURN AIR ECONOMY CYCLE;
                    =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
            =OUTSIDE AIR DUCT;
            =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK THROTTLING RANGE- Used to set the hot deck temperature based on the previous hours heating load. The deck temperature is adjusted somewhere between the hot deck set point and the set point plus the throttling range. Units: °F or °C

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

DUAL DUCT COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE- CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

B**AROMETRIC PRESSURE-** Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

DUAL DUCT HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

DUAL DUCT EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Dual Duct Variable Volume System

EQUIPMENT DESCRIPTION:

Dual duct variable air volume systems are used to obtain zone temperature control by mixing the cold and warm air in various volume combinations. Each fan is sized for the anticipated maximum coincident hot or cold volume, not the sum of the instantaneous peaks. This system has an advantage of a true single path VAV system, except for warm port leakage. When cold air is modulated for control before mixing, it operates similar to the VAV induction when mixing occurs without hot deck reheat. It is similar to a reheat system when mixing occurs while the hot deck is using the reheat coil. It uses more energy than a true VAV system, but less than a constant volume dual duct system.

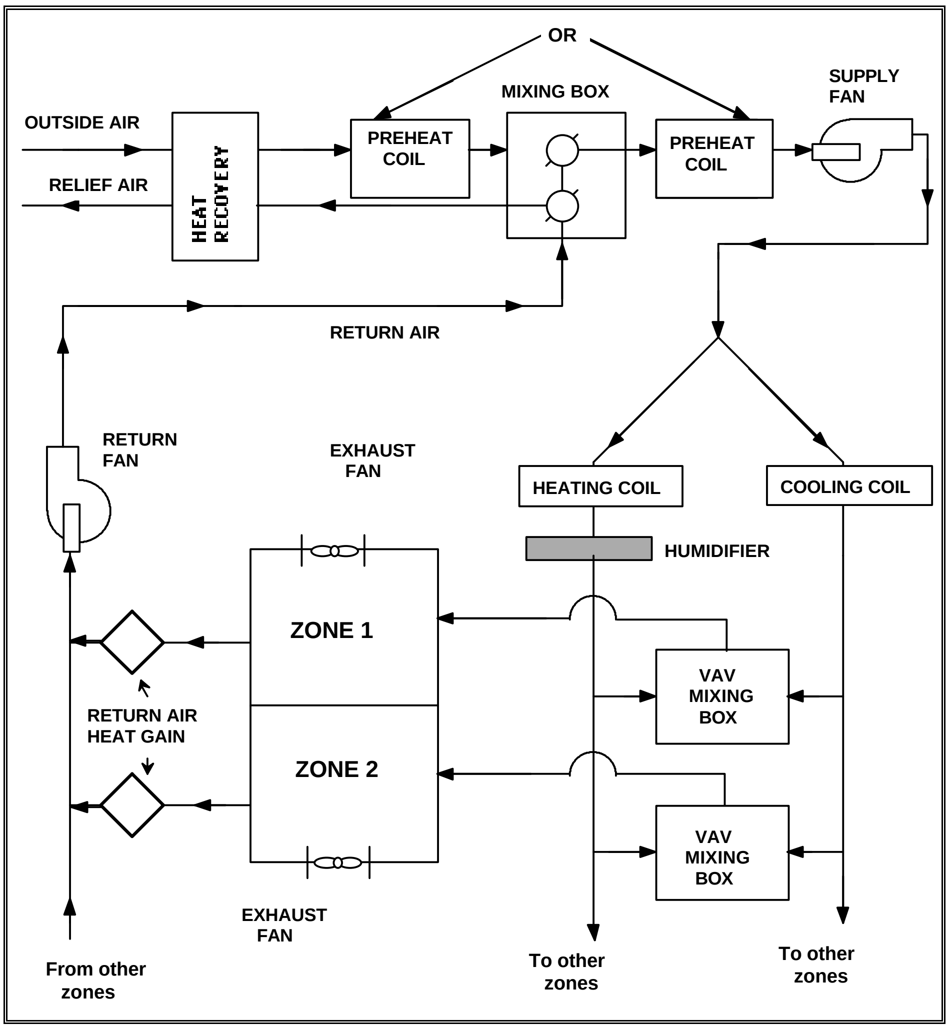


Figure 53. Diagram of a BLAST Dual Duct Variable Volume system

USING THE BLAST DUAL DUCT VAV SYSTEM:

Specifying a Dual Duct VAV System in HBLC

To specify a dual duct VAV system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select Dual Duct Variable Volume from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

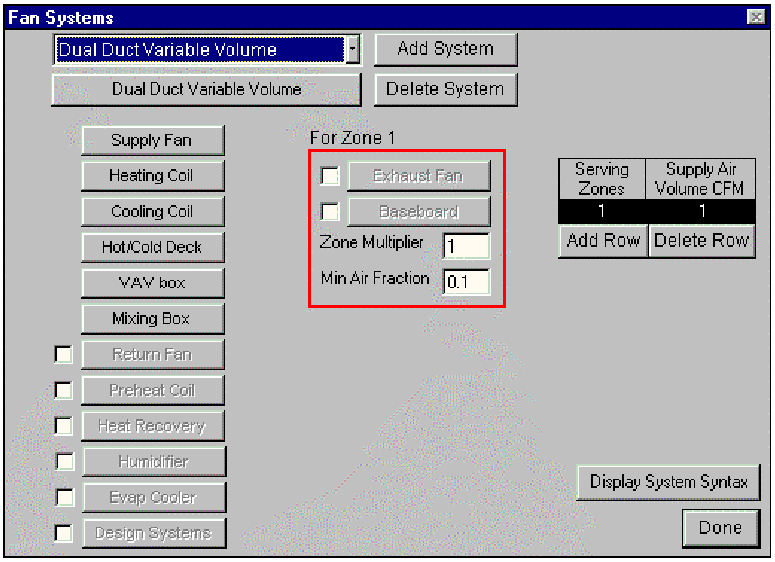


Figure 54. Dual Duct Variable Volume Fan System form

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the dual duct VAV system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

DUAL DUCT VAV SYSTEM 1

"DUAL DUCT VAV " SERVING ZONES 1;

```
FOR ZONE 1:
       SUPPLY AIR VOLUME=100;
       .   .   .   .       ZONE DATA BLOCK
       .   .   .   .        (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
   SUPPLY FAN PRESSURE=2.49783;
       .   .   .   .       OTHER SYSTEM DATA BLOCK
       .   .   .   .       (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
       .   .   .   .       COOLING COIL DATA BLOCK
       .   .   .   .       (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
       .   .   .   .       HEAT RECOVERY DATA BLOCK
           .   .   .   .       (Optional user input)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
   COPC=(11,34.09,-0.087);
       .   .   .   .       HEAT PUMP DATA BLOCK
       .   .   .   .       (Not applicable to this system)
       .   .   .   .
END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
   COPH2=(22,-3.9,0.022);
                           HEAT PUMP DATA BLOCK
           .   .   .   .       (Not applicable to this system)
           .   .   .   .
END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
       .   .   .   .       DX UNIT DATA BLOCK
       .   .   .   .       (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
       .   .   .   .       SCHEDULES DATA BLOCK
       .   .   .   .       (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
       =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

In the following topics, the dual duct VAV system syntax is shown in the context of a complete fan system description with English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The fan system syntax shown in these figures is sufficient to completely model the dual duct VAV system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the dual duct VAV system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the dual duct VAV system are listed in bold and all options as well as Metric (SI) units are italicized.

DUAL DUCT VAV ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
               =STEAM;
               =ELECTRIC;
               =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
               =STEAM;
               =ELECTRIC;
               =GAS;
    RECOOL CAPACITY=0.0 (0);
    INDUCED AIR FRACTION=2.0 (2);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

MINIMUM AIR FRACTION- Used to specify is the minimum fraction of the zone's design supply air volume which will be delivered to the space any time a VAV fan system is running.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

DUAL DUCT VAV OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED;
               =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED
               =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
               =FIXED AMOUNT;
               =TEMPERATURE ECONOMY CYCLE;
               =RETURN AIR ECONOMY CYCLE;
               =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
               =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
               =OUTSIDE AIR DUCT;
               =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
               =VARIABLE FAN SPEED;
               =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
               =STEAM
               =HOT WATER;
               =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONECONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK THROTTLING RANGE- Used to set the hot deck temperature based on the previous hours heating load. The deck temperature is adjusted somewhere between the hot deck set point and the set point plus the throttling range. Units: °F or °C

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

VAV MINIMUM AIR FRACTION- Used to specify the percentage of the supply air that passes through the VAV box when the damper is closed. This option is only employed if no minimum fraction is specified in the ZONE data block. The minimum fraction specified in the ZONE data block has precedence over the minimum fraction specified in the OTHER SYSTEM PARAMETERS data block.

VAV VOLUME CONTROL TYPE- Used to specify the type of fan used in a VAV system. All options will yield default fan power coefficients and can either be specified here or by using FAN POWER COEFFICIENTS. Both options can not be employed simultaneously. The options are INLET VANES, VARIABLE FAN SPEED, and DISCHARGE DAMPERS.

FAN POWER COEFFICIENTS- Used to specify the fan power for fixed volume systems and full-load fan power for VAV systems from default or user-specified fan pressure and efficiencies.

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

DUAL DUCT VAV COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

DUAL DUCT VAV HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

DUAL DUCT VAV EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

VAV MINIMUM AIR FRACTION SCHEDULE- Used to simulate a variable air volume system where the minimum air fraction is scheduled hourly. During the day, a larger minimum air fraction might be used to account for increased zone loads. A smaller minimum air fraction might be used during unoccupied hours to realize the energy savings.

DX Packaged Unit

EQUIPMENT DESCRIPTION:

Direct Expansion (DX) Package unit systems consist of factory matched refrigerant cycle components in air conditioning systems. A heating function compatible with the cooling system is usually incorporated into the system. The control system for the unit is usually packaged by the manufacturer and will reduce field wiring. Most units are sold according to actual capacities and generally range from 0.5 to 150 tons. In BLAST, the simulation for the DX Package is done in the fan system section and shows up as an electrical consumption in the Air Handling System Energy Use Summary.

Note that in the DX packaged unit, supply air temperature is allowed to fluctuate so that all system loads are met. Thus, BLAST will not limit unreasonable performance in this model, and will never show undercooling or underheating for a DX packaged unit. Undersizing is not possible.

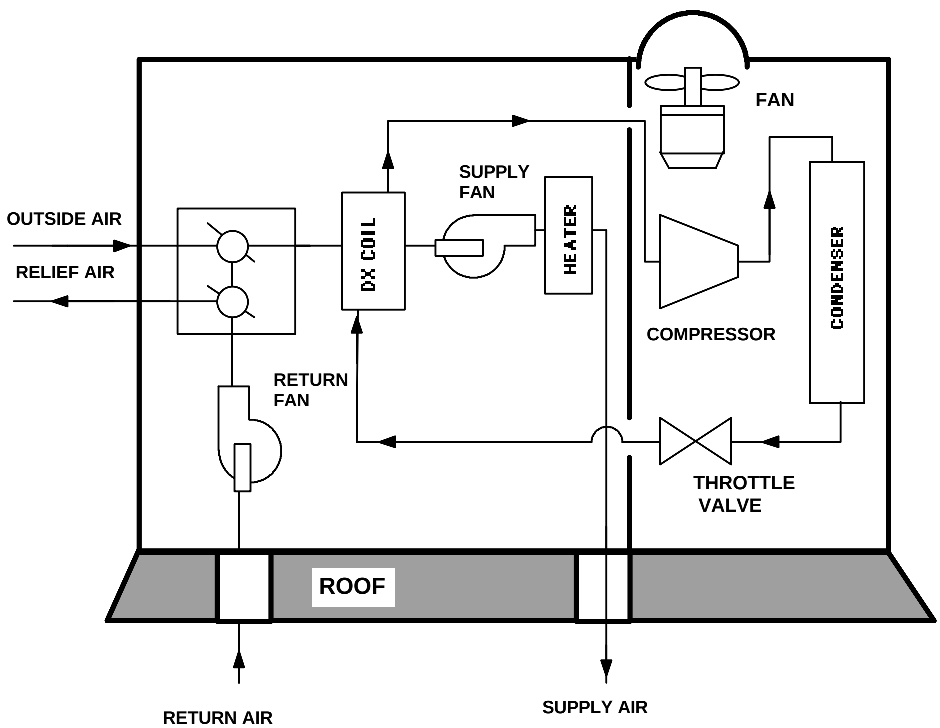


Figure 55. Diagram of a BLAST DX packaged unit

USING THE DX PACKAGE UNIT:

Specifying a DX Package Unit in HBLC:

To specify a DX Package unit as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select "DX Packaged Unit" from the pop up menu. After naming the system, the user must enter the zone number and Supply Air Volume for this system.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the DX package unit. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

DX PACKAGED UNIT SYSTEM 1

"DX PACKAGED UNIT" SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .       (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
   SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .      OTHER SYSTEM DATA BLOCK
      .   .   .   .      (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .      COOLING COIL DATA BLOCK
      .   .   .   .      (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
   .   .   .   .      HEAT RECOVERY DATA BLOCK
   .   .   .   .      (Not applicable to this system)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
   COPC=(11,34.09,-0.087);
   .   .   .   .      HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   .   .   .
END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
    COPH2=(22,-3.9,0.022);
                        HEAT PUMP DATA BLOCK
            .   .   .   .   (Not applicable to this system)
        .   .   .   .
END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
    .   .   .   .       DX UNIT DATA BLOCK
    .   .   .   .       (Optional expert user input)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the DX package unit syntax is shown in the context of a complete fan system description with both English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The fan system syntax shown in these figures is sufficient to completely model the DX package unit system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the DX package unit system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the DX package unit system are listed in bold and all options as well as Metric (SI) units are italicized.

DX UNIT ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                    =STEAM;
                    =ELECTRIC;
                    =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                    =STEAM;
                    =ELECTRIC;
                    =GAS;
    RECOOL CAPACITY=0.0 (0);
    INDUCED AIR FRACTION=2.0 (2);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is

specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

DX UNIT OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft³/min or m³/s

DX UNIT COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=DX;
    DXCOIL1(4589.14,1.63,-0.02011);
    DXCOIL2(-25.3454,0.02492,0.00461);
    DXCOIL3(0.01715,-0.000051,-0.00000001715);
END COOLING COIL DESIGN PARAMETERS;
```

NOTE- SEE COOLING COIL DESIGN PARAMETERS IN THE TECHNICAL REFERENCE SECTION OF THE MANUAL.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX).

DXCOIL1- Coefficient used to determine the performance of the DX unit coil.

DXCOIL2- Coefficient used to determine the performance of the DX unit coil.

DXCOIL3- Coefficient used to determine the performance of the DX unit coil.

DX CONDENSING UNIT PARAMETERS DATA BLOCK

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487.3 (142.8);
    DESIGN SATURATED SUCTION TEMPERATURE=40 (4.4);
    DESIGN SATURATED CONDENSING TEMPERATURE=122 (50);
    MINIMUM SATURATED CONDENSING TEMPERATURE=100 (37.8);
    UNLOADER THROTTLING RANGE=4 (2.2);
    CONDENSOR UA=27.43 (14.5);
    SCT TEMPERATURE RISE COEFFICIENT=2.63;
    DESIGN FULL LOAD POWER RATIO=0.326;
    RCAVCD(0.98772,-0.02288,0.00027);
    RPWRCD(0.1456,0.9554,-0.10476);
    ADJECD(0.2984,0.1334,34.603);
END HEAT RECOVERY PARAMETERS;
```

DX CONDENSING UNIT CAPACITY- Used to specify the capacity of the DX package unit. Units: kBtu/hr or kW

DESIGN SATURATED SUCTION TEMPERATURE- Used to specify the design compressor suction temperature of the DX package unit. Units: °F or °C

DESIGN SATURATED CONDENSING TEMPERATURE- Used to specify the design condenser suction temperature of the DX package unit. Units: °F or °C

MINIMUM SATURATED CONDENSING TEMPERATURE- Used to specify the minimum condenser suction temperature of the DX package unit. Units: °F or °C

UNLOADER THROTTLING RANGE- Used to specify the temperature throttling range for the unloader on the DX package unit. Units: °F or °C

CONDENSER UA- Used to specify the UA value of the DX package unit condenser. Units: kBtu/hr/°F or kW/°C

SCT TEMPERATURE RISE COEFFICIENT- Used to specify the actual suction temperature rise.

DESIGN FULL LOAD POWER RATIO- Used to specify the design compressor full load power ratio for the DX package unit.

RCAVCD- Used to specify the available capacity of the DX package unit.

RPWRCD- Used to specify fraction of full load power for the DX package unit.

ADJECD- Used to specify full load power ratio for the DX package unit.

DX UNIT EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by applying the following syntax:

```
HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

COOLING COIL OPERATION- Used to schedule the heating coil fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by applying the following syntax:

```
COOLING COIL OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see cooling coil operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Electric Boiler

EQUIPMENT DESCRIPTION:

The BLAST model of an electric boiler models a constant efficiency electric boiler.

USING THE BLAST ELECTRIC BOILER:

Specifying an Electric Boiler in HBLC

In order to specify a electric boiler as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Electric Boiler” from the “Boilers” sub-menu. Fill in the number of electric boilers and their unit capacity.

Adjusting the Performance Parameters of the Electric Boiler

Once the electric boiler has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for an electric boiler that has the following operating parameters:

Efficiency=100%

Parameter Descriptions:

EBEFF- Used to specify the constant efficiency of the simple boiler. ELEC = EBLNET/EBEFF where ELEC is the boiler electric power consumed and EBLNET is the boiler net energy output.

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the electric boiler syntax is shown in the context of a complete central plant description with English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the electric boiler. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

ELECTRIC BOILER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ELECTRIC BOILER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ELECTRIC BOILER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
HOT WATER=0.0, CONSTANT, FROM 01JAN THRU 31 DEC, AT 125.0 SUPPLIED
BY BOILER;
PLANT ELECTRICAL DEMAND=0.0,CONSTANT,FROM 1JAN THRU 31DEC:
PROCESS WASTE HEAT=0.0,CONSTANT,FROM 1JAN THRU 31DEC, AT LEVEL 5;
    .   .
END SCHEDULE;
PART LOAD RATIOS:
ELECTRIC BOILER(MIN=0.0,MAX=1.0,BEST=1.0,ELECTRICAL=1.05);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
EBEFF=1.0000;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

ELECTRIC BOILER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ELECTRIC BOILER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ELECTRIC BOILER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
HOT WATER=0, CONSTANT, FROM 01JAN THRU 31 DEC, AT 125.0 SUPPLIED BY
BOILER;
PLANT ELECTRICAL DEMAND=0.0,CONSTANT,FROM 1JAN THRU 31DEC:
PROCESS WASTE HEAT=0.0,CONSTANT,FROM 1JAN THRU 31DEC, AT LEVEL 5;
    .   .
END SCHEDULE;
PART LOAD RATIOS:
ELECTRIC BOILER(MIN=0.0,MAX=1.0,BEST=1.0,ELECTRICAL=1.05);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
EBEFF=1.0000;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
```

```
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Equipment Assignment

Users wishing to override all or some of the default operating rules should use the EQUIPMENT ASSIGNMENT data block. The general form of the EQUIPMENT ASSIGNMENT BLOCK is:

```
EQUIPMENT ASSIGNMENT:
    COOLING:
        FROM cdate1 THRU cdate2:
            FOR LOAD = usn1 USE    cname1 (a,b,c,d,e,f),
                cname2 (a,b,c,d,e,f),
                cname3 (a,b,c,d,e,f);
            FOR LOAD = usn2 USE...
            .
            .
        FROM cdate3 THRU cdate4:
            .
            .
    HEATING:
        FROM hdate1 THRU hdate2:
            FOR LOAD = usn1 USE    bname1 (a,b,c,d,e,f),
                bname2 (a,b,c,d,e,f);
            FOR LOAD = usn2 USE...
            .
            .
        FROM hdate3 THRU hdate4:
        .
        .
    ELECTRIC:
        FROM edate1 THRU edate2:
            FOR LOAD = usn1 USE    gname1 (a,b,c,d,e,f),
                gname2 (a,b,c,d,e,f),
                gname3 (a,b,c,d,e,f);
            FOR LOAD = usn2 USE...
            .
            .
        FROM edate3 THRU edate4:
        .
        .
END EQUIPMENT ASSIGNMENT;
```

where:

cdate1, hdate1, and edate1 are of the form DDMMM, i.e., 15JAN, and are the starting date of the block definition

cdate2, hdate2, and edate2 are of the form DDMMM, i.e., 15JAN, and are the ending date of the block definition

cname1-3, bname1-2, and gname1-3 are the names of the chillers, boilers, and generators specified in the EQUIPMENT SELECTION input block

usn1, usn2 ... are the upper limits of the load range

(a,b,c,d,e,f) specifies the number of units of each size which are allowed to operate for this load range

For example:

```
EQUIPMENT SELECTION:
    CHILLER:
        1 of size 100,
        2 of size 200;
    OPEN CHILLER:
        1 of size 1000,
        2 of size 2000;
END EQUIPMENT SELECTION;
EQUIPMENT ASSIGNMENT:
    COOLING:
        FROM 01SEP THRU 31MAR:
            FOR LOAD = 500 USE CHILLER (1,2),
                OPEN CHILLER (0,0);
        FROM 01MAY THRU 30AUG:
        FOR LOAD = 1000 USE CHILLER (0,0),
            OPEN CHILLER (1,0);
        FOR LOAD = 3000 USE CHILLER (0,0),
            OPEN CHILLER (1,1);
        FOR LOAD = 5000 USE CHILLER (0,0),
            OPEN CHILLER (1,2);
        FOR LOAD = 5500 USE CHILLER (1,2),
            OPEN CHILLER (1,2);
END EQUIPMENT ASSIGNMENT;
```

This input would assign equipment as follows:

1. For the period 1 September through 31 March, the open chillers would not operate regardless of the load. All three of the hermetic chillers would be operated to meet any cooling load.

2. For the period 1 May through 30 August, if the cooling load were 1000 kBtu/hr (318 kW) or less, one open chiller of size 1000 would be operating. If the load were between 1000 and 3000 kBtu/hr (318 and 955 kW), then one open chiller of size 1000 and one of size 2000 would be allowed to operate. If the load were between 3000 and 5000 kBtu/hr (955 and 1519 kW), then one open chiller of size 1000 and two open chillers of size 2000 would be operating. If the load were between 5000 kBtu/hr and 5500 kBtu/hr, then all the chillers specified in the equipment selection would be operating. If the load were greater than 5500 kBtu/hr then no chillers would be operating.

3. For the period 1 April through 30 April, the default equipment assignment strategy would be used.

HBLC is not able to generate equipment assignment syntax. If the user requires that the default operating rules be overridden, the input file must be modified with a text editor.

Equipment Performance Parameters

While there are generic models for each central plant component in the BLAST program, users may supply specific component performance coefficients to override these defaults and model one or more products of a particular manufacturer. The syntax for changing the defaults via this block is:

```
EQUIPMENT PERFORMANCE PARAMETERS:
       Ordered set of three coefficients of a quadratic
       least squares fit to tabular data.  The form is
    RFUELB(.801,.405,-.235); f(x) = a0 + a1x + a2x^2
       So, here, f(x) = .801+.405X-.235X²
    .
    .      Performance parameters of other equipment types.
    .      All parameters have identical entry format.
    .
END EQUIPMENT PERFORMANCE PARAMETERS;
```

Parameters may be entered in any order; some or all may be entered.

Parameters apply to all units of an equipment type, so each parameter may appear only once.

The meaning of each equipment performance parameter is discussed below. In general, components are modeled by quadratic equations of the form Y = usn1 + usn2 * X + usn3 * X^2. This is particularly convenient, since most manufacturers present the data on component performance as one-dimensional curves or tables where all variables except one are fixed. Dimensionless ratios are used whenever possible. Note that only one group of parameter sets (one model) is used for each component type, regardless of the number of different sizes selected.

Equipment Schedules

Equipment schedule parameters determine when the air-handling system components will operate. If system operation is specified as constant, the fan will operate throughout the simulation. Otherwise, its operation will be determined by the system schedule and the zone loads; i.e., the system will be on throughout the scheduled "on" period and off during the scheduled "off" period. However, the system will run even during the "off" period if there is a zone demand during any one hour. This schedule should, therefore, correspond to the control schedule specified in the zone load calculation phase. The fan operating mode and schedule can greatly affect the amount of energy required to heat and cool outside air. The preheat, heating, and cooling capacity schedules indicate the daily and seasonal period when these coils are supplied with energy. For example, if chillers are shut off at night and on weekends, the user should specify a cooling coil schedule that turns off the cooling coil on nights and weekends and specify the control profile in loads without a cooling profile. In this example, no cooling energy will be used at night or on weekends even if the fan runs continuously or comes on at night because of a heating (or cooling) load.

For TWO PIPE FAN COIL or TWO PIPE INDUCTION systems, the user *must* override the seasonal heating and cooling availability schedules with schedules that do not overlap. This is because two-pipe systems cannot simultaneously heat and cool.

General Syntax

The general form of the EQUIPMENT SCHEDULES input data block is:

```
EQUIPMENT SCHEDULES:
   component name =   sched name, FROM date1 THRU date2,
      usn1 MAXIMUM TEMPERATURE,
      usn2 MINIMUM TEMPERATURE;
END EQUIPMENT SCHEDULES;
```

where:

component name =

SYSTEM OPERATION	EXHAUST FAN OPERATION
PREHEAT COIL OPERATION	HEATING COIL OPERATION
COOLING COIL OPERATION	HUMIDIFIER OPERATION
REHEAT COIL OPERATION	RECOOL COIL OPERATION
HEAT PUMP COOLING OPERATION	HEAT PUMP BACKUP HEAT OPERATION
HEAT PUMP HEATING OPERATION	FANCOIL HEATING OPERATION
FANCOIL COOLING OPERATION	TSTAT BASEBOARD HEAT OPERATION
HEAT RECOVERY OPERATION	EVAP COOLER OPERATION
MINIMUM VENTILATION SCHEDULE	MAXIMUM VENTILATION SCHEDULE
SYSTEM ELECTRICAL DEMAND SCHEDULE	VAV MINIMUM AIR FRACTION

sched name = any previously defined library schedule name

date1 = first day this schedule applies (of form DDMMM, i.e., 02JAN)

date2 = last day this schedule applies (of form DDMMM, i.e., 31DEC)

usn1 = outdoor air dry-bulb temperature above which this schedule does not apply; i.e., equipment will be turned off

usn2 = outdoor air dry-bulb temperature below which this schedule does not apply; i.e., equipment will be turned off

Default Schedules

Specification of equipment schedules is optional. If equipment schedules are not specified for a component for a given date, the following default operating schedules apply:

SYSTEM OPERATION = on continuously all hours of all days of the simulation

The following schedules, by default, are on each hour the system is operating:

EXHAUST FAN OPERATION
HEATING COIL OPERATION
COOLING COIL OPERATION
HUMIDIFIER OPERATION
REHEAT COIL OPERATION
RECOOL COIL OPERATION
FANCOIL HEATING OPERATION
FANCOIL COOLING OPERATION
TSTAT BASEBOARD HEAT OPERATION
PREHEAT COIL OPERATION
EVAP COOLER OPERATION
HEAT PUMP COOLING OPERATION
HEAT PUMP HEATING OPERATION
HEAT PUMP BACKUP HEAT OPERATION

HEAT RECOVERY OPERATION = off all hours of all days of the simulation

MINIMUM VENTILATION SCHEDULE = 0.15 for each hour of weekdays; 0.05 for each hour of weekend holidays and special days

MAXIMUM VENTILATION SCHEDULE = 1.0 for every hour of every day

SYSTEM ELECTRICAL DEMAND SCHEDULE = 1.0 for every hour of every day

VAV MINIMUM AIR FRACTION = must be specified to be in effect

When equipment schedules are specified, up to 32 schedule entries are permitted. For example, 32 different SYSTEM OPERATION schedules could be input, or 10 SYSTEM OPERATION schedule, 10 EXHAUST FAN OPERATION schedules, and 12 HUMIDIFIER OPERATION schedules could be provided.

When equipment schedules are specified for a particular component, each part of the general input command form is optional. If parts are omitted, the defaults are:

sched name =CONSTANT

date1 = 01JAN

date2 = 31DEC

usn1 = 392°F (200°C)

usn2 = -328°F (-200°C)

For example, specifying

RECOOL COIL OPERATION = SCHED1;

is equivalent to specifying

RECOOL COIL OPERATION = SCHED1, FROM 01JAN THRU 31 DEC,

392 MAXIMUM TEMPERATURE,

-328 MINIMUM TEMPERATURE;

NOTE 1: The schedules for all equipment are defaulted "ON" even if not explicitly specified. Therefore, if an equipment schedule is deleted from the list, the equipment default schedule will be "ON" for the whole simulation period. To schedule equipment "OFF" it must be explicitly stated in the input file.

NOTE 2: Component schedules must be consistent with specified control profiles. See Interaction of Loads and Systems in the BLAST Technical Reference for additional information

---

Evaporative Condenser

EQUIPMENT DESCRIPTION:

The evaporative condenser combines the functions of the refrigerant condenser and the cooling tower. The discharge gas from the compressor condenses inside a bank of tubes over which water is spraying. The air flowing upward through the water spray eventually caries out the heat form the condensing refrigerant. One performance advantage of the evaporative condenser is that the condensing temperature is driven towards the wet-bulb temperature. This allows the refrigeration system to operate with a lower condensing temperature and thus conserve energy compared to other condenser types.

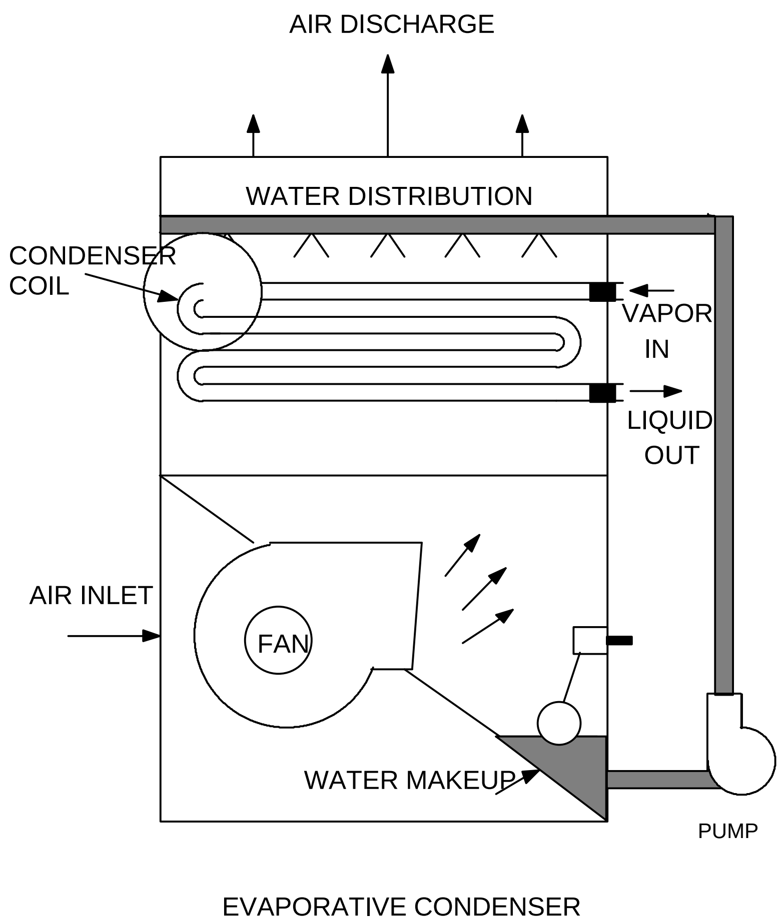


Figure 56. Diagram of a BLAST evaporative condenser

USING THE BLAST EVAPORATIVE CONDENSER:

Specifying an Evaporative Condenser in HBLC

To specify a evaporative condenser as one of the operating components in the central energy plant, the user must first select any chiller using the Central Plants input form. Double click on the chiller or select the chiller and press the “edit” button to open the chiller parameters dialog box.

When it is appropriate to choose an Evaporative Condenser, the choice will be available in the “Condenser Tower” pull down menu in the chiller parameters form. Click on edit and the form below will appear.

Evaporative Condenser parameters can be edited from the chiller parameter form by clicking edit, or once the Cooling Tower has been added to the plant it may be edited as with any piece of plant equipment.

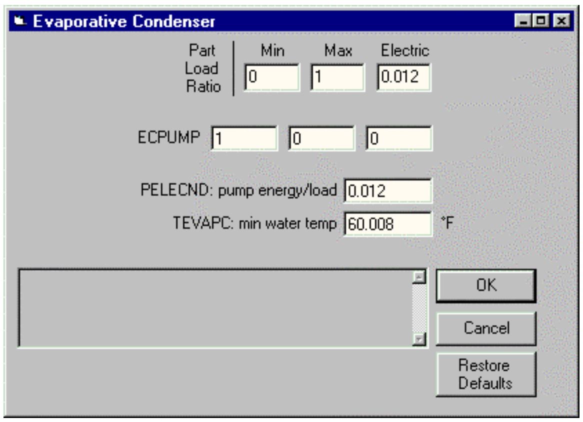


Figure 57. Evaporative Condenser form

Adjusting the Performance Parameters of the Evaporative Condenser

Once the evaporative condenser has been added using HBLC, the user must specify operating rules and parameters for the evaporative condenser. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for an evaporative condenser that has the following operating parameters:

Minimum leaving condenser water temperature = 60 °F

Ratio of electrical use to load=0.018

The default parameters have been devised so that the default evaporative condenser operates independently of the capacity.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

EPUMP- Used to determine the power consumption of the evaporative condenser pump

PELECND- The ratio of evaporative condenser pump electrical energy required to condenser load. Units: Dimensionless

TEVAPC- Minimum allowable temperature for water leaving the evaporative condenser. Units: °F or °C

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the evaporative condenser syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the evaporative condenser. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

EVAPORATIVE CONDENSER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "EVAPORATIVE CONDENSER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH EVAPORATIVE CONDENSER:
1 OF SIZE 100;
EVAPORATIVE CONDENSER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
EVAPORATIVE CONDENSER(MIN=0.0,MAX=1.00,ELECTRICAL=0.0125);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ECPUMP(1,0,0);
ADJT1C(95,2.77,44);
RCAV1C(1.006,-0.019,0.002);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PELECND=0.018;
TEVAPC=60.008;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

EVAPORATIVE CONDENSER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "SAMPLE PLANT" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH EVAPORATIVE CONDENSER:
1 OF SIZE 26;
EVAPORATIVE CONDENSER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
EVAPORATIVE CONDENSER(MIN=0.0,MAX=1.00,ELECTRICAL=0.0125);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ECPUMP(1,0,0);
ADJT1C(35,2.77,6.67);
RCAV1C(1.006,-0.027,0.007);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
```

```
.    .    .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PELECND=0.018;
TEVAPC=15.556;
.    .    .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Evaporative Cooler

EQUIPMENT DESCRIPTION:

Evaporative cooling has been applied to many types of buildings such as commercial offices as well as traditional industrial factories to improve worker comfort. There are two major types of evaporative coolers that are most commonly employed. The direct stage evaporates water directly in to the supply air simultaneously cooling and humidifying the air (adiabatic cooling). The indirect stage, where a secondary stream of air is humidified and used to cool the supply air through a heat exchanger separating the streams, therefore only sensibly cooling the supply air. See the Technical Reference for more information.

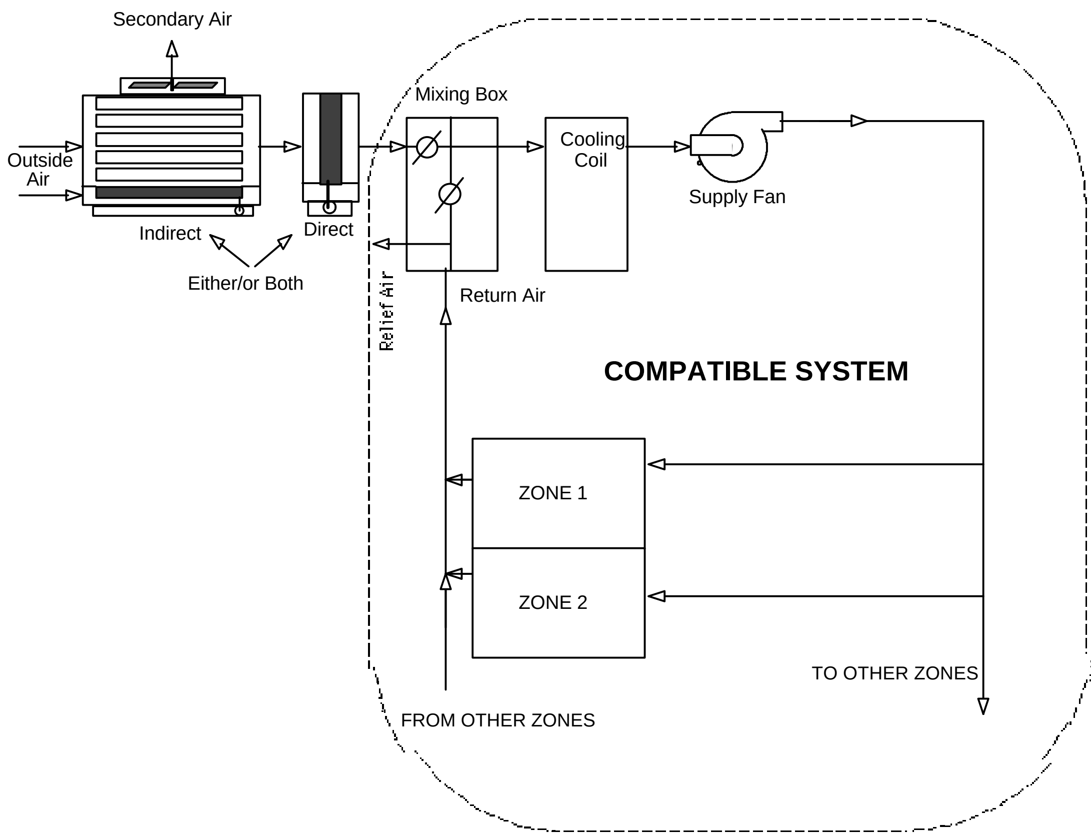


Figure 58. Diagram of a BLAST evaporative cooler

In the BLAST simulation, the evaporative cooler models are located in the outside air duct before the mixed air box. The mixed air box can be set to relieve all the return air and provide a 100% outside air configuration which is common for evaporative cooler fan systems. Putting the evaporative cooler in the outside air duct allows other possibilities than 100% outside air. The cooling coil can be used in conjunction with an evaporative cooler providing additional flexibility. The evaporative cooler will work with most fan systems in BLAST.

Fan System Type	Evaporative Cooler Availability
Multizone	Yes
Dual Duct	Yes
Three Deck Multizone	Yes
Variable Volume	Yes
Terminal Reheat	Yes
Subzone Reheat	Yes
Two Pipe Fan Coil	No
Four Pipe Fan Coil	No
Single Zone Draw Thru	Yes
DX Packaged Unit	Yes
Unit Ventilator	No
Unit Heater	No
Two Pipe Induction Unit	Yes
Packaged Heat-Pump System	No
Four Pipe Induction Unit	Yes

This is a duplicate to see how it looks:

Fan System Type	Evaporative Cooler Availability
Multizone	Yes
Dual Duct	Yes
Three Deck Multizone	Yes
Variable Volume	Yes
Terminal Reheat	Yes
Subzone Reheat	Yes
Two Pipe Fan Coil	No
Four Pipe Fan Coil	No
Single Zone Draw Thru	Yes
DX Packaged Unit	Yes
Unit Ventilator	No
Unit Heater	No
Two Pipe Induction Unit	Yes
Packaged Heat-Pump System	No
Four Pipe Induction Unit	Yes

Table 17. Evaporative Cooler System Availability

USING THE BLAST EVAPORATIVE COOLER:

Specifying an Evaporative Cooler in HBLC

To specify an evaporative cooler with one of the fan systems in the building simulation, the user must first have selected the fan system following the methods outlined in Fan Systems to create a fan system.

Some fan systems will not work with the evaporative cooler simulation; however HBLC knows which systems these are and the user will not have the option to activate an evaporative cooler for one of these systems.

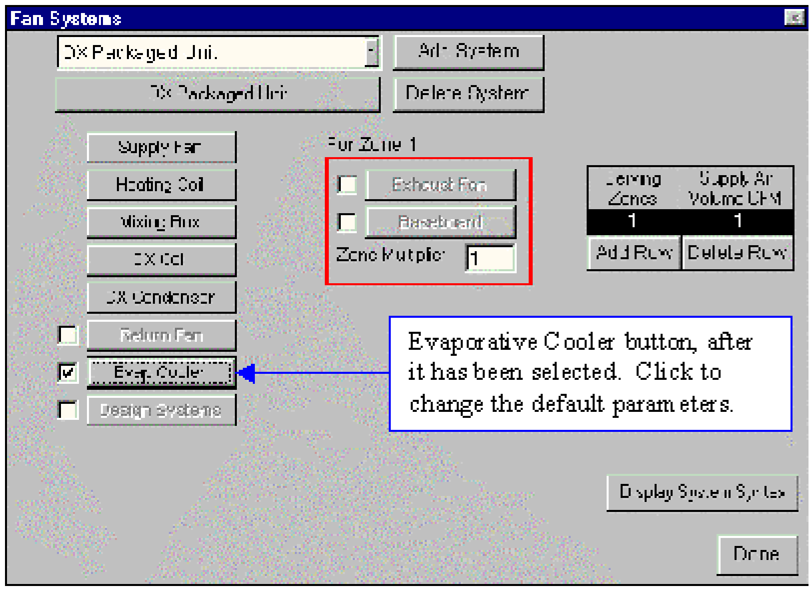


Figure 59. Fan Systems form showing the selection of an evaporative cooler in a DX Packaged Unit system.

To select an evaporative cooler, check the box next to the “Evap Cooler” button, which will then become highlighted. Click on the button to edit the evaporative cooler parameters.

The non-compatible systems are the two and four pipe fan coils and the unit heater and ventilator systems and the packaged heat pump system. Since they do not have a mixed air box, these systems are not compatible with evaporative coolers.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe a fan system with an evaporative cooler. Important data blocks are described in detail following the input file syntax.

BEGIN FAN SYSTEM DESCRIPTION;

MULTIZONE SYSTEM 1

"MULTIZONE " SERVING ZONES 1;

```
FOR ZONE 1:
       SUPPLY AIR VOLUME=100;
                         ZONE DATA BLOCK
       .   .   .   .      (Required user input)
       ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
   SUPPLY FAN PRESSURE=2.49783;
       .   .   .   .      OTHER SYSTEM DATA BLOCK
       .   .   .   .      (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
       .   .   .   .      COOLING COIL DATA BLOCK
       .   .   .   .      (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
       .   .   .   .      HEAT RECOVERY DATA BLOCK
           .   .   .   .      (Optional user input)
   HEAT RECOVERY CAPACITY=3412000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
   COPC=(11,34.09,-0.087);
       .   .   .   .      HEAT PUMP DATA BLOCK
       .   .   .   .      (Only applicable for heat pumps)
END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
   COPH2=(22,-3.9,0.022);       HEAT PUMP DATA BLOCK
           .   .   .   .      (Only applicable for heat pumps)
               .   .   .   .
END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
       .   .   .   .      DX UNIT DATA BLOCK
       .   .   .   .      (Only applicable for DX units)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
       .   .   .   .      SCHEDULES DATA BLOCK
       .   .   .   .      (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
       =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the evaporative cooler syntax is shown in the context of a complete fan system description with both English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The "Cold Deck Control", "Mixed Air Control", and "Desired Mixed

Air Control" parameters must be modified to the syntax shown below for the evaporative cooler to work correctly, and are not the defaults from HBLC. The proper options are easily chosen by selecting the radio button in front of the desired paramter.

The fan system syntax shown in these figures is sufficient to completely model the evaporative cooler. HBLC may include additional parameters and syntax that will not be used in the simulation if only the evaporative cooler is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the evaporative cooler are listed in bold and all options as well as Metric (SI) units are italicized.

EVAP COOLER OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
**EVAPORATIVE COOLER PARAMETERS
    EVAPORATIVE COOLER TYPE=DRY COIL TWO STAGE;
               =WET COIL TWO STAGE;
               =WET COIL INDIRECT;
               =DRY COIL INDIRECT;
               =DIRECT;
    INDIRECT FANSIZE=8000 (3.7756);
    INDIRECT FAN EFFICIENCY=0.7;
    SEC FAN PRESSURE DROP=0.1 (24.9);
    EFFECTIVENESS INDIRECT HX=0.6;
    INDIRECT PAD AREA=44 (4.08);
    DIRECT PAD AREA=20 (1.86);
    INDIRECT PAD DEPTH=1.0 (0.304);
    DIRECT PAD DEPTH=1.0 (0.304);
    WET COIL MAX EFF=0.8 (0.8);
    WET COIL FLOW RATIO=0.16 (0.16);
**END EVAPORATIVE COOLER PARAMETERS
    COLD DECK CONTROL=ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(32 AT 32,212 AT 212) (0 AT 0,100 AT
100);
    COLD DECK THROTTLING RANGE=0;
    MIXED AIR CONTROL=EVAP CONTROL NONE;
               =EVAP NO HUMIDITY CONTROL;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
               =(ARBITRAY FIXED VALUE);
END OTHER SYSTEM PARAMETERS;
```

NOTE 1: To control the evaporative cooler, see EVAPORATIVE COOLER in BLAST Technical Reference.

NOTE 2: Only parameters directly affecting the evaporative cooler are given above. Other parameters depend on the type of system used.

EVAPORATIVE COOLER TYPE- Used to specify what type of evaporative cooler configuration is being employed with the fan system. The five options are Direct, Wet Coil Indirect, Dry Coil Indirect, Dry Coil Two Stage, and Wet Coil Two Stage.

INDIRECT FANSIZE- Used to specify secondary flow rate of the indirect evaporative cooler. Applicable to all but direct stage evaporative coolers. Units: ft^3/min or m^3/s

INDIRECT FAN EFFICIENCY- Used to specify the efficiency of the indirect fan. Applicable to all but direct stage evaporative coolers.

SEC FAN PRESSURE DROP- Used to specify pressure drop across the secondary fan. Applicable to all but direct stage evaporative coolers. Units: inches H20 or N/m^2

EFFECTIVENESS INDIRECT HX- Used to specify the effectiveness of the indirect air-to-air heat exchanger. Applicable to only those systems that involve dry coil indirect stage coolers.

DIRECT PAD AREA- Used to specify the pad area of direct stage coolers. Units: ft^2 or m^2

DIRECT PAD DEPTH- Used to specify the pad depth of direct stage coolers. Units: ft or m.

INDIRECT PAD AREA- Used to specify the pad area of dry coil indirect stage coolers. Units: ft^2 or m^2.

INDIRECT PAD DEPTH- Used to specify the pad area of dry coil indirect stage coolers. Units: ft or m.

WET COIL MAX EFF- Used to specify the maximum efficiency for the heat exchanger in wet coil indirect stage coolers.

WET COIL FLOW RATIO- Used to specify the flow efficiency ratio in wet coil indirect stage coolers.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. When using an evaporative cooler this parameter should be set to ZONE CONTROLLED. This will allow the zone requiring the coolest air to establish the cold deck set point.

COLD DECK THROTTLING RANGE- Should be set to zero so the throttling range does not work with the cold deck control to adjust the air delivery temperature. The throttling range is intended for use with refrigeration coils and is used for controlling the amount of chilled water to the coil. The throttling range allows for part load control of a cooling coil. The throttling range should not be used with an evaporative cooler even if a cooling coil is used with an evaporative cooler, since it affects the operation of the evaporative cooler. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. This is not applicable when the "Zone Controlled" option is used. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Changing the schedule to"(32 at 32, 212 at 212)" simply sets the cold deck temperature equal to the temperature of the air required by the zone needing the coldest air for all possible situations. Remember that the zone requiring the coolest air is not necessarily the zone requiring the most cooling.

MIXED AIR CONTROL- The mixed air control determines how outside air is going to mix with return air to determine the mixed, supply air flow. Control Scheme I, is set by "EVAP CONTROL NONE". Control Scheme II, is set by "EVAP NO HUMIDITY CONTROL". (See technical reference manual.)

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. For the evaporative cooler, set the mixed air temperature equal to the cold deck temperature. Units: °F or °C

EVAP COOLER EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING  COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    EVAP COOLER OPERATION=ON,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRUI31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

EVAP COOLER OPERATION- Used to schedule the evaporative cooler operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges do not apply to the evaporative cooler.

Four Pipe Fan Coil System

EQUIPMENT DESCRIPTION:

This is a relatively low initial cost concept in which both chilled water and hot water coils can be used within the same system. This system works well in all seasons due to the availability of both heating and cooling supplies, and solves the intermediate season performance problems of a single coil system. There is no summer-winter change over requirement as in most two-pipe systems and therefore a four-pipe fan coil is much simpler to operate than the single fan coil system. The figure below shows the complete system for a single zone including mixing box, supply fan, and coils. If more than one zone is served by the system, the entire set of components is repeated for each zone.

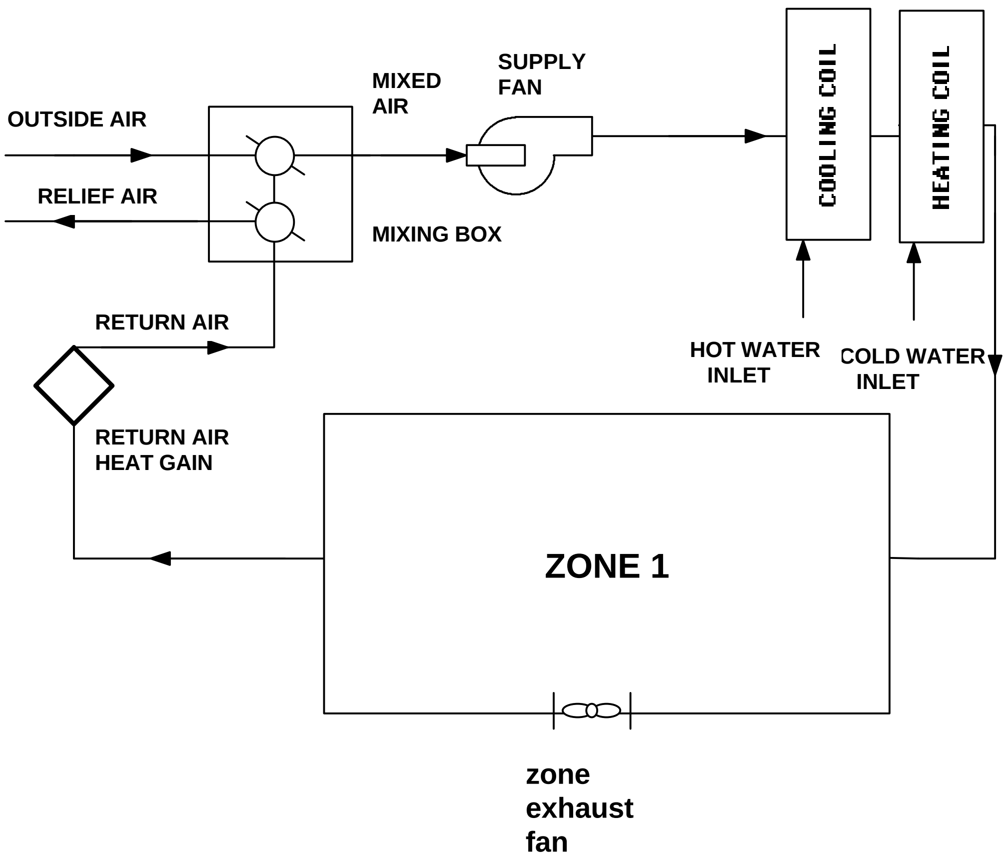


Figure 60. Diagram of a BLAST four pipe fan coil

USING THE BLAST FOUR-PIPE FAN COIL SYSTEM:

Specifying a Four-Pipe Fan Coil System in HBLC

To specify a four-pipe fan coil as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select “Four Pipe Fan Coil” from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

When declaring which zones your system will be serving, keep in mind that the BLAST fan coil systems are either fully on or fully off for a given hour. This means that all zones on a fan coil system in BLAST will operate in tandem. If the fan is running in one zone, it is running in all zones. This is not appropriate for modeling a fan coil system where the fans in individual zones cycle independently. For such a system, each zone must be served by a separate fan system.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button.

The Four Pipe Fan Coil system parameters form contains the schedules for heating and cooling, which may not overlap. HBLC provides non-overlapping defaults, but the user should verify the dates.

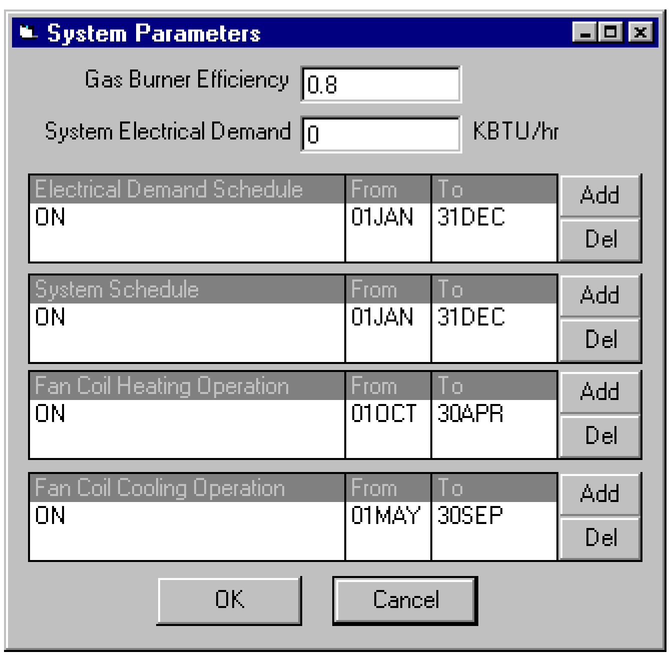


Figure 61. System Parameters form for a fan coil system

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the four pipe fan coil system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

FOUR PIPE FAN COIL SYSTEM 1

"FOUR PIPE FAN COIL " SERVING ZONES 1;

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100;
        .   .   .   .       ZONE DATA BLOCK
        .   .   .   .        (Required user input)
    ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=2.49783;
        .   .   .   .       OTHER SYSTEM DATA BLOCK
        .   .   .   .       (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
        .   .   .   .       COOLING COIL DATA BLOCK
        .   .   .   .       (Optional expert user input)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
        COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
        COPH2=(22,-3.9,0.022);
                            HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the four pipe fan coil system syntax is shown in the context of a complete fan system description with both English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The fan system syntax shown in these figures is sufficient to completely model the four pipe fan coil. HBLC may include additional parameters and syntax that will not be used in the simulation if only the four pipe fan coil system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the four pipe fan coil system are listed in bold and all options as well as Metric (SI) units are italicized.

FOUR PIPE FAN COIL ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD

HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

FOUR PIPE FAN COIL OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m^2

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

MIXED AIR CONTROL- The BLAST fan coil systems assume MIXED AIR CONTROL = FIXED PERCENT no matter what is specified in the input file. The MINIMUM VENTILATION SCHEDULE (MVS) and EXHAUST AIR VOLUME (EAV) control the amount of outside air; all other outside air parameters are ignored. For a given SUPPLY AIR VOLUME (SAV), the outside air volume (OAV) is calculated as follows:

OAV = Maximum(MVS*SAV, EAV)

In other words, the MINIMUM VENTILATION SCHEDULE sets the fraction of outside air unless the EXHAUST AIR VOLUME requires additional outside air to balance the air flow.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

FOUR PIPE FAN COIL COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE: The BLAST fan coil systems assume a chilled water cooling coil and use a coil model which is slightly different from the other BLAST chilled water coils.

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

FOUR PIPE FAN COIL EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

FANCOIL HEATING OPERATION- Used to schedule the fan coil heating operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan coil heating operation can be defined by using optional user syntax (see exhaust fan operation). The scheduling dates for operation must not overlap with FANCOIL COOLING OPERATION because two pipe fan coils cannot heat and cool simultaneously.

FANCOIL COOLING OPERATION- Used to schedule the fan coil cooling operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan coil cooling operation can be defined by using optional user syntax (see exhaust fan operation). The scheduling dates for operation must not overlap with FANCOIL HEATING OPERATION because two pipe fan coils cannot heat and cool simultaneously.

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Four Pipe Induction System

EQUIPMENT DESCRIPTION:

The four pipe induction unit is a common system that accomplishes space conditioning by using air and water sources distributed to induction units installed in required zones throughout the building. Four pipe induction units are primarily applicable to multizone structures and are able to handle a wide variety of sensible loads, but at a cost of accurate humidity control. The four pipe unit can simultaneously heat and cool in the intermediate seasons. Induction units are usually installed under a window at a perimeter wall, but can also be used as an over head unit. Some of the major advantages of an induction unit are individual zone control, separate heating and cooling sources, and the over all system size is comparatively small.

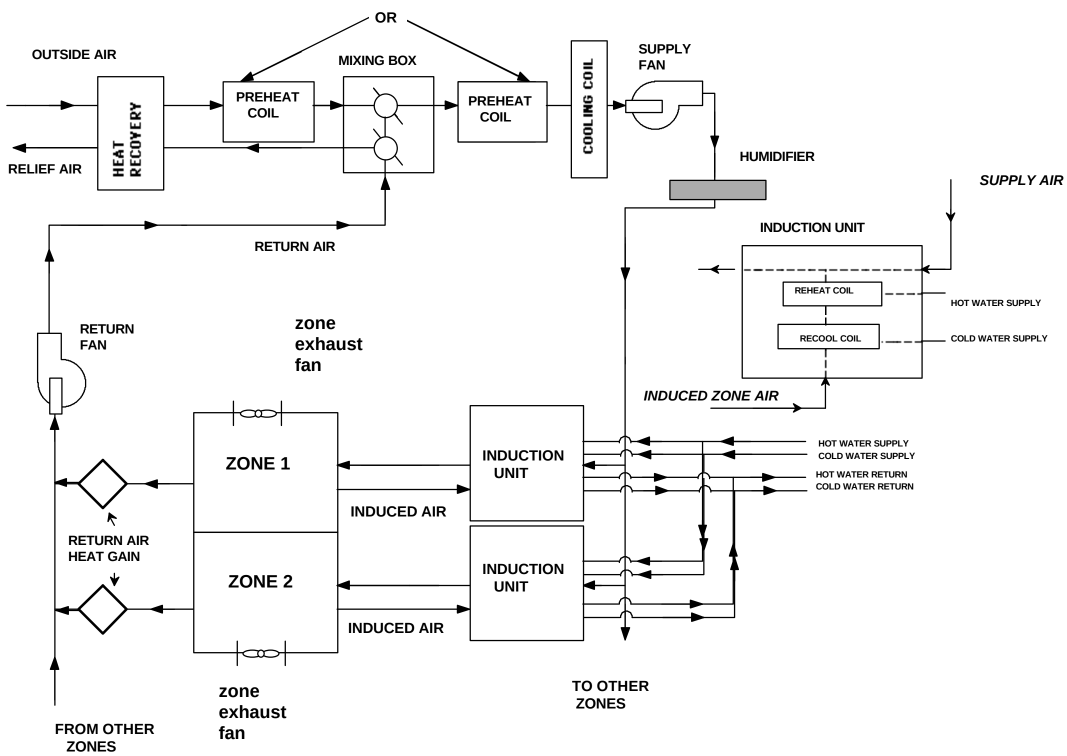


Figure 62. Diagram of a BLAST four pipe induction system

USING THE BLAST FOUR PIPE INDUCTION SYSTEM:

Specifying a Four Pipe Induction System in HBLC

To specify a four pipe induction system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select "Four

Pipe Induction" from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the four pipe induction system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

FOUR PIPE INDUCTION SYSTEM 1

"FOUR PIPE INDUCTION" SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .       (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .      OTHER SYSTEM DATA BLOCK
      .   .   .   .      (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .      COOLING COIL DATA BLOCK
      .   .   .   .      (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .      HEAT RECOVERY DATA BLOCK
      .   .   .   .      (Optional expert user input)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
      COPC=(11,34.09,-0.087);
      .   .   .   .      HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
       COPH2=(22,-3.9,0.022);
                          HEAT PUMP DATA BLOCK
       .   .   .   .      (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
       .   .   .   .      DX UNIT DATA BLOCK
       .   .   .   .      (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
       .   .   .   .      SCHEDULES DATA BLOCK
       .   .   .   .      (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
       =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the four pipe induction system syntax is shown in the context of a complete fan system description with both English and SI default values. The SI unit default value is shown in parentheses following the English unit default value. The fan system syntax shown in these figures is sufficient to completely model the four pipe induction system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the four pipe induction system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the four pipe induction system are listed in bold and all options as well as Metric (SI) units are italicized.

FOUR PIPE INDUCTION ZONE DATA BLOCK

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100 (.0473);
   EXHAUST AIR VOLUME=0 (0);
   MINIMUM AIR FRACTION=0.19 (0.1);
   BASEBOARD HEAT CAPACITY=0.0 (0);
   BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
              =STEAM;
              =ELECTRIC;
              =GAS;
   REHEAT CAPACITY=0.0 (0);
   REHEAT ENERGY SUPPLY=HOT WATER;
              =STEAM;
              =ELECTRIC;
              =GAS;
   RECOOL CAPACITY=0.0 (0);
   INDUCED AIR FRACTION=2.0 (2);
   ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is

specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

RECOOL CAPACITY- Used to specify the capacity of the recool coils. Currently, recool coils are allowed only for induction systems and are assumed to be chilled water coils which accomplish sensible cooling only.

INDUCED AIR FRACTION- The parameter INDUCED AIR FRACTION is used to specify the volume of air which is "induced" to flow through the induction box per unit volume of supply air. For example, if the INDUCED AIR FRACTION were specified as 1.75 and the SUPPLY AIR VOLUME as 1000 cfm, the total air flow through the induction unit would be 2750 cfm. As illustrated in , the SUPPLY AIR VOLUME goes over the main cooling coil while only the "induced" air flows over the reheat and recool coils. In addition, it should be pointed out that these fan systems assume no latent cooling occurs at the recoil coil.

NOTE: The zone parameters, INDUCED AIR FRACTION and MINIMUM AIR FRACTION, are both stored in the same variable in BLAST. The last one specified in the FAN SYSTEM DESCRIPTION will be the one BLAST uses, thus care should be taken to specify only one of these values to limit the possibility of error.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

FOUR PIPE INDUCTION OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m^2

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

HUMIDIFIER TYPE- Used to specify the what type of energy is used by the humidifier. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

FOUR PIPE INDUCTION COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

FOUR PIPE INDUCTION HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT  RECOVERY PARAMETERS:
   HTREC1(0.85,0,0);
   HTREC2(0,0,0);
   HTREC3(0,0,0);
   HTREC4(0,0,0);
   HTREC5(0,0,0);
   HTREC6(0,0,0);
   HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

FOUR PIPE INDUCTION EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

RECOOL COIL OPERATION- Used to schedule the recool coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for recool coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Free Cooling Chiller

EQUIPMENT DESCRIPTION:

The BLAST model of a free cooling chiller is simulated as a standard vapor compression refrigeration cycle with an water cooled condenser and a open centrifugal compressor which may obtain cooling with the compressor shut off when the condenser water temperature drops low enough by operating a small refrigerant pump as well as the chilled water and condenser pumps. The open centrifugal compressor is an open unit in which the motor and compressor are not in the same housing. The motor is connected to the compressor by way of a shaft that runs through a rotating seal on the compressor housing. This set up creates much better maintenance access and allows alternative drive installations. The down side of an open centrifugal compressor is that the motor is not cooled by the refrigerant and there is a higher possibility of seal leakage. After leaving the compressor or refrigerant pump, the refrigerant is condensed to liquid in a refrigerant to water condenser. The heat from the condenser is rejected to a cooling tower, evaporative condenser, or well water condenser depending on which one is selected by the user based on the physical parameters of the plant. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

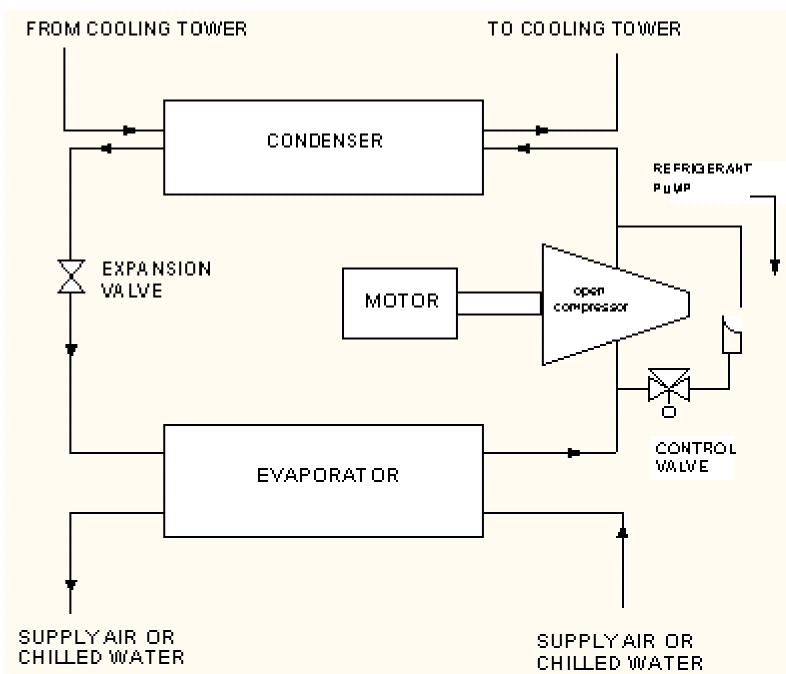


Figure 63. Diagram of BLAST free cooling chiller

USING THE BLAST FREE COOLING CHILLLER:

Specifying a Free Cooling Chiller in HBLC

To specify a free cooling chiller as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Free Cooling” from the “Chillers” sub-menu. Fill in the number of chillers and their unit capacity.

Adjusting the Performance Parameters of the Free Cooling Chiller

Once the free cooling chiller has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a free cooling chiller that has the following operating parameters:

Evaporator temperature	= 40 to 48 °F
Condenser temperature	= 70 to 100 °F
Capacity	= 920 to 1000 Tons

If your free cooling chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for a free cooling chiller are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJTFC- Used to calculate the equivalent temperature difference between the

RCAVFC- Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJEFC- Used to adjust the full load power consumption of the chiller.

RPWRFC- Used to determine the fraction of full load power.

CAVFCM- Used to describe the chiller in the free cooling mode. This parameter determines the amount of free capacity available.

PWRFCM- This parameter is used to compute the electric consumption of the chiller in the free cooling mode. There is no range on the default, but it should be a function of the part load ratio.

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

FCCTRL- Free cooling chiller control type. FCCTRL=1 allows the chiller to work in the free cooling mode between the dates of FCON and FCOFF. FCCTRL=2 allows the chiller to work in the free cooling mode if the outside air dry-bulb is less than FCTEMP. FCCTRL=3 allows the chiller to work in the free cooling mode if the outside air wet-bulb temperature is less than FCTEMP. FCCTRL=4 allows the chiller to work in the free cooling mode if condenser water temperature entering the chiller is less than desired leaving chilled water temperature. Units: Dimensionless

FCOFF- If FCCTRL=1, the date the free cooling chiller switches from the free cooling mode to regular mode. The date is computed from 32*month+day. Thus FCOFF for March 12 is 32*3+12. Units: Dimensionless

FCON- If FCCTRL=1, the date the free cooling chiller switches from the regular cooling mode to free cooling mode. The date is computed from 32*month+day. Thus FCOFF for March 12 is 32*3+12. Units: Dimensionless

FCTEMP- The free cooling chiller control temperature. If FCCTRL=2, FCTEMP will be compared with the outside air dry-bulb. If FCCTRL=3, FCTEMP will be compared with the outside air wet-bulb temperature.
Units: °F or °C

RWCFC- Ratio of condenser flow rate to free cooling chiller capacity. Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the free cooling chiller syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the free cooling chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

FREE COOLING CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "FREE COOLING CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
FREE COOLING CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
FREE COOLING CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTFC(95,2.5,44);
RCAVFC(1.018946,-0.03075,0.0001442);
ADJEFC((2.3201,-1.46167,.181478);
RPWRFC(0.239,-0.04045,0.795454);
CAVFCM(0,0.0227,0);
PWRFCM(0,0,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44;
RWCFC=124.882;
FCCTRL=1;
FCOFF=414;
FCON=33
FCTEMP=50;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

FREE COOLING CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "FREE COOLING CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
FREE COOLING CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 24;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
FREE COOLING CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTFC(35,2.5,6.667);
RCAVFC(1.018946,-0.05535,0.0004673);
ADJEFC((2.3201,-1.46167,.181478);
RPWRFC(0.239,-0.04045,0.795454);
```

```
CAVFCM(0,0.05,0);
PWRFCM(0,0,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.667;
RWCFC=0.0537;
FCCTRL=1;
FCOFF=414;
FCON=33
FCTEMP=10;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Gas Turbine Chiller

EQUIPMENT DESCRIPTION:

The gas turbine-driven chiller is an open centrifugal chiller driven directly by a gas turbine. The BLAST model of an open centrifugal chiller is modeled as standard vapor compression refrigeration cycle with a centrifugal compressor driven by a shaft power from an engine. The centrifugal compressor has the incoming fluid entering at the eye of a spinning impeller that throws the fluid by centrifugal force to the periphery of the impeller. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The heat from the condenser is rejected to a cooling tower, evaporative condenser, or well water condenser depending on which one is selected by the user based on the physical parameters of the plant. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

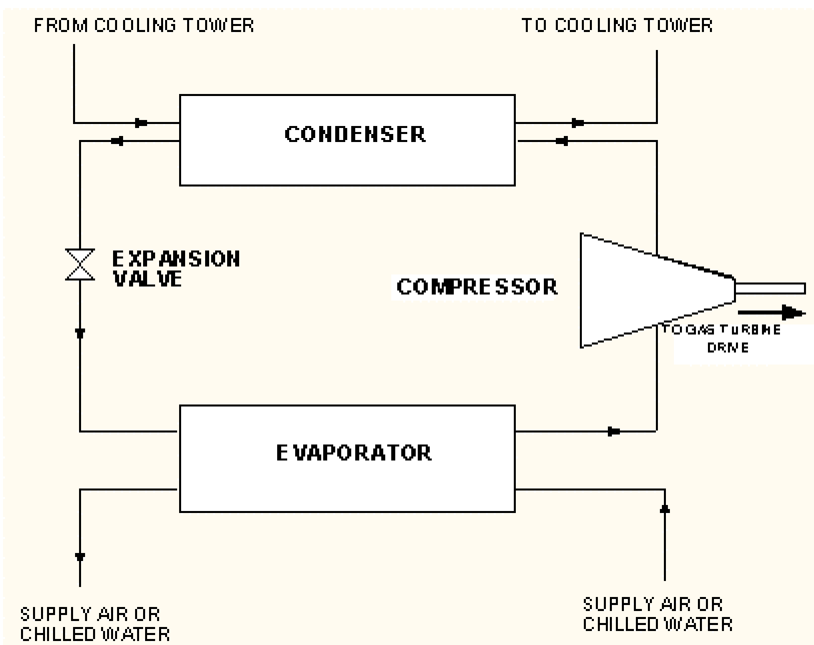


Figure 64. Diagram of a BLAST gas turbine chiller

USING THE BLAST GAS TURBINE CHILLER:

Specifying a Gas Turbine Chiller in HBLC

To specify a gas turbine driven chiller as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Gas Turbine Driven Chiller” from the “Chillers” sub-menu. Fill in the number of generators and their unit capacity.

Adjusting the Performance Parameters of the Gas Turbine Chiller

Once the gas turbine driven chiller has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a gas turbine driven chiller that has the following operating parameters:

Evaporator temperature = 40 to 48 °F

Condenser temperature = 70 to 100 °F

Capacity = 920 to 1000 Tons

If your gas turbine driven chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for a gas turbine driven chiller are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJEGC- Used to adjust the full load power consumption of the chiller.

ELUBGC- Used to adjust Gas Turbine Chiller Lube Oil Coefficient.

FUL1GC- Used to compute the ratio of fuel energy input to shaft energy output. (1-3)

RPWRGC- Used to adjust the Gas Turbine Chiller Energy Input/Output Coefficient.

ADJTGC- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

FEXGC- Used to calculate the Gas Turbine Chiller Exhaust Flow Coefficient.

FUL2GC- Used to compute the ratio of fuel energy input to shaft energy output. (4-6)

RCAVGC- Used to adjust the chiller capacity based on the equivalent temperature difference.

RCAVGC- Used to adjust the chiller capacity based on the equivalent temperature difference.

TEX1GC- Used to adjust the Gas Turbine Chiller Exhaust Temperature Coefficient. (1-3)

TEX2GC- Used to adjust the Gas Turbine Chiller Exhaust Temperature Coefficient. (4-6)

ELUBGC- Lube Oil Coefficient for Gas Turbine Chiller.

UACGC- Used to define heat recovery for the diesel engine.

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

RWCGC- Ratio of condenser flow rate to gas turbine chiller capacity. Units: Dimensionless

RMXKWGC- Maximum exhaust flow per unit capacity for gas turbine-driven chillers. The parameter sets an upper limit on exhaust gas flow, therefore exhaust gas heat recovery for gas turbines. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW capacity

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the gas turbine driven chiller syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the gas turbine driven chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

GAS TURBINE DRIVEN CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "GAS TURBINE DRIVEN CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
GAS TURBINE DRIVEN CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
GAS TURBINE DRIVEN
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.25);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTGC(95,2.5,44);
RCAVGC(1.018946,-0.03075,-0.0001442);
ADJEGC((2.3201,-1.46167,.181478);
RPWRGC(0.239,-0.04045,0.795454);
FUL2GC(1.004,.-0.0008,0);
FUL1GC(9.41,-9.48,4.32);
TEX1GC(916.992,307.998,79.992);
TEX2GC(1.0050,0.0018,0);
FEXGC(15.63799,-0.0306,0.0002);
ELUBGC(0.223,-0.4,0.2286);
UACGC(0.01907045,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
RWCGC=124.882;
RMXKWGC=11.7152000;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

GAS TURBINE DRIVEN CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "GAS TURBINE DRIVEN CHILLER " SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
GAS TURBINE DRIVEN CHILLER WITH COOLING TOWER;
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
GAS TURBINE DRIVEN
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.25);
.   .   .
END PART LOAD RATIOS;
```

```
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTGC(35,2.5,6.667);
RCAVGC(1.018946,-0.05535,-0.0004673);
ADJEGC((2.3201,-1.46167,.181478);
RPWRGC(0.239,-0.04045,0.795454);
FUL2GC(1.004,.-0.00144,0);
FUL1GC(9.41,-9.48,4.32);
TEX1GC(509.44,171.11,44.44);
TEX2GC(1.0050,0.00324,0);
FEXGC(0.0197,-0.00000694,-0.00000008);
ELUBGC(0.223,-0.4,0.2286);
UACGC(0.030346,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
RWCGC=0.0537;
RMXKWGC=0.00504;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Gas Turbine Generator

EQUIPMENT DESCRIPTION:

The basic gas-turbine cycle is the Brayton Cycle or open cycle, which consists of an adiabatic compression, constant pressure heating, and adiabatic expansion. The gas turbines are highly applicable to refrigeration components because they have high reliability and are very inexpensive.

USING THE BLAST GAS TURBINE GENERATOR:

Specifying a Gas Turbine Generator in HBLC

To specify a gas turbine generator as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on "Add" equipment and choose "Gas Turbine" from the "Generators" sub-menu. Fill in the number of generators and their unit capacity.

Adjusting the Performance Parameters of the Gas Turbine Generator

Once the gas turbine generator has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a gas turbine generator that has the following operating parameters:

Fixed rating temperature	= 25 °C
Exhaust flow per capacity	= 0.005 kg/sec per kW capacity

If your gas turbine generator does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

FUEL1G- Used to calculate the fuel energy consumption as a function of part-load ratio.

FUEL2G- Used to calculate the fuel energy consumption as a function of ambient (entering) air temperature.

TEX1G- Used to calculate the exhaust gas temperature as a function of part-load ratio.

TEX2G- Used to calculate the exhaust gas temperature as a function of ambient (entering) air temperature.

ELUBG- Lube Oil Coefficient for the Gas Turbine Generator.

FEXG- Used to determine the exhaust gas flow rate per unit capacity as a function of ambient (entering) air temperature

UACG- Used to determine amount of heat recovery using the UA product.

RMXKWG- Maximum exhaust flow per unit capacity for gas engines. The parameter sets an upper limit on exhaust gas flow and exhaust gas heat recovery for gas engines. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW capacity

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the gas turbine syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the gas turbine. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

GAS TURBINE BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "GAS TURBINE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
GAS TURBINE:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
GAS TURBINE(MIN=0.02,MAX=1.05,BEST=0.6,ELECTRICAL=0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
FUEL1G=(9.412,-9.48,4.32);
FUEL2G=(1.044,-0.0008,0);
TEX1G=(917,308,80);
TEX2G=(1.0056,0.0018,0);
ELUBG= 0.22300000, -0.40000000,  0.22860000);
FEXG=(15.637,-0.0367,-0.0002);
UACG=(0.0197,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
RMXKWG=11.715;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

GAS TURBINE BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION:
PLANT 1 "GAS TURBINE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
GAS TURBINE:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
GAS TURBINE(MIN=0.02,MAX=1.05,BEST=0.6,ELECTRICAL=0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
FUEL1G=(9.412,-9.48,4.32);
FUEL2G=(1.044,-0.00144,0);
TEX1G=(509.444,171.111,44.444);
TEX2G=(1.0056,0.0032,0);
ELUBG= 0.22300000, -0.40000000,  0.22860000);
FEXG=(0.00197,-0.000000649,-0.00000008);
UACG=(0.03067,0.9,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
RMXKWG=0.005;
```

```
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Heat Pump Water-Source

EQUIPMENT DESCRIPTION:

The BLAST model of a heat pump is simulated as a standard vapor compression refrigeration cycle with a double bundled condenser, the ability to be false-loaded from a solar tank to increase the rejected heat and a hermetic centrifugal compressor. The hermetic centrifugal compressor is a sealed unit that contains both the motor and the compressor. The closed housing is immune to leakage that often occurs in open type compressors. A double bundle condenser involves two separate flow paths through the condenser. One of these paths is to a standard cooling tower, evaporative condenser, or well water condenser depending on which one is selected by the user based on the physical parameters of the plant. The other path is to heating coils located in perimeter zones. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

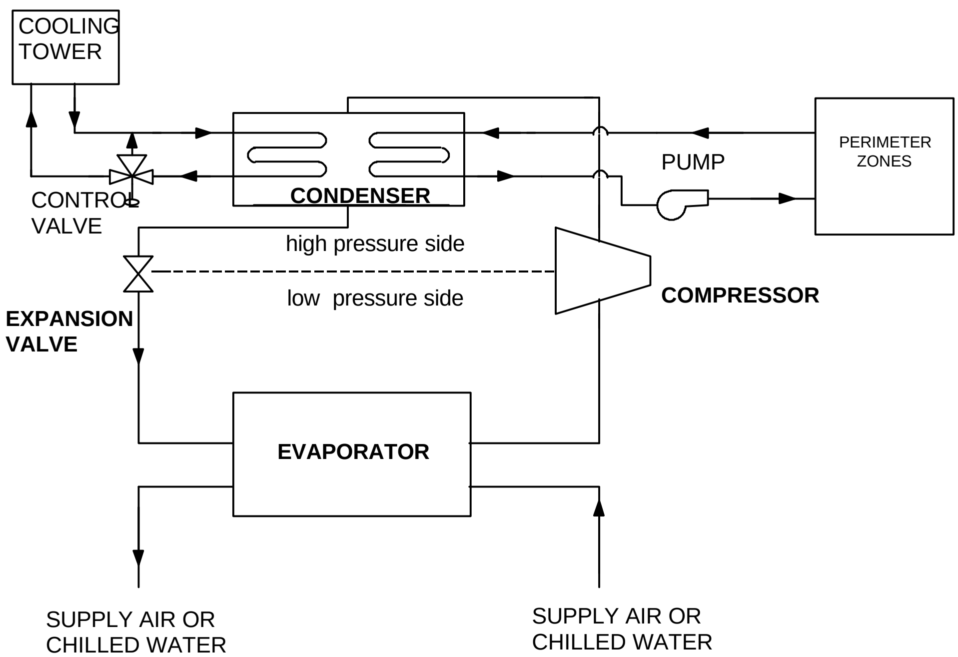


Figure 65. Diagram of a BLAST water-source heat pump

USING THE BLAST WATER-SOURCE HEAT PUMP:

Specifying a Water-Source Heat Pump in HBLC

To specify a water-source heat pump as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on "Add" equipment and choose "Water to Water Heatpump" from the "Heatpump" sub-menu. Fill in the number of heat pumps and their unit capacity.

Adjusting the Performance Parameters of the Water-Source Heat Pump

Once the water-source heat pump has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a water-source heat pump that has the following operating parameters:

Evaporator temperature	= 40 to 48 °F
Condenser temperature	= 70 to 100 °F
Capacity	= 920 to 1000 Tons

If your water-source heat pump does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data. Valid condenser types that may be specified by the user for a water-source heat pump are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main "Plants" form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJTHP- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAVHP- Used to adjust the heat pump capacity based on the equivalent temperature difference.

ADJEHP- Used to adjust the full load power consumption of the heat pump.

RPWRHP- Used to determine the fraction of full load power.

TCOOL- Temperature of chilled water leaving the heat pump. Units: °F or °C

RWCHP- Ratio of condenser flow rate to heat pump capacity. Units: Dimensionless

TCW- Temperature of the water leaving the condenser. Units: °F or °C

RAVRHHP- Fraction of heat pump heat that is recoverable. Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the water source heat pump syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the water source heat pump. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

HEAT PUMP BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "HEAT PUMP" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
HEAT PUMP WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
HEAT PUMP(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTHP(95,2.5,44);
RCAVHP(1.018946,-0.03075,-0.0001442);
ADJEHP((2.3201,-1.46167,.181478);
RPWRHP(0.239,-0.04045,0.795454);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
RWCHP=124.8834;
TCW=110.0;
RAVRHHP=0.95;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

HEAT PUMP BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "HEAT PUMP" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
HEAT PUMP WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 23.6;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=23.6, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
HEAT PUMP (MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJTGC(95,2.5,44);
RCAVGC(1.018946,-0.05535,-0.0004673);
ADJEGC((2.3201,-1.46167,.181478);
RPWRGC(0.239,-0.04045,0.795454);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.667;
```

```
RWCHP=0.0537;
TCW=43.44;
RAVRHHP=0.95;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Ice Storage: Ice Harvester

EQUIPMENT DESCRIPTION:

The BLAST direct ice storage model was developed for the purpose of simulating two types of ice storage configurations which build ice directly on the evaporator. The ice harvester, like the ice-on-coil device, uses a vapor compression refrigeration cycle. However, the ice harvester evaporator coils are in the shape of thin flat plates. Water from a storage tank is pumped across the evaporator plates where ice formation occurs. Periodically, the ice is removed by allowing hot gases from the compressor to flow through the evaporator plates. When the interface layer of ice melts, the remainder of the ice sheet falls from the plates and drops into a storage tank positioned below the evaporator plates. One of the disadvantages of the ice harvester system is that the dimensions of the storage tank must be larger than that of the ice-on-coil device. In addition, control of the ice harvester system is more difficult, and there is a significant heat gain from the ice removal process. The benefit of the ice harvester system is that the evaporating temperature can be maintained higher than the evaporating temperature of the ice-on-coil device. As a result, the refrigeration cycle will operate at a more favorable COP. For more information, see *Ice Storage (Direct)* in the *BLAST Technical Reference*.

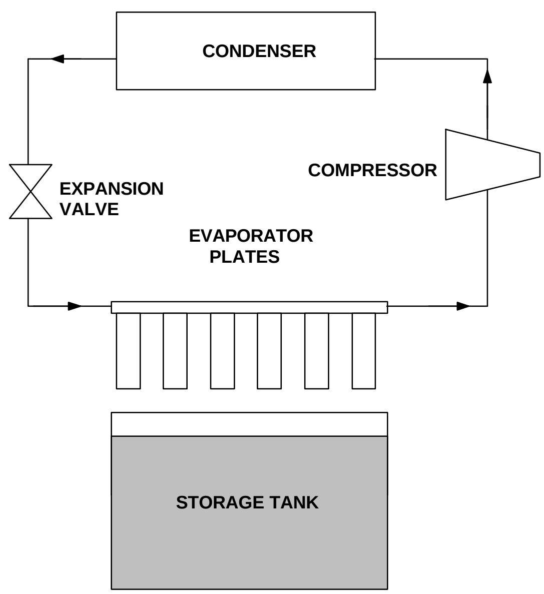


Figure 66. Diagram of a BLAST ice harvester

USING THE BLAST ICE HARVESTER:

Specifying a Ice Harvester in HBLC

To specify an Ice Harvester as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on "Add" equipment and choose "Ice Harvester" from the "Thermal Storage" sub-menu. Fill in the capacity of the ice harvester. HBLC will only allow one thermal storage device per plant.

Adjusting the Performance Parameters of the Ice Harvester

Once the Ice Harvester has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will, in most cases, allow a valid simulation for an Ice Harvester. The parameters should be studied closely and tailored to a specific use on the storage device.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

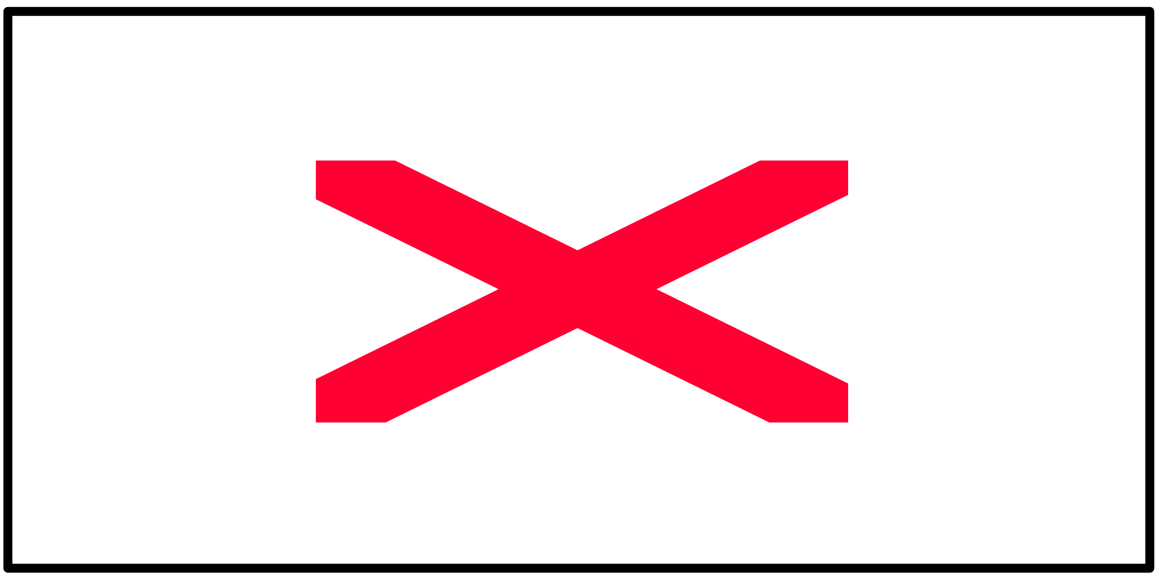
Parameter Descriptions:

STORE1- Used to calculate evaporator temperature performance.

STORE2- Used to calculate the condenser performance.

STORE3- Used to calculate the compressor capacity performance.

STORE4- Used to calculate the compressor capacity performance



STORE5- Used to calculate the compressor capacity and power performance.

STORE6- Used to calculate the compressor power performance.

STORE7- Used to calculate the compressor power performance and the minimum part load ratio.

STORE8- Used to calculate compressor part load ratio performance.

STORE9- Used to calculate compressor part load ratio performance.

CONTYP- Used to specify the type of condenser. (1**--**Evaporative, 2**--**air Cooled, 3--Water Cooled). Units: Dimensionless

CONDCP- Used to specify the condenser capacity. Units: kBtu/hr or kW

COMPCP- Used to specify the compressor capacity. Units: kBtu/hr or kW

REFTYP- Used to specify the refrigerant type. (1--R12, 2--R22, 3--R500, 4--R502, 5--R717). Units: Dimensionless

BGNPEAKE- Used to specify the hour beginning the on-peak period. Units: Dimensionless

ENDPEAKE- Used to specify the hour ending the on-peak period. Units: Dimensionless

COMPEF- Used to specify the compressor electric motor efficiency. Units: Dimensionless

ITGAIN- Used to specify the ice storage tank heat gain coefficient. Units: Dimensionless

IHARLS- Used to specify the ice harvester loss factor. Units: Dimensionless

ICEPAR1- Used to specify the parasitic loss factor during the melting phase. Units: Dimensionless

ICEPAR2- Used to specify the parasitic loss factor during the building phase. Units: Dimensionless

ICECTL- Used to specify the ice storage control strategy. (1--Full Storage, 2--Compressor Aided, 3--Shave, 4--Parallel Evaporator). Units: Dimensionless

PSHAVE- Used to specify the cooling not met by ice storage device. Units: Dimensionless

ICETYPE- Used to specify ice storage type (1--Ice-on-Coil, 2--Ice Harvester, 3--Ice Containers, 4--Ice Tanks). Units: Dimensionless

OFFPKI- Used to specify the off-peak period in more detail (1--All days have an on-peak period, 2--Entire weekend is considered off-peak, 3--Entire weekend and all holidays are considered off-peak). Units: Dimensionless

OFFPEAKC- Used to specify the off-peak charging control strategy (1--Equalized, 2--Full On with Delay, 3--Near Optimal). Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the ice harvester syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the ice harvester. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well. Additional information on the parameters can be found under *Ice Storage (Direct)* in the *BLAST Technical Reference*. The equipment assignment syntax shown below in italics is an advanced option, not available through HBLC. For more information, please see *Equipment Assignment* in the BLAST User Reference.

ICE HARVESTER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE HARVESTER:
1 OF SIZE 400;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(0.88768,-0.029155,0.0114526);
STORE2(0.33063,0.666443,0.0363369);
STORE3(30.9,33.44215,117.17);
STORE4(0.2136,-0.008037,-20.9236);
STORE5(77.6275,6.547,-15.8978);
STORE6(3.3219,-0.04873,0.00283277);
STORE7(8.4733,-2.1728,0.1);
STORE8(10.5069,-20.3086,9.8415);
STORE9(-2.45402,0.422024,3.12814);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=400;
COMPCP=320;
REFTYP=2;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
IHARLS=0.033;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=2;
OFFPKI=1;
OFFPEAKC=2;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

ICE HARVESTER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE HARVESTER:
1 OF SIZE 100;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
```

```
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(0.88768,-0.029155,0.0114526);
STORE2(0.33063,0.666443,0.0363369);
STORE3(30.9,33.44215,117.17);
STORE4(0.2136,-0.008037,-20.9236);
STORE5(77.6275,6.547,-15.8978);
STORE6(3.3219,-0.04873,0.00283277);
STORE7(8.4733,-2.1728,0.1);
STORE8(10.5069,-20.3086,9.8415);
STORE9(-2.45402,0.422024,3.12814);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=107.0;
COMPCP=85.0;
REFTYP=2;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
IHARLS=0.033;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=2;
OFFPKI=1;
OFFPEAKC=2;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Ice Storage: Ice-on-Coil

EQUIPMENT DESCRIPTION:

The BLAST direct ice storage model was developed for the purpose of simulating two types of ice storage configurations which build ice directly on the evaporator. The ice-on-coil ice storage device uses a vapor compression refrigeration cycle with the evaporator coils, in the shape of tubes, submerged in a tank of water. The evaporating temperature is maintained low enough to induce the water to freeze on the outside of the evaporator coils. As the refrigeration cycle operates, ice builds on the outside of the evaporator coils. One of the problems with the ice-on-coil system is that as ice forms on the coils the thermal resistance to heat flow increases, and the evaporating temperature must be reduced to continue the ice formation. The reduced evaporating temperature will lower the coefficient of performance (COP) of the refrigeration cycle. For more information, see *Ice Storage (Direct)* in the *BLAST Technical Reference*.

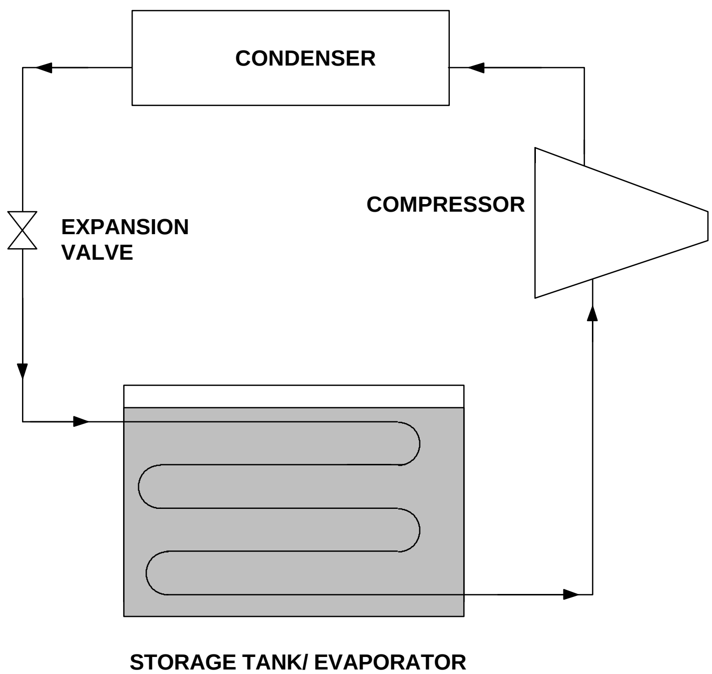


Figure 67. Diagram of a BLAST ice-on-coil

USING THE BLAST ICE-ON-COIL:

Specifying a Ice-on-Coil in HBLC

To specify an Ice-on-Coil as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Ice on Coil” from the “Thermal Storage” sub-menu. Fill in the capacity of the Ice on Coil.

Adjusting the Performance Parameters of the Ice-on-Coil

Once the Ice-on-Coil has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will, in most cases, allow a valid simulation for an Ice-on-Coil. The parameters should be studied closely and tailored to a specific use on the storage device.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

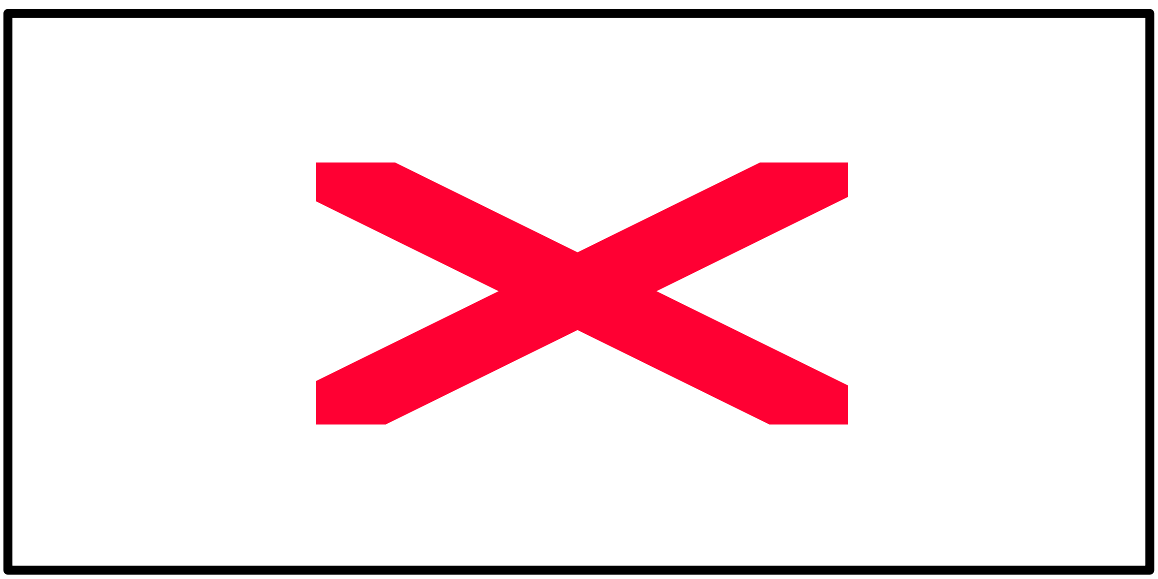
Parameter Descriptions:

STORE1- Used to calculate evaporator temperature performance.

STORE2- Used to calculate the condenser performance.

STORE3- Used to calculate the compressor capacity performance.

STORE4- Used to calculate the compressor capacity performance.



STORE5- Used to calculate the compressor capacity and power performance.

STORE6- Used to calculate the compressor power performance.

STORE7- Used to calculate the compressor power performance and the minimum part load ratio.

STORE8- Used to calculate compressor part load ratio performance.

STORE9- Used to calculate compressor part load ratio performance.

CONTYP- Used to specify the type of condenser. (1--Evaporative, 2--Air Cooled, 3--Water Cooled). Units: Dimensionless

CONDCP- Used to specify the condenser capacity. Units: kBtu/hr or kW

COMPCP- Used to specify the compressor capacity. Units: kBtu/hr or kW

REFTYP- Used to specify the refrigerant type. (1--R12, 2--R22, 3--R500, 4--R502, 5--R717). Units: Dimensionless

BGNPEAKE- Used to specify the hour beginning the on-peak period. Units: Dimensionless

ENDPEAKE- Used to specify the hour ending the on-peak period. Units: Dimensionless

COMPEF- Used to specify the compressor electric motor efficiency. Units: Dimensionless

ITGAIN- Used to specify the ice storage tank heat gain coefficient. Units: Dimensionless

ICEPAR1- Used to specify the parasitic loss factor during the melting phase. Units: Dimensionless

ICEPAR2- Used to specify the parasitic loss factor during the building phase. Units: Dimensionless

CONDEL- Used to specify the condenser electric consumption factor. Units: Dimensionless

ICECTL- Used to specify the ice storage control strategy. (1--Full Storage, 2--Compressor Aided, 3--Shave, 4--Parallel Evaporator). Units: Dimensionless

PSHAVE- Used to specify the cooling not met by the ice storage device. Units: Dimensionless

ICETYPE- Used to specify ice storage type (1--Ice-on-Coil, 2--Ice Harvester, 3--Ice Containers, 4--Ice Tanks). Units: Dimensionless

OFFPKI- Used to specify the off-peak period in more detail (1--All days have an on-peak period, 2--Entire weekend is considered off-peak, 3--Entire weekend and all holidays are considered off-peak). Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the ice-on-coil syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the ice-on-coil. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well. Additional information on the parameters can be found under *Ice Storage (Direct)* in the *BLAST Technical Reference*. The equipment assignment syntax shown below in italics is an advanced option, not available through HBLC. For more information, please see *Equipment Assignment* in the BLAST User Reference.

ICE ON COIL BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE ON COIL:
1 OF SIZE 400;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(0.88768,-0.029155,0.0114526);
STORE2(0.33063,0.666443,0.0363369);
STORE3(30.9,33.44215,117.17);
STORE4(0.2136,-0.008037,-20.9236);
STORE5(77.6275,6.547,-15.8978);
STORE6(3.3219,-0.04873,0.00283277);
STORE7(8.4733,-2.1728,0.1);
STORE8(10.5069,-20.3086,9.8415);
STORE9(-2.45402,0.422024,3.12814);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=400.0;
COMPCP=320.0;
REFTYP=2;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
IHARLS=0.0;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=1;
OFFPKI=1;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

ICE ON COIL BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE ON COIL:
1 OF SIZE 100;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
```

```
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(0.88768,-0.029155,0.0114526);
STORE2(0.33063,0.666443,0.0363369);
STORE3(30.9,33.44215,117.17);
STORE4(0.2136,-0.008037,-20.9236);
STORE5(77.6275,6.547,-15.8978);
STORE6(3.3219,-0.04873,0.00283277);
STORE7(8.4733,-2.1728,0.1);
STORE8(10.5069,-20.3086,9.8415);
STORE9(-2.45402,0.422024,3.12814);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=107.0;
COMPCP=85.0;
REFTYP=2;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
IHARLS=0.0;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=1;
OFFPKI=1;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Ice Storage: Ice Container

EQUIPMENT DESCRIPTION:

The BLAST indirect ice storage model was developed for the purpose of simulating two types of ice storage configurations: ice containers and ice tanks. Containers of any shape are filled with water, sealed, and placed into a storage tank. The containers may be made of any material. A brine solution passes through the storage tank and either removes or adds heat to the containers depending upon whether the storage system is being charged or discharged. During the discharge cycle, the energy absorbed by the containers is supplied by the air conditioning system of the building. During the charging phase, the refrigeration system removes the heat which has been absorbed by the phase change in the containers. For more information, see *Ice Storage(Indirect) in the BLAST Technical Reference*.

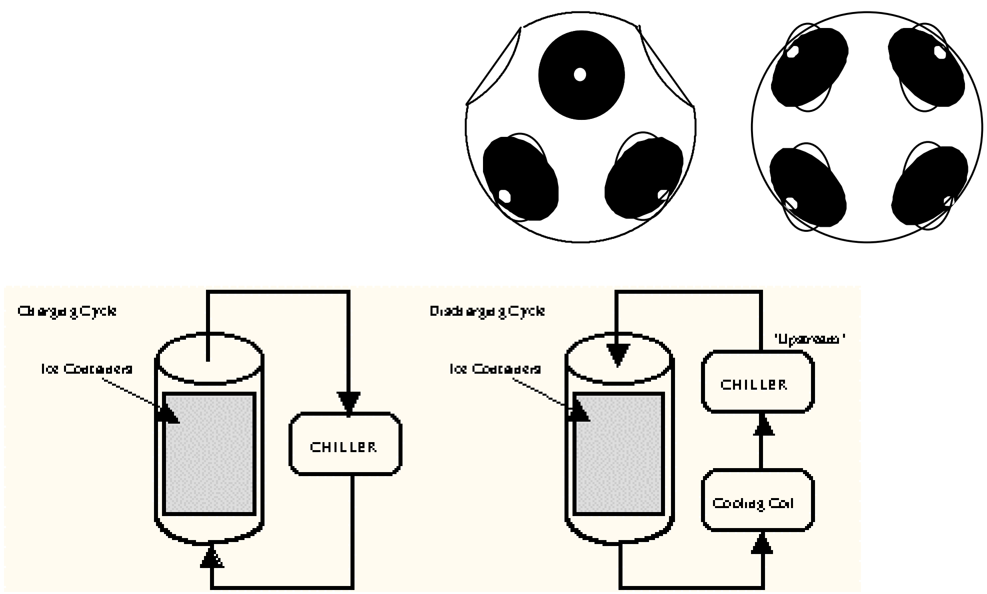


Figure 68. Diagram of a BLAST ice container system

USING THE BLAST ICE CONTAINER SYSTEM:

Specifying a Ice Container System in HBLC

To specify Ice Containers as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Ice Container” from the “Thermal Storage” sub-menu. Fill in the latent storage capacity of the Ice Containers (kBtu or kW-hr).

Adjusting the Performance Parameters of Ice Containers

Once the Ice Containers have been added using HBLC, the user must specify operating rules and parameters for the component. If these rules are not specified by the user, default parameters will be used. The default parameters specified by HBLC will, in most cases, allow a valid simulation for Ice Containers. The parameters should be studied closely and tailored to a specific use on the storage device.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

STORE1- Used to calculate discharging performance.

STORE2- Used to calculate discharging performance.

STORE3- Used to calculate discharging performance.

STORE4- Used to calculate discharging performance.

STORE5- Used to calculate charging performance.

STORE6- Used to calculate charging performance.

STORE7- Used to calculate charging performance.

STORE8- Used to calculate charging performance.

STORE9- Used to specify the time step of the performance model.

CPUMP- Used to determine the electric consumption of the chilled water (brine) pumps.

ADJTIC- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature of the ice storage chiller.

RCAVIC- Used to adjust the chiller capacity based on the equivalent temperature difference of the ice storage chiller.

COPCIC- Used to calculate the actual coefficient of performance of the ice storage chiller.

POW1IC- Used to determine the fraction of full load power of the ice storage chiller.

POW2IC- Used to determine the fraction of full load power of the ice storage chiller.

POW3IC- Used to determine the fraction of full load power of the ice storage chiller.

CONTYP- Used to specify the type of condenser. (1**--**Evaporative, 2**--**Air Cooled, 3**--**Water Cooled). Units: Dimensionless

CONDCP- Used to specify the condenser capacity. Units: kBtu/hr or kW

COMPCP- Used to specify the ice storage chiller capacity. Units: kBtu/hr or kW

BGNPEAKE- Used to specify the hour beginning the on-peak period. Units: Dimensionless

ENDPEAKE- Used to specify the hour ending the on-peak period. Units: Dimensionless

COMPEF- Used to specify the compressor electric motor efficiency. Units: Dimensionless

ITGAIN- Used to specify the ice storage tank heat gain coefficient. Units: Dimensionless

ICEPAR1- Used to specify the parasitic loss factor during the melting phase. Units: Dimensionless

ICEPAR2- Used to specify the parasitic loss factor during the building phase. Units: Dimensionless

CONDEL- Used to specify the condenser electric consumption factor. Units: Dimensionless

ICECTL- Used to specify the ice storage control strategy. (1--Full Storage, 3--Ice Priority, 4--Chiller Priority) Units: Dimensionless

PSHAVE- Used to specify the on-peak cooling met by ice storage chiller (Ice Priority). Units: Dimensionless

ICETYPE- Used to specify ice storage type (1--Ice-on-Coil, 2--Ice Harvester, 3--Ice Containers, 4--Ice Tanks). Units: Dimensionless

CHILLOPT- Used to specify the chiller placement with respect to the ice storage unit (1--Chiller Upstream, 2--Chiller Downstream, 3--Chiller Parallel). Units: Dimensionless

BRINECP- Used to specify the specific heat of the brine solution which is circulated through the ice storage unit. Units: Btu/lbm-°R or kJ/kg-K

CHFLRATE- Used to specify the maximum brine flow rate through the ice storage unit. Units: ft^3/min or m^3/s

CRENTEMP- Used to specify the maximum allowable fan system return temperature. Units: °F or °C

TCOOL- Used to specify the desired brine temperature entering the cooling coil. Units: °F or °C

OFFPEAKC- Used to specify the off-peak charging control strategy (1--Equalized, 2--Full On with Delay, 3--Near Optimal). Units: Dimensionless

BGNCHARG- Used to specify the hour in which charging is to begin (for the Full On with Delay charging strategy. Units: Dimensionless

DACTCOP- Used to specify the design actual coefficient of performance of the ice storage chiller. Units: Dimensionless

DCARCOP- Used to specify the design Carnot coefficient of performance of the ice storage chiller. Units: Dimensionless

TFREEZE- Used to specify the freezing temperature of the storage material (usually water). Units: °F or °C

OFFPKI- Used to specify the off-peak period in more detail (1**--**All days have an on-peak period, 2**--**Entire weekend is considered off-peak, 3**--**Entire weekend and all holidays are considered off-peak). Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND-Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the ice container syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model ice containers. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.. The default values shown were developed for the Cryogel 103 Ice Ball. Additional information on specifying customized parameters can be found under *Ice Storage (Indirect)* in the *BLAST Technical Reference*. The equipment assignment syntax shown below in italics is an advanced option, not available through HBLC. For more information, please see *Equipment Assignment* in the BLAST User Reference.

ICE CONTAINER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE CONTAINER:
1 OF SIZE 400;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.0000);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(-0.0264061,0.433831,-2.29525);
STORE2(5.37263,-5.45085,1.96304);
STORE3(1.41221,-8.03277,28.4556);
STORE4(-52.555,46.8684,-16.1022);
STORE5(0.209654,-1.75471,5.79567);
STORE6(-9.53262,7.84942,-2.57852);
STORE7(0.988275,-2.88575,7.24962);
STORE8(-11.0238,8.53979,-2.6827);
STORE9(0.0,0.0,1.0);
CPUMP(1.0,0.0,0.0);
ADJTIC(85.0,3.6,45.0);
RCAVIC(0.99528,-0.018903,0.000051146);
COPCIC(-0.191,1.5657,-0.3847);
POW1IC(0.4243,-0.26654,0.16104);
POW2IC(-0.60555,1.2683,-0.31791);
POW3IC(1.1725,-0.97465,0.14351);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=400;
COMPCP=320;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=3;
CHILLOPT=1;
BRINECP=0.91;
CHFLRATE=0.0
CRENTEMP=61.3;
TCOOL=44.0;
OFFPEAKC=2;
BGNCHARG=18;
DACTCOP=5.07;
DCARCOP=12.62;
TFREEZE=32.0;
OFFPKI=1;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
```

```
END CENTRAL PLANT DESCRIPTION;
```

ICE CONTAINER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE CONTAINER:
1 OF SIZE 100;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.0000);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(-0.0264061,0.433831,-2.29525);
STORE2(5.37263,-5.45085,1.96304);
STORE3(1.41221,-8.03277,28.4556);
STORE4(-52.555,46.8684,-16.1022);
STORE5(0.209654,-1.75471,5.79567);
STORE6(-9.53262,7.84942,-2.57852);
STORE7(0.988275,-2.88575,7.24962);
STORE8(-11.0238,8.53979,-2.6827);
STORE9(0.0,0.0,1.0);
CPUMP(1.0,0.0,0.0);
ADJTIC(29.44,3.6,7.22);
RCAVIC(0.99528,-0.018903,0.000051146);
COPCIC(-0.191,1.5657,-0.3847);
POW1IC(0.4243,-0.26654,0.16104);
POW2IC(-0.60555,1.2683,-0.31791);
POW3IC(1.1725,-0.97465,0.14351);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=107.0;
COMPCP=85.0;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=3;
CHILLOPT=1;
BRINECP=3.80;
CHFLRATE=0.0
CRENTEMP=61.3;
TCOOL=44.0;
OFFPEAKC=2;
BGNCHARG=18;
DACTCOP=5.07;
DCARCOP=12.62;
TFREEZE=0.0;
OFFPKI=1;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
```

```
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Ice Storage: Ice Tank

EQUIPMENT DESCRIPTION:

The BLAST indirect ice storage model was developed for the purpose of simulating two types of ice storage configurations: ice containers and ice tanks. Ice tanks are based upon the same concept that lead to the ice-on-coil system. The main difference between the ice-on-coil system and an ice tank is the location of the ice storage. In an ice-on-coil system, ice is stored directly on the evaporator. In an ice tank, ice is stored in a remote location, and energy is transferred through the use of a brine solution. One of the main advantages of the ice tank system over the ice-on-coil system is that it thaws from the inside out. The ice-on-coil melts ice by circulating water around the ice covered coils, thus thawing the ice from the outside toward the inside. If all of the stored ice is used the next day, there is no difference between the two systems. However, if there is ice remaining after the on-peak period, the ice tank system is more efficient because it starts freezing on a "bare" coil. An ice-on-coil system must build on the remaining ice which inhibits the heat transfer process. For more information, see *Ice Storage (Indirect)* in the *BLAST Technical Reference*.

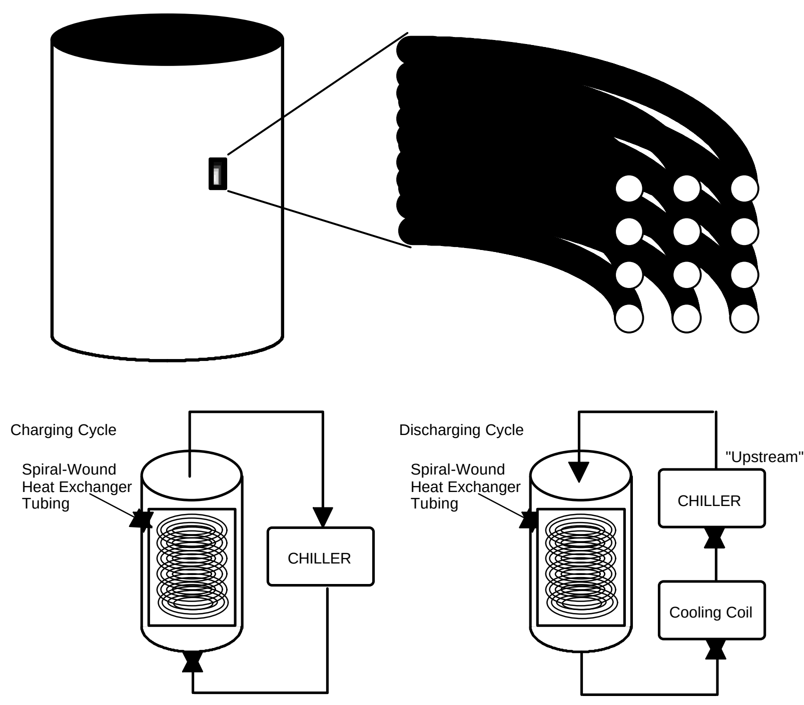


Figure 69. Diagram of a BLAST ice tank system

USING THE BLAST ICE TANK SYSTEM:

Specifying an Ice Tank System in HBLC

To specify an Ice Tank as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Ice Tank” from the “Thermal Storage” sub-menu. Specify the total latent storage capacity of the Ice Tank (kBtu or kW-hr).

Adjusting the Performance Parameters of an Ice Tank

Once the Ice Tank has been added using HBLC, the user must specify operating rules and parameters for the component. If these rules are not specified by the user, default parameters will be used. The default parameters specified by HBLC will, in most cases, allow a valid simulation for an Ice Tank. The parameters should be studied closely and tailored to a specific use on the storage device.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

STORE1- Used to calculate discharging performance.

STORE2- Used to calculate discharging performance.

STORE3- Used to calculate discharging performance.

STORE4- Used to calculate discharging performance.

STORE5- Used to calculate discharging and charging performance.

STORE6- Used to calculate charging performance.

STORE7- Used to calculate charging performance.

STORE8- Used to calculate charging performance.

STORE9- Used to calculate charging performance and to specify the time step of the performance model.

CPUMP- Used to determine the electric consumption of the chilled water (brine) pumps.

ADJTIC- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature of the ice storage chiller.

RCAVIC- Used to adjust the chiller capacity based on the equivalent temperature difference of the ice storage chiller.

COPCIC- Used to calculate the actual coefficient of performance of the ice storage chiller.

POW1IC- Used to determine the fraction of full load power of the ice storage chiller.

POW2IC- Used to determine the fraction of full load power of the ice storage chiller.

POW3IC- Used to determine the fraction of full load power of the ice storage chiller.

CONTYP- Used to specify the type of condenser. (1**--**Evaporative, 2**--**Air Cooled, 3**--**Water Cooled). Units: Dimensionless

CONDCP- Used to specify the condenser capacity. Units: kBtu/hr or kW

COMPCP- Used to specify the ice storage chiller capacity. Units: kBtu/hr or kW

BGNPEAKE- Used to specify the hour beginning the on-peak period. Units: Dimensionless

ENDPEAKE- Used to specify the hour ending the on-peak period. Units: Dimensionless

COMPEF- Used to specify the compressor electric motor efficiency. Units: Dimensionless

ITGAIN- Used to specify the ice storage tank heat gain coefficient. Units: Dimensionless

ICEPAR1- Used to specify the parasitic loss factor during the melting phase. Units: Dimensionless

ICEPAR2- Used to specify the parasitic loss factor during the building phase. Units: Dimensionless

CONDEL- Used to specify the condenser electric consumption factor. Units: Dimensionless

ICECTL- Used to specify the ice storage control strategy. (1--Full Storage, 3--Chiller Priority, 4--Ice Priority) Units: Dimensionless

PSHAVE- Used to specify the on-peak cooling met by ice storage chiller (Ice Priority). Units: Dimensionless

ICETYPE- Used to specify ice storage type (1--Ice-on-Coil, 2--Ice Harvester, 3--Ice Containers, 4--Ice Tanks). Units: Dimensionless

CHILLOPT- Used to specify the chiller placement with respect to the ice storage unit (1--Chiller Upstream, 2--Chiller Downstream, 3-- Chiller Parallel). Units: Dimensionless

HXFLMASS- Used to specify the mass of brine solution in the heat exchanger tubing of the ice tank at any one time. Units: lbm or kg

BRINECP- Used to specify the specific heat of the brine solution which is circulated through the ice storage unit. Units: Btu/lbm-°R or kJ/kg-K

CHFLRATE- Used to specify the maximum brine flow rate through the ice storage unit. Units: ft^3/min or m^3/s

CRENTEMP- Used to specify the maximum allowable fan system return temperature. Units: °F or °C

TCOOL- Used to specify the desired brine temperature entering the cooling coil. Units: °F or °C

OFFPEAKC- Used to specify the off-peak charging control strategy (1--Equalized, 2--Full On with Delay, 3--Near Optimal). Units: Dimensionless

BGNCHARG- Used to specify the hour in which charging is to begin (for the Full On with Delay charging strategy. Units: Dimensionless

DACTCOP- Used to specify the design actual coefficient of performance of the ice storage chiller. Units: Dimensionless

DCARCOP- Used to specify the design Carnot coefficient of performance of the ice storage chiller. Units: Dimensionless

TFREEZE- Used to specify the freezing temperature of the storage material (usually water). Units: °F or °C

OFFPKI- Used to specify the off-peak period in more detail (1**--**All days have an on-peak period, 2**--**Entire weekend is considered off-peak, 3**--**Entire weekend and all holidays are considered off-peak). Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the ice container syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model an ice tank. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well. The default values shown were developed for the Calmac Levload® Ice Bank (Models 1190 and 1500). Additional information on specifying customized parameters can be found under *Ice Storage (Indirect)* in the *BLAST Technical Reference*. The equipment assignment syntax shown below in italics is an advanced option, not available through HBLC. For more information, please see *Equipment Assignment* in the BLAST User Reference.

ICE TANK BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE TANK:
1 OF SIZE 400;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.0000);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(1.01297,0.05275487,-0.0515545);
STORE2(0.188784,-0.250814,0.136869);
STORE3(-0.0316664,0.368242,-0.398827);
STORE4(0.307811,-1.44751,2.33563);
STORE5(-0.011931,-0.0553311,-0.630517);
STORE6(4.07107,3.97124,-4.58788);
STORE7(0.0785825,-0.106416,-0.836916);
STORE8(1.10458,15.7629,-22.1439);
STORE9(54.9895,-65.8297,1.0);
CPUMP(1.0,0.0,0.0);
ADJTIC(85.0,3.6,45.0);
RCAVIC(0.99528,-0.018903,0.000051146);
COPCIC(-0.191,1.5657,-0.3847);
POW1IC(0.4243,-0.26654,0.16104);
POW2IC(-0.60555,1.2683,-0.31791);
POW3IC(1.1725,-0.97465,0.14351);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=400;
COMPCP=320;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=4;
CHILLOPT=1;
HXFLMASS=4100.0;
BRINECP=0.91;
CHFLRATE=0.0
CRENTEMP=61.3;
TCOOL=44.0;
OFFPEAKC=2;
BGNCHARG=18;
DACTCOP=5.07;
DCARCOP=12.62;
TFREEZE=32.0;
OFFPKI=1;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
```

```
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

ICE TANK BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ICE STORAGE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ICE TANK:
1 OF SIZE 100;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
END SCHEDULE;
EQUIPMENT ASSIGNMENT:
COOLING:
FROM 01JAN THRU 31DEC:
FOR LOAD = 5000 USE CHILLER (0),
ICE STORAGE (1);
END EQUIPMENT ASSIGNMENT;
PART LOAD RATIOS:
ICE STORAGE(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.0000);
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
STORE1(1.01297,0.05275487,-0.0515545);
STORE2(0.188784,-0.250814,0.136869);
STORE3(-0.0316664,0.368242,-0.398827);
STORE4(0.307811,-1.44751,2.33563);
STORE5(-0.011931,-0.0553311,-0.630517);
STORE6(4.07107,3.97124,-4.58788);
STORE7(0.0785825,-0.106416,-0.836916);
STORE8(1.10458,15.7629,-22.1439);
STORE9(54.9895,-65.8297,1.0);
CPUMP(1.0,0.0,0.0);
ADJTIC(29.44,3.6,7.22);
RCAVIC(0.99528,-0.018903,0.000051146);
COPCIC(-0.191,1.5657,-0.3847);
POW1IC(0.4243,-0.26654,0.16104);
POW2IC(-0.60555,1.2683,-0.31791);
POW3IC(1.1725,-0.97465,0.14351);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CONTYP=1;
CONDCP=107.0;
COMPCP=85.0;
BGNPEAKE=10;
ENDPEAKE=18;
COMPEF=0.975;
ITGAIN=0.00108;
ICEPAR1=0.0;
ICEPAR2=0.0012;
CONDEL=0.0042;
ICECTL=1;
PSHAVE=0.0;
ICETYPE=4;
CHILLOPT=1;
HXFLMASS=1860.0;
BRINECP=3.80;
CHFLRATE=0.0
CRENTEMP=61.3;
TCOOL=44.0;
OFFPEAKC=2;
BGNCHARG=18;
DACTCOP=5.07;
DCARCOP=12.62;
TFREEZE=0.0;
OFFPKI=1;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
```

```
FORSYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Infiltration

Infiltration rates in BLAST are adjusted each hour according to the weather conditions. The equations used for INFILTRATION are explained below. The optional coefficients vary the infiltration according to wind speed and temperature based on the following equation:

$$I_{act} = I_{\max} * F_{sch} * (A + B * [T_{zone} - T_{odb}] + C * W_{spd} + D * W_{spd}^2$$

where:

I_{act} = the actual infiltration ft³/min (m³/sec),

$I_{\max}$ = the maximum infiltration specified by the user (usn1),

F_{sch} = fractional infiltration from the user-specified library schedule (schedname),

T_{zone} = the inside temperature,

T_{odb} = the outside temperature,

W_{spd} = the wind speed,

A = first user-specified coefficient; default value = 0.606,

B = second user-specified coefficient; default value = 0.0202(1/°F)(0.036[1/°C]),

C = third user-specified coefficient; default value = 0.000598 min/ft (0.1177 s/m),

D = fourth user-specified coefficient; default value = 0.0 min²/ft² (0.0

Users who wish to have a constant infiltration rate (subject to the schedule used for infiltration) should set A equal to 1 and the other coefficients equal to 0. In BLAST, peak infiltration is the amount of infiltration which occurs at 7.5 mph (3.35 m/s) wind speed and a 0°F (0°C) zone to ambient temperature difference, i.e., a typical summer condition.

Specifying Infiltration in HBLC

Infiltration can be specified in HBLC using the “Scheduled Loads” form located under the “Environment” tab on the menu bar, as mentioned in Building Loads.

Enter the Infiltration **Parameters** described above and in the *BLAST Overview*

When infiltration is specified, the sensible portion of the infiltration ($\dot{m}$ $*c_p*\Delta T$) is calculated in the loads section and is displayed in the infiltration heat gain/loss columns in the Zone Loads report. The sensible portion of the infiltration affects the heating or cooling load shown in the Zone Loads report. For example, if an infiltration heat gain exists, the cooling load is increased.

The latent portion of the infiltration is accounted for in the fan system simulation. A moisture balance on the zone air is performed which includes the effects of latent loads from occupants, infiltration, equipment, and ventilation. The mass of water added to the moisture balance by the infiltration is equal to the mass flow rate of infiltration air multiplied by the outside air humidity ratio.

Internal Mass

It is a common practice to model zones by defining only the envelope surfaces and ignoring internal partitions and the zone contents. This often produces anomalous results because of the effect of radiant interchange. The statement INTERNAL MASS allows the user to overcome this problem. The description for INTERNAL MASS is the same as the minimum description of a partition. The wall type should be selected to represent the average conductive properties of the internal partitions and zone contents. The expression "(width BY height)" should be selected to give an area equal to the total surface area exposed to the zone (e.g., both sides of internal partitions). When significantly different materials are present, it may be necessary to use more than one INTERNAL MASS statement.

Specifying Internal Mass in HBLC

Internal mass can be specified in HBLC in the same way that a surface is specified from the “Zone Roof/Floor/Internal Mass” form under the “Geometry” menu bar tab. (The form can also be activated by double clicking on the body of the zone.)

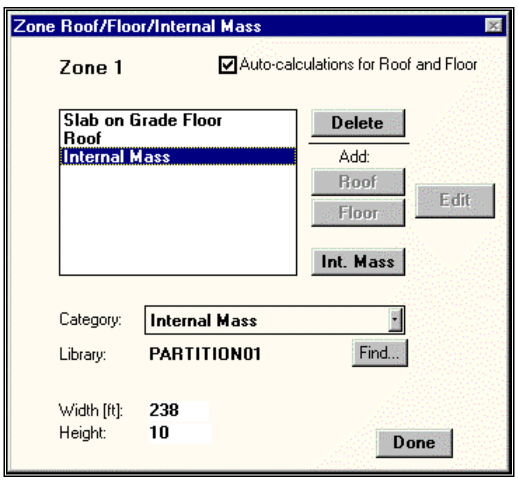


Figure 70. Zone Roof/Floor/Internal Mass form

Internal Mass Versus Interior Partitions

In deciding whether to treat interior walls which are fully contained in a zone as PARTITIONS or as INTERNAL MASS, the level of accuracy of the solar calculations must be considered. An INTERNAL MASS does not receive beam radiation directly, but it does receive diffuse radiation. The internal mass also transfers heat by convection to the zone air and by radiation to the mean radiant temperature[†]. The mean radiant temperature is defined as the sum of area times emissivity times surface temperature divided by the sum of area times emissivity for all surfaces in a zone.

If distribution of the effects of beam solar radiation are not needed (SOLAR DISTRIBUTION = 0 OR -1) then the interior wall can be described as

INTERNAL MASS or a PARTITION. These will be computationally equivalent provided the areas, masses, and various other wall parameters are entered correctly .

If a more detailed distribution of beam solar radiation is desired (SOLAR DISTRIBUTION = 1), then describing the interior wall as a PARTITION is not permitted. It must either be described as internal mass or as two separate zones with an interzone PARTITION. The reason for this stems from the fact that no surfaces can be enclosed in a zone SOLAR DISTRIBUTION = 1.

The appropriate parameters to be entered for both cases are as follows:

1. When entering a wall as an INTERNAL MASS, enter the total wall surface area exposed to the zone, including both sides of the wall. Enter the wall thickness, length, wall type, etc. as you would for any wall.

2. When entering a wall as a PARTITION, input the PARTITION two times, one time for each orientation. The area of one side of the wall is entered for each orientation. BLAST will automatically take one half of the mass for each orientation.

Surface Type	Solar Distribution	
	0 or -1	+1
Internal Mass	Simple Solar Heat Storage Only	Detailed Solar Heat Storage Only
Partition	Simple Solar Heat Storage Only	Not Allowed
Interzone Partition	Simple Solar Interzone Heat Transfer	Detailed Solar Interzone Heat Transfer

Table 18. Internal structure relationships with solar distribution

Library Modifications

The BLAST library is divided into 11 sections:

SCHEDULE	contains hourly and daily profiles used to schedule lighting, equipment, occupancy, and infiltration
LOCATION	contains latitude, longitude, and time zone data used to perform design day simulations
DESIGN DAYS	contains selected weather data for design or peak conditions
CONTROLS	contains hourly and daily zone temperature control strategies
MATERIALS	contains thermodynamic and optical properties of common construction materials (used to define walls, roofs, floors, windows, and doors)
WALLS	contains wall and partition sections
ROOF	contains roof and ceiling sections
FLOORS	contains interior and exterior floor sections
DOORS	contains door sections
WINDOWS	contains window sections

Each library section contains descriptions associated with unique names. These names are used to refer to these descriptions in other sections of the BLAST input. For example, in the WALLS section, the name EXTWALL04 refers to a description of a wall section. When this name is used in the BLAST input, information on each of the materials which make up the wall is automatically extracted from the library. This information may typically include a material name, thickness, density, and other properties.

The library distributed with the program contains materials and constructions from the *ASHRAE Handbook of Fundamentals*.

Libraries are easy to change using HBLC. The commands below are used for library modification using BTEXT. The user can change the library using any of four commands

TEMPORARY

DEFINE

REDEFINE

DELETE

TEMPORARY defines an entry with either a new or old name for the current simulation only. This is the command which most users should use. DEFINE, REDEFINE, and DELETE *permanently* change the users version of the BLAST Library.

DEFINE adds data stored under a new name to the library.

REDEFINE replaces old data with new data stored under an existing name in the library.

DELETE erases both name and data from the library.

Detailed examples of how to define temporary library entries are shown under each of the 11 library headings (SCHEDULE, LOCATION, DESIGN DAYS, CONTROLS, etc.) Simply replace the word TEMPORARY in the syntax of the input file to use either DEFINE or REDEFINE. The scripts or batch files that copy and delete the library must also be modified. The DELETE command is implemented as follows:

DELETE section (library name):

END section;

Example:

```
DELETE SCHEDULE (OFFICE OCCUPANCY):
END SCHEDULE;
```

Lights

Lighting energy is calculated as a part of the electric load in a zone. The total amount of electrical energy consumed by the lights is equal to (bulb wattage) x (ballast factor) at the peak lighting level. Off peak lighting usage is taken into account by the schedule name entry. For each hour of the day, the peak lighting level is multiplied by the appropriate factor (0-1) in the schedule as defined in the BLAST library or in the lead input section of the BLAST input file.

PERCENT RETURN AIR is used to specify the percent of the energy that is removed immediately from the room by the return air vents. This portion of the lighting energy is never seen as a load on the zone. The default value is zero percent.

The remaining amount of lighting energy is either seen as immediate convective load or is radiated to the zone surfaces where it is absorbed and re-emitted later. This radiated energy is of two types, that which falls within the thermal spectrum and that which falls within the visible spectrum. The percentage of radiant energy from the lights that fall within the thermal spectrum is given by the entry PERCENT RADIANT. The percentage of radiant energy that falls within the solar spectrum is given by the entry PERCENT VISIBLE. Default values for PERCENT RADIANT and PERCENT VISIBLE are both 20 percent and are appropriate for fluorescent lights. Values of 80 percent radiant and 10 percent visible are appropriate for incandescent lights.

PERCENT REPLACEABLE is used in conjunction with the DAYLIGHT statement which may also be specified by the user in the Building Description section of the BLAST input deck.

Specifying Lights in HBLC

Lights can be specified in HBLC using the following methods given in Building Loads. Open the Scheduled Loads form, and click on the “Lights” tab. Enter the **Parameters** described in the *BLAST Overview*

Minimum Air Fraction for VAV Systems

BLAST offers three different ways to specify the minimum air fraction of variable air volume fan systems. The minimum air fraction for an entire system can be set to a constant value by entering the appropriate value using the VAV MINIMUM AIR FRACTION syntax in the Other System Parameters Data Block. The minimum air fraction for individual zones can be specified by providing the MINIMUM AIR FRACTION syntax in the Zone Data Block. Finally, the VAV MINIMUM AIR FRACTION SCHEDULE can be used to vary the minimum air fraction for the entire system on an hourly basis.

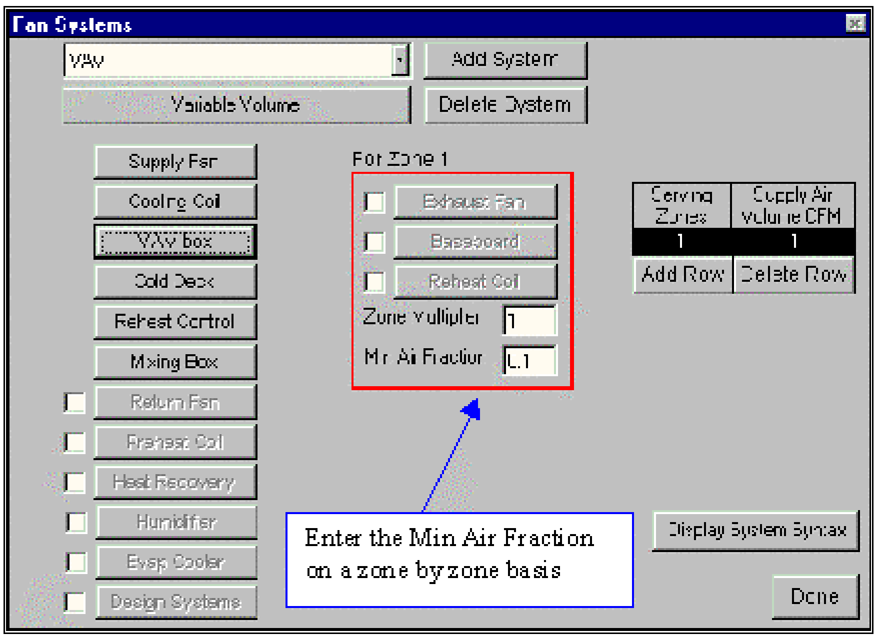


Figure 71. One way to set the minimum air fraction in HBLC

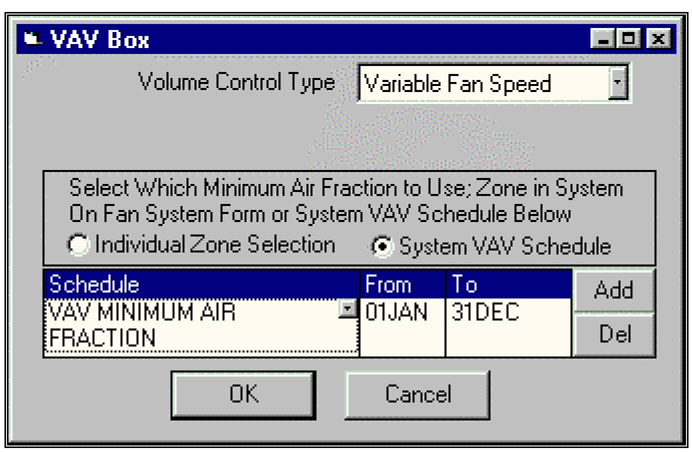


Figure 72. HBLC will override the previous method of setting the minimum air fraction

Of these parameters, the MINIMUM AIR FRACTION defined in the Zone Data Block takes precedence over the other values. In addition, the VAV MINIMUM AIR FRACTION SCHEDULE takes precedence over the value specified in the Other System Parameters Data Block. An example of this is shown below.

Note: HBLC will not allow the user to specify more than one minimum air fraction. The example below would have to be created using BTEXT or manually created with a text editor.

```
BEGIN FAN SYSTEM DESCRIPTION;
  VARIABLE VOLUME SYSTEM 1
  "VAV EXAMPLE" SERVING ZONES 1, 2;
    FOR ZONE 1:
      ...
      MINIMUM AIR FRACTION=0.4;
      ...
    END ZONE;
    FOR ZONE 2:
      ...
    END ZONE;
    OTHER SYSTEM PARAMETERS:
      ...
      VAV MINIMUM AIR FRACTION=0.2;
      ...
    END OTHER SYSTEM PARAMETERS;
    ...
    EQUIPMENT SCHEDULES:
      ...
      VAV MINIMUM AIR FRACTION SCHEDULE
              = VAVMAFSCHED,
                                    FROM 01JAN THRU 31DEC;
      ...
```

In this example, the minimum air fraction of zone 1 will always be 0.4. For zone 2, the minimum air fraction will be defined by the hourly value of the schedule VAVMAFSCHED.

Mixed Air Control

The mixed air controls in BLAST allow several methods for controlling outside air volumes in the fan system simulations. Any of the following parameters may apply to a given fan system: MIXED AIR CONTROL, DESIRED MIXED AIR TEMPERATURE, OUTSIDE AIR VOLUME, MINIMUM VENTILATION SCHEDULE, MAXIMUM VENTILATION SCHEDULE, and EXHAUST AIR VOLUME. The five types of MIXED AIR CONTROL are listed below with equations to describe how the volume of outside air is calculated. The following variables are used:

VOL_x = volume of outside air introduced for hour x

$MINVS_x$ MINVS$_x$= MINIMUM VENTILATION SCHEDULE for hour x

$MAXVS_x$ MAXVS$_x$= MAXIMUM VENTILATION SCHEDULE for hour x

OAV= OUTSIDE AIR VOLUME (specified in input)

SSV_x SSV$_x$= system supply for hour x

(note that this is not constant for variable volume systems)

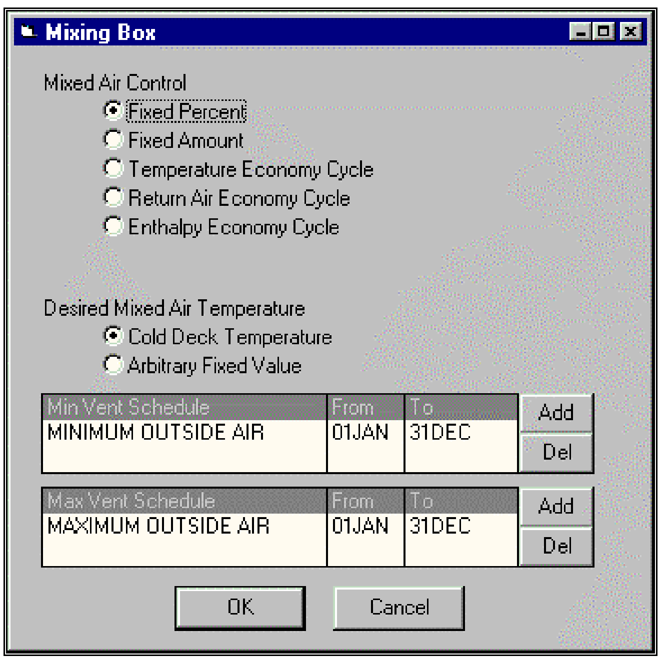


Figure 73. Mixing Box form, accessed from the Fan Systems form with a multizone system selected

1. *MIXED AIR CONTROL* = FIXED PERCENT

If a FIXED PERCENT is specified, the MINIMUM VENTILATION SCHEDULE determines the outside air supplied as a fraction of the total air supply during any hour. (This same MINIMUM VENTILATION SCHEDULE also determines the minimum fraction of outside air when economy cycles are used; see following sections.) The minimum outside air introduced is never less than the sum of the exhaust air flow specified for the zones on the air handler whenever the fan is running. Thus, a fixed minimum outside air amount for variable volume systems using economy cycles can be specified by selecting EXHAUST AIR VOLUME amounts for each zone which sum to the desired fixed amount of outside air, but this air would be exhausted and not returned to the mixed air box.

$$VOL_x = MINVS_x * SSV_x$$

VOL_x cannot be less than the sum of zone EXHAUST AIR VOLUMEs

2. *MIXED AIR CONTROL* = FIXED AMOUNT

If a FIXED AMOUNT of air is used, the specified OUTSIDE AIR VOLUME, adjusted by the normalized MINIMUM VENTILATION SCHEDULE, is the amount introduced whenever the fan is on.

$$VOL_x = MINVS_x * OAV$$

VOL_x cannot be less than the sum of zone EXHAUST AIR VOLUMEs

NOTE: Since OAV is not affected by a variable volume system this would also guarantee a constant amount of outside air in a VAV system.

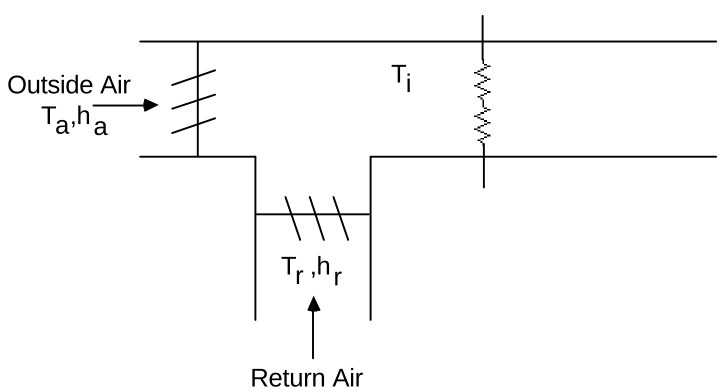
3. *MIXED AIR CONTROL* = TEMPERATURE ECONOMY CYCLE

If the TEMPERATURE ECONOMY CYCLE is used, excess outdoor air (above the minimum but less than the maximum) is introduced only when the outside air temperature is below the DESIRED MIXED AIR TEMPERATURE. Outside and return air are proportioned to maintain the desired mixed-air temperature (subject to the minimum and maximum ventilation constraint). For all economy cycles, the minimum ventilation schedule for the current day and hour multiplied by the current hour's total supply air volume, *or* the sum of the zone exhaust air volumes (whichever is larger) determines the minimum amount of ventilation introduced whenever the fan system is on.

VOL_x cannot be less than $MINVS_x * SSV_x$

VOL_x cannot be less than the sum of zone EXHAUST AIR VOLUMEs

VOL_x cannot be greater than $MAXVS_x * SSV_x$



TEMPERATURE ECONOMY CYCLE **-** Brings in excess outside air when $T_a \leq T_i$ (desired)

NOTE: Excess outside air means outside air above the minimum percentage, up to 100% outside air (but always less than the maximum ventilation schedule.) If $T_a <$ desired T_i, only enough outside air is brought in to bring T_i to the desired mixed air temperature.

---

4. *MIXED AIR CONTROL* = RETURN AIR ECONOMY CYCLE

Excess outside air is introduced when the outside air temperature is below the return air temperature. Outside and return air are proportioned to maintain the DESIRED MIXED AIR TEMPERATURE. For all economy cycles, the minimum ventilation schedule for the current day and hour multiplied by the current hour's total supply air volume, *or* the sum of the zone exhaust air volumes (whichever is larger) determines the minimum amount of ventilation introduced whenever the fan system is on.

VOL_x cannot be less than $MINVS_x * SSV_x$

VOL_x cannot be less than the sum of zone EXHAUST AIR VOLUMEs

VOL_x cannot be greater than $MAXVS_x * SSV_x$

RETURN AIR ECONOMY CYCLE **-** Brings in excess outside air when $T_a < T_r$

NOTE: Excess outside air means outside air above the minimum percentage, up to 100% outside air (but always less than the maximum ventilation schedule.) If $T_a <$ desired T_i, only enough outside air is brought in to bring T_i to the desired mixed air temperature.

---

5. *MIXED AIR CONTROL* = ENTHALPY ECONOMY CYCLE

This operates exactly like the RETURN AIR ECONOMY CYCLE, except that excess outside air is introduced when the outside air *enthalpy* is less than the return air enthalpy. For all economy cycles, the minimum ventilation schedule for the current day and hour multiplied by the current hour's total supply air volume, *or* the sum of the zone exhaust air volumes (whichever is larger) determines the minimum amount of ventilation introduced whenever the fan system is on.

ENTHALPY ECONOMY CYCLE **-** Brings in excess outside air when $h_a < h_r$

NOTE: Excess outside air means outside air above the minimum percentage, up to 100% outside air (but always less than the maximum ventilation schedule.) If $T_a <$ desired T_i, only enough outside air is brought in to bring T_i to the desired mixed air temperature.

SPECIAL NOTE:

TWO PIPE and FOUR PIPE FAN COIL systems use FIXED PERCENT outside air, no matter how the user specifies MIXED AIR CONTROL.

Economy Cycles and Throttling Ranges

When an economy cycle is chosen as the MIXED AIR CONTROL type, it is important to know what mixed air temperature will result. The economy cycle's function is to bring in excess outside air to bring the mixed air temperature down to the DESIRED MIXED AIR TEMPERATURE. If DESIRED MIXED AIR TEMPERATURE is set to a number such as 55°F, then the economy cycle will attempt to maintain that specific temperature. If the DESIRED MIXED AIR TEMPERATURE is set equal to COLD DECK TEMPERATURE, then the COLD DECK THROTTLING RANGE becomes important. BLAST determines the air temperature which should leave the cooling coil by evaluating the cold deck set point and throttling range. This temperature is then used to determine the economy cycle operation. When the cooling coil load is zero (which is typical during economy cycle operation) the cooling coil leaving air temperature will be calculated as the set point minus the full throttling range. This is the temperature which the economy cycle will attempt to deliver.

Example:

MIXED AIR CONTROL = TEMPERATURE ECONOMY CYCLE

DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMPERATURE

COLD DECK CONTROL = FIXED SET POINT

COLD DECK THROTTLING RANGE = 5

COLD DECK TEMPERATURE = 55

When the outside air is below 50 the economy cycle will deliver mixed air at 55 - 5 = 50, since there will be no load on the cooling coil.

Mixing

The MIXING statement causes some amount of air to be supplied to the zone from some other zone:

MIXING = usn1, schedule, FROM ZONE usn2, usn3 DEL TEMP,

FROM date1 THRU date2;

The minimum specification is the peak mixing (usn1) in ft^3/min (m^3/s) and the zone (usn2) from which air is being drawn. The default schedule is constant for all hours. When usn3 is positive, the temperature of the zone from which the air is being drawn (source zone) must be usn3 °F (°C) warmer than the zone air or else no mixing occurs. When usn3 is negative, the temperature of the source zone must be usn3 °F (°C) cooler than the zone air or else no mixing occurs. When usn3 is zero (default), mixing occurs regardless of temperatures. The time periods of multiple mixing statements with the same source zone may not overlap. There may be mixing from several different source zones simultaneously.

Note that MIXING affects only the receiving zone. *The air lost by the source zone must be taken into account by the user*. This may require INFILTRATION, VENTILATION, MIXING, or some other factor in the source zone's description.

Specifying Mixing in HBLC

MIXING can be specified in HBLC using the methods laid out in Building Loads. Once the form is brought up, fill in the receiving zone, the mixing schedule, the dates that the mixing is active, the source zone, the peak mixing in CFM, and the delta temperature.

Within a given zone's description block the time periods of multiple MIXING statements may not overlap when drawing air from the same source zone. However, MIXING with several different source zones simultaneously is allowed.

For example:

Zone 1:

MIXING = 100, CONSTANT, FROM ZONE 3, FROM 01JAN THRU 01 FEB;

MIXING = 100, FULL, FROM ZONE 2, FROM 01JAN THRU 01FEB;

MIXING = 100, HALF, FROM ZONE 4, FROM 01JAN THRU 01FEB;

(mixing with several different source zones at the same time is allowed)

Zone 1:

MIXING = 100, CONSTANT, FROM ZONE2, FROM 01JAN THRU 01FEB;

MIXING = 100, FULL. FROM ZONE 2, FROM 15JAN THRU 15FEB;

MIXING = 100, HALF, FROM ZONE 2, FROM 31JAN THRU 20FEB;

(this is not allowed **--** time periods of the multiple mixing statements, which are associated with the same source zone, overlap)

Another example:

Zone 1:

MIXING = 100, CONSTANT, FROM ZONE 2, FROM 01JAN THRU 01FEB;

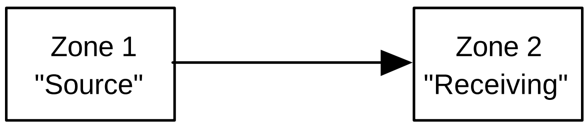
Zone 3:

MIXING = 100, CONSTANT, FROM ZONE 2, FROM 01JAN THRU 01FEB;

(two different zones drawing air from the same source zone at the same time -- this is allowed.)

Comparison of Mixing and Cross Mixing

There is a distinct difference between MIXING and CROSS MIXING. MIXING, which was described above, assumes that air from one zone is transported into a second zone. CROSS MIXING assumes that an equal amount of air is exchanged between two zones. The figure below illustrates the effects of a MIXING statement in BLAST.



Note that if there is a temperature difference between zones 1 and 2, the introduction of zone 1 air into zone 2 will affect the loads calculation of zone 2. Essentially, there is a transfer of energy via the air which is directly proportional to the peak MIXING volume, the MIXING schedule, and the temperature difference. However, the loads calculation for zone 1 is not affected by the mixing statement of zone 2. Zone 1 does not take into account that it is losing air to zone 2.

CROSS MIXING allows an equal amount of air to move from one zone to another and vice versa. As a result, the energy balance of both zones is affected. For more information, see *CROSS MIXING* in the *BLAST User Reference*.

Multizone System

EQUIPMENT DESCRIPTION:

Multizone systems condition all the air in a central apparatus and distribute it to the conditioned zones through two parallel ducts. One duct carries cold air and the other warm air, providing air sources for both heating and cooling at all times. In each conditioned zone, a mixing valve responsive to a room thermostat mixes the warm and cold air in proper proportions to satisfy the prevailing heating or cooling load of the space.

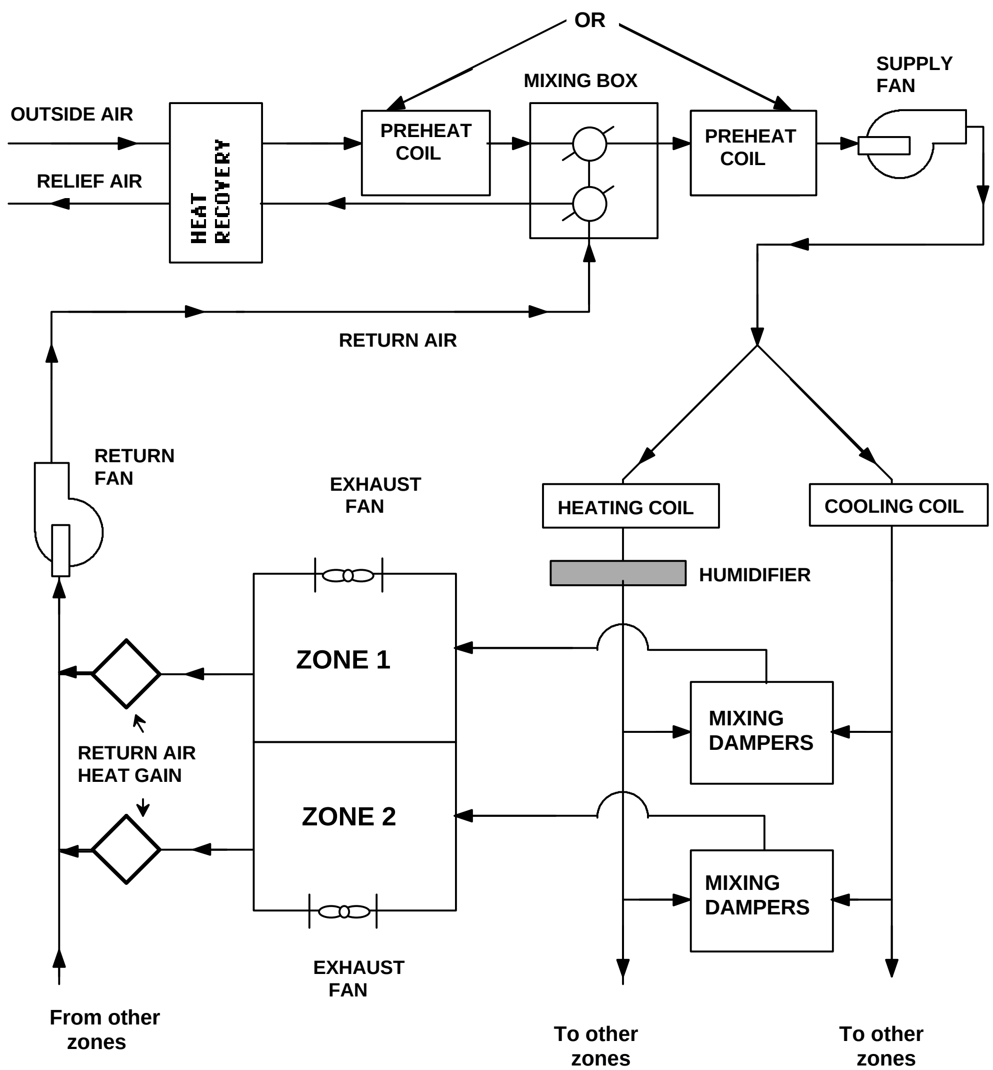


Figure 74. Diagram of a BLAST multizone system

USING THE BLAST MULTIZONE SYSTEM:

Specifying a Multizone System in HBLC

To specify a multizone system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select “Multizone” from the top of the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

MULTIZONE SYSTEM 1

"MULTIZONE " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .       ZONE DATA BLOCK
      .   .   .   .        (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .       OTHER SYSTEM DATA BLOCK
      .   .   .   .       (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .       COOLING COIL DATA BLOCK
      .   .   .   .       (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .       HEAT RECOVERY DATA BLOCK
      .   .   .   .       (Optional expert user input)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
       COPC=(11,34.09,-0.087);
       .   .   .   .       HEAT PUMP DATA BLOCK
       .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
       COPH2=(22,-3.9,0.022);
                           HEAT PUMP DATA BLOCK
       .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
       .   .   .   .       DX UNIT DATA BLOCK
       .   .   .   .       (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
       .   .   .   .       SCHEDULES DATA BLOCK
       .   .   .   .       (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
       =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the multizone system syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the multizone system. In the following examples, the parameters pertaining to the multizone system are listed in bold and all options as well as Metric (SI) units are italicized.

MULTIZONE ZONE DATA BLOCK

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100 (.0473);
   EXHAUST AIR VOLUME=0 (0);
   MINIMUM AIR FRACTION=0.19 (0.1);
   BASEBOARD HEAT CAPACITY=0.0 (0);
   BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
              =STEAM;
              =ELECTRIC;
              =GAS;
   REHEAT CAPACITY=0.0 (0);
   REHEAT ENERGY SUPPLY=HOT WATER;
              =STEAM;
              =ELECTRIC;
              =GAS;
   RECOOL CAPACITY=0.0 (0);
   ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is

specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

MULTIZONE OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK THROTTLING RANGE- Used to set the hot deck temperature based on the previous hours heating load. The deck temperature is adjusted somewhere between the hot deck set point and the set point plus the throttling range. Units: °F or °C

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

PREHEAT TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

HUMIDIFIER TYPE- Used to specify the what type of energy is used by the humidifier. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

MULTIZONE COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

MULTIZONE HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT  RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT  RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

MULTIZONE EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

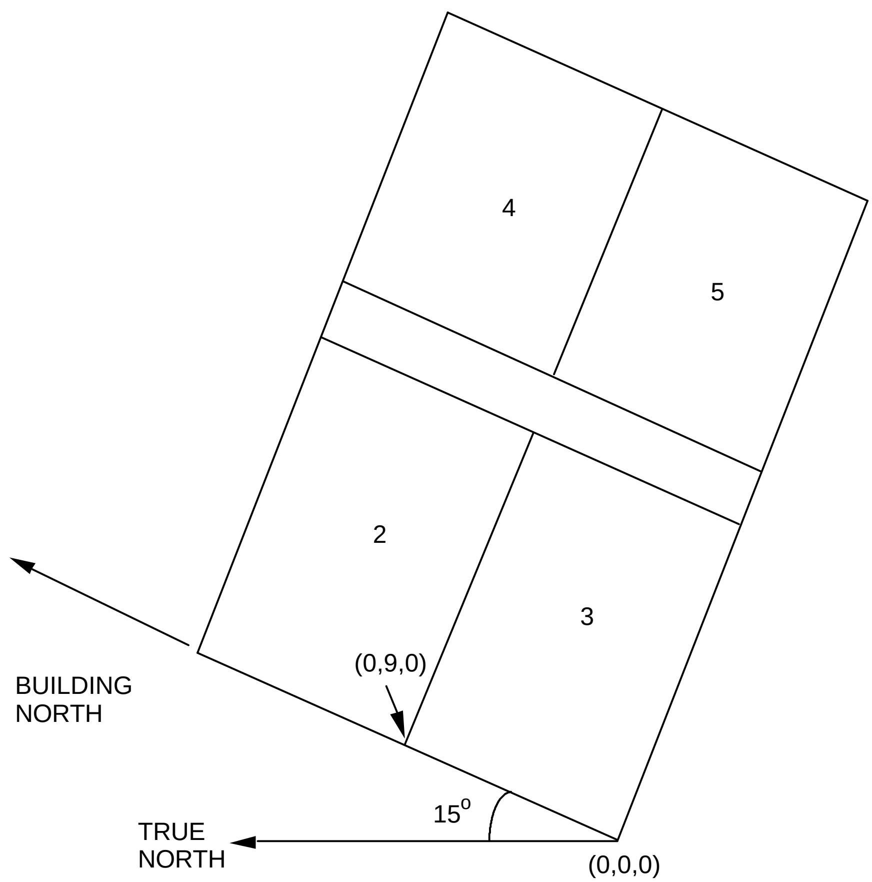
North Axis

The NORTH AXIS statement rotates the entire building or zone, depending on the location of the statement, the specified number of degrees (clockwise is positive). It establishes a new north axis which will usually correspond to a long line of the building or zone. Its default value is 0.

The building NORTH AXIS statement is used because buildings frequently do not line up with true north. The figure below shows how the building north axis can be rotated to correspond with one of the major axes of an actual building.

```
Begin Building Description :
NORTH AXIS = 15;
.                   Building north axis relative to true north
.
ZONE 1 :
NORTH AXIS = 15 :
.
.               Zone north axis relative to building north axis
```

.



HBLC Procedure for Specifying a Building North Axis

A building north axis can be specified in HBLC in the "Project Information" form under the "Environment" tab on the menu bar. The number can be typed in degrees (positive clockwise) to the right of "True North", where the user types in the difference (360° - Building North°). Alternatively, the user can click on the green compass.

HBLC Procedure for Specifying a Zone North Axis

A zone north axis cannot be specified in HBLC. If this is necessary, the user is advised to make the change manually with a text editor after having already generated the BLAST input file using HBLC. Follow the syntax given above.

One Stage Absorber

EQUIPMENT DESCRIPTION:

The BLAST model of a one stage absorber is simulated as a standard absorption refrigeration cycle. The condenser and evaporator are similar to that of a standard chiller which are both water to water heat exchangers. The compression operation is provided by the assembly of a generator and absorber. Low-pressure vapor from the evaporator is absorbed by the liquid solution in the absorber. A pump receives low-pressure liquid from the absorber, elevates the pressure of the liquid, and delivers the liquid to the generator. In the generator, heat from a high temperature source drives off the vapor that has been absorbed by the solution. The liquid solution returns to the absorber through a throttling valve whose purpose is to provide a pressure drop to maintain the pressure difference between the generator and absorber. The heat supplied to the absorber can be waste heat from a diesel jacket or the exhaust heat from diesel, gas and steam turbines. For more information on absorption chillers in BLAST, see *Absorption Chillers* in the *BLAST Technical Reference*.

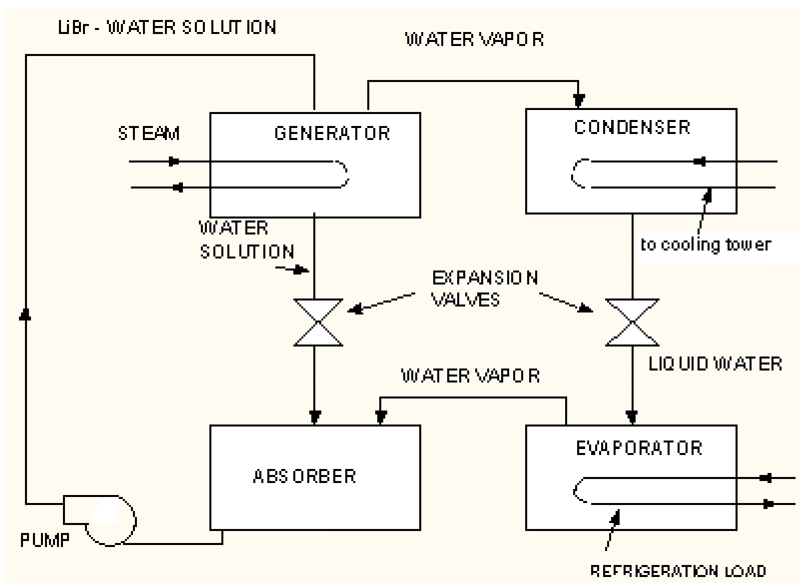
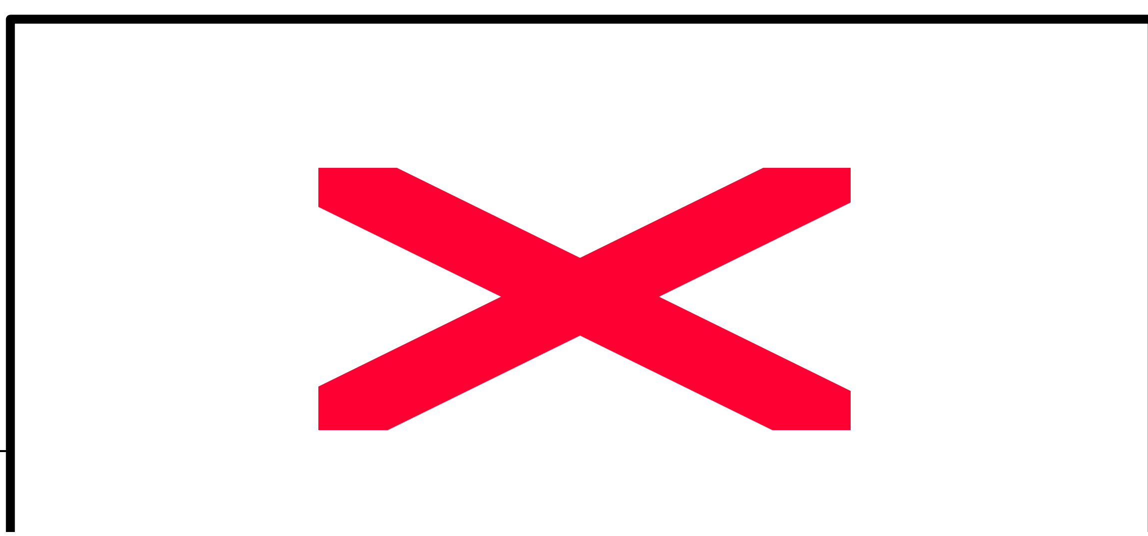


Figure 75. Diagram of a BLAST one stage absorber



ne
nd

Adjusting the Performance Parameters of the One Stage Absorber

Once the one stage absorber has been added using HBLC, the user must specify operating rules and parameters for the component. If these rules are not specified by the user, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a one stage absorber that has the following operating parameters:

Absorber temperature = 170 to 240 °F

Cooling Load/Heat power = 0.5 to 0.6

If your one stage absorber does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data. Valid condenser types that may be specified by the user for a one stage absorber are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main "Plants" form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

CAVL1A- Used to calculate the maximum part load ratio of the absorber.

REN1A-Used to calculate the heat power in-to-cooling ratio or inverse COP of the system.

TCOOL-Temperature of chilled water leaving the absorber. Units: °F or °C

PSTEAM- Gauge steam pressure of boiler steam. Units: Water Gauge or Pascals Gauge

STEAM-Enthalpy of steam to absorbers. If not specified, STEAM is calculated as he saturation enthalpy at PSTEAM and TSATUR. Units: Btu/lb or kJ/kg

TSATUR- Inlet temperature to absorber at full capacity. Units: °F or °C

RWCIA- Ratio of condenser water flow rate to one stage absorber capacity. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW of capacity

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the one stage absorber syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the one stage absorber. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

ONE STAGE ABSORBER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ONE STAGE ABSORBER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ONE STAGE ABSORBER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
ONE STAGE ABSORBER (MIN=0.05,MAX=1.1,BEST=.65,ELECTRICAL=0.0077);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
REN1A(.191,.91,0.388);
CAVL1A(1,-0.016,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PSTEAM=284.409;
STEAM=1168.7;
TSATUR=241.53;
RWCIA=124.882;
.   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

ONE STAGE ABSORBER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "ONE STAGE ABSORBER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
ONE STAGE ABSORBER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
ONE STAGE ABSORBER (MIN=0.05,MAX=1.1,BEST=.65,ELECTRICAL=0.0077);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
REN1A(.191,.91,0.388);
CAVL1A(1,-0.029,0);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
PSTEAM=70841.4;
STEAM=2716.49;
```

```
TSATUR=116.405;
RWCIA=0.05370;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Open Chiller

EQUIPMENT DESCRIPTION:

The BLAST model of a open chiller is simulated as a standard vapor compression refrigeration cycle with a water cooled condenser and an open centrifugal compressor. The open centrifugal compressor is an open unit in which the motor and compressor are not in the same housing. The motor is connected to the compressor by way of a shaft that runs through a rotating seal on the compressor housing. This set up creates much better maintenance access and allows alternative drive installations. The down side of a open centrifugal compressor is that the motor is not cooled by the refrigerant and there is a higher possibility of seal leakage. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The heat from the condenser is rejected to a cooling tower, evaporative condenser, or well water condenser. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water which is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

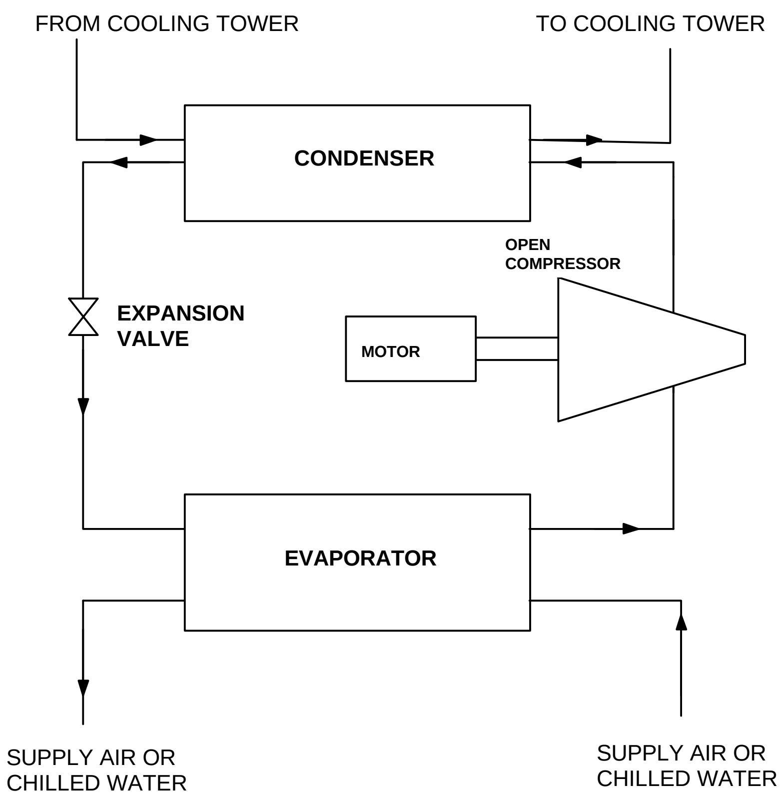


Figure 76. Diagram of a BLAST open chiller

USING THE BLAST OPEN CHILLER:

Specifying an Open Chiller in HBLC

To specify an open chiller as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Open Chiller” from the “Chillers” sub-menu. Fill in the number of chillers and their unit capacity.

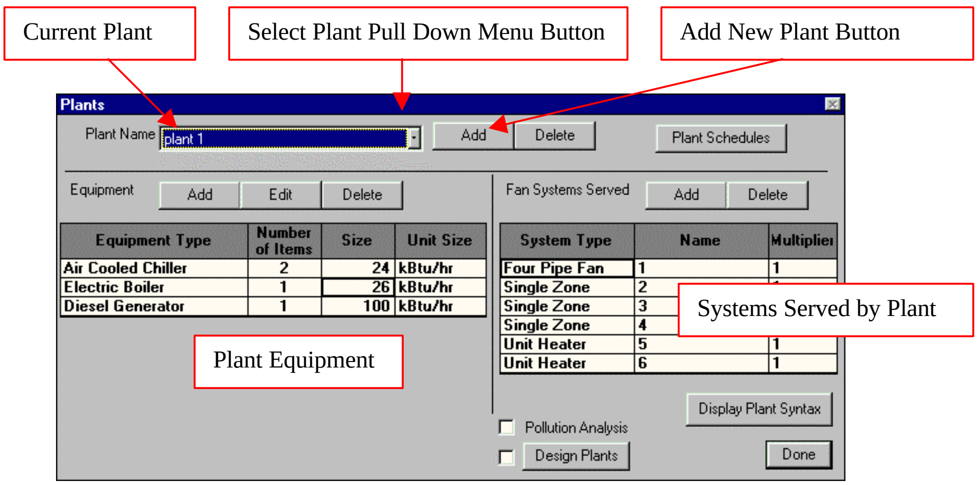


Figure 77. Specifying the Chiller in HBLC

Adjusting the Performance Parameters of the Open Chiller

Once the open chiller has been added using HBLC, the user must specify operating rules and parameters for the component. If these rules are not specified by the user in the input file, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for the open chiller that has the following operating parameters:

Evaporator temperature = 40 to 48 °F

Condenser temperature = 70 to 100 °F

Capacity = 920 to 1000 Tons

If your open chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for the open chiller are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Descriptions:

ADJT2C- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAV2C- Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJE2C- Used to adjust the full load power consumption of the chiller.

RPWR2C- Used to determine the fraction of full load power.

TCOOL- Temperature of chilled water leaving the chiller. Units: °F or °C

RWCOC- Ratio of condenser flow rate to open chiller capacity. Units: Dimensionless

Syntax Descriptions:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the open chiller syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the open chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

OPEN CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "OPEN CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
OPEN CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
OPEN CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJT2C(95,2.5,44);
RCAV2C(1.01836,-0.03075,-0.0001442);
ADJE2C(2.3201,-1.4617,0.181487);
RPWR2C(0.18717,0.122387,0.67436);
CPUMP(1,0,0);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
RWCOC=124.8228;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

OPEN CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "OPEN CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
OPEN CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 24;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
OPEN CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJT2C(35,2.5,6.667);
```

```
RCAV2C(1.01836,-0.05535,-0.0004673);
ADJE2C(2.3201,-1.4617,0.181487);
RPWR2C(0.18717,0.122387,0.67436);
CPUMP(1,0,0);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.667;
RWCOC=0.0537;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Other Side Coefficients

There is often confusion about the use of other side coefficients and how BLAST uses these numbers in the load calculation. By using the OTHER SIDE COEFFICIENTS statement in the surface description block, the temperature of the outer plane of a surface (see figure on following page) can be directly controlled. Other side coefficients can also be used to control the exterior convective heat transfer coefficient of a surface and the corresponding exterior air temperature. It should be noted that solar effects are not accounted for when other side coefficients are used. In addition, if other side coefficients are specified for a surface, they also hold true for subsurfaces of that surface. As a result, windows on an exterior surface with other side coefficients specified will not transmit solar radiation.

Other side coefficients have the same effect on all types of heat transfer surfaces. In other words, a partition with other side coefficients specified and an exterior wall with identical other side coefficients specified are simulated exactly the same. A surface that uses other side coefficients should be thought of as a new or separate type of surface. In BLAST, all heat transfer surfaces are simulated in the same manner through conduction transfer functions. The only difference between the various types of heat transfer surfaces is the environment on the other side of the surface. For example, the other side environment of an exterior surface is the outdoor environment. For a partition, the temperature of the outer plane of the surface is set equal to the temperature of the inner plane of the surface. Similarly, a surface with other side coefficients specified will allow the user to control the other side environment.

Heat transfer through a surface is an extremely important component in the calculation of zone loads. The information to calculate this heat transfer is readily available if the surface is exposed to the outdoor environment or to another zone that is being simulated. Occasionally, a user will want to model the heat transfer through a surface that is adjacent to an area that is not included in his BLAST model. For example, an office area is attached to a warehouse and the user is only interested in simulating the office area. A partition with other side coefficients specified could be used to control the environment on the other side of the surface, thereby accounting for the heat transfer through the adjoining surface. OTHER SIDE COEFFICIENTS affects the "other side" of a surface in the following way:

OTHER SIDE COEFFICIENTS (C_1, C_2, C_3, C_4, C_5, C_6, C_7)

Each coefficient has a special meaning. Since *position* is very important, if the user does not want to use a particular coefficient, a 0 should be entered to hold its place. Below a description of the seven coefficients in the Other Side Coefficients statement is given.

C1 - the first value can have two meanings. If it is greater than 0, then it is a surface film coefficient. BLAST will use the remaining terms to first calculate the outside air temperature, then calculate the outside surface temperature based on the air temperature and the film coefficient C1. If C1 is less than or equal to 0, BLAST will use the remaining terms to calculate the surface temperature (not the outside air temperature).

C2 - zone air temperature factor,

C3 - ambient dry bulb weighting factor,

C4 - constant temperature weighting factor

C5 - constant temperature to be used with the C4 weighting factor,

C6 - ground temperature weighting factor,

C7 - wind speed modifier.

The coefficients listed above are used in the following equation:

$$T = \frac{(C2*Tzone+C3*Toadb+C4*C5+C6*Tgrnd+C7*Wspd*Toadb)}{(C2+C3+C4+C6+C7*Wspd)}$$

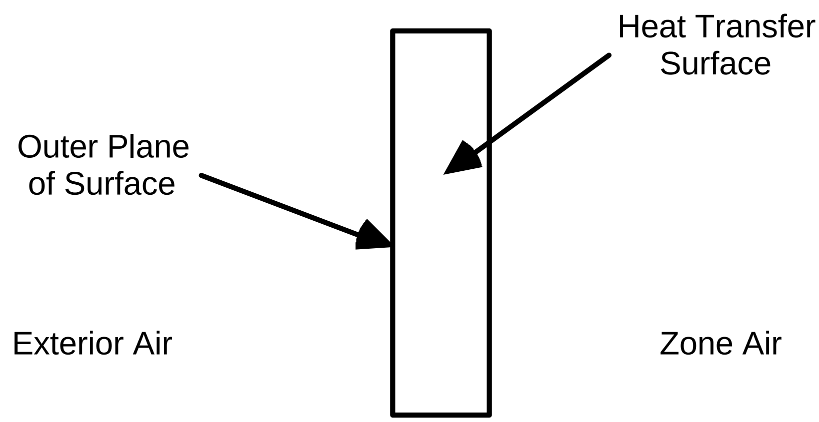
where: Tzone = Temperature of the zone being simulated °F (°C)

Toadb = Dry bulb temperature of the outdoor air °F (°C)

Tgrnd = Temperature of the ground °F (°C)

Wspd = Outdoor wind speed ft/min (m/sec)

If C1 is greater than zero, C1 is the external convective heat transfer coefficient, and T is the surrounding air temperature. Otherwise, T is the temperature of the outer plane of the surface.



Specifying Other Side Coefficients in HBLC

The specification of Other Side Coefficients in HBLC is not possible. If Other Side Coefficients are to be used for a particular surface, they must be added to the BLAST input file using a file editor.

Other System Parameters Data Block

Specifying OTHER SYSTEM PARAMETERS *only* affects the system being described; it has no effect on subsequent fan systems which may be described for simulation in the same BLAST run. Changes in the default values, if desired, must be repeated system by system. A table showing OTHER SYSTEM PARAMETERS and the Fan Systems they affect is shown in *BLAST Program Overview* under *Fan System Syntax*. Additional information on the following OTHER SYSTEM PARAMETERS may be found under the indicated *BLAST User Reference* entry as shown below.

OTHER SYSTEM PARAMETER	**BLAST USER REFERENCE**
COLD DECK CONTROL	*Cold and Hot Deck Control*
COLD DECK CONTROL SCHEDULE	*Cold and Hot Deck Control*
COLD DECK TEMPERATURE	*Cold and Hot Deck Control*
COLD DECK THROTTLING RANGE	*Cold and Hot Deck Control*
HOT DECK CONTROL	*Cold and Hot Deck Control*
HOT DECK CONTROL SCHEDULE	*Cold and Hot Deck Control*
HOT DECK TEMPERATURE	*Cold and Hot Deck Control*
HOT DECK THROTTLING RANGE	*Cold and Hot Deck Control*
COOLING SAT DIFFERENCE	*Design Systems*
HEATING SAT DIFFERENCE	*Design Systems*
FAN POWER COEFFICIENTS	*Fan Power Coefficients***
DESIRED MIXED AIR TEMPERATURE	*Mixed Air Control*
MIXED AIR CONTROL	*Mixed Air Control*
OUTSIDE AIR VOLUME	*Mixed Air Control*
PREHEAT COIL CAPACITY	*Preheat Coil*
PREHEAT COIL LOCATION	*Preheat Coil*
PREHEAT TEMPERATURE	*Preheat Coil*
REHEAT COIL CAPACITY	*Reheat Coil*
REHEAT COIL LOCATION	*Reheat Coil*
REHEAT TEMPERATURE	*Reheat Coil*

****** BLAST Technical Reference Entry only.

Table 19. BLAST Reference Manual Entries for Other System Parameters

The table below lists all OTHER SYSTEM PARAMETERS and their respective default values.

(All options and metric values given in italics)

```
OTHER SYSTEM PARAMETERS:
SUPPLY FAN PRESSURE=2.49783 (622.16);
SUPPLY FAN EFFICIENCY=0.7;
RETURN FAN PRESSURE=0.0;
RETURN FAN EFFICIENCY=0.7;
EXHAUST FAN PRESSURE=1.00396 (290.14);
EXHAUST FAN EFFICIENCY=0.7;
COLD DECK CONTROL=FIXED SET POINT;
           =OUTSIDE AIR CONTROLLED;
           =ZONE CONTROLLED;
COLD DECK TEMPERATURE=55.04 (12.8);
COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT 21);
COLD DECK THROTTLING RANGE=7.2 (4);
HEATING COIL ENERGY SUPPLY=HOT WATER;
           =GAS;
           =ELECTRIC;
           =STEAM;
HEATING COIL CAPACITY=34120000 (999716);
HOT DECK CONTROL=FIXED SET POINT;
           =OUTSIDE AIR CONTROLLED
           =ZONE CONTROLLED;
HOT DECK TEMPERATURE=140 (60);
HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
HOT DECK THROTTLING RANGE=7.2 (4);
REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
           =OUTSIDE AIR CONTROLLED;
REHEAT TEMPERATURE LIMIT=140 (60);
REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT 21);
MIXED AIR CONTROL=FIXED PERCENT;
               =FIXED AMOUNT;
               =TEMPERATURE ECONOMY CYCLE;
               =RETURN AIR ECONOMY CYCLE;
               =ENTHALPY ECONOMY CYCLE;
DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
               =(ARBITRAY FIXED VALUE);
OUTSIDE AIR VOLUME=0.0 (0);
PREHEAT COIL LOCATION=NONE;
           =OUTSIDE AIR DUCT;
           =MIXED AIR DUCT;
PREHEAT TEMPERATURE=46.4 (8);
PREHEAT COIL CAPACITY=0 (0);
GAS BURNER EFFICIENCY=0.8;
PREHEAT ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
VAV MINIMUM AIR FRACTION=0.1;
VAV VOLUME CONTROL TYPE=INLET VAVES;
               =VARIABLE FAN SPEED;
               =DISCHARGE DAMPERS;
HUMIDIFIER TYPE=NONE;
               =STEAM
               =HOT WATER;
               =ELECTRIC;
HUMIDISTAT LOCATION=(ZONE NUMBER);
HUMIDISTAT SET POINT=50;
**FAN POWER COEFFICIENTS=(0,0,0,0,0)
SYSTEM ELECTRICAL DEMAND=0.0;
** Following used in DESIGN SYSTEMS only
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

Part Load Ratios

Whether each equipment type operates and at what level it operates depend on its part-load ratio parameters. The format for using this part-load ratio block to override the default values is:

PART LOAD RATIOS:

GAS TURBINE (MIN=0.02, MAX=1.2, BEST=0.7, ELECTRICAL=0.0);

.

.

.

BOILER (MIN=0.02,MAX=1.0,BEST=0.85,ELECTRICAL=0.0);

.

.

.

CHILLER (MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);

. **Next equipment type, if any.**

. **If omitted, values from part-load**

. **ratio default tables are used.**

.

END PART LOAD RATIOS;

where:

MIN = minimum part-load ratio below which electricity or fuel consumption is constant.

MAX = maximum part-load ratio allowed.

BEST = most efficient (or best) part-load ratio.

ELECTRICAL = dimensionless ratio of full-load electrical input to nominal capacity.

Each equipment type may be entered once, so values apply to all sizes of each type. Input is accepted only for the equipment types specified in EQUIPMENT SELECTION block.

Some or all of the values for an equipment type may be entered. If omitted, they default to the basic part-load ratio data in the table below.

Boilers may have feed water pumps and draft fans which would make the electrical input-to-nominal capacity ratio slightly larger than zero. For electrically driven chillers, this ratio is large, since it represents the energy required per unit of cooling capacity. The default of 0.2275 corresponds to approximately 0.8 kW/ton. To convert kilowatt/ton to the appropriate dimensionless ratio, multiply by 0.2843.

For cooling towers, BEST and ELECTRICAL have the following meanings:

ELECTRICAL = ratio of fan power to cooling tower capacity

BEST = best part-load ratio when using more than one cooling tower

	Part-Load Ratios			Electric Input to Nominal Capacity Ratio
Equipment Type	**Minimum**	**Maximum**	**Optimum**	**(Dimensionless)**
AIR COOLED CHILLER	0.1	1.05	0.65	0.2275
BOILER	0.01	1	0.87	0
CHILLER	0.1	1.05	0.65	0.2275
COLD STORAGE TANK	N/A	N/A	N/A	N/A
COOLING TOWER	0	N/A	0.4365	0.012
DIESEL DRIVEN CHILLER	0.1	1.05	0.65	0.25
DIESEL GENERATOR	0.2	1.05	0.6	0
DIRECT COOLING TOWER	0	1	N/A	0.012
DOUBLE BUNDLE CHILLER	0.1	1.05	0.65	0.2275
ELECTRIC BOILER	0	1	1	1.05
EVAPORATIVE CONDENSER	0	1	N/A	0.012
FREE COOLING CHILLER	0.1	1.05	0.65	0.2275
GAS TURBINE	0.02	1.05	0.6	0
GAS TURBINE DRIVEN CHILLER	0.02	1.05	0.6	0.25
HEAT PUMP	0.1	1.05	0.65	0.2275
HOT STORAGE TANK	N/A	N/A	N/A	N/A
ONE STAGE ABSORBER	0.05	1.1	0.65	0.0077
OPEN CHILLER	0.1	1.05	0.65	0.2275
RECIPROCATING CHILLER	0.1	1.05	0.65	0.2275
SOLAR COLLECTORS	N/A	N/A	N/A	0
STEAM TURBINE	0.2	1.1	0.9	0
TWO STAGE ABSORBER	0.05	1.1	0.65	0.0077
TWO STAGE ABSORBER W/ECON	0.5	1.1	0.65	0.0077
WELL WATER CONDENSER	0	1	N/A	0.012

Table 20. Default part load ratios

People

The latent and sensible loads for people in a zone are calculated in BLAST based on the zone air temperature. The user does not have control over what fraction of the total load is split into sensible and latent. The function BLAST uses is based on a curve fit to data presented in Table 48 "Heat Gain for People" of Chapter 1 of the *Carrier Handbook of Air Conditioning System Design* 1965. Beyond the reported air temperature range of 70-82°F, the sensible loads are extrapolated using the following conditions: at 96°F the sensible load is set to 0 and the latent load is equal to the metabolic rate; at 30°F the latent load is set to 0 and the sensible load is equal to the metabolic rate. Under normal conditions, occupied zones will be controlled close to the 70-82°F range, and the latent load will be calculated according to the Carrier data. The latent fraction increases as the zone air temperature increases and as the activity level increases.

The user may specify the activity level; i.e., the amount of heat given off per person per hour in kBtu/hr (kW). The default is 0.450 kBtu/hr (0.13 kW) or the value for light office work (a factory worker would generate about 1.6 kBtu/hr [0.47 kW]). The amount of heat given off by a person occupying a building zone is split into sensible and latent components based on room temperature. The user may also specify what percent of the sensible heat is radiant; if the percent is not specified, a radiant default value of 70 percent is used. A table from the *ASHRAE Handbook of Fundamentals* which contains the rates of heat gain from occupants of conditioned spaces has been included on the following page. The total rate of heat gain may be entered as the ACTIVITY LEVEL when specifying a scheduled load for PEOPLE. The BLAST default value for ACTIVITY LEVEL is 0.45.

Rates of Heat Gain from Occupants of Conditioned Spaces (a)

Degree of Activity	Typical Application	Total Rate of Heat Gain (b) kBtu/hr
Seated at rest	Theater, movie	.35
Seated, very light work, writing	Offices, hotels, apts	.42
Seated, eating	Restaurant (c)	.58 (c)
Seated, light work, typing	Offices, hotels, apts	.51
Standing, light work or walking slowly	Retail store, bank	.64
Light bench work	Factory	.78
Walking, 3 mph, light machine work	Factory	1.04
Bowling (d)	Bowling alley	.96
Moderate dancing	Dance hall	1.28
Heavy work, heavy machine work, lifting	Factory	1.60

Heavy work, athletics	Gymnasium	1.80

Notes:

(a) Tabulated values are based on 78°F room dry-bulb temperature.

(b) The total rate of heat gain is based on the normal percentage of men, women and children for the application listed.

(c) This value for eating in a restaurant, includes 60 Btu/hr for food per individual.

(d) For bowling figure one person per alley actually bowling, and all others sitting or standing and walking slowly.

Table reprinted by permission from the *ASHRAE Handbook of Fundamentals*.

Specifying People in HBLC

People can be specified in HBLC using the methods outlined in Building Loads. Select the "People" tab in the "Scheduled Loads" form, and fill in the data cells with zone number, schedule, dates, max number of people, peak activity level, and percent radiant.

Preheat Coil

Note that the preheat coil, if specified, can be in either of two positions:

1. In the outside air duct.
2. In the mixed-air duct.

PREHEAT COIL LOCATION = NONE; **(default)**

(or) = OUTSIDE AIR DUCT;

(or) = MIXED AIR DUCT;

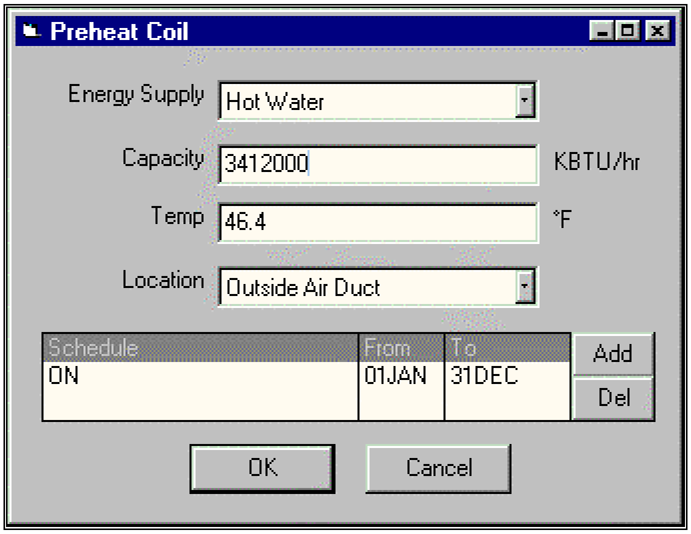


Figure 78. Preheat Coil form

If the preheat coil is specified as being in the outside air duct, the PREHEAT TEMPERATURE is the outside air temperature at which the preheat coil is turned on. Thus, if the preheat coil is in the outside air duct, it is either fully "on" or "off". If the preheat coil is in the mixed-air duct, the preheat coil is assumed to modulate and the PREHEAT TEMPERATURE is the temperature to be maintained immediately downstream of the preheat coil. If the preheat coil is in the mixed-air duct, it modulates to maintain the DESIRED MIXED AIR TEMPERATURE if PREHEAT TEMPERATURE is not specified.

Pumps (Hot Water & Chilled Water)

Pumps for hot and chilled water are modeled in the central plant automatically if a heating and/or cooling load exists in the plant.

Chilled Water Pumps

The model for the chilled water pump is:

$$CELEC = CCAP * PELCL * (A_1 + A_2 * CPLR + A_3 * CPLR^2)$$

where:

CELEC = chilled water pump electrical consumption for the current hour

CCAP = installed chiller capacity

PELCL = pump power demand per unit cooling capacity

(see special parameter discussion)

CPLR = PLR which is CLOAD/total installed chiller capacity for the current hour

A_1, A_2, A_3 = the coefficients of the CPUMP set.

Default Value:

CPUMP (1.0,0.0,0.0);

Hot Water Pumps

The model for the hot water pump is:

$$HELEC = HCAP * PELHT * (A_1 + A_2 * HPLR + A_3 * HPLR^2)$$

where:

HELEC = hot water pump electrical consumption for current hour

HCAP = installed boiler capacity

PELHT = pump power demand per unit of boiler capacity (see special parameter discussion)

HPLR = PLR which is HLOAD/total installed boiler capacity

A_1, A_2, A_3 = coefficients of the HPUMP set

Default Value:

HPUMP (1.0,0.0,0.0);

Purchased Heating/Purchased Cooling

EQUIPMENT DESCRIPTION:

Purchased heating and purchased cooling are used if the building being simulated will meet cooling/heating coil loads by purchasing hot/cold water from outside source. The user could also use this option to determine the effect of inefficiencies of the plant equipment on the annual energy consumption.

Specifying Purchased Heating/Cooling in HBLC

To specify purchased heating/cooling in the central energy plant, the user must first select it using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Purchased Heating” or “Purchased Cooling” from the “Other” sub-menu. Specify the capacity (kBtu/hr or kW).

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Purchased heating and purchased cooling can be specified in the Equipment Selection Block of the BLAST input file as follows:

```
EQUIPMENT SELECTION:
    PURCHASED HEATING:
        1 OF SIZE 500;
    PURCHASED COOLING:
        1 OF SIZE 750;
END EQUIPMENT SELECTION;
```

This syntax implies that there is 500 kBtu/hr (kW) of purchased heating available and there is 750 kBtu/hr (kW) of purchased cooling available. It may seem a little awkward to specify purchased heating/cooling as an equipment type of size xxx. The size should be considered as the amount of purchased cooling and heating that is available.

With most plant types the user can specify equipment assignment in the equipment assignment data block. This option is not available for purchased heating and purchased cooling. The default algorithm for the use of purchased heating/cooling is that purchased heating/cooling will be used only if the demand is not met by all other equipment types. For example, the user specifies a Chiller and Purchased Cooling. Purchased cooling would only be used if the chiller capacity for a given hour was not large enough to meet the demand.

Purchased heating/cooling usage is reported in the Building/Fan/Plant Energy Utilization Summary report under the Purchased Heating and Purchased Cooling columns. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well

PURCHASED ENERGY BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEAFULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "PURCHASED ENERGY " SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
PURCHASED HEATING
1 OF SIZE 100;
PURCHASED COOLING
1 OF SIZE 100;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

PURCHASED ENERGY BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "PURCHASED ENERGY " SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
PURCHASED HEATING
1 OF SIZE 25;
PURCHASED COOLING
1 OF SIZE 25;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Radiant Equipment

High Temperature Radiant Heaters in BLAST

High Temperature Radiant Heaters are the implementation of Phase I of the BLAST Radiant Heat Enhancements. This type of radiant heater includes high temperature gas or electric heaters that give off a directional component of infrared radiant heat. This type of radiant heater is not to be confused with Low Temperature Radiant Heaters, which include heated floor slabs and radiant ceiling panels. The following sections will describe the syntax necessary to simulate scheduled High Temperature Radiant Heaters within BLAST.

Specifying and Controlling Radiant Heaters in BLAST

High Temperature Radiant Heaters in BLAST can be described as either **scheduled** or **temperature controlled**. The RADIANT EQUIPMENT statement defines a **scheduled** radiant heater and is nearly identical to OTHER EQUIPMENT in the building description except that the radiant component given off by the scheduled radiant heater is dispersed to the surfaces as specified by the user. A **temperature controlled** radiant heater is similar to the heating load that is determined in the BLAST Loads simulation by a control profile, i.e. the CONTROL statement in the BLAST input file. The difference between the two is that the radiant heater disperses direct and/or diffuse radiant energy to the zone occupants and surfaces. For more information on temperature controlled radiant heaters, see *Controlled Radiant Heater* in the *BLAST User Reference*. For more general information pertaining to both, see *High Temperature Radiant Heaters* in the *BLAST Technical Reference*.

Specifying Scheduled Radiant Heaters in HBLC

A scheduled High Temperature Radiant Heater can be specified in HBLC using the Scheduled Loads dialog box under the Environment tab on the menu bar. Add the High Temperature Radiant Heater as “Radiant Equipment.” For more information on creating and editing scheduled loads, see the *Building Loads* section of the User Reference.

Example of a Scheduled Radiant Heater

```
RADIANT EQUIPMENT = 50.00, INT,
        65 PERCENT RADIANT ELECTRIC HEAT,
        15 PERCENT LATENT,
        0 PERCENT LOST,
        0.0005 RADIANT FLUX FACTOR,
        FROM 01JAN THRU 31DEC;
```

This format specifies an electric scheduled radiant heater with a capacity of 50 kBtu/hr. Its operating schedule is the BLAST 3.0 Standard Library schedule

INT. 65 percent of the total energy is radiant energy; 15 percent of the energy from this heater is latent; none of the energy input is lost. The remaining 20 percent of the energy input is added to the zone heat balance as convective heat. The Radiant Flux Factor has been defined as 0.0005/ft^2. The heater operates the entire year.

Reciprocating Chiller

EQUIPMENT DESCRIPTION:

The BLAST model of a reciprocating chiller is simulated as a standard vapor compression refrigeration cycle with a water cooled condenser and a reciprocating compressor. The reciprocating compressor is one of the most common types of compressors and is used in many types of refrigeration applications. The reciprocating compressor has two major operating positions, a suction stroke and a discharge stroke. During the suction stroke of the piston, low-pressure refrigerant gas is drawn in through the suction valve, which may be located in the piston or in the head. During the discharge stroke the piston compresses the refrigerant and then pushes it out through the discharge valve, which is usually located in the cylinder head. After leaving the compressor, the refrigerant is condensed to liquid in a refrigerant to water condenser. The heat from the condenser is rejected to a cooling tower, evaporative condenser, or well water condenser depending on which one the user selects based on the physical parameters of the plant. The refrigerant pressure is then dropped through a throttling valve so that fluid can evaporate at a low pressure that provides cooling to the evaporator. The evaporator can chill water that is pumped to chilled water coils in the building, or directly cool supply air in DX coils throughout the building.

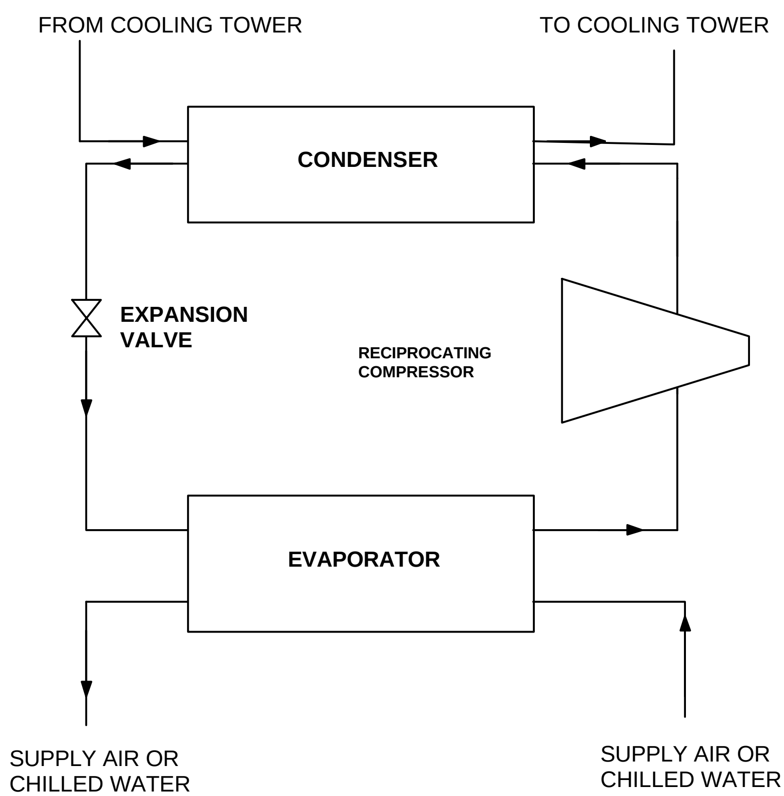


Figure 78. Diagram of a BLAST reciprocating chiller

USING THE BLAST RECIPROCATING CHILLER:

Specifying a Reciprocating Chiller in HBLC

To specify a reciprocating chiller as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Reciprocating” from the “Chillers” sub-menu. Fill in the number of chillers and their unit capacity.

Adjusting the Performance Parameters of the Reciprocating Chiller

Once the reciprocating chiller has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a reciprocating chiller that has the following operating parameters:

Evaporator temperature = 40 to 48 °F

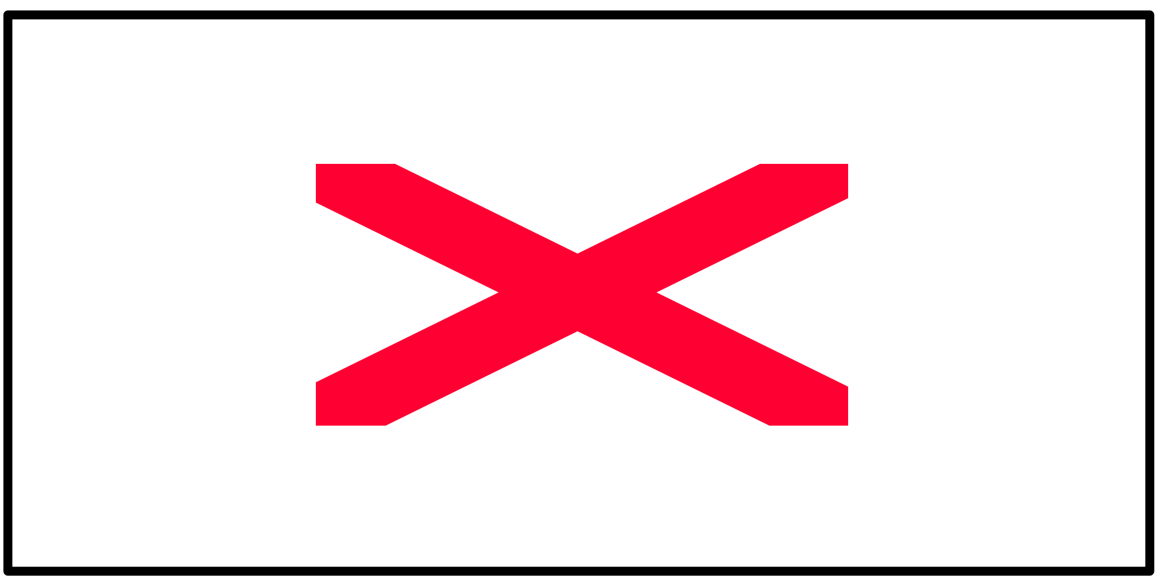
Condenser temperature = 70 to 100 °F

Capacity = 920 to 1000 Tons

If your reciprocating chiller does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data using the "Chiller" program. Valid condenser types that may be specified by the user for a reciprocating chiller are:

Cooling tower

Direct cooling tower



Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

ADJT3C- Used to calculate the equivalent temperature difference between the leaving condenser water and the leaving chilled water temperature.

RCAV3C-Used to adjust the chiller capacity based on the equivalent temperature difference.

ADJE3C- Used to adjust the full load power consumption of the chiller.

RPWR3C-Used to determine the fraction of full load power.

TCOOL-Temperature of chilled water leaving the chiller. Units: °F or °C

RWCRC- Ratio of condenser flow rate to reciprocating chiller capacity. Units: Dimensionless

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND-Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the reciprocating chiller syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the reciprocating chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

RECIPROCATING CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "RECIPROCATING CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
RECIPROCATING CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
RECIPROCATING
CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
ADJT3C(95,2.5,44);
RCAV3C(1.01836,-0.03075,-0.0001442);
ADJE3C(2.3201,-1.4617,0.181487);
RPWR3C(0.1494,0.9568,-0.11184);
CPUMP(1,0,0);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
RWCRC=124.8228;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

RECIPROCATING CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "RECIPROCATING CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
RECIPROCATING CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 24;
.   .   .
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24,CONSTANT,FROM 01JAN THRU 31DEC;
.   .   .
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
RECIPROCATING
CHILLER(MIN=0.1,MAX=1.05,BEST=0.65,ELECTRICAL=0.2275);
.   .   .
.   .   .
END PART LOAD RATIOS;
```

```
EQUIPMENT PERFORMANCE PARAMETERS:
ADJT3C(35,2.5,6.667);
RCAV3C(1.01836,-0.05535,-0.0004673);
ADJE3C(2.3201,-1.4617,0.181487);
RPWR3C(0.1494,0.9568,-0.11184);
CPUMP(1,0,0);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.667;
RWCRC=0.0532;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Reheat Coil

The reheat coil is specified in much the same way that the hot deck is specified except that there is no throttling range or zone controlled option for the reheat coil. For VAV, terminal reheat, subzone reheat, unit ventilator, and unit heater systems, the reheat temperature control parameters (REHEAT TEMPERATURE CONTROL, REHEAT TEMPERATURE LIMIT, and REHEAT CONTROL SCHEDULE) are used to determine the maximum allowable temperature of the air leaving the reheat coils.

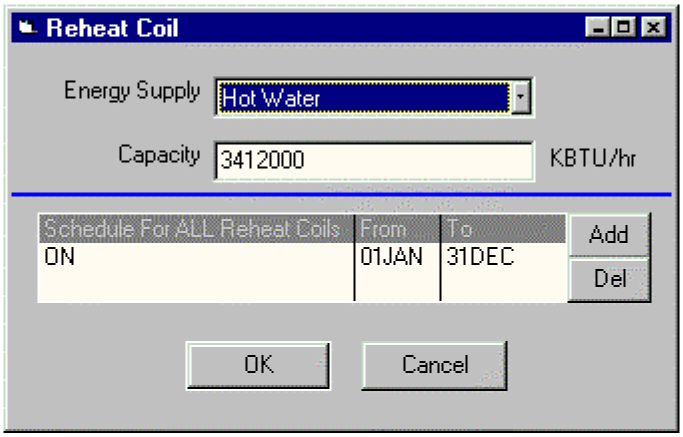


Figure 79. Reheat Coil form in HBLC

Fixed Set Point Control of the Reheat Coil

One of the options for controlling the reheat coil is fixed set point control. In this case, the temperature of the air leaving the reheat coil is limited by the value specified by the REHEAT TEMPERATURE LIMIT statement. This type of control is specified by including the following syntax in the Other System Parameters Data Block of the appropriate fan system:

REHEAT TEMPERATURE CONTROL = FIXED SET POINT;

REHEAT TEMPERATURE LIMIT = 140;

The second line of syntax defines a set point temperature of 140°F. The temperature of the air leaving the reheat coil is modulated to meet the demand, but it never exceeds the limit of 140°F. This is the default value for fixed set point control.

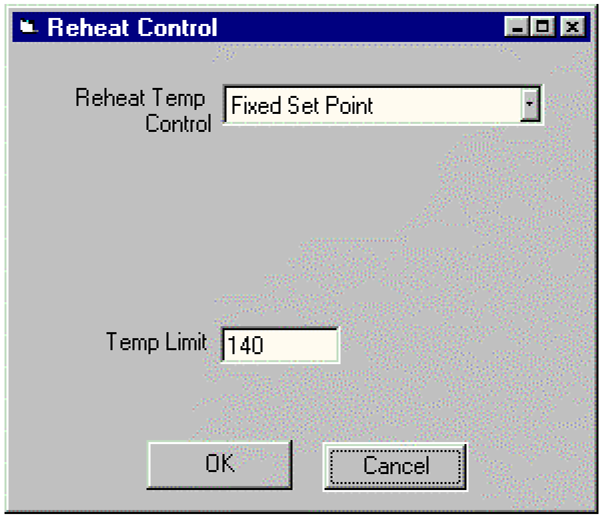


Figure 80. Reheat Control form in HBLC

Outside Air Control of the Reheat Coil

The second option for controlling the reheat coil is outside air control. In outside air control, the temperature of the air leaving the reheat coil temperature limit is modulated as described by the REHEAT CONTROL SCHEDULE. This type of control is specified by including the following syntax in the Other System Parameters Data Block of the appropriate fan system:

REHEAT TEMPERATURE CONTROL = OUTSIDE AIR CONTROLLED;

REHEAT CONTROL SCHEDULE = (140 AT 0, 70 AT 70);

The second line of syntax sets the temperature limit of the air leaving the reheat coil at 140°F when the outside air temperature is at or below 0°F. Above 70°F, the temperature limit of the air leaving the reheat coil is maintained at 70°F. Between 0°F and 70°F, the temperature limit of the air leaving the reheat coil is modulated (linearly) from 140°F and 70°F. This is the default schedule for outside air control.

Reports

The REPORTS parameter of RUN CONTROL allows the user to request reports other than those that are automatically printed during any BLAST run. Detailed descriptions of these reports may be found in the *BLAST OUTPUT* section.

Specifying Reports in HBLC

Reports can be specified in HBLC by accessing the “Reports” form, which can be found under the “Environment” tab of the menu bar. Check the boxes in front of the desired reports. Selecting some reports may activate a separate button, which will allow the user to tailor that report to their specific needs.

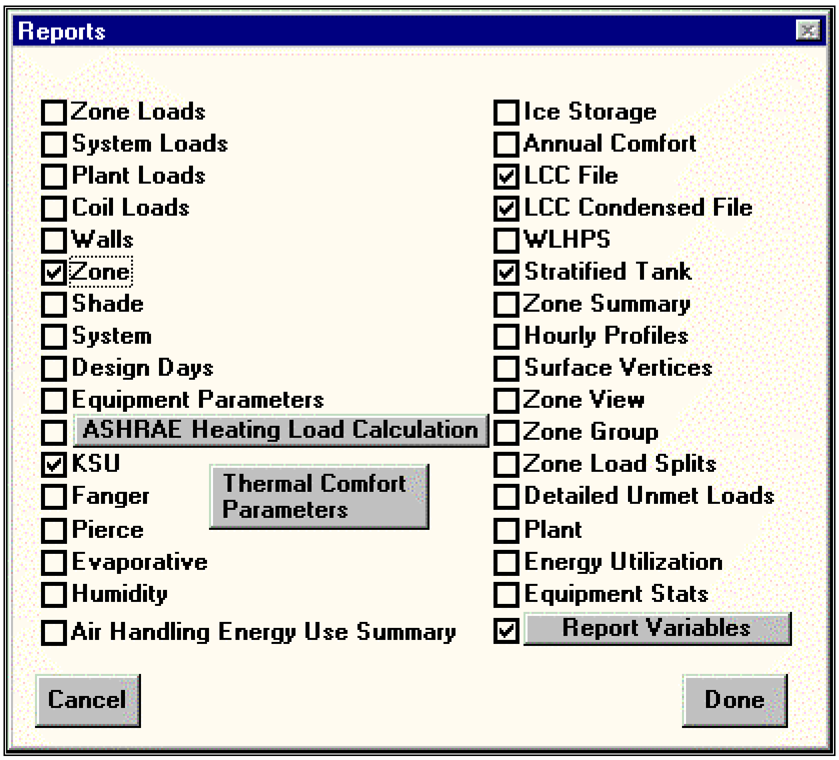


Figure 81. Reports form

Clicking on the “Report Variables” button will bring up a list of variables that can be selected by the user. The report can be based on zones, systems, and plants, zones served by systems, and systems served by plants.

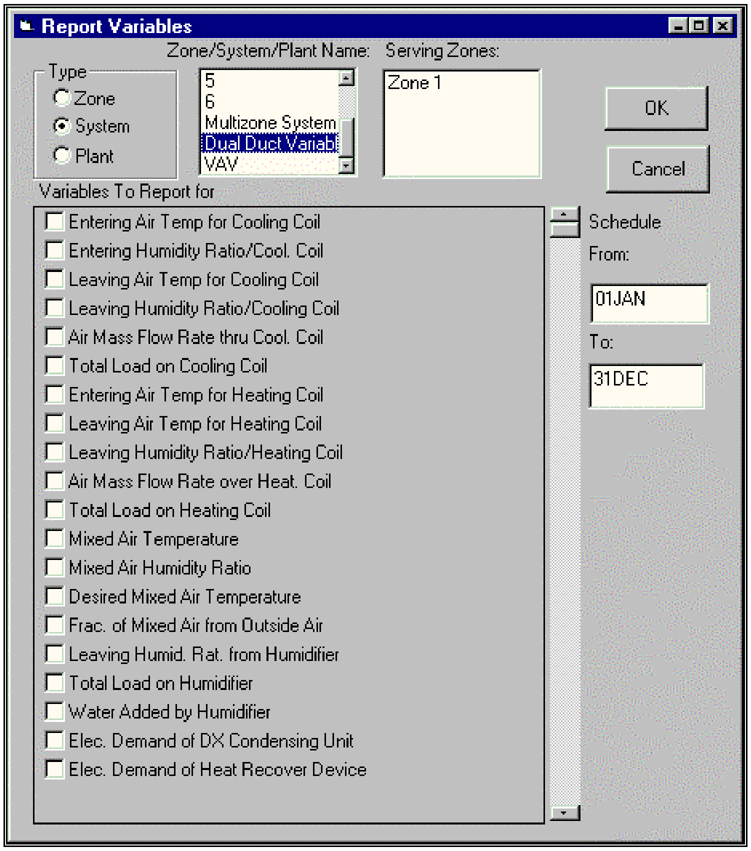


Figure 82. Report Variables form

Default Reports

The following reports are produced from any BLAST run that includes simulation elements (Zones, Systems, Plants).

Review Summary Report

REVIEW SUMMARY REPORT summarizes the total BLAST simulation by presenting information from each segment of BLAST (i.e. LOADS, FAN SYSTEM, and CENTRAL PLANT simulations). Approximate zone volume, floor area, and height; summary of walls, roofs, floors, etc. used in the building envelope; and a summary of scheduled loads, infiltration and ventilation, and control profiles are all displayed for each zone. A plan view of the building surfaces is also displayed. Zone loads, system loads, and plant loads are summarized and presented.

Simulation Summary

This simple report tells the user what will be simulated during the run, the number of environments with some descriptive information.

Psychrometric Error Summary

This report shows the user the summary of psychrometric errors produced during each simulation segment (initial, loads, systems, plants) as well as a summary at the end of all errors.

Optional Reports

The following reports may be produced at the user's discretion.

Design Day Environment Report

DESIGN DAY- Based on the date and design day specified the declination of the Earth's tilt is calculated values of SINE, COSINE, AND EQTIME (equation of time) are reported. These values are needed for calculating sun angles. Reported for each hour of the designing day are the following parameters: rain, snow, dry bulb, wet bulb, barometric pressure, humidity ratio, wind speed wind direction, sky temperature, beam radiation, diffuse radiation, horizontal radiation and the total amount of radiation reflected from the ground. The average or total values are reported as appropriate.

Building Loads Reports

The following reports are produced from BLAST runs that include Zones.

Default Building Loads Reports

Since the main default report (Review Summary Report), reports much of the information about the Building Loads, including envelope construction, there are no default Building Loads Reports produced with each run.

Optional Building Loads Reports

When requested, BLAST will print the following optional reports from runs that include Zones.

1. ZONE GROUP LOADS REPORT - This report includes names, total heating and cooling requirements, peak heating and cooling loads, and maximum and minimum temperatures for each zone. In addition, those quantities are summarized for the group of zones.
2. HOURLY PROFILES - This report is composed of two profiles used by the group of zones, titled TEMPERATURE CONTROL PROFILES and GENERAL SCHEDULE PROFILES. TEMPERATURE CONTROL PROFILES includes an index number, a list of control points, and a graphic description of each control profile. GENERAL SCHEDULE PROFILES includes an index number, a list of hourly capacity percents, and a graphic display of capacity fractions for each schedule profile. A profile with no capacity greater than 5 percent will not be reported.
3. ZONE SUMMARY - This report, titled DESCRIPTION OF ZONE report includes, for each zone in the group, a list of the surfaces of the zone, a description of all scheduled loads, and all temperature control strategies. The surface U-value includes

inside and outside film coefficients, as appropriate. The descriptions of schedules and controls refer to the index numbers of the temperature control profile and general schedule profile reports.

4. WALLS - This report option gives a detailed description of the building surfaces. It describes the material layers and their thermal properties and lists the conduction transfer functions that define the time dependent thermal conductivity of the surface. It also gives the optical properties of all window types. This report enables the user to verify that the simulation has used the correct parameters for the building surface.
5. ZONE - This report produces a plan view of the heat transfer surfaces of the zone and the coordinates of the vertices of all zone surfaces. It is useful in checking that the geometry of the zone has been properly described. The line printer sketch of the zone plan gives a quick indication of error; the report of the surface vertices can be used to show which surface is out of position.
6. SHADE - This report causes the periodic printing (14 times per zone per annual simulation) of 24-hour values of sunlit area functions for all zone heat transfer surfaces. This report is useful for doing DESIGN DAY calculations to determine proper dimensions for overhangs and wings. It may also be useful to see if individual windows can be combined without changing solar gains.
7. ZONE LOADS - For design days, this report lists the loads by the hour, along with return air heat gain, infiltration heat loss and infiltration heat gain.
8. ZONE LOAD SPLITS - For design days, this report presents approximate sensible load splits for various elements of the building model on a zone by zone basis. More detail on the fractions of the conduction loads are also shown for various zone surfaces.
9. ASHRAE HEATING LOAD CALCULATION - This report lists the ASHRAE design heating load (UAΔT) for each surface and zone. It also compares the ASHRAE heating load with the BLAST peak heating load for each design day.

Thermal Comfort Reports -- Optional

1. PIERCE - This report list the hour by hour thermal comfort indices for all design day environments using the Pierce Two Node Model. The following values are reported:
   a. TIME - time of day,
   b. METAB - the metabolic rate,
   c. ICL - clothing insulation in 'clo',
   d. VEL - the air velocity,
   e. WORK - the rate of doing work,
   f. PA - partial pressure of the water vapor in the zone,

g. MAT - the Mean Air Temperature,

h. CMRT - the Calculate Mean Radiant Temperature,

i. TSK - the Skin Temperature,

j. TCR - the body core temperature,

k. PMV(ET) - the PMV calculated with ET,

l. DISC - the discomfort index,

m. PMV(SET) - the PMV calculated with SET,

n. TSENS - the thermal sensation index.

1. KSU - This report list the hour by hour thermal comfort indices for all design day environments using the KSU Two Node Model. The following values are reported:

a. TIME - time of day,

b. METAB - the metabolic rate,

c. ICL - clothing insulation in 'clo',

d. VEL - the air velocity,

e. WORK - the rate of doing work,

f. PA - partial pressure of the water vapor in the zone,

g. MAT - the Mean Air Temperature,

h. CMRT - the Calculate Mean Radiant Temperature,

i. TSK - the Skin Temperature,

j. TCR - the body core temperature,

k. ESW - the skin wetness factor,

l. WET - the skin wettedness,

m. EVC - the vasoconstriction factor,

n. TSV - the thermal sensation vote.

1. FANGER - This report list the hour by hour thermal comfort indices for all design day environments using the Fanger Comfort Model. The following values are reported:

a. TIME - time of day,

b. METAB - the metabolic rate,

c. ICL - clothing insulation in 'clo',

d. VEL - the air velocity,

e. WORK - the rate of doing work,

f. PA - partial pressure of the water vapor in the zone,

g. MAT - the Mean Air Temperature,

h. CMRT - the Calculate Mean Radiant Temperature,

i. FCL - the ratio of the surface area of the clothed body to that of a nude body,

j. PMV - the predicted mean vote.

Air Handling System Reports

The following reports are produced from BLAST runs that include Systems.

Default Air Handling System Reports

The default Air Handling System reports are produced only when there are elements to report. They are produced to help the user tune the simulation, if necessary.

1. AIR HANDLING SYSTEM LOADS NOT MET SUMMARY lists the excess of demand over capacity (where all demand is met, a zero or "NO UNMET LOADS FOR THIS ZONE" is printed). Unmet zone loads are caused by (a) insufficient air flow, (b) a deck temperature specified too low or high to deliver air hot or cold enough to meet all loads, or (c) coils scheduled to be off when they should be energized. This report prints the total and peak unmet load and the number of hours of unmet load (hourly and daily) for design days; it also prints the same information (monthly and annually) for weather simulations.

2. UNDERHEATING/UNDERCOOLING - When the fan system does not provide all of the heating/cooling demanded by the zone loads simulation, this condition will be reported as fan system underheating/undercooling. Causes of this condition include:

   a. Insufficient supply air volume,

   b. Deck temperatures too low/high,

   c. Heating/cooling coil scheduled off.

3. OVERHEATING/OVERCOOLING - When the fan system provides more heating/cooling than is demanded by the zone loads simulation, fan system overheating/cooling will be reported. Causes of this condition include:

   a. Fan heat greater than heating load,

   b. Improper control profile for VAV system,

   c. Reheat coil scheduled off.

4. HEATING/COOLING PROVIDED WITHOUT DEMAND - Heating/cooling provided without demand occurs when the fan system heats/cools a zone even though there was no heating/cooling demand from the building simulation. Causes of this condition include:

   a. Improper system operation schedule,

   b. Improper control profile,

   c. Inherent problems when using the VENTILATION option in the building description.

Optional Air Handling System Reports

When requested, BLAST will print the following optional reports from runs that include Systems.

1. AIR HANDLING SYSTEM ENERGY USE SUMMARY lists the total and peak demand for building and fan system consumption of electricity, gas, steam, hot water, and chilled water. For design day simulations, this information is reported hourly and daily; for weather tape simulations, this information is reported monthly and annually.
2. COIL LOADS **-** This report, titled AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY, lists energy consumption and use statistics for all coils, humidifiers, and baseboard heat.
3. SYSTEM LOADS **-** This report, titled AIR HANDLING SYSTEM LOADS SUMMARY, lists the total and peak heating and cooling demands placed on the system by the building and the actual total and peak heating and cooling provided by the system. This report also produces an "energy budget" for the system and the building it serves.
4. SYSTEM **-** This report, titled AIR HANDLING SYSTEM DESCRIPTION, prints all input values for the fan system description including values specifically input by the user or supplied as defaults by the program. Users are cautioned that not all the variables printed in this report will apply to any particular fan system.
5. SYSTEM DESIGN REPORT SUMMARY is produced only if the DESIGN SYSTEM option has been used. The report indicates the zone supply air quantities that were calculated by the program.

1. EVAPORATIVE REPORT **-** Displayed in this report are the amount of water consumed from the evaporation process and the amount of electric energy consumed by the secondary fans and pumps. The electrical consumption will also show up in the Air Handling System Energy Use Summary under Electricity in the Total Use column. This report will also give the cooling provided by the evaporative cooler and the chilled water consumption of the cooling coil.
2. HUMIDITY REPORT **-** The fields in this report are calculated only for the system operating hours. When the fan system is not operating, the humidities in the zone are undefined. The maximum and minimum humidities, the month, day, and hour are reported. The humidity report was developed for use with the evaporative cooler simulations but can be run for any fan system with or without an evaporative cooler specified.

Water Loop Heat Pump System Report -- Optional

1. WLHPS SYSTEM ENERGY USAGE REPORT lists the following variables for either a design day or an annual run:

   HEAT PUMPS**-**The total heat pump network consumption and peak values.

LOOP PUMP-The loop pump consumption and peak values.

HEAT LOAD-The supplemental heating load required by the loop.

COOL LOAD-The supplemental cooling load required by the loop.

LOOP TEMPERARTURE- The maximum and minimum hourly heat pump inlet temperature.

TANK TEMPERATURE-The maximum and minimum hourly storage tank temperature.

2. HEAT PUMP NETWORK SUMMARY REPORT provides the individual heat pump unit energy demand summaries and the heat pump network outlet temperature for either a design day or an annual run.
3. COOLING TOWER ENERGY USAGE SUMMARY provides the cooling tower energy usage broken down by fan consumption, pump consumption, and total usage for either a design day or an annual run.
4. WATER LOOP SYSTEM LOADS REPORT provides the user with the heating and cooling supplied by the water loop heat pumps to each zone for either a design day or an annual run.

Central PlantReports

The following reports are produced from BLAST runs that include Plants.

Default Central Plant Reports

The default Central Plant reports are produced only when there are elements to report. They are produced to help the user tune the simulation, if necessary.

PLANT LOADS NOT MET SUMMARY lists the excess of demand over capacity (where all demand is met, a zero is printed). Unmet plant loads are caused by undersized equipment or improper equipment scheduling. This report prints the total and peak unmet load and the number of hours that the unmet load occurred for each month.

Optional Central Plant Reports

1. CENTRAL PLANT ENERGY UTILIZATION SUMMARY displays the energy demand and consumption of the Plant. This information is presented in a table of 13 columns.
2. PLANT LOADS- PLANT LOAD SUMMARY - This report displays the total and peak plant heating, cooling, and electrical demand as well as the time that the peak occurred. It also shows the total energy purchased from one of five utilities (i.e. electricity, diesel fuel, gas turbine fuel, boiler fuel, steam), and energy recovered in the plant.
3. EQUIPMENT PARAMETERS - This report displays the equipment size, availability, and part load ratios of all the equipment used in describing the plant, along with a listing of all

of the Equipment Performance Coefficients and Special Parameters.

3. DESIGN PLANT - CENTRAL PLANT EQUIPMENT DESIGN REPORT - This report displays maximum cooling, heating, boiler fuel, and electric demands; the values of the capacity multipliers used (i.e. PDPCCM, PDPBCM, PDPEGM); and the size of the equipment used based upon the percentage of the peak load that was chosen for the equipment, and is produced only if the Design Plant option is used.

4. LCC reports – This report keyword causes BLAST to produce a special file that contains information relevant to Life Cycle Cost Studies about the fuel consumption of the simulation.

Ice Storage Reports – Optional

ICE STORAGE REPORT - The design day report gives hourly values for the ice storage device. Displayed are the amount of ice built and used per hour, parasitic ice and electric losses, condenser and compressor electric use, and the total electric consumption of the ice storage device.

The annual report shows monthly values for the amount of energy that the ice storage device has stored (reported in the Building/Fan/Plant Energy Utilization Summary Report) less the amount of stored energy lost. The electric consumption is broken into on-peak and off-peak consumption during the period. The number of hours that the ice storage device did not meet the cooling demand and the amount by which it failed to meet the demand are also displayed.

Thermally Stratified Tank Report -- Optional

The STRATIFIED TANK REPORT has the ability to display information regarding a design day or an annual run. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the ideal stratified tank capacity is given. An explanation of each variable is given below.

Variable (Design Day)	Description
Energy Stored This Hour	The amount of energy added to the tank this hour based on the enthalpy of the water introduced at the tank inlet.
Energy Used This Hour	The amount of energy removed from the tank this hour based on the enthalpy of the water removed at the tank outlet.
Current Tank Capacity	The energy capacity of the tank is reported as a change in internal energy. It is important to note that the reference for the tank capacity calculations is different from the energy stored and energy used calculations. Therefore, one can not subtract or add the energy stored or energy used to obtain the tank capacity.
Pump Electric	The pump electric consumption during this hour.
Parasitic Electric	Parasitic electric consumption during this hour.

Variable (Annual Run)	Description
Energy Stored	The amount of energy added to the tank based on the enthalpy of the water introduced at the tank inlet.
Energy Used	The amount of energy removed from the tank based on the enthalpy of the water removed at the tank outlet.
Electric Consumption	Total electric consumption of the stratified tank storage.
Total Hours Not Met	The number of hours that the stratified tank did not meet the required demand.
Total Consumption Not Met	The total consumption that the stratified storage tank did not meet.

Same As

If two zones are identical (or very nearly identical), only one needs to be simulated during the BLAST load calculation phase. A zone multiplier can be used to describe the zone's fan system to account for the many zones that may be nearly or exactly identical to it. However, zones which are similar but face in different directions or have other different features are very quickly described by using the "SAME AS" feature. For example:

ZONE 13 "MY ZONE":

ORIGIN: (0,0,0);

NORTH AXIS = 30;

SAME AS ZONE 2 EXCEPT:

(Any surfaces, non-geometric factors, or other differences between zone 13 and zone 2)

END ZONE;

There are a few important rules to follow in using the "SAME AS" feature:

1. If the user wishes to redescribe a single surface of a given type, all the surfaces of that type must also be redescribed.
2. If a user wants to delete any surfaces of a type that existed in a previously described zone, the following statement must be used:

   DELETE surface type;

3. Users cannot change room dimensions by simply changing the DIMENSION statement. Any surface or subsurface dimensions that have changed must be redescribed. This is necessary because, when a dimension statement is used to describe a zone, BLAST replaces the dummy dimensions with the actual numbers as soon as they are encountered in a zone description. Thus, changing the dimension statement will have no effect on the zone unless the changed dimensions are repeated in a description of the surfaces *after* the dimension statement is used.
4. The similar zone must be in the same building description as original zone.

Specifying a "SAME AS" Zone in BTEXT

A zone that is to be described using the "SAME AS" feature can be described in BTEXT using the following series of commands:

Choose **B** (Building and Zone Descriptions) from the Main Menu

Choose **Z** (Zone Description) from the Building and Zone Choices Menu

Enter a **name**, **north axis**, and **origin** for the new zone

Choose **A** (Same As) from the Zone Description Choices Menu

Enter the **Zone Number** which the new zone is to be "SAME AS"

Please note that the "SAME AS" feature can only be used while in BTEXT Detail Level 5. For more information on BTEXT Detail Levels, see *Detailed Geometry* in the *BLAST User Reference*. In addition, BTEXT will only allow you to create a duplicate zone. Any changes that need to be made to the new zone must be done in the BLAST input file using a file editor.

The following description uses the "SAME AS" feature to describe the simple four zone building shown below.

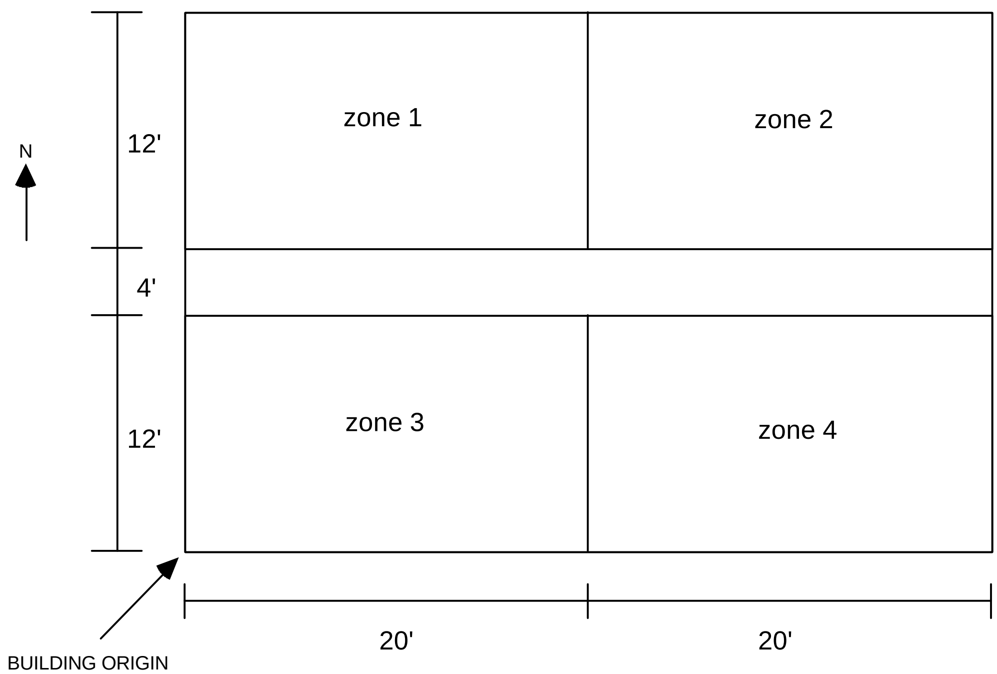


Figure 83. Simple Four Zone Building

```
BEGIN BUILDING DESCRIPTION;
DIMENSIONS:  N=0, E=90, S=180, W=270;
ZONE 1 "NORTHWEST OFFICE":
       ORIGIN:  (0,16,0);
       EXTERIOR WALLS:
.
..     full description of zone 1
.
END ZONE;
ZONE 2 "NORTHEAST OFFICE":
       ORIGIN:  (20,16,0);
       SAME AS ZONE 1 EXCEPT:
       EXTERIOR WALLS:
.
.
.      redescribe each exterior wall
.
       PARTITIONS:
.
.
.      redescribe each partition;
.
END ZONE;
ZONE 3 "SOUTHWEST OFFICE":
       ORIGIN:  (20,12,0);
       NORTH AXIS = 180:
       SAME AS ZONE 2 EXCEPT:
END ZONE;
ZONE 4 "SOUTHEAST OFFICE":
       ORIGIN:  (40,12,0);
       NORTH AXIS = 180;
       SAME AS ZONE 1 EXCEPT:
END ZONE;
END BUILDING DESCRIPTION
```

The specifications for PEOPLE, LIGHTS, ELECTRIC EQUIPMENT, GAS EQUIPMENT, OTHER, VENTILATION, MIXING, CROSS MIXING, BASEBOARD HEATING, DAYLIGHT, INTERNAL MASS, INFILTRATION, and CONTROLS of each zone of the four-zone building described above are the same. In this case, zone 1 is identical to zone 4 except for its origin and the angle toward which its north axis is pointed. Similarly, zones 2 and 3 are identical except for their north axis and origin. The figure above shows how zone movement and rotation have been accomplished. For example, if the origin of zone 1 were moved to the origin shown for zone 4 and rotated 180 degrees, zone 1 would correspond exactly with zone 4. If zone 2's origin is then moved to the origin shown for zone 3 and rotated 180 degrees, zone 2's new description would be identical to the description of zone 3. Zone 2 is also described as being like zone 1; however, use of the "SAME AS" feature in this case requires that the exterior walls and partitions be redescribed since no possible combination of origin movement and north axis rotation will cause zone 1 to look like zone 2.

To avoid building description errors, the SAME AS statement should only be used to reference zones that have been previously described in detail; SAME AS statements should not be "cascaded" in the building description.

For example, if zone 1, zone 2, and zone 3 are all similar and zone 1 is described in detail, both zone 2 and zone 3 should be described as SAME AS zone 1. Zone 3 should not be described as SAME AS zone 2 because the "cascaded" SAME AS statements (zone 2 SAME AS zone 1; zone 3 SAME AS zone 2) may result in an erroneous geometrical description of zone 3.

Specifying a "SAME AS" Zone in HBLC

HBLC does not support the “Same As” function. If the user wishes to use “Same As”, it must be implemented either manually with a text editor or by using BTEXT.

HBLC has the “Duplicate Zone” command located under the “Geometry” tab of the menu bar. Duplicate Zone creates a geometric copy of the currently selected zone. Other data applied to the zone (e.g. scheduled loads, thermal comfort parameters, controls) should be edited or added as desired.

Note: HBLC will not duplicate a zone if it has surfaces that have been designated as interzone partitions, floors, or ceilings.

Schedule

During Plant simulations, BLAST allows specification of domestic hot water demand, plant electrical demand, and availability of process waste heat. The syntax for the hot water input is as follows:

HOT WATER = usn1, schedname, FROM date1 THRU date2, AT usn2 SUPPLIED BY esource;

where: usn1 = peak demand for hot water in 1000 Btu/hr (or kW) (default=0.0)

usn2 = HOT WATER supply temperature

schedname = any previously defined schedule name from the library

(default=CONSTANT)

date1 = start date for this load (of form DDMMM, i.e., 15JAN) (default=01JAN)

date2 = stop date for this load (of form DDMMM, i.e., 15JAN) (default=31DEC)

esource = simple fuel boiler, fuel domestic hot water heater, or electric domestic hot water heater.

The value of usn2 is not currently used anywhere, but a value must be specified to make the input acceptable. Note that HBLC creates the correct syntax. This command can be repeated up to 12 times.

The PLANT ELECTRICAL command is used to describe a demand for electricity in the plant that is not otherwise accounted for. The syntax is:

PLANT ELECTRICAL DEMAND = usn1, schedname, FROM date1 THRU date2;

where: usn1 = peak demand for electricity in 1000 Btu/hr (or kW) (default=0.0)

schedname = any previously defined schedule name from the library (default=CONSTANT)

date1 = start date for this load (of form DDMMM, i.e., 15JAN) (default=01JAN)

date2 = stop date for this load (of form DDMMM, i.e., 15JAN) (default=31DEC)

This command may be repeated up to 12 times.

The PROCESS WASTE HEAT command is used to describe the availability of waste heat for use in the plant. The syntax is:

PROCESS WASTE HEAT = usn1, schedname, FROM date1 THRU date2 AT LEVEL usn2;

where: usn1 = peak amount of waste heat available in 1000 Btu/hr (or kW) (default=0.0)

schedname = any previously defined schedule name from the library (default=CONSTANT)

date1 = start date for this load (of form DDMMM, i.e., 15JAN) (default=01JAN)

date2 = stop date for this load (of form DDMMM, i.e., 15JAN) (default=31DEC)

usn2 = level number corresponding to the level of the waste energy available (default=5)

An example SCHEDULE block is:

```
SCHEDULE:
        HOT WATER = 10, INTERMITTENT, FROM 01JAN THRU 31
            DEC;
        HOT WATER = 100, FROM 10JUN THRU 20JUN;
        PROCESS WASTE HEAT = 1000, CONSTANT, FROM 01JUN
            THRU 31 JUL;
                AT LEVEL 3,
END SCHEDULE;
```

Specifying Electrical Demand and Waste Heat Availability in HBLC

Clicking on the "Plant Schedules" button in the upper right hand corner of the Plants dialog box will bring up the Plant Schedules form, shown below.

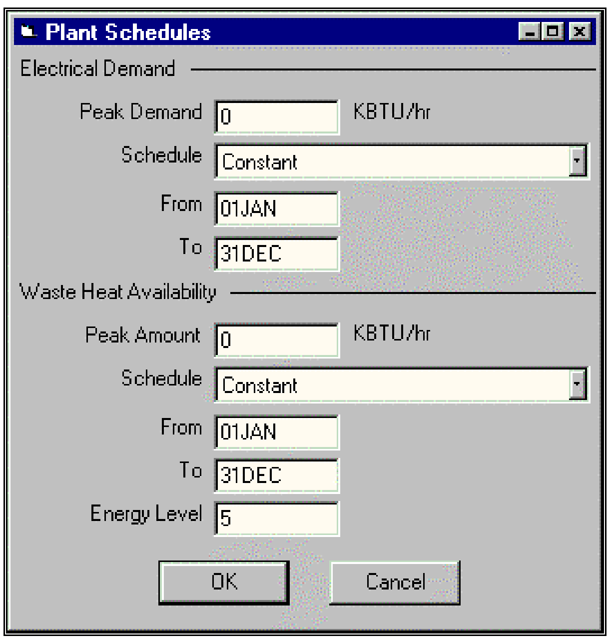


Figure 84. Plant Schedules form

Simple Chiller

EQUIPMENT DESCRIPTION:

A simple chiller is simulated in BLAST as a standard vapor compression refrigeration cycle with a constant coefficient of performance (COP). Unlike other BLAST chiller models, the performance of the simple chiller does not exhibit changes in the available capacity and energy consumption at different operating conditions.

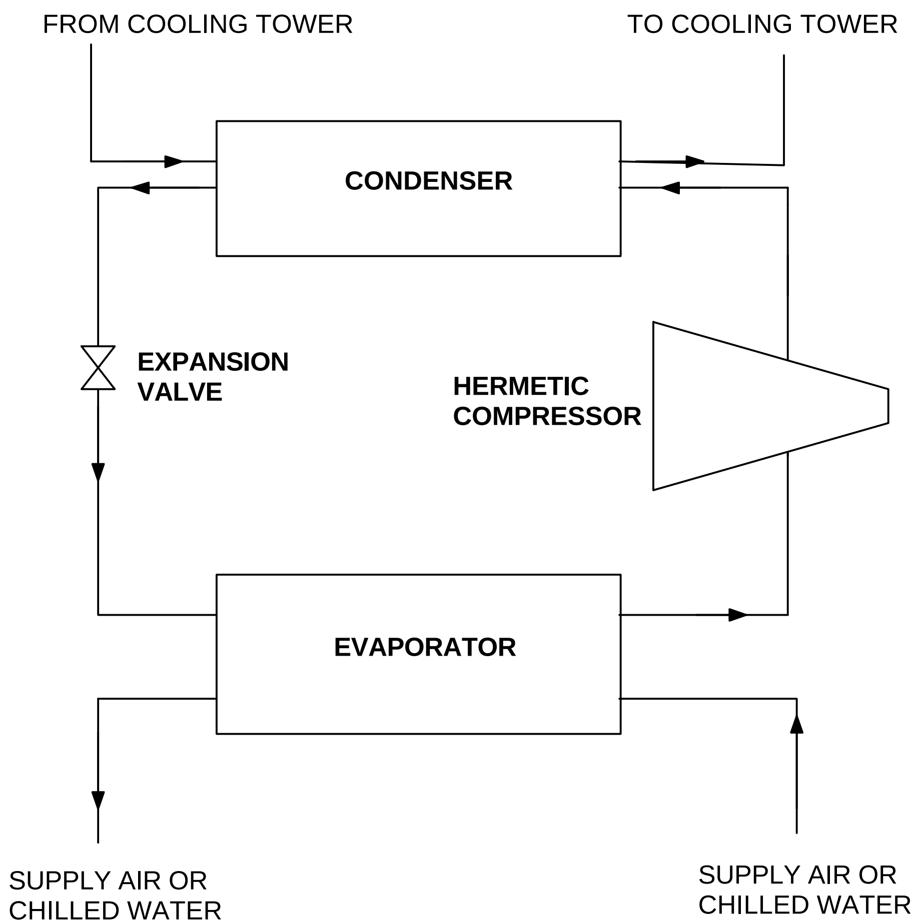


Figure 85. Diagram of a BLAST simple chiller

USING THE BLAST SIMPLE CHILLER:

Specifying a Simple Chiller in HBLC

To specify a simple chiller as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Simple” from the “Chillers” sub-menu. Fill in the number of chillers and their unit capacity.

ADJUSTING THE PERFORMANCE PARAMETERS OF THE SIMPLE CHILLER:

Once the Simple Chiller has been added, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a simple chiller that has the following operating parameter:

COP = 3.25

Valid condenser types that may be specified by the user for a chiller are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

CHLREF- Used to specify the COP of the chiller. ELEC = ECLNET/CHLREF: and TOWER = ECLNET + ELEC are the governing formulas where ELEC is the electrical energy input, ECLNET is the chiller net energy output, and TOWER is the load on the cooling tower.

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the simple chiller syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the simple chiller. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

SIMPLE CHILLER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 " SIMPLE CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
SIMPLE CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CHLREF=3.25;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

SIMPLE CHILLER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "SIMPLE CHILLER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
SIMPLE CHILLER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
CHLREF=3.25;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Simple Fuel Boiler

EQUIPMENT DESCRIPTION:

The Simple Fuel Boiler equipment type models a constant efficiency boiler. BLAST can model either a simple boiler or the standard fuel boiler. Both cannot be simulated in the same central plant.

The fuel consumption for the simple boiler is reported in the BUILDING / FAN / PLANT ENERGY UTILIZATION SUMMARY report under boiler fuel column for the amount of fuel used and under the appropriate electric consumption column for the parasitic electric consumption. In addition, the consumption is reported in the PLANT EQUIPMENT ENERGY INPUT BREAKDOWN report under Fuel Boiler and Fuel Boiler Electric for the fuel and electricity consumed, respectively.

Again, BLAST can model either a simple boiler or the standard fuel boiler. Both cannot be simulated in the same Central Plant. Some users may wonder why only a simple fuel boiler is added and not a simple electric boiler. The reason is that the present electric boiler model in BLAST assumes a constant efficiency; therefore, a simple electric boiler would be redundant.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

BOILEF- Used to specify the constant efficiency of the simple boiler. EFUELB = EBLNET/BOILEF where EFUELB is the boiler fuel energy consumed and EBLNET is the boiler net energy output.

BOLELE- Used to adjust the parasitic electric consumption of the simple fuel boiler. ELEC = OCAP*BOLELE where ELEC is the parasitic electric consumption of the boiler, OCAP is the boiler capacity, and BOLELE is the user specified special parameter for the ratio capacity to parasitic electric load.

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the simple boiler syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the simple boiler. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

SIMPLE BOILER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 " SIMPLE BOILER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
SIMPLE BOILER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
BOILEF=0.75;
BOLELE=0;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

SIMPLE BOILER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "SIMPLE BOILER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
SIMPLE BOILER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
BOILEF=0.75;
BOLELE=0;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Single Zone Draw Through System

EQUIPMENT DESCRIPTION:

One of the simplest of all-air systems is a supply unit serving a single temperature controlled zone. Ideally the system is responsive to all the zones needs. Well designed systems can maintain temperature and humidity very accurately and efficiently. They can also be shut down when desired without affecting the operation of adjacent areas. Since control is directly from space temperature and humidity, the system conditions can be closely regulated, but without reheat, humidity can not be controlled independently of temperature requirements.

Note that in the Single Zone Draw Through system, supply air temperature is allowed to fluctuate so that all system loads are met. Thus, BLAST will not limit unreasonable performance in this model, and will never show undercooling or underheating in a Single Zone Draw Through system. Undersizing is not possible.

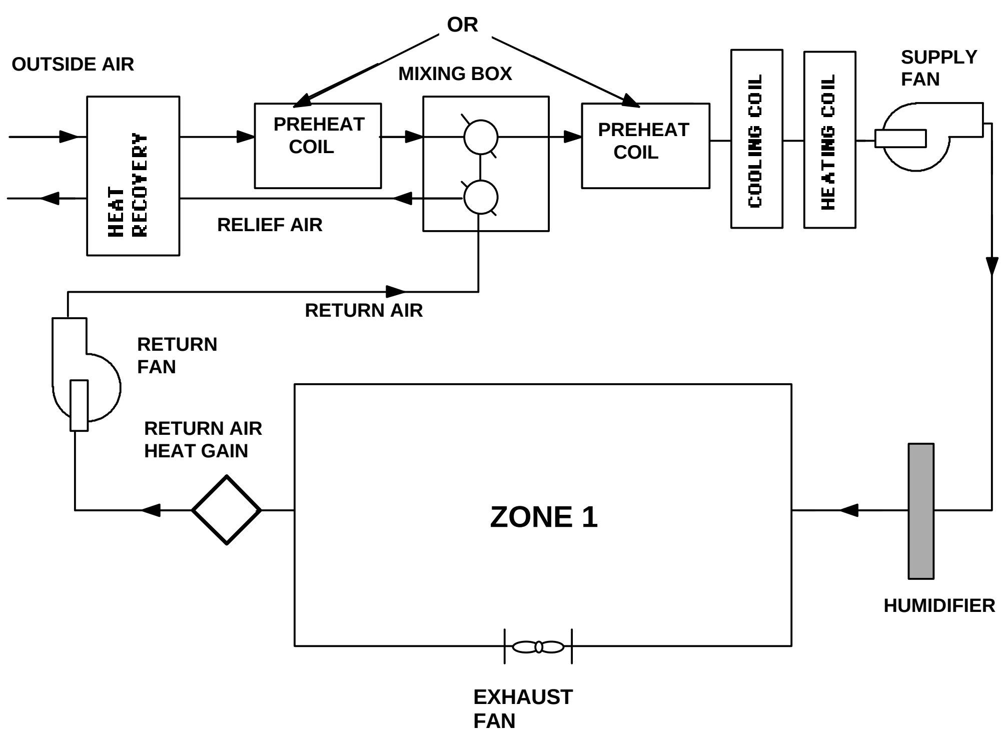


Figure 86. Diagram of a BLAST single zone draw through system

USING THE SINGLE ZONE DRAW THROUGH SYSTEM:

Specifying a Single Zone Draw Through System in HBLC

To specify a single zone draw through system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select "Single Zone Draw Thru" from the pop up menu. After naming the system, the user must enter the zone number and Supply Air Volume.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the single zone draw through system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

SINGLE ZONE DRAW THROUGH SYSTEM 1

"SINGLE ZONE DRAW THROUGH " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .       (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .      OTHER SYSTEM DATA BLOCK
      .   .   .   .      (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .      COOLING COIL DATA BLOCK
      .   .   .   .      (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .      HEAT RECOVERY DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
      COPC=(11,34.09,-0.087);
      .   .   .   .      HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
      COPH2=(22,-3.9,0.022);
                         HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
      .   .   .   .      DX UNIT DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      .   .   .   .      SCHEDULES DATA BLOCK
      .   .   .   .      (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
      =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the single zone draw through system syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the single zone draw through system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the single zone draw through system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the single zone draw through system are listed in bold and all options as well as Metric (SI) units are italicized.

SINGLE ZONE DRAW THROUGH ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

SINGLE ZONE DRAW THROUGH OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED;
               =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED
               =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
               =FIXED AMOUNT;
               =TEMPERATURE ECONOMY CYCLE;
               =RETURN AIR ECONOMY CYCLE;
               =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
               =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
               =OUTSIDE AIR DUCT;
               =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
               =VARIABLE FAN SPEED;
               =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
               =STEAM
               =HOT WATER;
               =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft³/min or m³/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

SINGLE ZONE DRAW THROUGH COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE TECHNICAL REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

SINGLE ZONE DRAW THROUGH HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT  RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

SINGLE ZONE DRAW THROUGH EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;=
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

```
EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM
TEMPERATURE,-328 MINIMUM TEMPERATURE;
```

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Solar Distribution

Simplified Zone Geometry Description

When shading of windows and walls has a significant effect on zone loads, the building's geometry must be carefully described. However, many cases exist in which the load can be adequately calculated without considering shading. The following command placed before the first zone description will allow a simpler description of zone geometry:

SOLAR DISTRIBUTION = -1;

When this command is in effect for the building, shading effects of detached shading surfaces and zone walls are not considered. It is therefore possible to remove the phrase "STARTING AT (usn,usn,usn)" from all surface descriptions. The shading effects of wings and overhangs on walls and windows are unchanged.

Setting the SOLAR DISTRIBUTION determines how BLAST will treat beam sunlight entering a zone through windows. When using SOLAR DISTRIBUTION = -1, all beam sunlight is assumed incident on the floor, where it is absorbed according to the floor's solar absorbance. Any not absorbed by the floor is added to the transmitted diffuse radiation, which is uniformly incident on all interior surfaces. If no floor is present in the zone, the incident beam solar radiation is absorbed on all interior surfaces. The zone heat balance is then applied at each surface and on the zone's air with the absorbed radiation being treated as a flux on the surface.

Enhanced Zone Geometry Description

When a slightly more detailed solar calculation and zone geometry are desired, the following command should be included in the BLAST input file:

SOLAR DISTRIBUTION = 0;

Shadow patterns on exterior surfaces caused by detached shading, wings, overhangs, and exterior surfaces of all zones are now computed. Beam sunlight transmitted through windows is assumed to be incident on the floor, where it is absorbed according to the floor's solar absorbence. Any not absorbed is added to the transmitted diffuse radiation that is uniformly incident on all interior surfaces. If there is no floor present, the incident beam solar radiation is handled the same as for SOLAR DISTRIBUTION = -1.

Detailed Zone Geometry Description

When it is expected that loads will be affected by the distribution of solar energy on the inside surfaces of the zone, the user should give the command:

SOLAR DISTRIBUTION = 1;

BLAST will then calculate the amount of beam radiation falling on each surface in the zone by projecting the sun's rays through the windows. If this option is used, the user should ensure that the surfaces of the zone totally enclose a space.

Specifying Solar Distribution in HBLC

Solar Distribution can be specified in HBLC by checking the appropriate radio button on the “Project Information” form found under the “Environment” tab of the menu bar. The three choices correspond to the three solar distribution integer values.

Note: When a passive solar study is not the primary objective of the BLAST run, it is recommended that SOLAR DISTRIBUTION = -1 or 0 be used in order to allow less detailed zone descriptions. It should also be noted here that the only way to allow solar radiation into the zone is through windows. If glass doors are specified, BLAST treats them like walls and no solar radiation will be transmitted through them.

Special Parameters

SPECIAL PARAMETERS are additional constants needed to simulate central energy plants. These constants include boiler and chiller operating temperatures, heat content of fuels, system pressures and flow rates, and the efficiency of off-site power stations and others. The format of this block is:

```
SPECIAL PARAMETERS:
    TCOOL = 44;
    RFLASH = .10;
    .
    .
    .
END SPECIAL PARAMETERS;
```

The following table shows which special parameters are associated with particular equipment types. For example, the complete entry of special parameters for gas turbines would be:

```
SPECIAL PARAMETERS:
    .
    .
    TSATUR =  ;
    RMXKWG =  ;
    .
    .
END SPECIAL PARAMETERS;
```

Entries for parameters may be in any order.

Some or all of the special parameters may be entered. Omitted ones that are applicable to the equipment will take the default values given in the following table.

Special Parameters Table		
Special Parameter Name	**Special Parameter Description**	**Default Value (English)**
AZMUTH	Collector Array Azimuth Angle	180.0000
EBEFF	Electric Boiler Efficiency	1.0
FCCTRL	Free Cooling Chiller Control Type	1.0
FCOFF	Free Cooling Chiller Off Date	415.0
FCON	Free Cooling Chiller On Date	33.0
FCTEMP	Free Cooling Chiller Control Temp	50.0
FLOWRT	Mass Flow/Collector Area	9.2167
HFUELB	Heat Content of Fuel	20013.3845
HTXEFF	Tank Collector Ht Excgr Effectiveness	0.9000
MXTNKT	Maximum Solar Tank Temp	212.0000
PDPBCM	Plant Design Boiler Capac Multiplier	1.0
PDPCCM	Plant Design Chilr Capac Multiplier	1.0
PDPEGM	Plant Design Elec Generation Multiplier	1.0
PELCL	Elec Inp to Circ Pump/Cooling Load	0.0180

PELDTWR	Elec Inp Dir Twr Pump/Direct Twr Capac	0.12
PELECND	Elec Inpu Evap Cond Pump/Evap Cond Design Cap	0.012
PELHT	Elec Inp to Circ Pump/Heating Load	0.0060
PELTWR	Elec Inp to Tower/Tower Cool Load	0.0130
PELWWC	Elec Inp Well Water Cond Pump/Well Water Cond Cap	0.012
PSTEAM	Steam Pressure	284.4099
PSTMTUR	Entering Steam Pressure	6920.1708
RAVRHDB	Available Recoverable Heat Ratio	0.9500
RAVRHHP	Available Recoverable Heat Ratio	0.9500
RFLASH	Boiler Flash Water/Steam Feed	0.0170
RHFLASH	Recovered Heat/Flash Steam Energy	0.5000
RMXKWD	Max Exh Flow/kW Output	1.4644
RMXKWDC	Max Exh Flow/Power Output Diesel Chilr	1.46
RMXKWG	Max Exh Flow/kW Output	11.7152
RMXKWGC	Max Exh Flow/Power Output Gas Turbine Chilr	11.71
RPMNOM	Nom Speed, RPM	3600.0000
RWC1A	Tower Water/One Stage Absorber Capac	124.8
RWC2A	Tower Water/Two Stage Absorber Capac	124.8
RWC2AE	Tower Water/Two Stage Absorber Capac	124.8
RWCDB	Tower Water/Dbund Chilr Capac	124.8225
RWCDC	Tower Water/Diesel Chilr Capac	124.8
RWCFC	Tower Water/Free Cooling Chilr Capac	124.8
RWCGC	Tower Water/Gas Turbine Chilr Capac	124.8
RWCHC	Tower Water/Hermetic Chilr Capac	124.8
RWCHP	Tower Water/Heat Pump Capac	124.2230
RWCOC	Tower Water/Open Chilr Capac	124.8
RWCRC	Tower Water/Reciprocating Chilr Capac	124.8
RWSTUR	Condensate/Entering Steam	0.9700
SRATB	Air, Fuel Stoich Ratio	17.0000
STEAM	Steam Enthalpy	1168.6785
SYSLOSS1	Collector Performance Modifier	0.95
SYSLOSS2	Above Ground Storage Tank UA	0.0
SYSLOSS3	Below Ground Storage Tank UA	0.0
TDCTWR	Min Leave Dir Cooling Twr Water Temp	32.5
TEVAPC	Min Leav Evap Cond Water Temp	60.0
TNKTEM	Initial Tank Temperature	140.0000
TCOOL	Chilled Water Temp	44.0060
TCW	Leaving Condenser Water Temp	110.0000
TILT	Solar Collector Tilt Angle	40.0000
TLEAVE	Boiler Stack Leaving Temp	550.0400
TMINC	Min Tank Temp for Cooling	179.9960

TMINH	Min Tank Temp for Heating	100.0040
TMINHP	Min Tank Temp for Ht Pump	79.8800
TNKCAP	Storage Tank Cap/Col Area	10.2408
TOWOPR	Tower Operation Type	2.0000
TSATUR	Steam Saturation Temp	241.5302
TSTMTUR	Entering Steam Temp	572.0000
TTOWR	Minimum Leaving Tower Water Temp	60.0080
TWWC	Min Leave Well Water Cond Water Temp	32.5

Steam Turbine Generator

EQUIPMENT DESCRIPTION:

The principal use of steam turbines in the air-conditioning and refrigeration field is to drive centrifugal compressors. Such compressors are usually part of a water or brine chilling system utilizing one of the hydrocarbon refrigerants.

USING THE BLAST STEAM TURBINE GENERATOR:

Specifying a Steam Turbine Generator in HBLC

To specify a steam turbine generator as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Steam Turbine” from the “Generators” sub-menu. Fill in the number of generators and their unit capacity.

Adjusting the Performance Parameters of the Steam Turbine Generator

Once the steam turbine generator has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a steam turbine generator that has the following operating parameters:

Engine speed = 3600 RPM

Entering steam temperature = 572 °F

Entering steam pressure = 6980 in water gauge

If your steam turbine generator does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

PSTEAM-Steam turbine exhaust pressure. Units: in. water gauge or Pascal gauge

PSTMTUR- Entering steam pressure. Units: in. water gauge or Pascal

RPMNOM- Steam turbine angular speed. Units: revolutions per minute (RPM)

RWSTUR- Ratio of condensate flow to entering steam flow for steam turbines. Accounts for steam and/or condensate leaks in the turbine. Units: Dimensionless

STEAM- Enthalpy of steam from heat recovery. Units: Btu/lb or kJ/kg

TSATUR- Steam saturation temperature. Units: °F or °C

TSTMTUR- Entering steam temperature to steam turbines. Units: °F or °C

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the steam turbine syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the steam turbine. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

STEAM TURBINE GENERATOR BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "STEAM TURBINE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
STEAM TURBINE:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
STEAM TURBINE (MIN=0.02,MAX=1.1,BEST=0.9,ELECTRICAL=0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
PSTEAM=284.409;
PSTMTUR=6980.17;
RPMNOM=3600;
RWSTUR=0.97;
STEAM=1168.67;
TSATUR=241.6;
TSTMTUR=572;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
BEGIN CENTRAL PLANT DESCRIPTION:
```

STEAM TURBINE GENERATOR BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGING CENTRAL PLANT DESCRIPTION;
PLANT 1 "STEAM TURBINE" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
STEAM TURBINE:
1 OF SIZE 23.6;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=23.6, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
STEAM TURBINE (MIN=0.02,MAX=1.1,BEST=0.9,ELECTRICAL=0);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
PSTEAM=70841.4;
PSTMTUR=1783690;
RPMNOM=3600;
RWSTUR=0.97;
STEAM=2716.52;
TSATUR=116.4;
```

```
TSTMTUR=300;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Subzone Reheat System

EQUIPMENT DESCRIPTION:

The subzone reheat system is a constant volume reheat system that is not commonly used for conventional purposes and is usually reserved for special applications. The system cooling capabilities are provided by way of a cooling coil that supplies cooling to the entire supply air volume. A single or master zone controls the cooling coil. Zone control is accomplished by heating (reheating) the secondary air flows into each zone. Heat recovery and supply air preheating are both available options for a subzone reheat system.

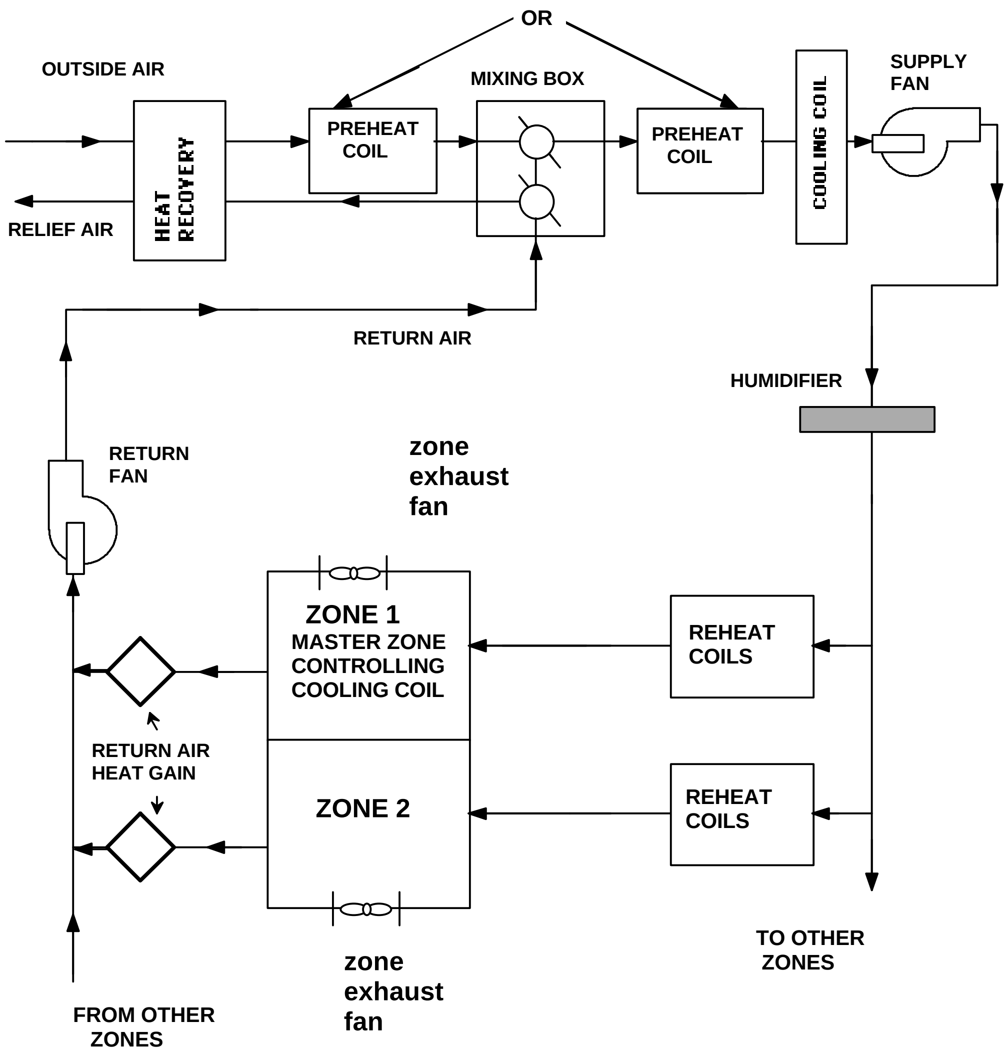


Figure 87. Diagram of a BLAST subzone reheat system

USING THE BLAST SUBZONE REHEAT SYSTEM:

Specifying a Subzone Reheat System in HBLC

To specify a subzone reheat system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select Subzone Reheat from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the subzone reheat system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

SUBZONE REHEAT SYSTEM 1

"Subzone reheat" SERVING ZONES 1;

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100;
        .   .   .   .       ZONE DATA BLOCK
        .   .   .   .        (Required user input)
    ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=2.49783;
        .   .   .   .       OTHER SYSTEM DATA BLOCK
        .   .   .   .       (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
        .   .   .   .       COOLING COIL DATA BLOCK
        .   .   .   .       (Optional expert user input)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .      HEAT RECOVERY DATA BLOCK
      .   .   .   .      (Optional expert user input)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
      COPC=(11,34.09,-0.087);
      .   .   .   .      HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
      COPH2=(22,-3.9,0.022);
                         HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
      .   .   .   .      DX UNIT DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      .   .   .   .      SCHEDULES DATA BLOCK
      .   .   .   .      (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
      =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the subzone reheat syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the subzone reheat system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the subzone reheat system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the subzone reheat system are listed in bold and all options as well as Metric (SI) units are italicized.

SUBZONE REHEAT ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

REHEAT CAPACITY- Used to specify the capacity of the reheat coils. Units: kBtu/hr or kW

REHEAT ENERGY SUPPLY- Used to specify the reheat coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

SUBZONE REHEAT OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT CONTROL LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m^2

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m^2

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

REHEAT TEMPERATURE CONTROL- Used to specify how the reheat deck is controlled. The two options are fixed set point and outside air controlled.

REHEAT TEMPERATURE LIMIT- Used to specify the maximum temperature of the reheat coil. Units: °F or °C

REHEAT CONTROL SCHEDULE- Used to determine the reheat deck temperature if the deck is outside air controlled.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

SUBZONE REHEAT COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE TECHNICAL REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

SUBZONE REHEAT HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

SUBZONE REHEAT EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRUI 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

REHEAT COIL OPERATION- Used to schedule the reheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Surface Types

Allowable surface types are:

ROOF

CEILING

EXTERIOR WALLS

PARTITIONS

WALLS TO UNCOOLED SPACES

BASEMENT WALL

FLOOR

SLAB ON GRADE FLOOR

EXPOSED FLOOR

INTERZONE PARTITION

INTERZONE CEILING

INTERZONE FLOOR

CEILINGS, FLOORS, and PARTITIONS are assumed to divide temperature-controlled spaces. Thus, in the absence of OTHER SIDE COEFFICIENTS, the program assumes that the surface temperatures on both sides of the surface are the same. This means that even though heat may be stored in a partition, ceiling, or floor, no heat flows *through* it. EXTERIOR WALLS, ROOFS, WALLS TO UNCOOLED SPACES, and EXPOSED FLOORS divide the temperature controlled space from the outside environment. EXTERIOR WALLS, EXPOSED FLOORS, and ROOFS feel the full effect of both solar radiation and outside temperature and the outside air film resistance for these surfaces changes with wind speed and wind direction. WALLS TO UNCOOLED SPACES are not affected by solar radiation and have constant outside convective air film resistance. BASEMENT WALLS and SLAB ON GRADE FLOORS separate the space from the earth surrounding the surfaces; therefore, the outside surface temperatures become the ground temperature. (A 1 to 2 ft [0.3 m to 0.6 m] layer of earth is typically included for basement walls and slab floor construction when materials to be used for basement walls and slab floors are defined in the library.)

INTERZONE PARTITIONS, INTERZONE CEILINGS and INTERZONE FLOORS separate zones that are being modeled simultaneously. The three types have different default tilts: 90°, 0°, and 180°, respectively. Each interzone surface must include the expression "ADJACENT TO ZONE (usn)", where usn is the zone number which is on the other side of the interzone surface. When that zone is described, it *must* include an interzone surface adjacent to the first zone. It may be necessary to use different wall sections if the wall layers are not symmetric; wall sections are defined starting at the outside layer. Two adjacent zones refer to different "outsides". Thermal capacitance effects are fully accounted for in the BLAST interzone calculations.

Specifying Surfaces in HBLC

Surfaces can be modified several different ways in HBLC. The first step is to select the wall to be modified by clicking on it. If more than one wall is to be modified in the same way, multiple walls can be selected by pressing shift while clicking on them. A surface can then be selected from a library by clicking on the "Find" button in the Building Information Block. If the current library is not appropriate, a new one can be selected from the "Wall Type" drop down menu.

Temporary Controls

The definition of control strategies requires first that control profiles be specified, then that each profile can be appropriately assigned to a time of day for each day of the week.

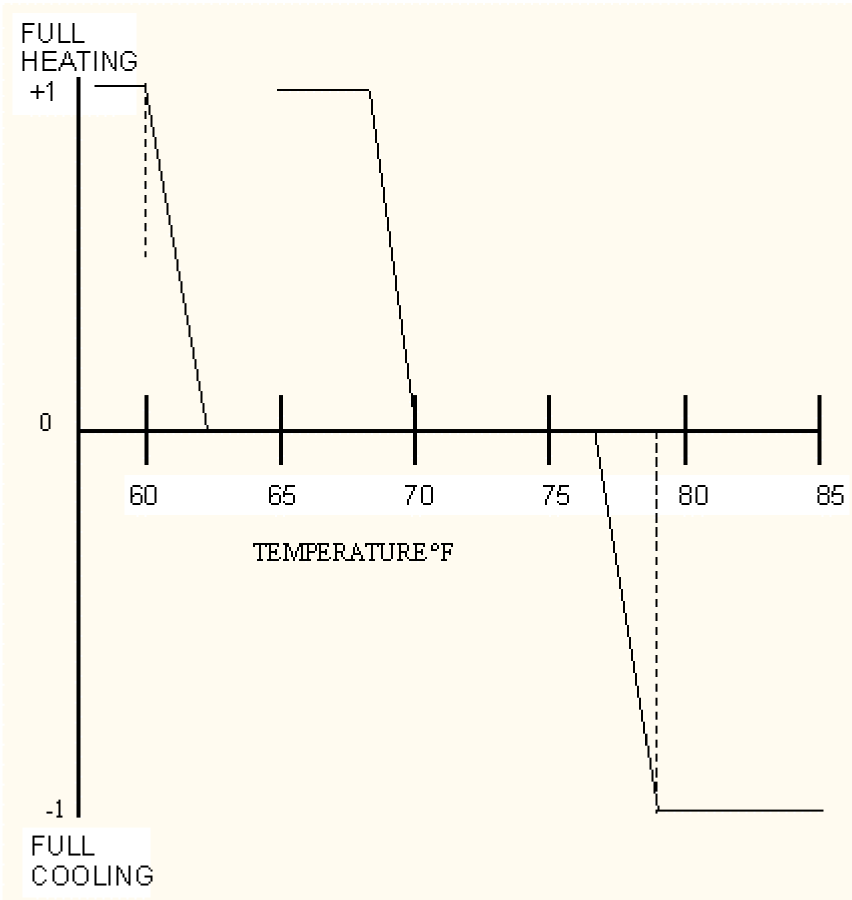


Figure 88. Graphical Representation of the Temporary Control Profile

Specifying Temporary Control Profiles in HBLC

Temporary control profiles can be specified in HBLC in the “Custom Controls” form, which is accessible under the “Library” tab of the menu bar.

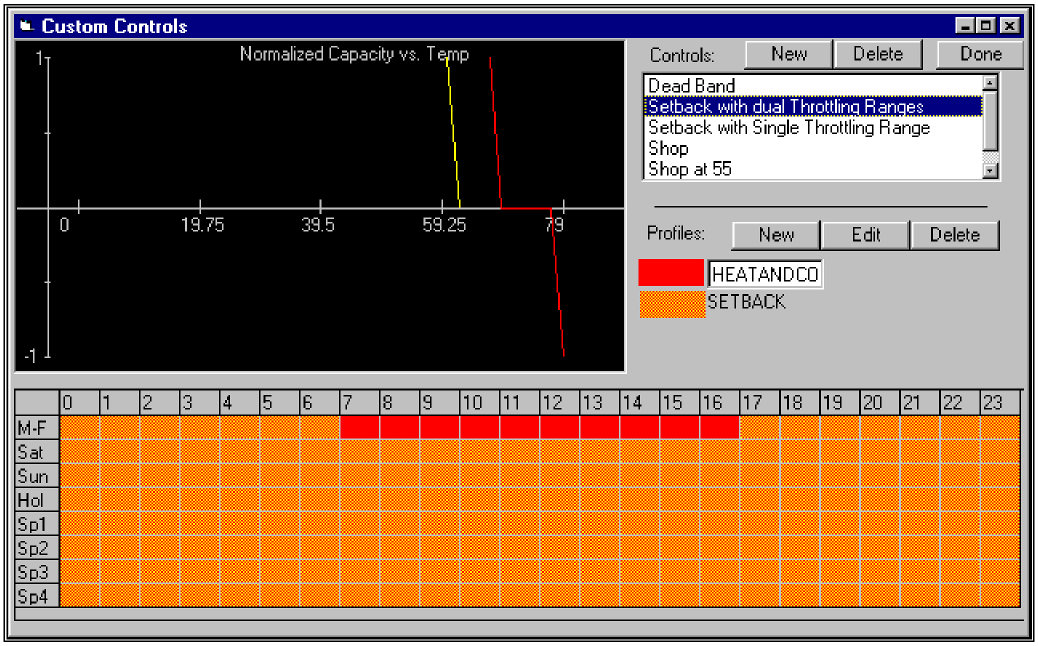


Figure 89. Custom Controls form

To create a new control, click on "Controls: New" at the top-right corner of the form. After creating a custom control, profiles can be created by clicking on "Profiles: New". All of the hours of every day will be set to the first profile created. To change a time block to a different profile, select the time range to be changed and then click on the desired profile's color box.

<u>Note</u>: Default controls cannot be deleted or modified.

Temporary Design Days

Design days, used to calculate peak heating and cooling loads, are defined in the same way as library modifications for other library subsets. The general syntax for defining design days is:

```
TEMPORARY DESIGN DAYS:
    usname =
    (HIGH=usn1,LOW=usn2,WB=usn3,DATE=usdate,PRES=usn4,
    WS=usn5,DIR=usn6,CLEARNESS=usn7,usname1,usname2);
END DESIGN DAYS;
```

where:

usname = an arbitrary name for the design day

HIGH = the day's high dry bulb temperature, °F (°C)

LOW = the day's low dry bulb temperature, °F (°C)

WB = the wet bulb temperature corresponding to the daily high, °F (°C)

DATE = the day and month for the design day with a one or two number format day and a month abbreviated to three characters

PRES = the barometric pressure in inches of water (or Pascals)

WS = the wind speed for the day in ft/min (m/s)

DIR = the wind direction (from 0 to 360° - compass notation)

CLEARNESS = the clearness number for the site on the design day

usname1 = one of WEEKDAY, WEEKEND, HOLIDAY, SUNDAY, MONDAY,TUESDAY, WEDNESDAY, THURSDAY, FRIDAY ,SATURDAY,SPECIAL1, SPECIAL2, SPECIAL3, and SPECIAL4. (Schedules and control strategies for MONDAY are used if WEEKDAY is selected and for Sunday if WEEKEND is selected.

usname2 = one of RAIN or SNOW or no entry (if RAIN is specified, exterior surface temperatures will take on the value of the outdoor wet bulb temperature; if SNOW is specified, the ground reflectivity will be adjusted upward when the design day calculations are performed).

Specifying Temporary Design Days in HBLC

Temporary design days can be specified in HBLC by selecting “Design Days” from the “Environment” tab of the menu bar. The user will then be able to create a custom design day by filling in the data boxes with the design day parameters. Once the form is completed, click on the “Save” button. The new design day will appear in the list at the left side of the form. To add the design day to the current project, select it and click on the “Add to Selection” button

The following syntax is a sample design day definition.

TEMPORARY DESIGN DAYS:

```
        BOISE WINTER =
(HIGH=6,LOW=6,WB=25,DATE=21JAN,PRES=405,
                WS=660,DIR=245,CLEARNESS=0.0,WEEKDAY,SNOW);
        BOISE SUMMER =
(HIGH=88,LOW=65,WB=73,DATE=2AUG,PRES=410,
                WS=352,DIR=230,CLEARNESS=1.05,WEEKDAY);
END DESIGN DAYS;
```

Temporary Location

Locations can be defined in a fashion similar to other library entries (data in this sample modification are the latitude, longitude, and time zone of Boise, ID):

```
TEMPORARY LOCATION:
    BOISE = (LAT=43.57,LONG=116.22,TZ=7);
END LOCATION;
```

Data for a particular location entered into the library, as shown above, are later used to allow the sun's position to be accurately determined when design day simulations are performed. However, when a weather tape is made available for annual simulations, the latitude, longitude, and time zone are taken from the weather data tape, and the location specified by the user is ignored.

Appendix B gives latitude and longitude for 50 major US cities with each state represented.

Specifying Temporary Locations in HBLC

Temporary locations can be specified in HBLC by accessing the “Location” form under the “Environment” tab of the menu bar. Click on “New” to begin entering new location data. The default values for the form are the values for the previously selected location. HBLC will not allow changes to the standard locations, although the user is able to select a location, create a new name and then make modifications.

Temporary Materials

Materials are defined in a format similar to that used for walls, roofs, floors, windows, and doors. The data set that defines materials lists the thermodynamic and optical properties of the material being defined. The general sequence for defining materials is as follows:

TEMPORARY MATERIALS:

usname =
(L=usn1,K=usn2,CP=usn3,D=usn4,ABS=usn5,TABS=usn6,

R=usn7,TRANS=usn8,IR=usn9,FILMTRANS=usn10,

REF=usn11,SC=usn12,roughness,asg);

.

. other materials

.

END MATERIALS;

where:

L = the thickness in ft (or m)

K = conductivity in Btu/hr-ft-°F (W/m-°K)

CP = specific heat in Btu/lbm-°F (kJ/kg-°K)

D = density lbm/ft^3 (kg/m^3)

ABS = absorptivity in the solar spectrum (if not specified, the default is 0.75) See Appendix A for typical construction material absorptivity

TABS = absorptivity to thermal radiation (if not specified, the default is 0.9)

R = overall R value of the material in hr-sq ft-°F/Btu (m^2-°K/W)

TRANS = the transmittance of glass or shades (for glass with reflective films or coatings, this is the transmissivity of the bare glass)

FILMTRANS = the transmittance of the same glass with its reflective film (specified only for glass with reflective films or coatings)

IR = index of refraction (if not specified, the default is 1.52 for glass and 1.0 for air)

REF = the reflectance of interior shading devices

SC = shading coefficient

roughness = one of the following phrases indicating the surface roughness:

VERY ROUGH - Stucco, built-up roof with stone, wood shingles

ROUGH - Brick, plaster, concrete block

MEDIUM ROUGH - Concrete, asphalt, shingles

MEDIUM SMOOTH - Clear pine

SMOOTH - Smooth plaster or metal

VERY SMOOTH - Glass or smooth painted surfaces

asg = the air, shade, or glass indicator used to specify materials which may later form parts of a window section (must be AIR for air layers, SHADE for interior shades [i.e., drapes, venetian blinds], or GLASS for glass layers). These indicators are used in establishing the optical properties of window constructions.

It is never necessary to specify all the above parameters when defining materials. For example, the only parameters required to define opaque walls, roofs, or floor materials are L, CP, D, K, ABS, and roughness. In addition, ABS and roughness need not be specified if the defaults are acceptable for the specified materials. TABS defaults to 0.9, a value typical of most common materials. Alternatively, R can be used in place of the L, CP, D, and K (if R is not specified, then L, CP, D *and* K [all four] must be specified). Using R is appropriate for lightweight materials or for materials that are highly conductive compared to their total ability to store heat. For example, the only parameters required to define glass are R, TRANS, and the word GLASS. Roughness will default to VERY SMOOTH, and IR will default to 1.52. If the glass is unusually thick, L, CP, D, and K may be specified to account for its heat storage effect.

For air spaces, the R value and the word AIR are the only requirements. IR will default to 1.0, based on the occurrence of the word AIR; since the material is very lightweight and can store little heat, the R value alone suffices to describe it thermodynamically (for AIR layers, TRANS and ABS are *not* used by BLAST, even if specified).

For interior shades used in defining window sections, TRANS, REF, and the word SHADE are the only requirements since, in BLAST, a SHADE only affects the optical properties of a window (if insulating drapes or other interior shade affect the conductive properties of the window section, additional resistance [a larger R] should be specified for the air layer between the glass and the interior shade).

A shading coefficient, SC, should only be specified for GLASS materials for which data on TRANS or IR are not available (i.e., glass block or frosted glass). GLASS materials for which SC is specified may be used *only* as the outside layer when defining windows. SC becomes the shading coefficient for the entire window section and optical properties of other layers (if any) are ignored.

Transparent materials in the materials library subset are identified as AIR, SHADE or GLASS layers. When describing windows, only those materials identified as AIR, SHADE, or GLASS should be used; all other materials are assumed to be opaque.

The following are examples of temporary materials definitions:

```
TEMPORARY MATERIALS:
    E5 - ACOUSTIC TILE = (L=.0625,K=.035,D=30,CP=.20,ABS=.32,
        MEDIUM SMOOTH);
    E4 - CEILING AIR SPACE = (R=1.0,AIR);
    C12 - 2 IN HW CONCRETE = (L=.167,K=1.0,D=140,CP=.2,ABS = .65,
        MEDIUM ROUGH);
END MATERIALS;
```

Specifying Temporary Materials in HBLC

Temporary materials can be specified in HBLC by accessing the “Custom Materials” form under the “Library” tab on the menu bar. Enter a name for the material, then fill out the appropriate data boxes depending on the selected material type and method of definition. Click on “Save” to keep the material, “Clear” to start over, or “Delete” to get rid of a custom material. To modify an existing custom material, select it and simply change the data values.

Temporary Schedules

The definition of schedules (and room temperature control strategies) requires a somewhat different format other than library modifications because considerably more data are specified. Each schedule is separately defined; i.e., DEFINE, REDEFINE, or TEMPORARY commands are issued for each schedule, followed by the appropriate END command.

Schedules define 24-hour profiles for (1) each day of the week, (2) holidays, and (3) special days. These schedules are then used to describe (1) lighting, occupancy, equipment, and infiltration profiles for the zone, (2) equipment operation and ventilation profiles of building systems, and (3) scheduled load profiles of building plants.

In addition to the seven regular days of the week, four more day types are allowed: SPECIAL1, SPECIAL2, SPECIAL3, and SPECIAL4. Each of the four special days must be specified separately (for example, FRIDAY THRU SPECIAL4 is *not* allowed), but special days may be equated to other day types. An example of a schedule definition using special days is:

```
TEMPORARY SCHEDULE (NEWSCHED):
    MONDAY THRU FRIDAY = (18 to 07 - 0.4, 07 to 18 - 0.9),
    SATURDAY THRU SUNDAY = (00 TO 24 - 0.1),
    HOLIDAY = SUNDAY;
    SPECIAL1 = (00 TO 24 - 0);
    SPECIAL3 = MONDAY;
    SPECIAL4 = (18 TO 07 - 1.0, 07 TO 18 - 0.9);
END SCHEDULE;
```

If profiles for any of SPECIAL1, SPECIAL2, SPECIAL3, or SPECIAL4 are not specified, they default to the HOLIDAY profiles.

Schedules can also be defined in the following way using a list of 24 values:

```
TEMPORARY SCHEDULE (OFFICE LIGHTING):
    MONDAY THRU FRIDAY =
(0.0,0.0,0.1,0.1,0.2,0.2,0.3,0.3,0.4,0.4,0.5,0.5,
        0.7,0.8,1.0,1.0,0.7,0.5,0.3,0.1,0.0,0.0,0.0,0.0)
    SATURDAY THRU SUNDAY = (00 TO 24 - 0.05),
    HOLIDAY = SUNDAY;
END SCHEDULE;
```

In each of the samples above, the schedule definition begins with the phrase ‘TEMPORARY SCHEDULE (usname):’. Following this initial statement, 24-hour profiles are defined for each day of the week. In the examples, the profiles are the same for Monday, Tuesday, Wednesday, Thursday, and Friday; hence, MONDAY THRU FRIDAY was used to define the weekday profile. Similarly, the weekend (SATURDAY THRU SUNDAY) has one profile. Holidays have the same profile as the weekend. However, if separate profiles are to be specified for each day, the input would be:

```
TEMPORARY SCHEDULE (schedule name):
    MONDAY = (24-hour profile data);
    TUESDAY = (24-hour profile data);
    .
    .
    .
    HOLIDAY = (24-hour profile data);
END SCHEDULE;
```

Note how THRU and TO are spelled and used in the daily profiles. These usage conventions follow normal English idiom; i.e., "I work on Monday thru Friday from 8 to 5." The days of the week can be specified in any order. For example, FRIDAY THRU MONDAY will include Friday, Saturday, Sunday, and Monday. TUESDAY THRU MONDAY will include the entire week. Holidays must be separately specified. Any day of the week (or holiday) can be equated to any other day whose schedule has already been defined.

Specifying Temporary Schedules in HBLC

Temporary schedules can be specified in HBLC by accessing the “Custom Schedules” form under the “Library” tab of the menu bar. The main Custom Schedules form shows bar graphs for each type of day.

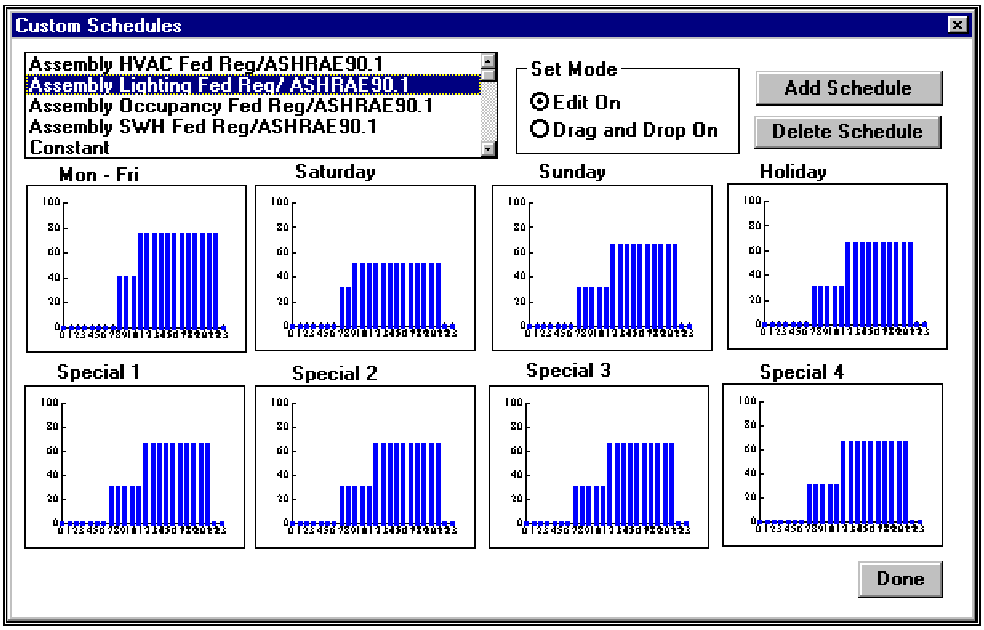


Figure 90. Custom Schedules form

The user can not edit the standard schedules. To change a schedule, the user can double click on a daily profile. HBLC will create a new custom schedule with the same profiles as the standard schedule. A daily profile can then be modified in the form shown below.

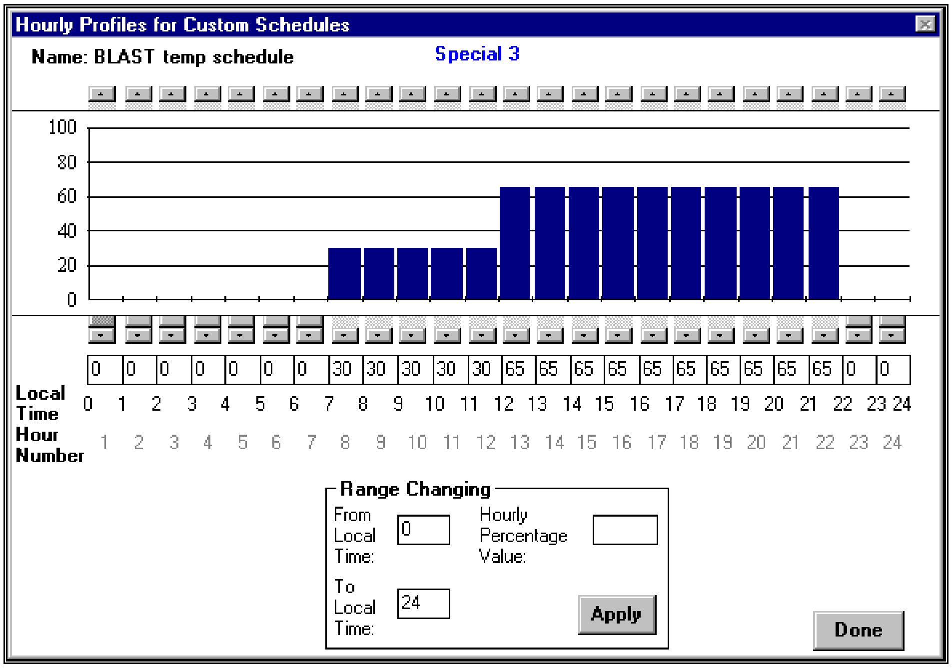


Figure 91. Hourly Profiles form

Temporary Surfaces

For walls, roofs, floors, windows, and doors, data within the parentheses are the names of materials from the materials subset of the library or names of TEMPORARY materials defined earlier in the input file. They are given in order from *outside to inside* and are separated by commas (no comma after the last specified layer). Up to ten layers may be specified. In FLOOR38 below, for example, the outside layer is the acoustic tile below the floor, the next layer is the air space above the tile, and the inside layer is the concrete floor deck. CEILING38 in the ROOFS subset has the materials in the opposite order (i.e., concrete floor deck, air space, and acoustic tile). Outside and inside air film resistances are *never* given as part of a wall, roof, floor, window, or door definition since they are adjusted hourly during the BLAST simulation.

Library subset name

```
TEMPORARY FLOORS:

  FLOOR38 = (E5 - ACOUSTIC TILE, E4 - CEILING AIR SPACE,
             C12 - 2 IN HW CONCRETE);
```

Names under which data are stored in the library

Data

```
  FLOOR37 = (B11 - 3 IN WOOD);
END FLOORS;
```

Specifying Temporary Surfaces in HBLC

Temporary surfaces can be specified in HBLC by accessing the “Custom Building Elements” form from under the “Library” tab on the menu bar. Click on the “New Element” button to create a new construction. (The standard libraries can not be edited.) After naming the element, simply drag materials from the bottom of the screen to the “Material Layers” window. Note that the top of the materials list is the outside layer and the bottom is the inside layer. Different building elements can be selected using the drop down menu located at the top of the form.

Customizing Windows in BLAST

While the *BLAST 3.0 Standard Library* contains numerous different windows to choose from for a simulation, some users feel it necessary to be able to create their own windows for use within BLAST. With Temporary Materials and Temporary Windows, BLAST users have the ability to customize the windows that are simulated in a BLAST run. Library modifications such as Temporary Materials and Temporary Windows must be input in the Lead Input section of the BLAST input file.

In many instances, there is no need to define Temporary Materials. The *BLAST 3.0 Standard Library* has a multitude of glass types that can be used to create Temporary Windows. The materials that are in the BLAST Library are under the heading Materials Library. For example, a triple pane window can be defined by adding the following lines to the Lead Input of a BLAST input file:

```
TEMPORARY WINDOWS:
    TRIPLE PANE WINDOW = (GL2,B1,GL2,B1,GL2)
END WINDOWS;
```

Both GL2 and B1 already exist in the BLAST Standard Library and do not need to be input as Temporary Materials. GL2 is defined as a 0.25 inch thick glass plate; B1 is defined as air resistance. Then, each time a triple pane window is to be specified in the building description, one would replace the default with the name of the Temporary Window, i.e. "TRIPLE PANE WINDOW".

However, the use of BLAST Standard Library Materials is not necessary to create Temporary Windows. Users can define Temporary Materials to be used in their Temporary Window definitions.

Temporary Materials for windows are defined as any other material. The minimum specification for window glass must include an R value for the glass, the transmittance of the glass, and the word GLASS. Using the word GLASS will default the roughness to VERY SMOOTH and the index of refraction to 1.52. The user can also specify solar absorptivity and thermal absorptivity for the glass. Air spaces can also be defined as Temporary Materials, if necessary. The minimum requirements for air spaces are an R value and the word AIR. Interior shade definitions require that the user specify at least the transmittance and the reflectance and include the word SHADE in the definition. If R values are not known for a certain material, the user may specify all of the following values instead: thickness, specific heat, conductivity, and density.

Here is how a Temporary Window using Temporary Materials can be defined:

```
    TEMPORARY MATERIALS:
        MYGLASS=(R=0.0625,TRANS=0.40,GLASS)
        MYAIRSPACE=(R=0.82,AIR)
        MYSHADE=(TRANS=0.5,REF=0.3,SHADE)
    END MATERIALS;
    TEMPORARY WINDOWS:
        NEW TPW=(MYGLASS,B1,MYGLASS,B1,MYGLASS)
        TPW2=(MYGLASS,MYAIRSPACE,MYGLASS,MYAIRSPACE,
               MYGLASS,MYSHADE)
    END WINDOWS;
```

Definitions start with the outer most layer, which must be a glass, and end with the inner most layer, which must be either a glass or a shade. Note that Temporary Windows can mix Temporary Materials and BLAST Standard Library Materials.

Terminal Reheat System

EQUIPMENT DESCRIPTION:

The terminal reheat system is a constant volume reheat system that is not commonly used for conventional purposes and is usually reserved for special applications. The systems cooling capabilities are provided by way of cooling coil that supplies cooling to the entire supply air volume. The cooling coil is controlled by a single zone or master zone. Zone control is accomplished by heating (reheating) the secondary air flows into each zone. Heat recovery and supply air preheating are both viable options for a terminal reheat system.

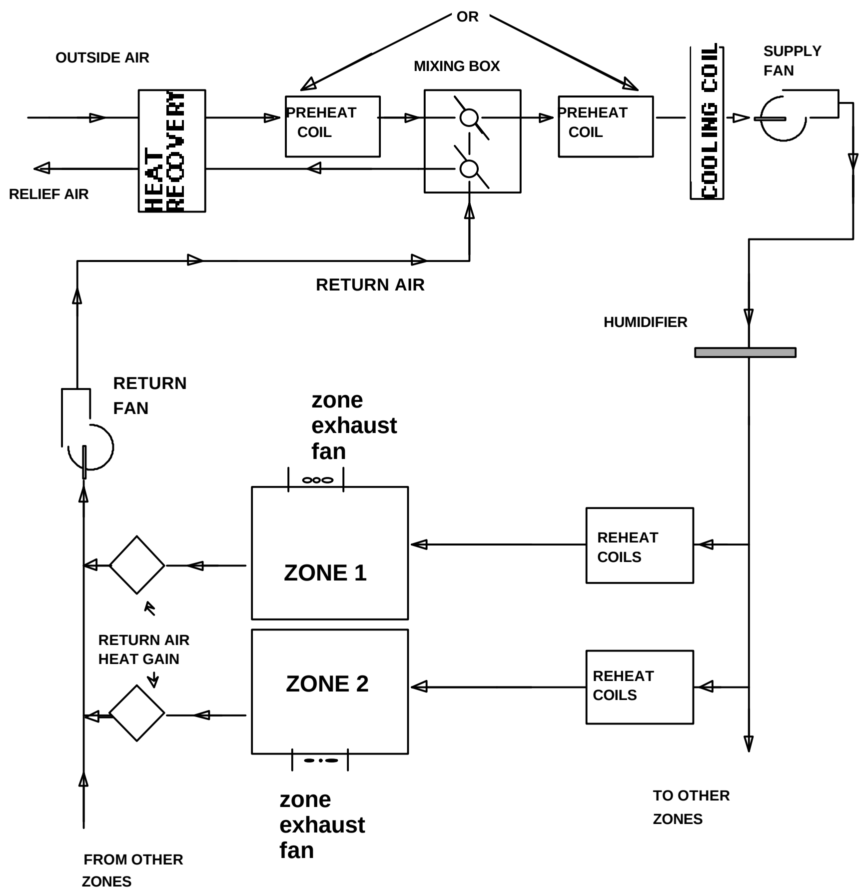


Figure 92. Diagram of a BLAST Terminal Reheat System

USING THE BLAST TERMINAL REHEAT SYSTEM:

Specifying a Terminal Reheat System in HBLC

To specify a terminal reheat system as one of the fan systems in the building simulation, the user must first select the component using the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select Terminal Reheat from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the terminal reheat system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

TERMINAL REHEAT SYSTEM 1

"TERMINAL REHEAT " SERVING ZONES 1;

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100;
        .   .   .   .       ZONE DATA BLOCK
        .   .   .   .        (Required user input)
    ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=2.49783;
        .   .   .   .       OTHER SYSTEM DATA BLOCK
        .   .   .   .       (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
        .   .   .   .       COOLING COIL DATA BLOCK
        .   .   .   .       (Optional expert user input)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .       HEAT RECOVERY DATA BLOCK
      .   .   .   .       (Optional expert user input)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
      COPC=(11,34.09,-0.087);
      .   .   .   .       HEAT PUMP DATA BLOCK
      .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
      COPH2=(22,-3.9,0.022);
                          HEAT PUMP DATA BLOCK
      .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
   DX CONDENSING UNIT CAPACITY=487;
      .   .   .   .       DX UNIT DATA BLOCK
      .   .   .   .       (Not applicable to this system)
   DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      .   .   .   .       SCHEDULES DATA BLOCK
      .   .   .   .       (Required user input)
   SYSTEM ELECTRICAL DEMAND SCHEDULE
      =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the terminal reheat system syntax is shown in the context of a complete fan system . The fan system syntax shown in these figures is sufficient to completely model the terminal reheat system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the terminal reheat system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the terminal reheat system are listed in bold and all options as well as Metric (SI) units are italicized.

TERMINAL REHEAT ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

REHEAT CAPACITY- Used to specify the capacity of the reheat coils. Units: kBtu/hr or kW

REHEAT ENERGY SUPPLY- Used to specify the reheat coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

TERMINAL REHEAT OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m^2

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

REHEAT TEMPERATURE CONTROL- Used to specify how the reheat deck is controlled. The two options are fixed set point and outside air controlled.

REHEAT TEMPERATURE LIMIT- Used to specify the maximum temperature of the reheat coil. Units: °F or °C

REHEAT CONTROL SCHEDULE- Used to determine the reheat deck temperature if the deck is outside air controlled.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

TERMINAL REHEAT COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

TERMINAL REHEAT HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT  RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT  RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

TERMINAL REHEAT EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

REHEAT COIL OPERATION- Used to schedule the reheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Thermal Comfort

Specifying Thermal Comfort Models in BLAST

Selecting Thermal Comfort models in BLAST is very simple. The name of the corresponding model must be added to the REPORT statement in the lead input section of the BLAST input file. Thus, the syntax for specifying Thermal Comfort in BLAST is:

REPORTS(...,**KSU**,**FANGER**,**PIERCE**,...);

where:

KSU = the KSU Two-Node model

FANGER = the Fanger Comfort model

PIERCE= the Pierce Two-Node model

Each Thermal Comfort model selected will generate a separate report, by zone, for each design day environments. For more information on the individual reports, see the *BLAST Output Reports*.

An annual comfort report is also available and is produced in conjunction with one or more of the Thermal Comfort models.

Specifying Thermal Comfort in HBLC

A Thermal Comfort report can be selected in HBLC by accessing the “Reports” dialog under the “Environment” tab of the menu bar. The three Thermal Comfort reports are available among the other reports.

After checking one of the Thermal Comfort reports’ boxes, the “Thermal Comfort Parameters” button will appear. Click on it to tailor the Thermal Comfort reports to the current BLAST design day simulation.

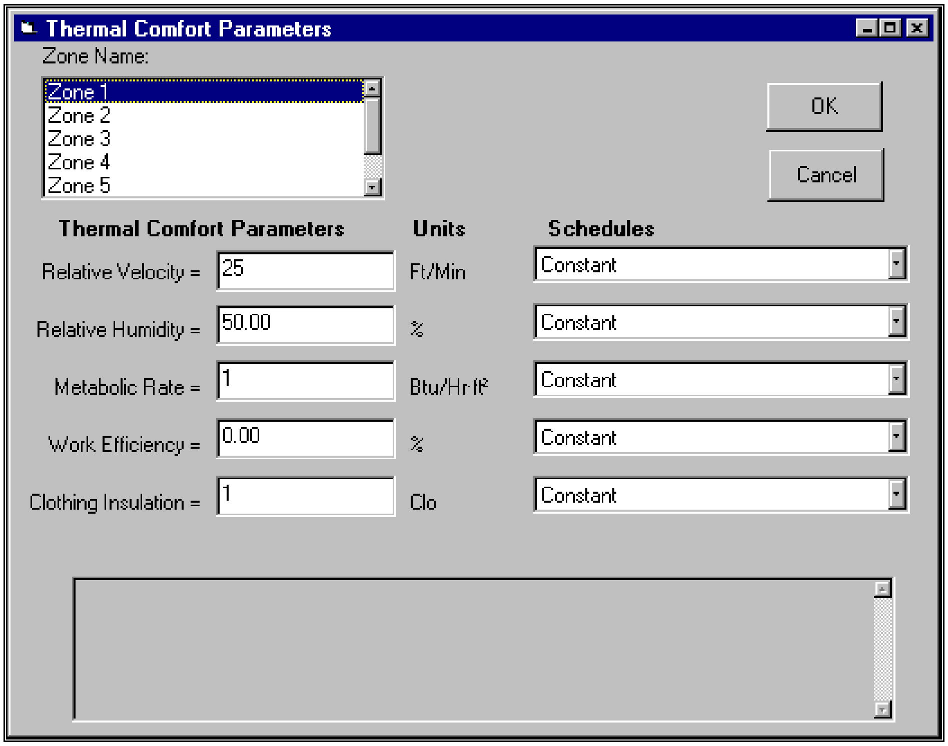


Figure 93. Thermal Comfort Parameters form

An Example of Thermal Comfort in BLAST

Below is an example of a simple one zone building illustrating the use of the thermal comfort models. The five thermal comfort parameters are specified in the zone description. The KSU and Fanger reports are generated.

BEGIN INPUT;

RUN CONTROL:

REPORTS(KSU,FANGER),

UNITS (IN=ENGLISH,OUT=ENGLISH);

LOCATION = CHANUTE;

DESIGN DAYS=CHANUTE WINTER;

BEGIN BUILDING DESCRIPTION;

ZONE 1 "THERMAL COMFORT EXAMPLE":

EXTERIOR WALLS :

STARTING AT (0.00, 0.00, 0.00)

FACING(180.00)

TILTED(90.00)

EXTERIOR (100.00 BY 15.00);

CONTROLS = DB, 200 HEATING, 200 COOLING, 0.00 PERCENT MRT,

```
FROM 01JAN THRU 31DEC;
RELATIVE VELOCITY = 25.0, CONSTANT;
RELATIVE HUMIDITY = 0.3, CONSTANT;
METABOLIC RATE = 2.0, CONSTANT;
WORK EFFICIENCY = 0.5, CONSTANT;
CLOTHING INSULATION = 0.2, CONSTANT;
END ZONE;
END BUILDING DESCRIPTION;
END INPUT;
```

Annual Thermal Comfort Report

In order to produce the annual comfort report, certain syntax must be included in the BLAST input deck. HBLC will generate this syntax if the appropriate selections are made:

1) The **Annual Comfort Report** is is selected in the reports dialog box.

2) A thermal comfort model (**KSU, FANGER,** or **PIERCE**) are selected in the reports dialog box. You should select the appropriate comfort conditions for each zone.

3) An annual simulation (you can simulate as small a period as 1 day) is selected along with an appropriate weather file.

The term Annual Comfort Report is a bit of a misnomer as BLAST produces a separate file using this set of commands (using HBLC this file will be named *proj.TCD*) which then must be run through the Comfort auxiliary program (available from the HBLC menu of Programs) to actually produce a printed type report. The figure below provides an example of output from the TCD file.

Note: When simulating design days and thermal comfort models on the same run as an annual comfort report, the thermal comfort models will be listed before the annual comfort report and its specified models.

You do not have to include people in a zone for the analysis, but if people are not specified, all reporting will be for unoccupied hours.

Comfort Program

To sort the thermal comfort data in the <filename>.TCD file, the COMFORT program must be used. This program may be executed from the “Programs” menu in HBLC. The program will prompt the user as follows:

Please enter file name with comfort data

At the prompt type <filename>.TCD, the COMFORT program sorts all of the hourly data into thermal comfort "bins". COMFORT will then prompt the user for a report filename. Once COMFORT finishes, open the report file with any editor.

Refer to the table below for an example of this report. Note that this report would have been generated by using the Annual Comfort Report along with a Fanger thermal comfort model.

If ANNUAL COMFORT REPORT is specified, BLAST will create the *.tcd file whether or not a model has also been specified. If no model has been specified COMFORT will create a blank report. Thermal comfort reports can be very useful in quickly determining if comfort conditions are being maintained within each zone during occupied hours. One can also quickly determine how far out of range a space may be and for how long. Also given are the associated temperatures and humidities that correspond with each thermal comfort "bin".

Warning!!! Be selective when specifying a weather tape duration. The <filename>.TCD file contains hour by hour output for each zone. This can quickly become an extremely large file! First preview the weather file and find specific weather conditions and dates (or weeks, or months) and use these to determine the effects of certain weather conditions on the interior environment.

In the TCD file, there will be some header lines, showing how many zones, how many hours in the data, and so forth. Then there will be one data line for each zone for each hour of simulation. This is illustrated below with cuts shown in <> for brevity.

Then, the Comfort program can be used with the TCD file. Again, a table is shown with the actual output. Groups of for Occupied, Unoccupied and the combination are shown for the thermal comfort model values (e.g. Fanger uses Predicted Mean Vote or PMV), Temperatures, and Relative Humidity. These can give you a very complete picture of thermal comfort in your building. The report is broken out for each zone in the simulation.

Table 21 Example Annual Comfort File/Report

```
BLAST-FORMAT 3.0 "Thermal Comfort Reports Data File
 NUMBER OF ZONES =                      7
 NUMBER OF HOURS =                     72
USER ZONE NUMBERS:
     1     2     3     4     5     6     7
VARIABLES ARE:
DATE  = DATE IN MM/DD FORMAT
TIME  = CLOCK TIME
UZN   = USER ZONE NUMBER
MAT   = MEAN AIR TEMPERATURE
RH    = RELATIVE HUMIDITY (PERCENT)
P-PMV = PIERCE PREDICTED MEAN VOTE - SET
P-TSI = PIERCE THERMAL SENSATION INDEX - SET
P-PMVet = PIERCE PREDICTED MEAN VOTE - ET
P-TSIet = PIERCE THERMAL SENSATION INDEX - ET
F-PMV = FANGER PREDICTED MEAN VOTE
K-TSV = KANSAS STATE THERMAL SENSATION VOTE

** NOTE:  VALUES OF -99 INDICATE THAT A PARTICULAR
          THERMAL COMFORT REPORT WAS NOT TURNED ON.


 DATE/TIME   UZN    MAT    RH (%)   Occ   P-PMV   P-TSI  P-PMVet P-TSIet  F-PMV   K-TSV

  1  2  1      1   68.02      50.    F     -0.25   -0.29   -0.95   -0.29   -1.24   -0.71
  1  2  1      2   68.02      50.    F     -0.25   -0.29   -0.95   -0.29   -1.23   -0.71
  1  2  1      3   68.02      50.    F     -0.22   -0.26   -0.91   -0.26   -1.17   -0.67
  1  2  1      4   68.02      50.    F     -0.22   -0.26   -0.91   -0.26   -1.17   -0.67
  1  2  1      5   68.02      50.    F     -0.22   -0.27   -0.92   -0.27   -1.18   -0.68
  1  2  1      6   68.02      50.    F     -0.26   -0.30   -0.96   -0.30   -1.24   -0.71
  1  2  1      7   68.02      50.    F     -0.25   -0.29   -0.95   -0.29   -1.23   -0.71
<Previous is basically repeated until hour 7 when occupancy begins>
  1  2  7      1   68.02      50.    T     -0.25   -0.29   -0.95   -0.29   -1.23   -0.71
  1  2  7      2   68.02      50.    T     -0.25   -0.29   -0.95   -0.29   -1.22   -0.70
  1  2  7      3   68.02      50.    T     -0.22   -0.26   -0.92   -0.26   -1.18   -0.68
  1  2  7      4   68.02      50.    F     -0.21   -0.26   -0.91   -0.26   -1.17   -0.67
  1  2  7      5   68.02      50.    F     -0.21   -0.25   -0.90   -0.25   -1.16   -0.66
  1  2  7      6   68.02      50.    T     -0.25   -0.29   -0.96   -0.29   -1.24   -0.71
  1  2  7      7   68.02      50.    T     -0.25   -0.29   -0.95   -0.29   -1.23   -0.71
  1  2  8      1   68.02      50.    T     -0.22   -0.26   -0.91   -0.26   -1.17   -0.67
  1  2  8      2   68.02      50.    T     -0.21   -0.25   -0.90   -0.25   -1.16   -0.66
  1  2  8      3   68.02      50.    T     -0.20   -0.25   -0.89   -0.25   -1.15   -0.66
  1  2  8      4   68.02      50.    F     -0.19   -0.23   -0.88   -0.23   -1.12   -0.64
  1  2  8      5   68.02      50.    F     -0.12   -0.18   -0.80   -0.18   -1.00   -0.57
  1  2  8      6   68.02      50.    T     -0.23   -0.27   -0.92   -0.27   -1.19   -0.68
  1  2  8      7   68.02      50.    T     -0.22   -0.27   -0.92   -0.27   -1.18   -0.68
  1  2  9      1   68.02      50.    T     -0.18   -0.23   -0.87   -0.23   -1.11   -0.64
  1  2  9      2   68.02      50.    T     -0.16   -0.21   -0.85   -0.21   -1.08   -0.62
  1  2  9      3   68.02      50.    T     -0.17   -0.22   -0.85   -0.22   -1.08   -0.62
  1  2  9      4   68.02      50.    F     -0.17   -0.22   -0.86   -0.22   -1.09   -0.63
  1  2  9      5   68.02      50.    F     -0.10   -0.16   -0.77   -0.16   -0.95   -0.55
  1  2  9      6   68.02      50.    T     -0.19   -0.24   -0.89   -0.24   -1.13   -0.65
  1  2  9      7   68.02      50.    T     -0.20   -0.25   -0.89   -0.25   -1.14   -0.65
  1  2 10      1   68.02      50.    T     -0.16   -0.21   -0.85   -0.21   -1.07   -0.61
  1  2 10      2   68.02      50.    T     -0.14   -0.20   -0.83   -0.20   -1.04   -0.60
  1  2 10      3   68.02      50.    T     -0.14   -0.20   -0.83   -0.20   -1.04   -0.60
  1  2 10      4   68.02      50.    F     -0.16   -0.21   -0.84   -0.21   -1.07   -0.61
  1  2 10      5   68.02      50.    F     -0.08   -0.14   -0.75   -0.14   -0.91   -0.52
  1  2 10      6   68.02      50.    T     -0.17   -0.22   -0.86   -0.22   -1.09   -0.63
  1  2 10      7   68.02      50.    T     -0.18   -0.23   -0.87   -0.23   -1.11   -0.64
<hours deleted for brevity)
  1  2 15      1   68.51      50.    T     -0.10   -0.16   -0.77   -0.16   -0.93   -0.54
  1  2 15      2   68.02      50.    T     -0.11   -0.17   -0.79   -0.17   -0.97   -0.56
  1  2 15      3   68.02      50.    T     -0.10   -0.16   -0.78   -0.16   -0.96   -0.55
  1  2 15      4   68.02      50.    F     -0.13   -0.19   -0.81   -0.19   -1.02   -0.58
  1  2 15      5   68.02      50.    F     -0.04   -0.11   -0.71   -0.11   -0.83   -0.45
  1  2 15      6   68.02      50.    T     -0.14   -0.19   -0.82   -0.19   -1.02   -0.59
  1  2 15      7   68.02      50.    T     -0.14   -0.20   -0.83   -0.20   -1.04   -0.60
  1  2 16      1   69.49      50.    T     -0.02   -0.12   -0.72   -0.12   -0.82   -0.48
  1  2 16      2   68.47      50.    T     -0.09   -0.15   -0.76   -0.15   -0.92   -0.54
```

1	2	16	3	68.02	50.	T	-0.11	-0.17	-0.79	-0.17	-0.97	-0.56
1	2	16	4	68.02	50.	F	-0.13	-0.19	-0.81	-0.19	-1.01	-0.58
1	2	16	5	68.02	50.	F	-0.01	-0.10	-0.70	-0.10	-0.82	-0.44
1	2	16	6	68.02	50.	T	-0.14	-0.19	-0.82	-0.19	-1.03	-0.59
1	2	16	7	68.02	50.	T	-0.14	-0.20	-0.82	-0.20	-1.04	-0.59
1	2	17	1	68.02	50.	T	-0.13	-0.19	-0.81	-0.19	-1.01	-0.58
1	2	17	2	68.02	50.	T	-0.12	-0.18	-0.80	-0.18	-1.00	-0.57
1	2	17	3	68.02	50.	T	-0.13	-0.19	-0.81	-0.19	-1.01	-0.58
1	2	17	4	68.02	50.	F	-0.13	-0.19	-0.81	-0.19	-1.02	-0.59
1	2	17	5	68.02	50.	F	-0.01	-0.10	-0.70	-0.10	-0.82	-0.45
1	2	17	6	68.02	50.	T	-0.15	-0.20	-0.84	-0.20	-1.05	-0.60
1	2	17	7	68.02	50.	T	-0.15	-0.21	-0.84	-0.21	-1.06	-0.61
1	2	18	1	68.02	50.	T	-0.16	-0.22	-0.85	-0.22	-1.08	-0.62
1	2	18	2	68.02	50.	T	-0.16	-0.21	-0.84	-0.21	-1.06	-0.61
1	2	18	3	68.02	50.	T	-0.15	-0.20	-0.84	-0.20	-1.05	-0.60
1	2	18	4	68.02	50.	F	-0.15	-0.21	-0.84	-0.21	-1.05	-0.60
1	2	18	5	68.02	50.	F	-0.09	-0.15	-0.76	-0.15	-0.93	-0.53
1	2	18	6	68.02	50.	T	-0.18	-0.23	-0.86	-0.23	-1.10	-0.63
1	2	18	7	68.02	50.	T	-0.18	-0.23	-0.86	-0.23	-1.10	-0.63

<Zones no longer occupied>

Table 22. Example Report produced by the Comfort Program

```
===============================================================================
 Reporting for Fanger
 Using Zones    1     2     3     4     5     6     7
 Weather Period Jan  1 -- Jan  3

       Occupied Bins (Hours)
 Zone|  <-3  |-3<>-2 |-2<>-1 ||-1<>-.5|-.5<>.5| .5<>1 ||  1<>2 |  2<>3 |  >3   |
 ===============================================================================
   1 |       |       |    13 ||    11 |       |       ||       |       |       |
   2 |       |       |    12 ||    12 |       |       ||       |       |       |
   3 |       |       |    14 ||    10 |       |       ||       |       |       |
   4 |       |       |       ||       |       |       ||       |       |       |
   5 |       |       |       ||       |       |       ||       |       |       |
   6 |       |       |    24 ||       |       |       ||       |       |       |
   7 |       |       |    24 ||       |       |       ||       |       |       |
 ===============================================================================

       Unoccupied Bins (Hours)
 Zone|  <-3  |-3<>-2 |-2<>-1 ||-1<>-.5|-.5<>.5| .5<>1 ||  1<>2 |  2<>3 |  >3   |
 ===============================================================================
   1 |       |       |    48 ||       |       |       ||       |       |       |
   2 |       |       |    48 ||       |       |       ||       |       |       |
   3 |       |       |    43 ||     5 |       |       ||       |       |       |
   4 |       |       |    68 ||     4 |       |       ||       |       |       |
   5 |       |       |    51 ||    21 |       |       ||       |       |       |
   6 |       |       |    48 ||       |       |       ||       |       |       |
   7 |       |       |    48 ||       |       |       ||       |       |       |
 ===============================================================================

       Both Occupied and Unoccupied Bins (Hours)
 Zone|  <-3  |-3<>-2 |-2<>-1 ||-1<>-.5|-.5<>.5| .5<>1 ||  1<>2 |  2<>3 |  >3   |
 ===============================================================================
   1 |       |       |    61 ||    11 |       |       ||       |       |       |
   2 |       |       |    60 ||    12 |       |       ||       |       |       |
   3 |       |       |    57 ||    15 |       |       ||       |       |       |
   4 |       |       |    68 ||     4 |       |       ||       |       |       |
   5 |       |       |    51 ||    21 |       |       ||       |       |       |
   6 |       |       |    72 ||       |       |       ||       |       |       |
   7 |       |       |    72 ||       |       |       ||       |       |       |
 ===============================================================================
```

<Occupied and Unoccupied Temperatures deleted for brevity>

```
 Temperatures (Both Occupied and Unoccupied)
 Zone|  <-3  |-3<>-2 |-2<>-1 ||-1<>-.5|-.5<>.5| .5<>1 ||  1<>2 |  2<>3 |  >3   |
     |Min/Max|Min/Max|Min/Max||Min/Max|Min/Max|Min/Max||Min/Max|Min/Max|Min/Max|
 ===============================================================================
   1 |***/***|***/***| 68/ 68|| 68/ 71|***/***|***/***||***/***|***/***|***/***|
   2 |***/***|***/***| 68/ 68|| 68/ 70|***/***|***/***||***/***|***/***|***/***|
   3 |***/***|***/***| 68/ 68|| 68/ 68|***/***|***/***||***/***|***/***|***/***|
   4 |***/***|***/***| 68/ 68|| 68/ 68|***/***|***/***||***/***|***/***|***/***|
   5 |***/***|***/***| 68/ 68|| 68/ 68|***/***|***/***||***/***|***/***|***/***|
   6 |***/***|***/***| 68/ 68||***/***|***/***|***/***||***/***|***/***|***/***|
   7 |***/***|***/***| 68/ 68||***/***|***/***|***/***||***/***|***/***|***/***|
 ===============================================================================
```

<Occupied and Unoccupied Relative Humidiy deleted for brevity>

```
 Relative Humidity (Both Occupied and Unoccupied)
 Zone|  <-3  |-3<>-2 |-2<>-1 ||-1<>-.5|-.5<>.5| .5<>1 ||  1<>2 |  2<>3 |  >3   |
     |Min/Max|Min/Max|Min/Max||Min/Max|Min/Max|Min/Max||Min/Max|Min/Max|Min/Max|
 ===============================================================================
   1 |***/***|***/***| 50/ 50|| 50/ 50|***/***|***/***||***/***|***/***|***/***|
   2 |***/***|***/***| 50/ 50|| 50/ 50|***/***|***/***||***/***|***/***|***/***|
   3 |***/***|***/***| 50/ 50|| 50/ 50|***/***|***/***||***/***|***/***|***/***|
   4 |***/***|***/***| 50/ 50|| 50/ 50|***/***|***/***||***/***|***/***|***/***|
   5 |***/***|***/***| 50/ 50|| 50/ 50|***/***|***/***||***/***|***/***|***/***|
   6 |***/***|***/***| 50/ 50||***/***|***/***|***/***||***/***|***/***|***/***|
   7 |***/***|***/***| 50/ 50||***/***|***/***|***/***||***/***|***/***|***/***|
 ===============================================================================
```

Thermally Stratified Tank

EQUIPMENT DESCRIPTION:

Thermal energy storage technologies have been applied in commercial buildings to shift the energy purchase from on peak to off peak hours. In space cooling, such systems are known as cool storage systems. Cool storage applies a storage medium and conventional heating, ventilating, and air conditioning (HVAC) equipment to store the cooling energy produced during the off-peak hours and use that energy during the peak hours.

The two most common types of cool storage systems are chilled water storage and ice storage. Because ice storage systems have higher energy density than chilled water, ice storage tanks require smaller space and are available as packages. Chilled water systems operate at higher temperatures and are in most cases more energy efficient than ice storage systems. Several methods are currently used to store chilled water. One of the most commonly applied techniques is a thermally stratified chilled water storage system that relies on the difference in water density to separate the warm and cold water.

Chilled water systems can be used with existing building systems, which makes it more feasible than ice storage in many buildings. A chilled water tank can also serve as fire fighting reservoir, a valuable benefit for many facilities.

Thermally stratified systems use distribution manifolds and laterals (diffusers) to supply/remove water to/from the tank. This distribution equipment is designed to minimize the turbulence and mixing in the tank. Mixing in the tank can reduce the tank cooling capacity since the difference in buoyancy separating chilled and warm water is very small and flow forces caused by mixing can easily over come the buoyancy forces in the mixing region. Well-stratified tanks operate at thermal efficiencies of 90 to 98 percent.

A chilled water thermally stratified system is shown below. The region in the tank were the cooler water comes in contact with the warmer water is defined as the thermocline in the tank.

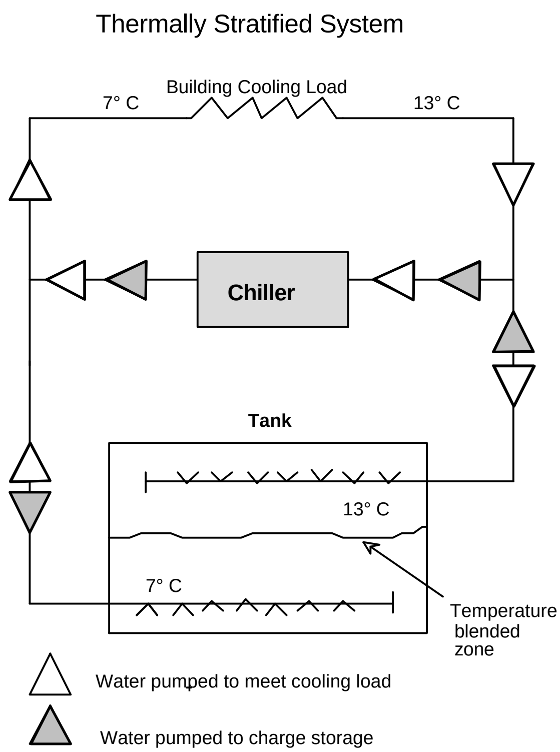


Figure 94. Thermally stratified system

This type of chilled water storage system is attractive since the chilled water air conditioning system on the building side is essentially the same as a conventional system. Being able to use existing air conditioning systems is one of the reasons why water is used almost exclusively in stratified storage tanks. Other justifications for the use of water include abundance, low cost, high heat capacity, non-toxicity, and availability for fire control.

Storage tanks are usually made of concrete, plastic, or steel, with steel and concrete tanks being the most common. A tank may be set in the basement of a building, buried, or located on-grade. Tanks generally operate at atmospheric pressure.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The central plant description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major central plant data blocks with a few parameters in each. The graphic shows how the different central plant data blocks fit together to describe the thermally stratified tank model. Important data blocks are described in detail in the following topics. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

STRATIFIED TANK BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
  PLANT 1 "plant #1 " SERVING SYSTEM
    1, 2 ;
  EQUIPMENT SELECTION:
    BOILER :
       1 OF SIZE 482;
    CHILLER :
       1 OF SIZE 418;
    STRATIFIED TANK :
       1 OF SIZE 1;
  END EQUIPMENT SELECTION;
  PART LOAD RATIOS:
    BOILER(MIN=.0100,MAX=1.0000,BEST=.8700,ELECTRICAL=0.0000);
    CHILLER(MIN=.1000,MAX=1.0000,BEST=.6500,ELECTRICAL=.2275);
  END PART LOAD RATIOS;
  SCHEDULE:
    HOT WATER=0.0,CONSTANT,FROM 1JAN THRU 31DEC,
                  AT 125.0 SUPPLIED BY BOILER;
  END SCHEDULE;
  EQUIPMENT PERFORMANCE PARAMETERS:
    CWTPUMP(0.0,0.9,0.0);
  END EQUIPMENT PERFORMANCE PARAMETERS;
  SPECIAL PARAMETERS:
    CONTMODE=1;
    MLLSU=170;
    MLLCU=170;
    WRHEIGHT=11.74;
    WALLAREA=789.26;
    FLORAREA=190.312;
    TANKLOCN=0;
    SLTMPJAN=55;
    SLTMPFEB=55;
    SLTMPMAR=55;
    SLTMPAPR=55;
    SLTMPMAY=55;
    SLTMPJUN=55;
    SLTMPJUL=55;
    SLTMPAUG=55;
    SLTMPSEP=55;
    SLTMPOCT=55;
    SLTMPNOV=55;
    SLTMPDEC=55;
    CHFLRATE=3.907;
    CHINTEMP=42;
    CRENTEMP=61.3;
    ELENUMBR=28;
    TANKUVAL=0.439;
    MIXCOEFF=0.05;
    BTSPEAK=7;
    ETSPEAK=16;
    TSTPAR=0.0002;
    TPELCL=0.018;
    OFFPKI=1;
  END SPECIAL PARAMETERS;
  OTHER PLANT PARAMETERS:
    REPORT VARIABLES=(7)
  END OTHER PLANT PARAMETERS;
  FOR SYSTEM 1:
    SYSTEM MULTIPLIER=1;
  END SYSTEM;
  FOR SYSTEM 2:
    SYSTEM MULTIPLIER=1;
  END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

STRATIFIED TANK BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "plant #1 " SERVING SYSTEM
   1, 2 ;
  EQUIPMENT SELECTION:
    BOILER :
       1 OF SIZE 482;
    CHILLER :
       1 OF SIZE 418;
    STRATIFIED TANK :
       1 OF SIZE 1;
  END EQUIPMENT SELECTION;
  PART LOAD RATIOS:
    BOILER(MIN=.0100,MAX=1.0000,BEST=.8700,ELECTRICAL=0.0000);
    CHILLER(MIN=.1000,MAX=1.0000,BEST=.6500,ELECTRICAL=.2275);
  END PART LOAD RATIOS;
  SCHEDULE:
    HOT WATER=0.0,CONSTANT,FROM 1JAN THRU 31DEC,
                  AT 125.0 SUPPLIED BY BOILER;
  END SCHEDULE;
  EQUIPMENT PERFORMANCE PARAMETERS:
    CWTPUMP(0.0,0.9,0.0);
  END EQUIPMENT PERFORMANCE PARAMETERS;
  SPECIAL PARAMETERS:
    CONTMODE=1;
    MLLSU=50;
    MLLCU=50;
    WRHEIGHT=4.493;
    WALLAREA=80.757;
    FLORAREA=20.189;
    TANKLOCN=0;
    SLTMPJAN=12.78;
    SLTMPFEB=12.78;
    SLTMPMAR=12.78;
    SLTMPAPR=12.78;
    SLTMPMAY=12.78;
    SLTMPJUN=12.78;
    SLTMPJUL=12.78;
    SLTMPAUG=12.78;
    SLTMPSEP=12.78;
    SLTMPOCT=12.78;
    SLTMPNOV=12.78;
    SLTMPDEC=12.78;
    CHFLRATE=0.001938355;
    CHINTEMP=5.5555;
    CRENTEMP=16.278;
    ELENUMBR=28;
    TANKUVAL=2.493;
    MIXCOEFF=0.05;
    BTSPEAK=7;
    ETSPEAK=16;
    TSTPAR=0.0002;
    TPELCL=0.018;
    OFFPKI=1;
  END SPECIAL PARAMETERS;
  OTHER PLANT PARAMETERS:
    REPORT VARIABLES=(7)
  END OTHER PLANT PARAMETERS;
  FOR SYSTEM 1:
    SYSTEM MULTIPLIER=1;
  END SYSTEM;
  FOR SYSTEM 2:
    SYSTEM MULTIPLIER=1;
  END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

In the following topics the Thermally Stratified Tank syntax is shown in the context of a complete central plant description with English default values. The central plant syntax presented is sufficient to completely model the stratified storage tank. In the following examples, the parameters pertaining to the Stratified Storage Tank are listed in bold, and all options are italicized.

EQUIPMENT SELECTION BLOCK:

```
EQUIPMENT SELECTION:
    BOILER :
    1 OF SIZE 482;
    CHILLER :
    1 OF SIZE 418;
    STRATIFIED TANK :
    1 OF SIZE 1;
END EQUIPMENT SELECTION;
```

STRATIFIED TANK- Used to specify the Stratified Tank in the Equipment Selection Data Block. The user should specify only one storage tank. The size specification does not refer to the capacity of the storage tank. The capacity is a function of the tank geometry defined in the special parameters block. Therefore, the user should always set the stratified tank size equal to one.

EQUIPMENT PERFORMANCE PARAMETERS BLOCK:

```
EQUIPMENT PERFORMANCE PARAMETERS:
    CWTPUMP(0.0,0.9,0.0);
END EQUIPMENT PERFORMANCE PARAMETERS;
```

CWTPUMP- Performance parameters for the chilled water tank pump model. (Note technical reference for details on the pump model.)

SPECIAL PARAMETERS BLOCK:

```
SPECIAL PARAMETERS :
    CONTMODE=1;
    MLLSU=170;
    MLLCU=170;
    WRHEIGHT=11.74;
    WALLAREA=789.26;
    FLORAREA=190.312;
    TANKLOCN=0;
    SLTMPJAN=55;
    SLTMPFEB=55;
    SLTMPMAR=55;
    SLTMPAPR=56;
    SLTMPMAY=61;
    SLTMPJUN=66;
    SLTMPJUL=70;
    SLTMPAUG=68;
    SLTMPSEP=66;
    SLTMPOCT=64;
    SLTMPNOV=61;
    SLTMPDEC=58;
    CHFLRATE=3.907;
    CHINTEMP=42;
    CRENTEMP=61.3;
    ELENUMBR=28;
    TANKUVAL=0.439;
    MIXCOEFF=0.05;
    BTSPEAK=7;
    ETSPEAK=16;
    TSTPAR=0.0002;
    TPELCL=0.018;
    OFFPKI=1;
END SPECIAL PARAMETERS;
```

CONTMODE - Used to specify the thermally stratified tank control mode.

1 = Full storage control

2 = Load leveling chiller control

3 = Load leveling storage control

CHFLRATE - Used to specify the charging water volumetric flow rate to the stratified tank. Units: CFM or m^3/sec

CHINTEMP - Used to specify the charging inlet temperature to the tank. Units: °F or °C

CRENTEMP - Used to specify the coil return temperature. Units: °F or °C

ELENUMBR - Used to specify the number of tank elements used in the simulation model.

TANKUVAL - Used to specify the tank loss coefficient (U value). Units: Btu/hr*ft^2*R or W/m^2*K

MIXCOEFF - Used to specify the percent of tank volume mixed near the diffuser. Units: Dimensionless

BTSPEAK - Used to specify the hour that on-peak period begins.

ETSPEAK - Used to specify the hour that on-peak period ends.

TSTPAR - Used to specify parasitic load coefficient. Units: Dimensionless

TPELCL - Used to specify the pump power demanded per unit of cooling capacity. Units: Dimensionless

OFFPKI - Used to specify the off-peak period in more detail (1**--**All days have an on-peak period, 2**--**Entire weekend is considered off-peak, 3**--**Entire weekend and all holidays are considered off-peak). Units: Dimensionless

Thermostatic Baseboard

Thermostatic baseboard heat has been changed to increase the flexibility and usefulness of the model. The baseboard heat option in the fan system specification data block can now be used with any of the BLAST fan systems. In addition, the model allows the baseboard heater to provide heat to a zone without turning on the system fans.

Using Thermostatic Baseboard

Baseboard heat is specified in the fan system zone data block. The following example shows how a user might specify baseboard heat in one of two zones served by a multizone system.

```
MULTIZONE SYSTEM 1 "SYS WITH BB" SERVING ZONES 1,2;
FOR ZONE 1:
    SUPPLY AIR VOLUME = 200;
    BASEBOARD HEAT CAPACITY=50;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
END ZONE;
FOR ZONE 2:
    SUPPLY AIR VOLUME = 100;
END ZONE;
END SYSTEM;
```

The operating schedule of the baseboard heater should also be specified. The default schedule makes baseboard heat available for every hour of every day. An example with baseboard heat scheduled off for the summer and on for the winter is shown below.

```
EQUIPMENT SCHEDULES:
    .
    .
    .
    TSTAT BASEBOARD HEAT OPERATION = ON, FROM 01 SEP
        THRU 31 MAR,OFF,FROM 01 APR THRU 31 AUG;
    .
    .
END EQUIPMENT SCHEDULES;
```

Thermostatic Baseboard Features

Where available, the baseboard heater will supply heat to reduce or eliminate any unmet heating load or overcooling load generated by the system. When used in conjunction with a heating or reheat coil, baseboard heat acts as a supplementary heat source that is independent of air flow, hot deck temperature, or reheat temperature limit. It can also be used as the sole source of heat for a zone.

The baseboard heat control scheme was designed to allow the baseboard heater to operate without turning on the fan system. If baseboard heat is available and the system is off, a heating load will not turn the system on. The baseboard heater will attempt to meet the load without operating the system. If the baseboard heater capacity is insufficient to meet the load, an unmet heating load will be recorded.

Examples of Baseboard Heat Usage

1. Night heating with system fans off

   The user desires to turn off a multizone system at night and supply nighttime heat with hot water thermostatic baseboard. By using baseboard heat, the user insures that the system fans will not run to provide heat for the zone. The Air Handling System Energy Use Summary report will show hot water consumption but no fan electricity consumption.

2. Heating perimeter zones

   The user desires to heat the perimeter zones of a building using thermostatic baseboard heat. The core zones do not require heat. During the day the system is scheduled on and provides cooling as needed to the core zones. Any heating required by the perimeter zones is supplied by the baseboard heat. At night the system is scheduled off and heating loads in the perimeter zones will be met by the baseboard heater without turning on the system. A night setback control profile insures that no loads occur in the core zones of the building.

Three Deck Multizone System

EQUIPMENT DESCRIPTION:

Three-deck multizone systems condition all the air in a central apparatus and distribute it to the conditioned spaces through three parallel ducts. One duct carries cold air, one carries unconditioned mixed air and the other warm air, providing air sources for both heating and cooling at all times. In each conditioned zone, a mixing valve responsive to a room thermostat mixes the warm, unconditioned, and cold air in proper proportions to satisfy the heat load of the zone.

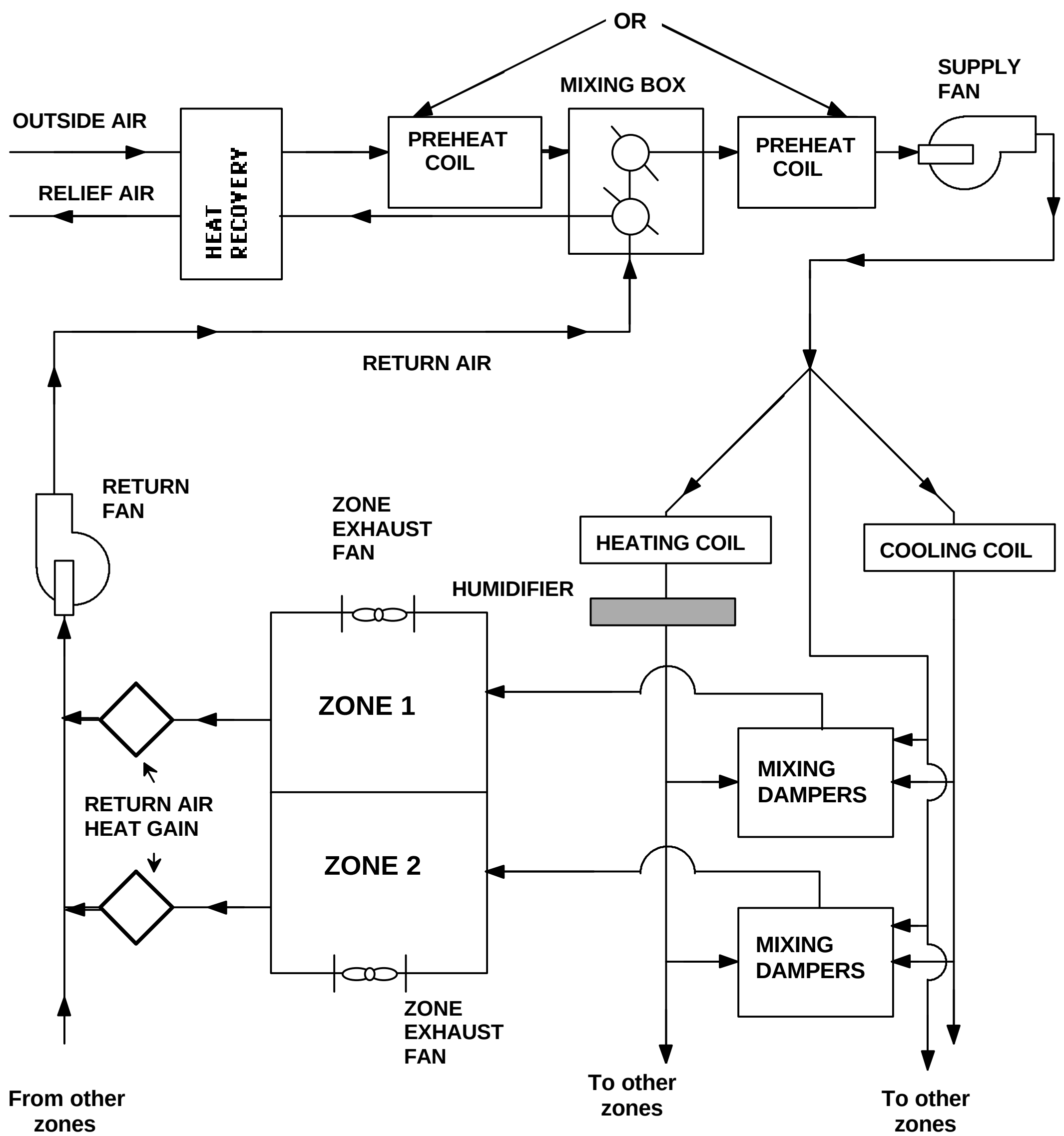


Figure 95. Diagram of a BLAST Three Deck Multizone system

USING THE BLAST THREE DECK MULTIZONE SYSTEM:

Specifying a Three Deck Multizone System in HBLC

To specify a Three Deck Multizone system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select Three Deck Multizone from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the three deck multizone system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

THREE DECK MULTIZONE SYSTEM #

"THREE DECK MULTIZONE " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .       (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .      OTHER SYSTEM DATA BLOCK
      .   .   .   .      (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .      COOLING COIL DATA BLOCK
      .   .   .   .      (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
        .   .   .   .       (Optional expert user input)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
        COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
        COPH2=(22,-3.9,0.022);
                            HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the multizone system syntax is shown in the context of a complete fan system. The fan system syntax shown in these figures is sufficient to completely model the Three Deck Multizone system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the Three Deck Multizone system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the Three Deck Multizone system are listed in bold and all options as well as Metric (SI) units are italicized.

THREE DECK MULTIZONE ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

THREE DECK MULTIZONE OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK THROTTLING RANGE- Used to set the hot deck temperature based on the previous hours heating load. The deck temperature is adjusted somewhere between the hot deck set point and the set point plus the throttling range. Units: °F or °C

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

THREE DECK MULTIZONE COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

THREE DECK MULTIZONE HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT  RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

THREE DECK MULTIZONE EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Tilt Angle

TILTED (usn5) specifies the angle from the Z-axis (the upward pointing axis) to the outward pointing normal of the surface. If TILTED is omitted, tilts take on the following defaults: Roofs and ceilings = 0°, walls = 90°, and floors =

The tilt angle of a surface determines how it will be treated in BLAST. To be treated as a floor, the surface tilt must be between 172-188°. Normally floors are tilted at 180°, walls at 90°, and flat roofs at 0°. Sloping roofs are normally given tilts greater than 0° and less than 90°.

The tilt angle is used in calculating the inside and outside convection coefficients. It is used in calculating the view to sky and view to ground for diffuse radiation. The tilt angle is especially important in determining how much surface area receives solar radiation.

Note that tilt angle is the key to determining if a surface is considered to be a floor. Even if the surface type is specified as a FLOOR, BLAST will not treat the surface as a floor unless the tilt angle is between 172-188°. Alternatively, even if a surface is specified as a WALL, BLAST will treat the surface as a floor if the tilt angle is between 172-188°.

Specifying Tilt Angle in HBLC

The tilt angle of a surface is specified on the "Wall Subsurfaces" form, which can be opened in any of the following ways: double clicking on the wall, selecting the wall and pressing 'w', or selecting the wall and choosing "Wall Subsurfaces" from the "Geometry" menu bar tab.

Note: Subsurfaces on a wall are the same tilt as the wall.

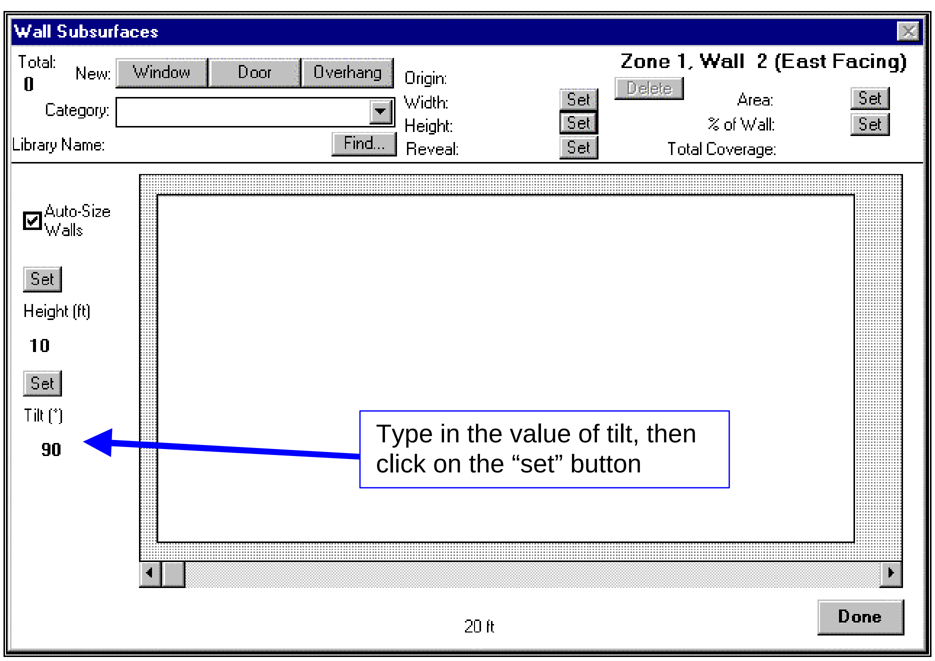


Figure 96. Wall Subsurfaces form

Tilt for roof and floor surfaces is specified by selecting the zone in the plan view, and then choosing "Zone Roof/Floor/Internal Mass…" from the "Geometry" tab, or by double clicking on the zone. In the form that appears, the user can select available floor and roof surfaces and then click on "edit."

Note: Editing a roof or floor will turn off the auto-calculations for roofs and floors.

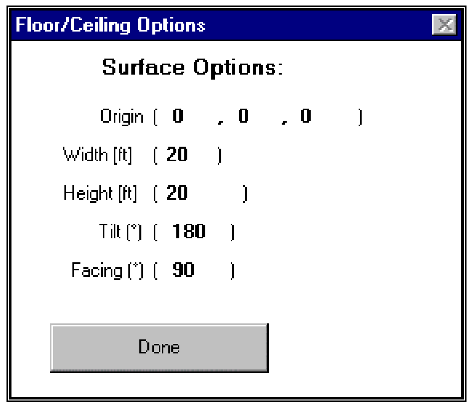


Figure 97. Floor/Ceiling Options form

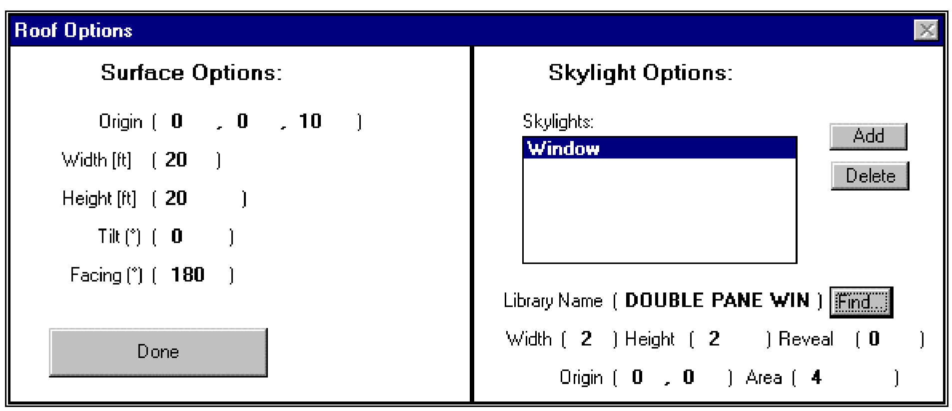


Figure 98. Roof Options form

The user will notice that there are additional options for roof surfaces pertaining to skylights. Skylights, though not overhangs, can be added to the model using this method.

Though Exposed Floors support windows on their surfaces, HBLC does not support this option.

Two Pipe Fan Coil System

EQUIPMENT DESCRIPTION:

This is a low initial cost concept in which either chilled water or hot water is supplied through the same piping system. The fan-coil unit has a single coil and room temperature controls must be arranged to reverse their action depending on whether hot or cold water is available at the unit coil. This system works well in warm weather when all rooms have a cooling requirement and in cold weather when all rooms have a heating requirement. It does not have simultaneous heating or cooling capability that is required for most projects during intermediate seasons, when some rooms have a cooling requirement while others have a heating requirement. The figure below shows the complete system for a single zone including mixing box, supply fan, and coils. If more than one zone is served by the system, the entire set of components is repeated for each zone.

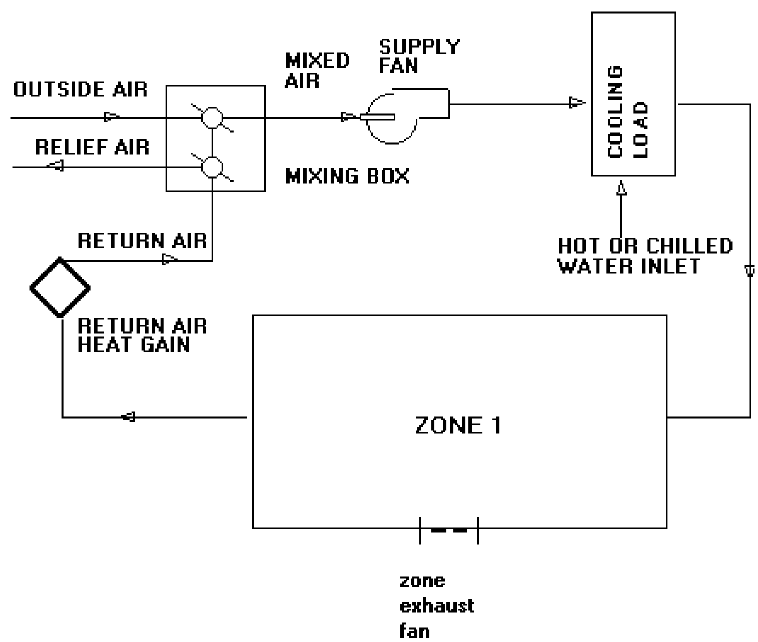


Figure 99. Diagram of a BLAST Two Pipe Fan Coil system

USING THE BLAST TWO-PIPE FAN COIL SYSTEM:

Specifying a Two-Pipe Fan Coil System in HBLC

To specify a two-pipe fan coil as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select Two Pipe Fan Coil from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

When declaring which zones your system will be serving, keep in mind that the BLAST fan coil systems are either fully on or fully off for a given hour. This means that all zones on a fan coil system in BLAST will operate in tandem. If the fan is running in one zone, it is running in all zones. This is not appropriate for modeling a fan coil system where the fans in individual zones cycle independently. For such a system, each zone must be served by a separate fan system.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button. The Two Pipe Fan Coil system parameters form contains the schedules for heating and cooling, which may not overlap. HBLC provides non-overlapping defaults, but the user should verify the dates.

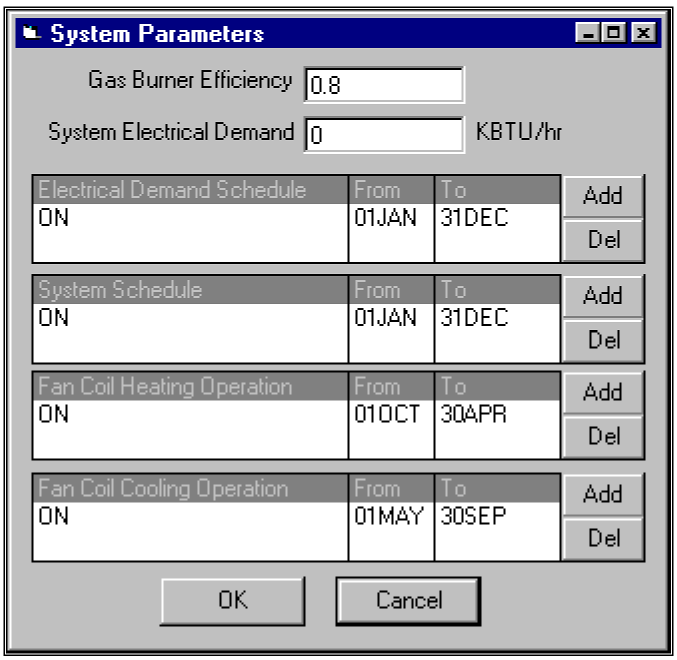


Figure 100. System Parameters form for a fan coil system

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the two pipe fan coil system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

TWO PIPE FAN COIL SYSTEM 1

"TWO PIPE FAN COIL " SERVING ZONES 1;

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100;
        .   .   .   .       ZONE DATA BLOCK
        .   .   .   .        (Required user input)
    ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=2.49783;
        .   .   .   .       OTHER SYSTEM DATA BLOCK
        .   .   .   .       (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
        .   .   .   .       COOLING COIL DATA BLOCK
        .   .   .   .       (Optional expert user input)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
        COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
        COPH2=(22,-3.9,0.022);
                            HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the two-pipe fan coil system syntax is shown in the context of a complete fan system. The fan system syntax shown in these figures is sufficient to completely model the two-pipe fan coil. HBLC may include additional parameters and syntax that will not be used in the simulation if only the two pipe fan coil system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the two-pipe fan coil system are listed in bold and all options as well as Metric (SI) units are italicized.

TWO PIPE FAN COIL ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

TWO PIPE FAN COIL OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

MIXED AIR CONTROL- The BLAST fan coil systems assume MIXED AIR CONTROL = FIXED PERCENT no matter what is specified in the input file. The MINIMUM VENTILATION SCHEDULE (MVS) and EXHAUST AIR VOLUME (EAV) control the amount of outside air; all other outside air parameters are ignored. For a given SUPPLY AIR VOLUME (SAV), the outside air volume (OAV) is calculated as follows:

OAV = Maximum(MVS*SAV, EAV)

In other words, the MINIMUM VENTILATION SCHEDULE sets the fraction of outside air unless the EXHAUST AIR VOLUME requires additional outside air to balance the air flow.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

TWO PIPE FAN COIL COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE: The BLAST fan coil systems assume a chilled water cooling coil and use a coil model which is slightly different from the other BLAST chilled water coils.

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

TWO PIPE FAN COIL EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

FANCOIL HEATING OPERATION- Used to schedule the fan coil heating operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan coil heating operation can be defined by using optional user syntax (see exhaust fan operation). The scheduling dates for operation must not overlap with FANCOIL COOLING OPERATION because two pipe fan coils cannot heat and cool simultaneously.

FANCOIL COOLING OPERATION- Used to schedule the fan coil cooling operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan coil cooling operation can be defined by using optional user syntax (see exhaust fan operation). The scheduling dates for operation must not overlap with FANCOIL HEATING OPERATION because two pipe fan coils cannot heat and cool simultaneously.

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Two Pipe Induction System

EQUIPMENT DESCRIPTION:

The two pipe induction unit is a common system that accomplishes space conditioning by using air and water sources distributed to induction units installed in required zones throughout the building. Two pipe induction units are primarily applicable to multizone structures and are able to handle a wide variety of sensible loads, but at a cost of accurate humidity control. Induction units are usually installed under a window at a perimeter wall, but can also be used as an overhead unit. Some of the major advantages of an induction unit are individual zone control, separate heating and cooling sources, and the overall system size is comparatively small.

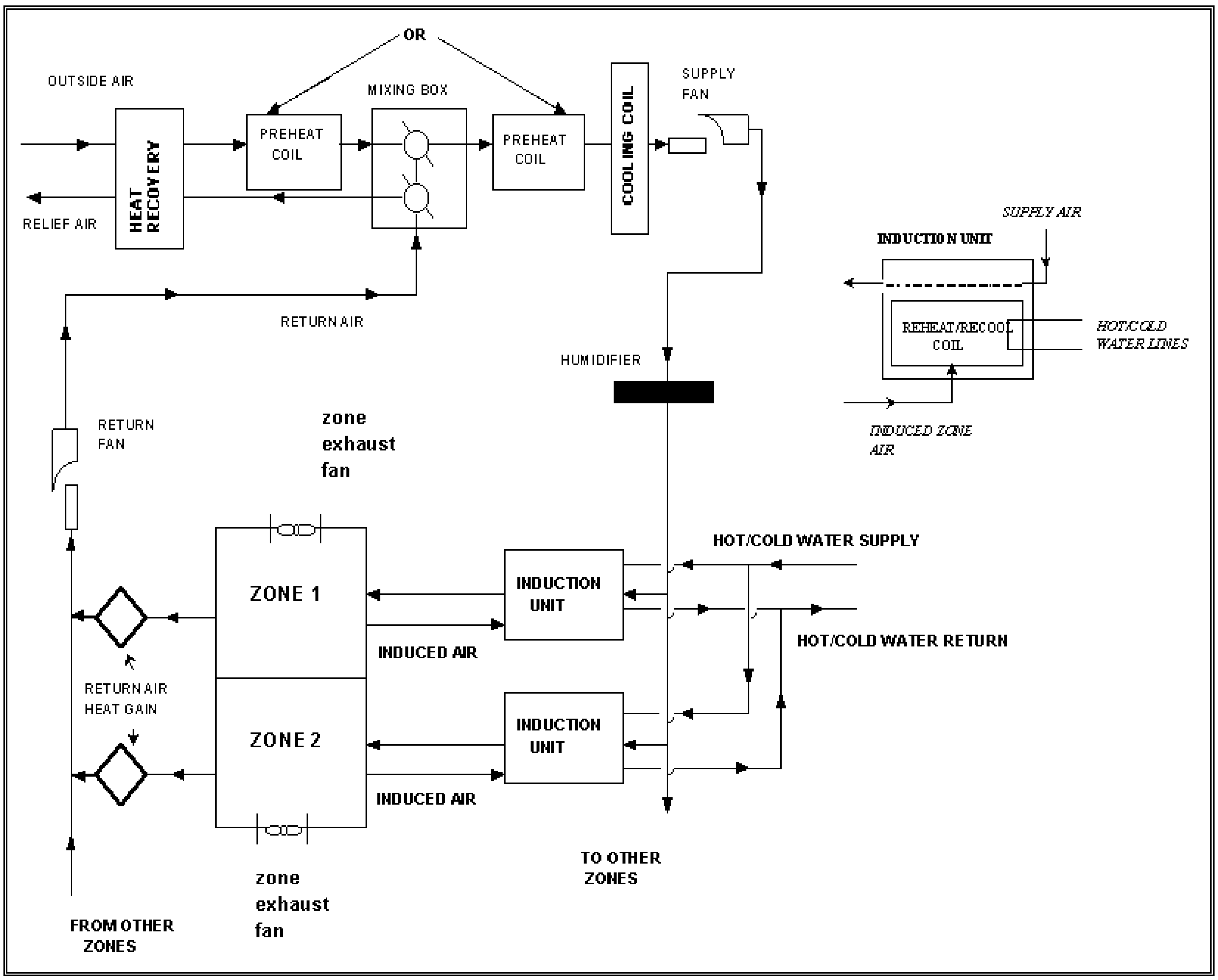


Figure 101. Diagram of a BLAST Two Pipe Induction system

USING THE BLAST TWO PIPE INDUCTION SYSTEM:

Specifying a Two Pipe Induction System in HBLC

To specify a two-pipe induction system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing "Add System", select Two Pipe Induction from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the two pipe induction system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

TWO PIPE INDUCTION SYSTEM 1

"TWO PIPE INDUCTION" SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
       .   .   .   .       ZONE DATA BLOCK
       .   .   .   .        (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
       SUPPLY FAN PRESSURE=2.49783;
       .   .   .   .       OTHER SYSTEM DATA BLOCK
       .   .   .   .       (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
       .   .   .   .       COOLING COIL DATA BLOCK
       .   .   .   .       (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
        .   .   .   .       (Optional expert user input)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
        COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
        COPH2=(22,-3.9,0.022);
                            HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the two-pipe induction system syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the two pipe induction system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the two pipe induction system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the two pipe induction system are listed in bold and all options as well as Metric (SI) units are italicized.

TWO PIPE INDUCTION ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    INDUCED AIR FRACTION=2.0 (2)
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

RECOOL CAPACITY- Used to specify the capacity of the recool coils. Currently, recool coils are allowed only for induction systems and are assumed to be chilled water coils that accomplish sensible cooling only.

INDUCED AIR FRACTION- The parameter INDUCED AIR FRACTION is used to specify the volume of air which is "induced" to flow through the induction box per unit volume of supply air. For example, if the INDUCED AIR FRACTION was specified as 1.75 and the SUPPLY AIR VOLUME as 1000 cfm, the total air flow through the induction unit would be 2750 cfm. As illustrated in the figure above, the SUPPLY AIR VOLUME goes over the main cooling coil while only the "induced" air flows over the reheat and recool coils.

In addition, it should be pointed out that these fan systems assume no latent cooling occurs at the recoil coil.

NOTE: The zone parameters, INDUCED AIR FRACTION and MINIMUM AIR FRACTION, are both stored in the same variable in BLAST. The last one specified in the FAN SYSTEM DESCRIPTION will be the one BLAST uses, thus care should be taken to specify only one of these values to limit the possibility of error.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

TWO PIPE INDUCTION OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify the how the hot deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

HUMIDIFIER TYPE- Used to specify the what type of energy is used by the humidifier. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

TWO PIPE INDUCTION COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

TWO PIPE INDUCTION HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT  RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT  RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

TWO PIPE INDUCTION EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,**-** 328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

RECOOL OPERATION- Used to schedule the recool coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for recool coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Two Stage Absorber

EQUIPMENT DESCRIPTION:

The BLAST model of a two stage absorber is simulated as a standard absorption refrigeration cycle. The condenser and evaporator are similar to that of a standard chiller, which are both water to water heat exchangers. The compression operation is provided by the assembly of a two generators and absorber. Low-pressure vapor from the evaporator is absorbed by the liquid solution in the absorber. A pump receives low-pressure liquid from the absorber, elevates the pressure of the liquid, and delivers the liquid to the first generator. In the generator, heat from a high temperature source drives off the vapor that has been absorbed by the solution. The liquid solution flows to a second generator where more heat is added and then returns to the absorber through a throttling valve whose purpose is to provide a pressure drop to maintain the pressure difference between the generator and absorber. The heat supplied to the absorber can be exhaust heat from diesel, gas and steam turbines. For more information on absorption chillers in BLAST, see *Absorption Chillers* in the *BLAST Technical Reference*.

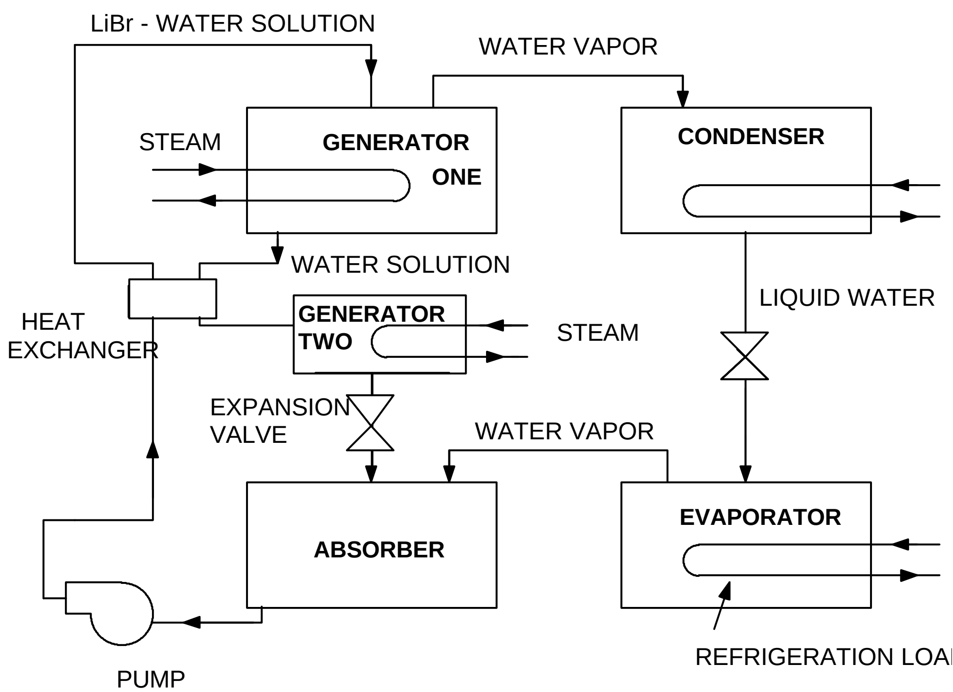


Figure 102. Diagram of a BLAST Two Stage Absorber

USING THE BLAST TWO STAGE ABSORBER:

Specifying a Two Stage Absorber in HBLC

To specify a two stage absorber as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Two Stage” from the “Absorbers” sub-menu. Fill in the number of absorbers and their unit capacity.

Adjusting the Performance Parameters of the Two Stage Absorber

Once the two stage absorber has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a two stage absorber that has the following operating parameters:

Absorber temperature	= 170 to 240 °F
Cooling Load/Heat power	= 0.5 to 0.6

If your two stage absorber does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data. Valid condenser types that may be specified by the user for a two stage absorber are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

REN2A- Used to calculate the heat power in-to-cooling ratio or inverse COP of the system.

TCOOL- Temperature of chilled water leaving the absorber. Units: °F or °C

PSTEAM- Gauge steam pressure of boiler steam. Units: Water Gauge or Pascals Gauge

STEAM- Enthalpy of steam to absorbers. If not specified, STEAM is calculated as he saturation enthalpy at PSTEAM and TSATUR. Units: Btu/lb or kJ/kg

TSATUR- Inlet temperature to absorber at full capacity. Units: °F or °C

RWC2A- Ratio of condenser water flow rate to tow stage absorber capacity. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW of capacity.

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the two stage absorber syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the two stage absorber. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

TWO STAGE ABSORBER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "STWO STAGE ABSORBER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
TWO STAGE ABSORBER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
TWO STAGE ABSORBER (MIN=0.05,MAX=1.1,BEST=.65,ELECTRICAL=0.0077);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
REN1A(.1146,.67212,0.21212);
.   .   .
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44;
PSTEAM=284.409;
STEAM=1168.7;
TSATUR=241.53;
RWCIA=124.882;
.   .   .
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

TWO STAGE ABSORBER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "SAMPLE PLANT" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
TWO STAGE ABSORBER WITH COOLING TOWER:
    WITH WELL WATER CONDENSER
    WITH EVAPORATIVE CONDENSER
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
TWO STAGE ABSORBER (MIN=0.05,MAX=1.1,BEST=.65,ELECTRICAL=0.0077);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
REN1A(.1146,.67212,0.21212);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
PSTEAM=70841.4;
STEAM=2716.49;
TSATUR=116.405;
RWCIA=0.05370;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Two Stage Absorber with Economizer

EQUIPMENT DESCRIPTION:

The BLAST model of a two stage absorber is simulated as a standard absorption refrigeration cycle. The condenser and evaporator are similar to that of a standard chiller, which are both water to water heat exchangers. The compression operation is provided by the assembly of a two generators and absorber. Low-pressure vapor from the evaporator is absorbed by the liquid solution in the absorber. A pump receives low-pressure liquid from the absorber, elevates the pressure of the liquid, and delivers the liquid to the first generator. In the generator, heat from a high temperature source drives off the vapor that has been absorbed by the solution. The liquid solution flows to a second generator where more heat is added and then returns to the absorber through a throttling valve whose purpose is to provide a pressure drop to maintain the pressure difference between the generator and absorber. There is an economizer located between the second generator outlet to absorber inlet and the absorber outlet to the first generator inlet. The heat supplied to the absorber can be exhaust heat from diesel, gas and steam turbines. For more information, see *Absorption Chillers* in the *BLAST Technical Reference*.

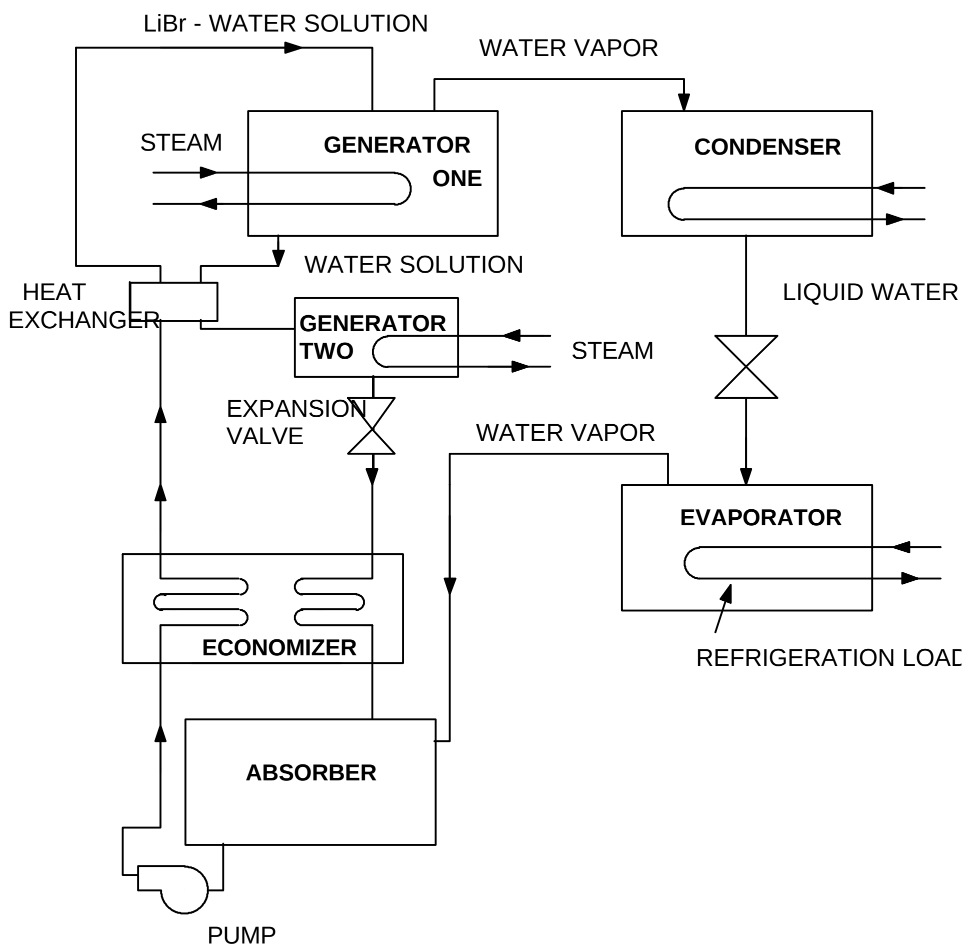


Figure 103. Diagram of a BLAST Two Stage Absorber with Economizer

USING THE BLAST TWO STAGE ABSORBER WITH ECONOMIZER:

Specifying a Two Stage Absorber with Economizer in HBLC

To specify a two stage absorber with economizer as one of the operating components in the central energy plant, the user must first select the component using the procedure outlined in Central Plants.

Once the plant has been created, click on “Add” equipment and choose “Two Stage W/ Econ” from the “Absorbers” sub-menu. Fill in the number of absorbers and their unit capacity.

Adjusting the Performance Parameters of the Two Stage Absorber with Economizer

Once the two stage absorber with economizer has been added using HBLC, the user must specify operating rules and parameters for the component. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a two stage absorber with economizer that has the following operating parameters:

Absorber temperature	= 170 to 240 °F
Cooling Load/Heat power	= 0.5 to 0.6

If your two stage absorber with economizer does not fall within these ranges, a new set of parameters must be generated from manufacturers or test data. Valid condenser types that may be specified by the user for a two stage absorber with economizer are:

Cooling tower

Direct cooling tower

Well water condenser

Evaporative condenser

Select a condenser from the pull down menu and it will automatically be added to the list of plant equipment. Condenser parameters can be edited from the chiller parameter form, or as a separate piece of equipment on the main “Plants” form.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

REN2AE- Used to calculate the heat power in-to-cooling ratio or inverse COP of the system.

TCOOL- Temperature of chilled water leaving the absorber. Units: °F or °C

PSTEAM- Gauge steam pressure of boiler steam. Units: Water Gauge or Pascals Gauge

STEAM- Enthalpy of steam to absorbers. If not specified, STEAM is calculated as he saturation enthalpy at PSTEAM and TSATUR. Units: Btu/lb or kJ/kg

TSATUR- Inlet temperature to absorber at full capacity. Units: °F or °C

RWC2AE- Ratio of condenser water flow rate to two stage absorber with economizer capacity. Units: lb/hour per kBtu/hour of capacity or kg/sec per kW of capacity

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the two stage absorber with economizer syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the two stage absorber with economizer. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

TWO STAGE ABSORBER WITH ECONOMIZER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "TWO STAGE ABSORBER WITH ECONOMIZERS" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
TWO STAGE ABSORBER WITH ECONOMIZERS WITH COOLING TOWER:
1 OF SIZE 100;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
TWO STAGE ABSORBER
W/ECON(MIN=0.05,MAX=1.1,BEST=.65,ELECTRICAL=0.0077);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
REN2AE(.12917,.36902,0.51136);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44;
PSTEAM=284.409;
STEAM=1168.7;
TSATUR=241.53;
RWC2AE=124.882;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

TWO STAGE ABSORBER WITH ECONOMIZER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "TWO STAGE ABSORBER WITH ECONOMIZERS" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
TWO STAGE ABSORBER WITH ECONOMIZERS WITH COOLING TOWER:
1 OF SIZE 26;
.   .   .
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=26, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
TWO STAGE ABSORBER
W/ECON(MIN=0.05,MAX=1.1,BEST=.65,ELECTRICAL=0.0077);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
REN2AE(.12917,.36902,0.51136);
.   .   .
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=6.67;
PSTEAM=70841.4;
STEAM=2716.5
TSATUR=116.405;
RWC2AE=0.055371;
.   .   .
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
.   .   .
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Unit Heater System

EQUIPMENT DESCRIPTION:

The principle functions of unit heaters are to heat specified areas. The advantages of unit heaters are a relatively large heating capacity in compact casings, the ability to keep a controlled temperature over a large space, and relatively low installation and maintenance costs. The essential components of the unit are the fan, motor, heating element, and dampers, which are all encased in a housing. Unit heaters are used primarily in schools, meeting rooms, offices, and other areas where the heating requirement is limited to a controllable area. Unit heaters are also used to aid in drying and curing operations, fog reduction, and condensation removal.

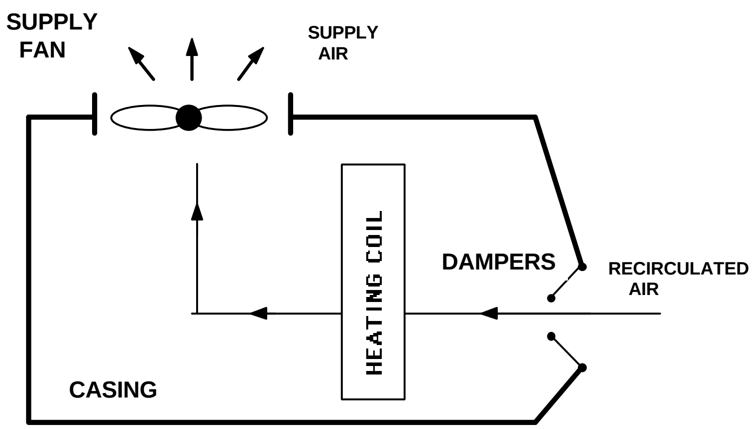


Figure 104. Diagram of a BLAST Unit Heater

USING THE BLAST UNIT HEATER SYSTEM:

Specifying a Unit Heater System in HBLC

To specify a unit heater system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select Unit Heater from the pop up menu. After naming the system, the user must enter the zone number and Supply Air Volume.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the unit heater system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

UNIT HEATER SYSTEM 1

"UNIT HEATER " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .      ZONE DATA BLOCK
      .   .   .   .       (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .      OTHER SYSTEM DATA BLOCK
      .   .   .   .      (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .      COOLING COIL DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .      HEAT RECOVERY DATA BLOCK
      .   .   .   .      (Not applicable to this system)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
      COPC=(11,34.09,-0.087);
      .   .   .   .      HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
      COPH2=(22,-3.9,0.022);
                         HEAT PUMP DATA BLOCK
      .   .   .   .      (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the unit heater system syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the unit heater system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the unit heater system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the unit heater system are listed in bold and all options as well as Metric (SI) units are italicized. When using a unit heater system note the following rules of operation:

1. Only one zone may be served.
2. Heating capacity may be specified as either HEATING COIL CAPACITY or REHEAT CAPACITY. If both are specified, the REHEAT CAPACITY will be used.
3. No outside air is simulated.
4. No return air heat gain is simulated.
5. No exhaust air is simulated.
6. No return fan is simulated.

UNIT HEATER ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

REHEAT CAPACITY- Used to specify the capacity of the reheat coils. Units: kBtu/hr or kW

REHEAT ENERGY SUPPLY- Used to specify the reheat coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

UNIT HEATER OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

REHEAT TEMPERATURE CONTROL- Used to specify how the reheat deck is controlled. The two options are fixed set point and outside air controlled.

REHEAT TEMPERATURE LIMIT- Used to specify the maximum temperature of the reheat coil. Units: °F or °C

REHEAT CONTROL SCHEDULE- Used to determine the reheat deck temperature if the deck is outside air controlled.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

UNIT HEATER EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

REHEAT COIL OPERATION- Used to schedule the reheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by applying the following syntax:

REHEAT COIL OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,- 328 MINIMUM TEMPERATURE;

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see reheat coil operation).

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

Unit Ventilator System

EQUIPMENT DESCRIPTION:

The principle functions of unit ventilators are to heat, ventilate, and cool a space by inducing outdoor air in large quantities. The heating medium is usually steam, hot water, gas, or electricity. The essential components of the unit are the fan, motor, heating element, and dampers, which are all encased in a housing. Unit ventilators are used primarily in schools, meeting rooms, offices, and other areas where the density of occupancy requires controlled ventilation. In normal operation, the typical unit is equipped with a control system that permits the heating, ventilating, and cooling effect to be varied while the fans are operating continually.

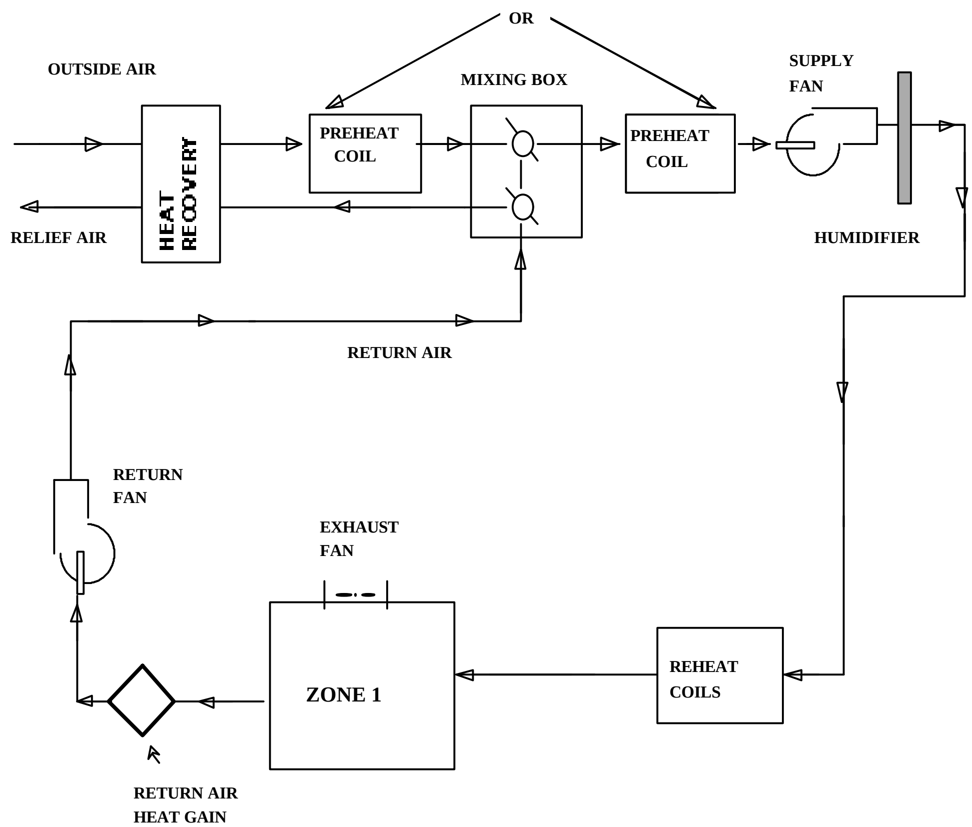


Figure 105. Diagram of a BLAST Unit Ventilator

USING THE BLAST UNIT VENTILATOR SYSTEM:

Specifying a Unit Ventilator System in HBLC

To specify a unit ventilator system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select Unit Ventilator from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option's parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the unit ventilator system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

UNIT VENTILATOR SYSTEM 1

"UNIT VENTILATOR " SERVING ZONES 1;

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100;
        .   .   .   .       ZONE DATA BLOCK
        .   .   .   .        (Required user input)
    ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=2.49783;
        .   .   .   .       OTHER SYSTEM DATA BLOCK
        .   .   .   .       (Required user input)
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
    AIR VOLUME FLOW RATE=600.06682;
        .   .   .   .       COOLING COIL DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
        .   .   .   .       (Optional user input)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
        COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
       COPH2=(22,-3.9,0.022);
                          HEAT PUMP DATA BLOCK
       .   .   .   .      (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
       .   .   .   .      DX UNIT DATA BLOCK
       .   .   .   .      (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
       .   .   .   .      SCHEDULES DATA BLOCK
       .   .   .   .      (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the unit ventilator system syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the unit ventilator system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the unit ventilator system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the unit ventilator system are listed in bold and all options as well as Metric (SI) units are italicized.

UNIT VENTILATOR ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
               =STEAM;
               =ELECTRIC;
               =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
               =STEAM;
               =ELECTRIC;
               =GAS;
    RECOOL CAPACITY=0.0 (0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

REHEAT CAPACITY- Used to specify the capacity of the reheat coils. Units: kBtu/hr or kW

REHEAT ENERGY SUPPLY- Used to specify the reheat coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

UNIT VENTILATOR OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED;
               =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED
               =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
               =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
               =FIXED AMOUNT;
               =TEMPERATURE ECONOMY CYCLE;
               =RETURN AIR ECONOMY CYCLE;
               =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
               =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
               =OUTSIDE AIR DUCT;
               =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
               =GAS;
               =ELECTRIC;
               =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
               =VARIABLE FAN SPEED;
               =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
               =STEAM
               =HOT WATER;
               =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m^2

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m^2

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

REHEAT TEMPERATURE CONTROL- Used to specify how the reheat deck is controlled. The two options are fixed set point and outside air controlled.

REHEAT TEMPERATURE LIMIT- Used to specify the maximum temperature of the reheat coil. Units: °F or °C

REHEAT CONTROL SCHEDULE- Used to determine the reheat deck temperature if the deck is outside air controlled.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

UNIT VENTILATOR HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

UNIT VENTILATOR EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,- 328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

REHEAT COIL OPERATION- Used to schedule the reheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

Units

The UNITS parameter of RUN CONTROL indicates whether input and output are to be in English or metric units. If this parameter is omitted, BLAST will expect English units as input and will print reports in English units. The table "Input Unit Conversions" illustrates the required units for various quantities. Likewise, the "Output Unit Conversions" table illustrates the units that will be shown on reports and other outputs from BLAST. Input and Output units may be different. For example:

UNITS (IN = ENGLISH, OUT = METRIC)

In HBLC, the input units are set in the “Project Information” form when creating a new project and may not be changed subsequently. Output units are set on the same form, and may be changed by selecting the appropriate radio button.

Table 23. Input Unit Conversions

Description	English	Metric
area	ft^2	m^2
delta temperature	R or °F	K or °C
energy	1000 BTU	kW/hr
enthalpy	BTU/lbm	kJ/kg
flow per capacity	lbm/1000 BTU	kg/kJ
length	ft	m
mass	lbm	kg
mass flow	lbm/hr	kg/sec
mass per area	lbm/ft^2	kg/m^2
power capacity	1000 BTU/hr	kW
pressure	inches H_2O	Pa
specific heat	BTU/lbm R	kJ/kg K
temperature	°F	°C
U-value	BTU/hr ft^2 R	W/m^2 K
velocity	ft/min	m/sec
volume flow	ft^3/min	m^3/sec

Table 24. Output Unit Conversions

Description	English	Metric
area	ft^2	m^2
conductivity	BTU/hr ft R	W/m K
delta temperature	R or °F	K or °C
density	lbm/ft^3	kg/m^3
energy	1000 BTU	kW/hr
enthalpy	BTU/lbm	kJ/kg
heat flux	BTU/hr ft^2	W/m^2
length	ft	m
mass	lbm	kg
mass flow	lbm/hr	kg/sec
power	1000 BTU/hr	kW
pressure	inches H_2O	Pa
R-value	hr ft^2 R/BTU	m^2 K/W
radiant flux factor	$1/ft^2$	$1/m^2$
specific heat	BTU/lbm R	kJ/kg K
speed	ft/min	m/sec
temperature	°F	°C
U-value	BTU/hr ft^2 R	W/m^2 K
volume	ft^3	m^3
volume flow	ft^3/min	m^3/sec
volume flow rate	gallons/hr	liters/hr

NOTE:

[1] Celsius is not a true SI scale (°K is strictly more correct) but is a derived SI unit and much more convenient as an input variable unit. Some equipment performance parameters (see Chapter 6) must be developed using absolute temperature (°K or °R). The user should carefully note these parameters.

[2] 1 cu ft = 7.48 gallons.

Variable Volume System

EQUIPMENT DESCRIPTION:

Variable air volume (VAV) systems control the dry bulb temperature inside a zone by varying the supply air volume instead of the air temperature. VAV systems can be used in interior or perimeter zones, with a common or separate fan systems, common or separate air temperature control and auxiliary heating devices. The VAV concept may vary according to the VAV box locations, air temperature controls and types of heating elements. Simple VAV systems are typically used for cooling only service with no requirement for simultaneous heating and cooling in various zones. Heating can usually be provided by use of preheat, reheat coils, and thermostatic baseboard.

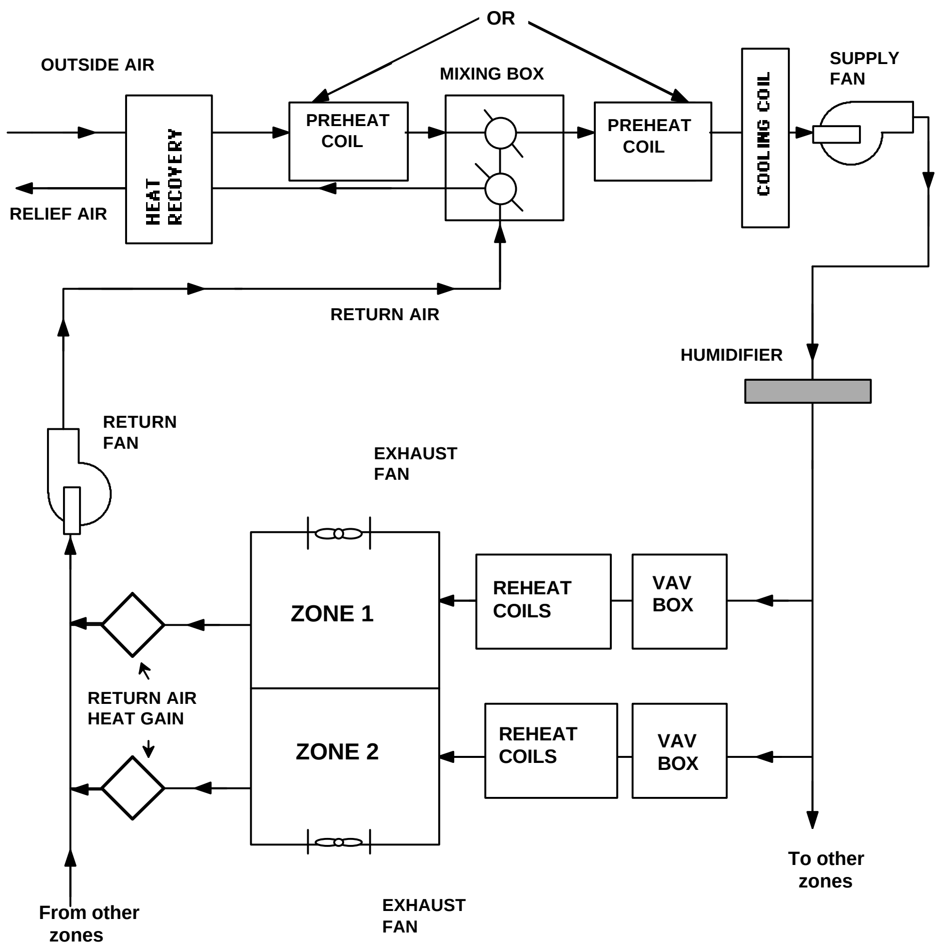


Figure 106. Diagram of a BLAST VAV system

USING THE BLAST VAV SYSTEM:

Specifying a VAV System in HBLC

To specify a VAV system as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select Variable Volume from the pop up menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the VAV system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

VARIABLE VOLUME SYSTEM 1

" VAV " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .       ZONE DATA BLOCK
      .   .   .   .        (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .       OTHER SYSTEM DATA BLOCK
      .   .   .   .       (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .       COOLING COIL DATA BLOCK
      .   .   .   .       (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0)
        .   .   .   .       HEAT RECOVERY DATA BLOCK
        .   .   .   .       (Optional user input)
    HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
        COPC=(11,34.09,-0.087);
        .   .   .   .       HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
        COPH2=(22,-3.9,0.022);
                            HEAT PUMP DATA BLOCK
        .   .   .   .       (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
        .   .   .   .       DX UNIT DATA BLOCK
        .   .   .   .       (Not applicable to this system)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
        .   .   .   .       SCHEDULES DATA BLOCK
        .   .   .   .       (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics, the VAV system syntax is shown in the context of a complete fan system description. The fan system syntax shown in these figures is sufficient to completely model the VAV system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the VAV system is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the VAV system are listed in bold and all options as well as Metric (SI) units are italicized.

VAV ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=100 (.0473);
    EXHAUST AIR VOLUME=0 (0);
    MINIMUM AIR FRACTION=0.19 (0.1);
    BASEBOARD HEAT CAPACITY=0.0 (0);
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    REHEAT CAPACITY=0.0 (0);
    REHEAT ENERGY SUPPLY=HOT WATER;
                =STEAM;
                =ELECTRIC;
                =GAS;
    RECOOL CAPACITY=0.0 (0);
    INDUCED AIR FRACTION=2.0 (2.0);
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

MINIMUM AIR FRACTION- Used to specify is the minimum fraction of the zone's design supply air volume which will be delivered to the space any time a VAV fan system is running.

REHEAT CAPACITY- Used to specify the capacity of the reheat coils. Units: kBtu/hr or kW

REHEAT ENERGY SUPPLY- Used to specify the reheat coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier.

VAV OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=55.04 (12.8);
    COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70) (13 AT 39,18 AT
21);
    COLD DECK THROTTLING RANGE=7.2 (4);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=140 (60);
    HOT DECK CONTROL SCHEDULE=(140 AT 0,70 AT 70) (60 AT -18, 21 AT
21);
    HOT DECK THROTTLING RANGE=7.2 (4);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    COOLING SAT DIFFERENCE=20 (11.1);
    HEATING SAT DIFFERENCE=70 (38.8);
    AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the cold deck is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

COOLING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the cold deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

HEATING SAT DIFFERENCE- Used to specify the temperature difference between the zone and the hot deck for system sizing when the DESIGN SYSTEM option is employed. Units: °F or °C

AIR VOLUME COEFFICIENT- Used to increase or decrease the supply air volume for the DESIGN SYSTEM option. The coefficient is multiplied by the original supply air volume.

REHEAT TEMPERATURE CONTROL- Used to specify how the reheat deck is controlled. The two options are fixed set point and outside air controlled.

REHEAT TEMPERATURE LIMIT- Used to specify the maximum temperature of the reheat coil. Units: °F or °C

REHEAT CONTROL SCHEDULE- Used to determine the reheat deck temperature if the deck is outside air controlled.

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

PREHEAT COIL LOCATION- Used to specify the location in the air duct of the preheat coil. The options are OUTSIDE AIR DUCT or MIXED AIR DUCT.

PREHEAT COIL CAPACITY- Used to set the capacity of the preheat coil. Units: kBtu/hr or kW

PREHEAT COIL TEMPERAURE- Used to set the temperature of the preheat coil. Units: °F or °C

PREHEAT ENERGY SUPPLY- Used to specify the type of energy that supplies the preheat coil. Options include hot water, gas, electric and steam.

VAV MINIMUM AIR FRACTION- Used to specify the percentage of the supply air that passes through the VAV box when the damper is closed. This option is only employed if no minimum fraction is specified in the ZONE data block. The minimum fraction specified in the ZONE data block has precedence over the minimum fraction specified in the OTHER SYSTEM PARAMETERS data block.

VAV VOLUME CONTROL TYPE- Used to specify the type of fan used in a VAV system. All options will yield default fan power coefficients and can either be specified here or using FAN POWER COEFFICIENTS. Both options can not be employed simultaneously. The options are INLET VANES, VARIABLE FAN SPEED, and DISCHARGE DAMPERS. Refer to the "FAN POWER COEFFICIENTS" entry in the BLAST Technical Reference for additional information.

FAN POWER COEFFICIENTS- Used to specify the fan power for fixed volume systems and full-load fan power for VAV systems from default or user-specified fan pressure and fan efficiencies. In this example, "FAN POWER COEFFICIENTS" have been commented out with **. Refer to the "FAN POWER COEFFICIENTS" entry in the BLAST Technical Reference for additional information.

HUMIDIFIER TYPE- Used to specify what type of energy the humidifier uses. Options include hot water, steam, and electric.

HUMIDISTAT LOCATION- Used to specify the zone where the humidistat is located.

HUMIDISTAT SET POINT- Used to specify the relative humidity percentage, below which humidification is employed.

VAV COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER
    AIR VOLUME FLOW RATE=600.06682 (0.2832);
    BAROMETRIC PRESSURE=406.8136 (101094);
    AIR FACE VELOCITY=490 (2.48);
    ENTERING AIR DRY BULB TEMPERATURE=80.006 (26.7);
    ENTERING AIR WET BULB TEMPERATURE=66.992 (19.45);
    LEAVING AIR DRY BULB TEMPERATURE=60.404 (15.78);
    LEAVING AIR WET BULB TEMPERATURE=54.0 (12.2);
    ENTERING WATER TEMPERATURE=44.996 (7.2);
    LEAVING WATER TEMPERATURE=54.644 (12.55);
    WATER VOLUME FLOW RATE=0.5348 (0.0003);
    WATER VELOCITY=275 (1.397);
    ENTERING REFRIGERANT TEMPERATURE=40 (4.4);
    LEAVING REFRIGERANT TEMPERATURE=40 (4.4);
    TOTAL COOLING LOAD=488 (143);
    NUMBER OF TUBE CIRCUITS=20;
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

VAV HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT RECOVERY PARAMETERS:
    HTREC1(0.85,0,0);
    HTREC2(0,0,0);
    HTREC3(0,0,0);
    HTREC4(0,0,0);
    HTREC5(0,0,0);
    HTREC6(0,0,0);
    HEAT RECOVERY CAPACITY=3412000 (999716);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBtu/hr or kW

VAV EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    RECOOL COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
    VAV MINIMUM AIR FRACTION SCHEDULE=VAV MIN FRAC, FROM 01JAN THRU
31DEC
 END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the fan system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,**-** 328 MINIMUM TEMPERATURE;

PREHEAT COIL OPERATION- Used to schedule the preheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

HUMIDIFIER OPERATION- Used to schedule the humidifier operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for humidifier operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

REHEAT COIL OPERATION- Used to schedule the reheat coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for coil operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPERATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

VAV MINIMUM AIR FRACTION SCHEDULE- Used to simulate a variable air volume system where the minimum air fraction is scheduled hourly. During the day, a larger minimum air fraction might be used to account for increased zone loads. A smaller minimum air fraction might be used during unoccupied hours to realize the energy savings.

Ventilation

Ventilation may be used in BLAST to provide cooling to a zone, with or without electrically powered ventilating fans. When there is forced ventilation in a zone, the electrical load due to the fan blowing air into or out of the zone is taken into account. Moisture carried with the incoming air is assumed to be carried out of the zone as well, so ventilation does not affect the latent load on a zone.

Description of Operation

Ventilation in BLAST is modulated to try to cool the ventilated zone to the ventilation set point. The amount of ventilation available each hour is determined by the specified peak ventilation rate (which is an air volume flow rate) and the schedule (which is a general schedule). Ventilation will never operate to cause a heating load on the zone.

The ventilation set point is the highest of three possible values.

1. The specified MIN TEMP
2. The heating set point from the zone controls
3. The outside air temperature plus the DEL TEMP

If ventilation is used with no controls on the zone, then the ventilation will be modulated to provide behavior similar to the following example. In the example, the outside air dry bulb (ODB) varied from 40 to 65ºF, a PEOPLE load was assigned to the zone, and the following specification for ventilation was used:

```
VENTILATION=1000.00,CONSTANT,
    50.00 MIN TEMP, 5.00 DEL TEMP,
    1.00 EXHAUST FAN PRESSURE, 0.60 FAN EFFICIENCY,
    FROM 01JAN THRU 31DEC;
```

which indicates the peak ventilation rate is 1000 CFM, the schedule is CONSTANT, the minimum zone temperature for ventilation is 50ºF, and DEL TEMP is 5ºF. The fan parameters only affect electrical use since it is an exhaust fan. The dates at the end indicate the effective dates for the ventilation statement.

DEL TEMP may be thought of as the minimum temperature difference between the zone and the outside air for which ventilation will run. DEL TEMP is always positive.

The results are shown in the figure. The ventilation runs whenever the zone mean air temperature (MAT) is pushed above the ventilation set point by the loads on the zone. For hours 1 through 8, the ventilation set point is MIN TEMP. From hour 9 to hour 24, the ventilation set point becomes the outside air temperature plus DEL TEMP. Ventilation does not run from hour 12 through 17 because the zone MAT drifts by itself to below the ventilation set point (ODB + DEL TEMP).

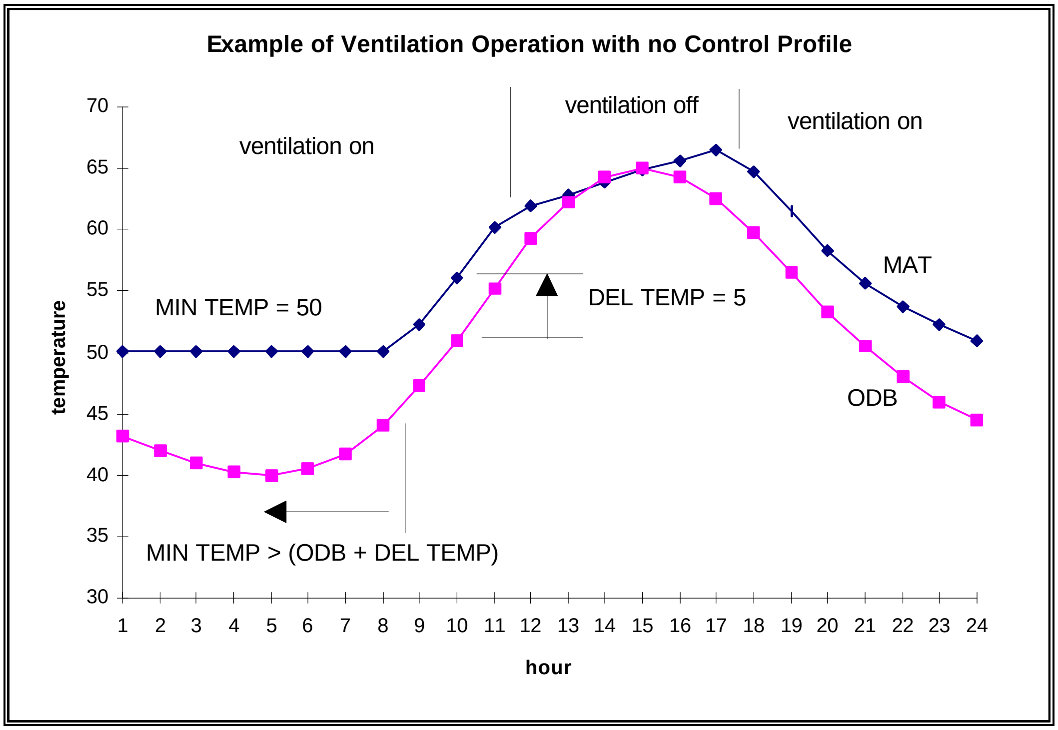


Figure 107. Example of Ventilation Operation

The next example could be a warehouse, which has heating available through a CONTROLS statement (see CONTROLS in the User Reference for more information) but only ventilation for cooling. The ventilation syntax is as follows:

```
VENTILATION=1000.00,CONSTANT ,
    0.00 MIN TEMP, 0.00 DEL TEMP,
    1.00 EXHAUST FAN PRESSURE, 0.60 FAN EFFICIENCY,
    FROM 01JAN THRU 31DEC;
```

If the heating set point in the CONTROLS schedule is 60ºF, then the MIN TEMP in the ventilation statement is never used (since 0ºF < 60ºF). Since DEL TEMP is 0, then the ventilation set point is either the heating set point or the outside dry bulb temperature, whichever is higher. As shown in the diagram below, if the outside air is colder than 60ºF, then ventilation will be modulated to try to bring the zone to 60ºF. If the outside dry bulb is greater than 60ºF, then the zone will be ventilated to try to reach the outside air temperature. The scale on the left of the figure is for the control profile shown by the heavy black line.

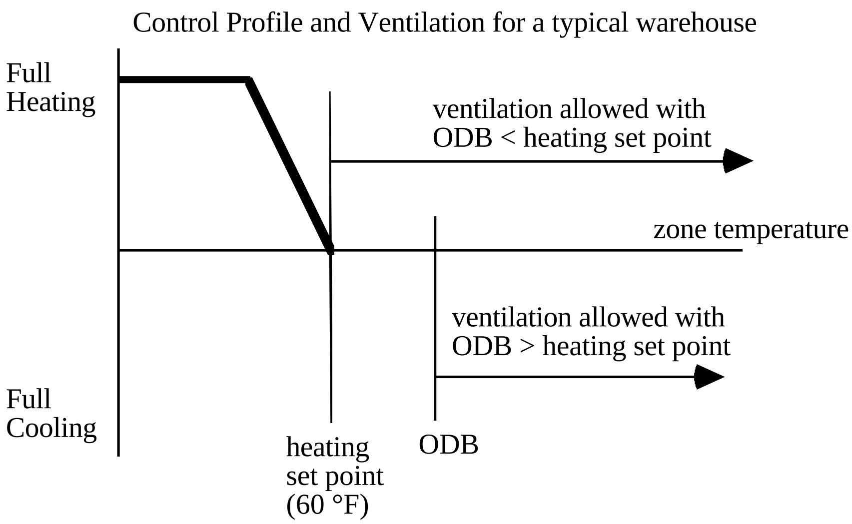


Figure 108. Control Profile for a typical warehouse including Ventilation

The use of ventilation becomes more complex if cooling is available through a CONTROLS statement. If ventilation alone is unable to keep the zone temperature below the cooling set point of the CONTROLS schedule, then the controls kick in and the entire cooling load is allocated to the fan system. Once the cooling load has been allocated to the fan system via CONTROLS, then all cooling loads will be allocated to the fan system (ventilation will not be used) until the cooling load falls to zero and the zone temperature falls below the cooling set point. Then ventilation will again try to cool the zone further to the ventilation set point. This is similar to cooling an apartment by opening the windows and running a fan (ventilation) until the outside air becomes too hot for this to be effective. Then the windows are closed and the air conditioner is turned on until the hot period ends. When the apartment naturally drifts below the air conditioner's control temperature, then the windows are opened again and the fan is run. The figure below tries to show how this works.

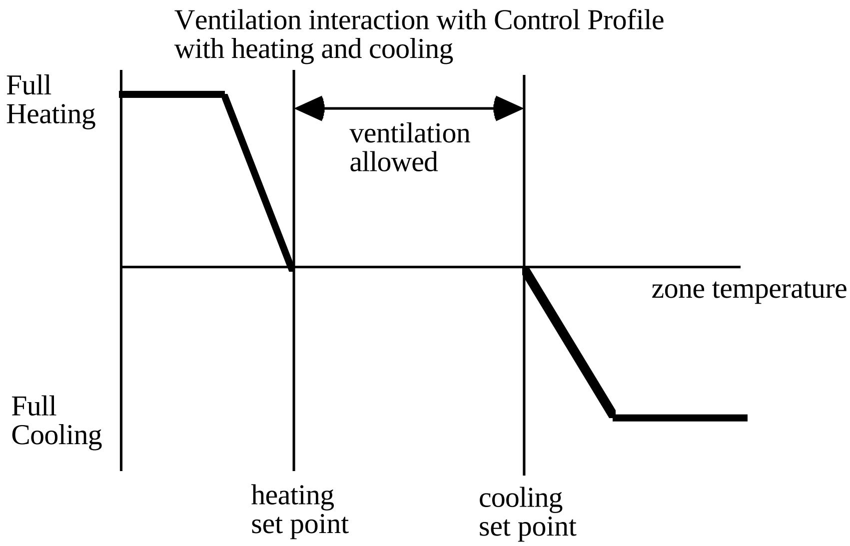


Figure 109. Control Profile with Ventilation Interactions

For more flexible use of natural cooling, use economy cycles with the fan system simulation (see Mixed Air Control in the User Reference).

The DEFAULT parameters for the VENTILATION statement are:

peak ventilation rate	= 0.0
schedule	= CONSTANT
MIN TEMP	= 0.0
DEL TEMP	= 0.0
EXHAUST FAN PRESSURE	= 0.0
INTAKE FAN PRESSURE	= 0.0
FAN EFFICIENCY	= 1.0

The results of using an INTAKE or EXHAUST FAN is that the electric energy consumption of the ventilator fan is now accounted for in the ELECTRIC LOADS column of the ZONE LOADS REPORT. Furthermore, for an INTAKE FAN, the electric energy consumed by the ventilator fan will also be added into the energy balance of the room by adding fan heat to the incoming ventilation air. If a user wants to consider ventilation without considering the electrical energy consumed, as in the old VENTILATION statement, then allowing the default values of 0.0 for INTAKE FAN PRESSURE and EXHAUST FAN PRESSURE will eliminate the fan energy.

Effect of Exhaust and Intake Fans

The BLAST model allows for intake or exhaust fans for moving air through the zone, accounting for the electrical load (and heat from an intake fan).

Both exhaust fans and intake fans add to the electrical load on the zone, according to the equation:

FAN POWER = OAMFL*(FAN PRESS)/(EFFICIENCY*AIRDEN) where

OAMFL	= outside air mass flow rate
FAN PRESS	= fan pressure
EFFICIENCY	= fan efficiency
AIRDEN	= air density

If no power use is desired, the fan pressure should be set to zero.

Intake fans add heat to the incoming air as well, according to the equation

FANDEG = FAN PRESS/(EFFICIENCY*AIRDEN*CPAIR)

where

FANDEG	= temperature increase of incoming air due to fan
FAN PRESS	= fan pressure
EFFICIENCY	= fan efficiency
CPAIR	= specific heat of air

Specifying Ventilation

Ventilation cannot be specified in HBLC. If a simulation requires ventilation, the user is advised to use an editor to place the correct syntax into the input file, or use BTEXT and the following series of commands:

Choose **S** (Scheduled Loads) from the Main Menu

Choose **A** (Add) from the Scheduled Loads Menu

Select the **Zone Number** to which ventilation is to be added

Choose **V** (Ventilation) from the Scheduled Loads Choices Menu

Enter the **Parameters** described in the *BLAST Quick Reference*

View From Person/Source

Specifying Parameters to Control Radiant Exchange

The VIEW FROM PERSON and VIEW FROM RADIANT SOURCE statements can be used to more exactly define the distribution of radiant energy on the zone surfaces. The VIEW FROM PERSON statement allows the user to specify the view factor from a person or temperature controller (In Thermal Comfort Models, people act as the "temperature controller" for a zone.) in the zone to a particular zone surface. This view factor determines how a person in the zone exchanges radiant energy with the zone surfaces. More precisely, it defines the fraction of radiant energy leaving the person that the zone surface intercepts. The VIEW FROM RADIANT SOURCE statement specifies how much of the radiation given off by the radiant heater is directed toward a certain zone surface. This allows the user to define the directionality of the radiant heater. Note that only one of each of these two statements can be used per surface.

BLAST Syntax for Controlling Radiant Exchange

The following syntax is required to control radiant exchange in BLAST:

VIEW FROM PERSON (usn1)

where: usn1 = the direct view factor from the person (temperature controller) to the surface.

The default value for usn1 is zero. If none of the surfaces in the zone use this statement, then the BLAST Mean Radiant Temperature (MRT) will be used. The MRT of a zone is basically an area-emissivity average of all zone surface temperatures. The sum of all of the view factors in a zone must be less than or equal to 1.0. Otherwise, BLAST will issue an error message and abort. If the sum of the view factors is less than 1.0, the remainder, i.e. what is not specified as directional by a VIEW FROM PERSON statement, will be assumed to see all surfaces.

VIEW FROM RADIANT SOURCE (usn2)

where: usn2 = the percent of direct radiant energy that is incident on the surface from the radiant source.

The default value for usn2 is zero. If this parameter is not specified for any of the surfaces in the zone, the radiant component of energy is assumed to be diffuse. If the sum of all VIEW FROM RADIANT SOURCE statements is less than 1.0, the remainder of the radiant energy is assumed to be diffuse (non-directional). The sum of all direct radiant energy must not be greater than 1.0. If more than 100% of the radiant energy is accounted for, BLAST will issue an error message and abort. Note that the radiation incident on a surface is uniform. Thus, if a VIEW FROM RADIANT SOURCE statement is used for a surface that has a subsurface, the percent that will be incident on the subsurface will be based on an area weighted ratio multiplied by the percent incident on the entire surface (defined by usn2).

Procedure for Controlling Radiant Exchange

HBLC is not able to specify Radiant View Factors. If view factors are required in the simulation, the user is advised to use an editor to place the syntax shown below into the input file, or use BTEXT as is described in the following paragraph.

In BTEXT, Radiant View Factors is a toggle function. When Radiant View Factors is toggled ON, BTEXT will ask for a VIEW FROM PERSON value and a VIEW FROM RADIANT SOURCE value each time a new surface is defined. If Radiant View Factors is OFF, BTEXT will not prompt the user for these values. The procedure for toggling Radiant View Factors ON/OFF is:

Choose **B** (Building and Zone Descriptions) from the Main Menu

Choose **R** (Radiant View Factors) from the Building and Zone Choices Menu

Example of a One Zone Building Using VIEW FROM Statements

```
BEGIN INPUT;
 . . .
BEGIN BUILDING DESCRIPTION;
    ZONE 1 "RADIANT HEATER EXAMPLE":
    EXTERIOR WALLS :
        STARTING AT (0.00, 0.00, 0.00)
        FACING (180.00)
        TILTED (90.00)
        EXTERIOR (100.00 BY 15.00)
        VIEW FROM PERSON (0.2),
        STARTING AT (100.00, 0.00, 0.00)
        FACING(90.00)
        TILTED(90.00)
        EXTERIOR (100.00 BY 15.00)
        VIEW FROM PERSON(0.2);
    SLAB ON GRADE FLOORS :
        STARTING AT (0.00 , 100.00, 0.00)
        FACING (180.00)
        TILTED (180.00)
        SLAB FLOOR (100.00 BY 100.00)
        VIEW FROM RADIANT SOURCE (0.8);
    RADIANT EQUIPMENT = 30.00, INT, 40 PERCENT RADIANT GAS
        HEAT, 30 PERCENT LATENT, 15 PERCENT LOST,
        0.0005 RADIANT FLUX FACTOR,
        FROM 01JAN THRU 31DEC;
    END ZONE;
END BUILDING DESCRIPTION;
END INPUT;
```

The syntax statements listed above could be used to describe a one zone building with a scheduled gas radiant heater. All of the statements pertinent to High Temperature Radiant Heaters have been highlighted. 80 percent of the radiant heat is directed towards the slab on grade floor. The remaining 20 percent of radiant heat is added to the zone as diffuse radiation. The view factor from the person to the each of the exterior walls is 0.2. The remaining portion of the radiation from the person is assumed to see all zone surfaces.

View to Sky and Ground**

See Also:

Technical Reference

**Refer to encyclopedic listing in BLAST Technical Reference for more information.

Solar Concepts

Solar radiation is composed of both beam and diffuse parts. Beam radiation is parallel radiation while diffuse radiation strikes a surface equally from all directions. BLAST uses correlations to calculate the fraction of diffuse and beam if it is not already split in the weather data. These fractions are a function of the sky clearness, location and date. During a particular day, the fraction of diffuse and beam, as well as the total solar radiation, is changing. The radiation load on a surface then becomes the sum of direct beam radiation, diffuse radiation from the sky, and diffuse radiation from the ground. In equation form, the load from the sun can be written as:

$$Q_{solar} = A[q_{beam}\cos(\theta) + F_{vs}q_{diff} + F_{vg}\rho(q_{beam} + q_{diff})]$$

where:

F_{vs} = view to sky,

F_{vg} = view to ground,

A = area of the surface,

θ = angle between the surface and the solar angle,

q_{beam} = flux of beam radiation at normal incidence,

q_{diff} = flux of diffuse radiation on a horizontal surface,

ρ = reflectivity of the ground (0.2 no snow, 0.7 for snow).

The sky diffuse, ground diffuse, and normal beam radiation on an hourly basis can be seen in the BLAST Design Day Report for design day simulations and can be obtained from WIFE for weather tapes.

View to Sky and View to Ground

VIEW TO SKY and VIEW TO GROUND are functions that BLAST uses to calculate how much diffuse solar radiation to place on an outside wall. Each point of a surface on an outside wall sees a certain fraction of diffuse solar radiation from the ground and a certain fraction of diffuse radiation from the sky. These effects are then integrated across the surface to obtain a fraction of diffuse solar radiation that comes from the sky and a fraction that comes from the ground. It is easier to think of the VIEW TO SKY as the fraction of the wall that sees the diffuse solar radiation from the sky and the VIEW TO GROUND as the remaining part of the wall that sees the diffuse solar radiation from the ground.

Default values of the VIEW TO SKY and VIEW TO GROUND for a wall of tilt 90° are 0.5 and 0.5 respectfully. If the tilt of the wall changes, then the default views to sky and ground also change. BLAST uses a simple formula to calculate the default views:

$$F_{vs} = \frac{[1 + \cos(tilt)]}{2}$$

$$F_{vg} = \frac{[1 - \cos(tilt)]}{2}$$

Water Loop Heat Pump System (WLHPS)

EQUIPMENT DESCRIPTION

A water loop heat pump system (WLHPS) is an energy-conserving, modular HVAC system that can meet simultaneous heating and cooling requirements very efficiently. WLHPS consist of a series of zoned water source heat pump units linked by a common water circulation loop that acts as a thermal sink. Water loop heat pump systems have been used in space conditioning applications since the late 1960's. Recently these water systems have gained popularity due to their low cost and energy efficient means for air conditioning applications. The use of these systems accounts for less than 7% of the industrial air conditioning market, but it is estimated that they are applicable to more than 50% of new and existing structures.

There are four major components in a basic water loop heat pump system. These components include a network of zoned water source heat pump units, a heat rejection unit, a supplementary heating unit, and a water circulation pump.

In a water loop heat pump system, a series or network of zoned water source heat pump units act independently of each other to control the loads in each zone. This process requires each unit to add or reject heat to the water in the circulation loop. This independent operation allows increased energy savings by transferring or balancing heat from different zones of a building. The loop temperature is usually maintained between 60 °F and 90 °F by a closed circuit heat rejection device such as a cooling tower or chiller and a supplementary heating device. Common heating devices are electric, gas, and oil boilers, district steam, water to water heat pumps and solar devices. The low operating temperature range also allows the loop to be easily controlled and non-insulated.

Thermal storage in the circulation loop can also be increased by an added thermal storage tank or by geothermal means. The added thermal storage option allows heat stored in the system loop to be utilized at different times in the day as well as in different zones throughout a building. The addition of a storage device is most common when load smoothing through a diurnal cycle is to be achieved or a larger thermal sink capacity is desired.

A decentralized WLHPS is able to take advantage of building load diversity. The independent heat pump units can be zone controlled to allow efficient simultaneous heating and cooling operations with small incremental energy demands regardless of the building size. This operation is very unlike a large central plant such as a chiller or boiler in which high part load operations during low load demand periods can cause low efficiencies. The water loop heat pump system can also save space-conditioning energy by transferring heat from portions of a building requiring cooling to those needing heating at the same time. This typically occurs in a core and perimeter type of building.

The cost of WLHPS systems is another reason that they are becoming popular. Because of their modular nature and low operating and installation costs, WLHPS are very economical to install and maintain. These systems can be easily added to existing buildings because of the small amount of duct work required and there is not a need for a mechanical room. WLHPS can also be integrated into existing fire protection systems and plumbing systems.

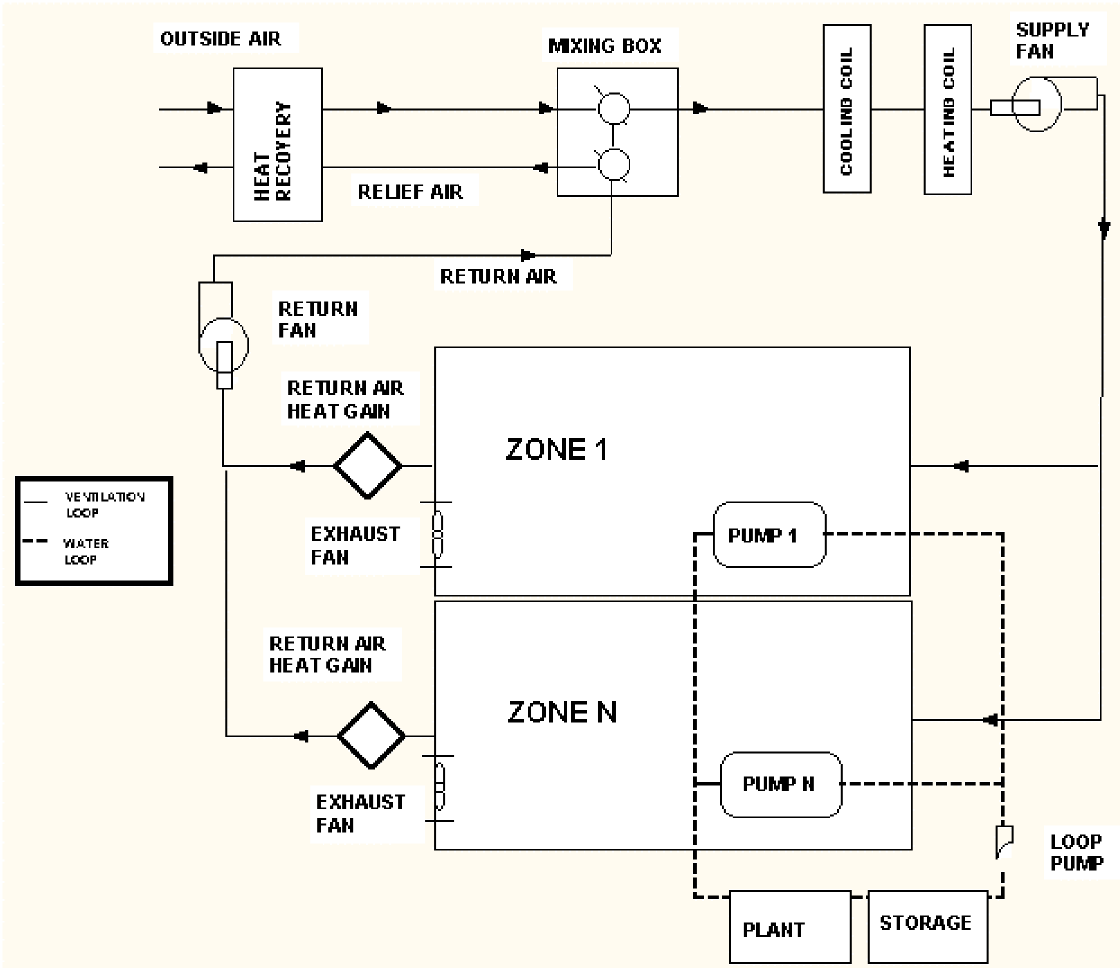


Figure 110. Diagram of a BLAST WLHP System

USING THE WLHPS;

Specifying a WLHPS in HBLC

To specify a WLHPS as one of the fan systems in the building simulation, the user must first follow the methods outlined in Fan Systems to create a fan system. After choosing “Add System”, select Water Loop Heat Pump from the Heat Pumps sub-menu. After naming the system, the user must enter the zone numbers and their corresponding Supply Air Volumes.

In addition to the data cells, the user should click on all the highlighted buttons and fill out those forms with simulation specific data for more accurate BLAST results. The buttons with checkboxes represent optional items which are not necessary to a BLAST simulation, but which a user may include depending on the particular situation. The inactive options may be utilized by checking the boxes on their left. The option’s parameter form may then be edited by clicking the (now highlighted) button.

Please note that the Water Loop Heat Pump System cannot be sized using DESIGN SYSTEMS. Please see Water Loop Heat Pump in the BLAST Technical Reference.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX

The fan system description section of the BLAST input file is shown below in skeletal form. The simplified syntax shows all major fan system data blocks with a few parameters in each. The graphic shows how the different fan system data blocks fit together to describe the water loop heat pump system. Important data blocks are described in detail in the following topics.

BEGIN FAN SYSTEM DESCRIPTION;

WATER LOOP HEAT PUMP SYSTEM 1

"WLHPS " SERVING ZONES 1;

```
FOR ZONE 1:
   SUPPLY AIR VOLUME=100;
      .   .   .   .        ZONE DATA BLOCK
      .   .   .   .         (Required user input)
   ZONE MULTIPLIER=1;
END ZONE;
```

```
OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      .   .   .   .        OTHER SYSTEM DATA BLOCK
      .   .   .   .        (Required user input)
   AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
```

```
COOLING COIL DESIGN PARAMETERS:
   AIR VOLUME FLOW RATE=600.06682;
      .   .   .   .        COOLING COIL DATA BLOCK
      .   .   .   .        (Optional expert user input)
   WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0,0)
      .   .   .   .        HEAT RECOVERY DATA BLOCK
      .   .   .   .        (Optional expert user input)
   HEAT RECOVERY CAPACITY=34120000;
END HEAT RECOVERY PARAMETERS;
```

```
WATER SOURCE HEAT PUMP PARAMETERS:
   HHCP(-3.6975,4.3374,0.0745);
                           WATER LOOP HEAT PUMP DATA BLOCK
                           (Optional expert user input)
   WLPT(0.0,1.0,0.0);
END WATER SOURCE HEAT PARAMETERS;
```

```
HEAT PUMP COOLING PARAMETERS:
      COPC=(11,34.09,-0.087);
      .   .   .   .        HEAT PUMP DATA BLOCK
      .   .   .   .        (Not applicable to this system)

END HEAT PUMP COOLING PARAMETERS;
```

```
HEAT PUMP HEATING PARAMETERS:
       COPH2=(22,-3.9,0.022);
                          HEAT PUMP DATA BLOCK
       .   .   .   .      (Not applicable to this system)

END HEAT PUMP HEATING PARAMETERS;
```

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487;
       .   .   .   .      DX UNIT DATA BLOCK
                          (Optional expert user input)
    DESIGN FULL LOAD POWER RATIO=.326;
END DX CONDENSING UNIT PARAMETERS;
```

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
       .   .   .   .      SCHEDULES DATA BLOCK
       .   .   .   .      (Required user input)
    SYSTEM ELECTRICAL DEMAND SCHEDULE
        =ON,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

In the following topics the WLHPS unit syntax is shown in the context of a complete fan system . The fan system syntax shown in these figures is sufficient to completely model the WLHP system. HBLC may include additional parameters and syntax that will not be used in the simulation if only the WLHPS is specified. The user is advised to generate all syntax using HBLC. Extraneous parameters need not be removed from the BLAST input file. In the following examples, the parameters pertaining to the WLHPS are listed in bold and all options as well as Metric (SI) units are italicized.

WLHPS ZONE DATA BLOCK

```
FOR ZONE 1:
    SUPPLY AIR VOLUME = 0.00001 (0.00001);
    EXHAUST AIR VOLUME = 0.0 (0.0);
    MINIMUM AIR FRACTION = 0.19 (0.1);
    BASEBOARD HEAT CAPACITY = 0.0 (0.0);
    BASEBOARD HEAT ENERGY SUPPLY  = HOT WATER;
        = STEAM;
        = ELECTRIC;
        = GAS:
    REHEAT CAPACITY = 0.0 (0);
    REHEAT ENERGY SUPPLY   = HOT WATER;
        = STEAM;
        = ELECTRIC;
        = GAS;
    RECOOL CAPACITY = .0 (0);
    INDUCED AIR FRACTION = 2.0 (2);
    HEAT PUMP FLOW RATE = 7.936641439 (0.001);
    HEAT PUMP CAPACITY = 0.0 (0.0);
    HEAT PUMP EER = 11.0;
    HEAT PUMP COP = 4.0;
    ZONE MULTIPLIER = 1.0;
END ZONE;
```

*These parameters are specified for the individual heat pump unit in the zone, each heat pump unit is specified separately with a maximum of one unit per zone.

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery. If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

BASEBOARD HEAT CAPACITY- Used to specify thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEAT PUMP FLOW RATE- Used to set the mass flow rate of water through water loop heat pump in the zone. Please note that the HEAT PUMP FLOW RATE should equal the NOMINAL FLOW RATE times the HEAT PUMP CAPACITY. Units: kg/s or lbm/hr

HEAT PUMP CAPACITY- Used to set the nominal or base capacity for the water loop heat pump in the zone. Units: kW or kBtu/hr

HEAT PUMP EER- Used to specify the nominal or base EER of the water loop heat pump in the zone. Units: Dimensionless

HEAT PUMP COP- Used to specify the nominal or base COP of the water loop heat pump in the zone. Units: Dimensionless

WLHPS OTHER SYSTEM PARAMETERS DATA BLOCK

```
OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783 (622.16);
    SUPPLY FAN EFFICIENCY=0.7 ;
    RETURN FAN PRESSURE=0;
    RETURN FAN EFFICIENCY=0.7 ;
    EXHAUST FAN PRESSURE=1.00396 (290.14);
    EXHAUST FAN EFFICIENCY=0.7;
    COLD DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
                =ZONE CONTROLLED;
    COLD DECK TEMPERATURE=100.0 (37.78);
    COLD DECK CONTROL SCHEDULE=(80 AT 90,90 AT 70) (26.67 AT 32,-32
AT 21);
    COLD DECK THROTTLING RANGE=1.8 (1.0);
    HEATING COIL ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    HEATING COIL CAPACITY=34120000 (999716);
    HOT DECK CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED
                =ZONE CONTROLLED;
    HOT DECK TEMPERATURE=50 (10);
    HOT DECK CONTROL SCHEDULE=(50 AT 0,40 AT 70) (10 AT -18, 4.4 AT
21);
    HOT DECK THROTTLING RANGE=1.8 (1.0);
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
                =OUTSIDE AIR CONTROLLED;
    REHEAT TEMPERATURE LIMIT=140 (60);
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70) (60 AT -18, 21 AT
21);
    MIXED AIR CONTROL=FIXED PERCENT;
                =FIXED AMOUNT;
                =TEMPERATURE ECONOMY CYCLE;
                =RETURN AIR ECONOMY CYCLE;
                =ENTHALPY ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
                =(ARBITRAY FIXED VALUE);
    OUTSIDE AIR VOLUME=0.0 (0);
    PREHEAT COIL LOCATION=NONE;
                =OUTSIDE AIR DUCT;
                =MIXED AIR DUCT;
    PREHEAT TEMPERATURE=46.4 (8);
    PREHEAT COIL CAPACITY=0 (0);
    GAS BURNER EFFICIENCY=0.8;
    PREHEAT ENERGY SUPPLY=HOT WATER;
                =GAS;
                =ELECTRIC;
                =STEAM;
    VAV MINIMUM AIR FRACTION=0.1;
    VAV VOLUME CONTROL TYPE=INLET VANES;
                =VARIABLE FAN SPEED;
                =DISCHARGE DAMPERS;
    HUMIDIFIER TYPE=NONE;
                =STEAM
                =HOT WATER;
                =ELECTRIC;
    HUMIDISTAT LOCATION=(ZONE NUMBER);
    HUMIDISTAT SET POINT=50;
    **FAN POWER COEFFICIENTS=(0,0,0,0,0);
    SYSTEM ELECTRICAL DEMAND=0.0;
    LOOP MASS RATIO = 0.5;
    SYSTEM PRESSURE HEAD = 401.474213311 (100000.0);
    LOOP PUMP EFFICIENCY = 0.85;
    TANK TEMPERATURE = 75.65 (24.25);
    FIXED LOOP TEMPERATURE = 75.65 (24.25);
    MAXIMUM LOOP TEMPERATURE = 92.3 (33.5);
    MINIMUM LOOP TEMPERATURE = 59.0 (15.0);
    STORAGE VOLUME = 35315.0 (1000.0);
    SUPPLEMENTAL HEAT TYPE = HOT WATER;
                = STEAM;
                = ELECTRIC;
```

```
                  = GAS;
    SUPPLEMENTAL COOL TYPE = COMPRESSION;
                  = TOWER
    NOMINAL FLOW RATE = 125.52 (0.054);
    NOMINAL PRESSURE DROP = 0.004014742 (1.0);
    LOOP MASS = 1100000.0 (500000.0);
    LOOP CONTROL = FIXED TEMPERATURE;
                  = DEAD BAND;
                  = HOURLY SCHEDULE
    COOLING TOWER CAPACITY = 3414425.0931119 (1000000.0);
    TOWER ELECTRIC COEFFICIENT = 0.241;
    TOWER PUMP COEFFICIENT = 0.013;
    PUMP TYPE = CONSTANT FLOW;
                  = VARIABLE FLOW;
END OTHER SYSTEM PARAMETERS;
```

SUPPLY FAN PRESSURE- Used to specify the pressure drop across the supply fan. Units: inches H20 or N/m²

SUPPLY FAN EFFICIENCY- Used to specify the efficiency of the supply fan.

RETURN FAN PRESSURE- Used to specify the pressure drop across the return fan. Units: inches H20 or N/m²

RETURN FAN EFFICIENCY- Used to specify the efficiency of the return fan.

EXHAUST FAN PRESSURE- Used to specify the pressure drop across the exhaust fan. Units: inches H20 or N/m²

EXHAUST FAN EFFICIENCY- Used to specify the efficiency of the exhaust fan.

COLD DECK CONTROL- Used to specify how the coiling coil in the ventilation system is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

COLD DECK THROTTLING RANGE- Used to specify the cold deck temperature based on the previous hours cooling load. The deck temperature is adjusted somewhere between the cold deck set point and the set point minus the throttling range. Units: °F or °C

COLD DECK TEMPERATURE- Used to specify the fixed point cold deck temperature. Units: °F or °C

COLD DECK CONTROL SCHEDULE- Used to specify the cold deck temperature if the deck is outside air or zone controlled.

HOT DECK CONTROL- Used to specify the how coiling coil in the ventilation system is controlled. The three options are FIXED SET POINT, OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK TEMPERATURE- Used to set the fixed point hot deck temperature. Units: °F or °C

HEATING COIL ENERGY SUPPLY- Used to specify the heating coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

HEATING COIL CAPACITY- Used to specify the capacity of the heating coil. Units: kBtu/hr or kW

HOT DECK CONTROL SCHEDULE- Used to determine the hot deck temperature if the deck is OUTSIDE AIR CONTROLLED and ZONE CONTROLLED.

HOT DECK THROTTLING RANGE- Used to set the hot deck temperature based on the previous hours heating load. The deck temperature is adjusted somewhere between the hot deck set point and the set point plus the throttling range. Units: °F or °C

MIXED AIR CONTROL- The mixed air control includes three economy cycles and two methods for fixing the outside air volume if an economy cycle is not used.

DESIRED MIXED AIR TEMPERATURE- The mixed air temperature includes two methods for fixing the mixed air temperature. One possible method is to set the mixed air temperature equal to the cold deck temperature and the other option is fixing the temperature at any desired value. Units: °F or °C

OUTSIDE AIR VOLUME- Used to specify the amount of outside air that is taken through the system when the FIXED AMOUNT option is employed and it is regulated by a ventilation schedule (see schedules). Units: ft^3/min or m^3/s

GAS BURNER EFFICIENCY- Used to specify the efficiency of the gas burner.

SYSTEM ELECTRICAL DEMAND- Used to specify the parasitic electric consumption of the fan system. Units: kBtu/hr or kW

LOOP MASS RATIO- The division of the total loop mass between the central plant and the heat pump network inlet. Units: Dimensionless

SYSTEM PRESSURE HEAD- Used to specify the pressure head of the water loop excluding the heat pump units. Units: inches H20 or N/m^2

LOOP PUMP EFFICIENCY- Used to specify the efficiency of the water loop pump. Units: Dimensionless

TANK TEMPERATURE- Used to specify the initial temperature of the storage tank. Units: °C or °F

FIXED LOOP TEMPERATURE- Used to specify the fixed loop temperature for control option: FIXED TEMPERATURE. Units: °C or °F

MAXIMUM LOOP TEMPERATURE- Used to specify the maximum loop temperature for control options: DEAD BAND. Units: °C or °F

MINIMUM LOOP TEMPERATURE-Used to specify the minimum loop temperature for control options: DEAD BAND. Units: °C or °F

STORAGE - Used to specify the volume of the water storage tank. Units: m^3

SUPPLEMENTAL HEAT TYPE- Used to specify the central plant heating unit source. Options are gas, steam, hot water, electric.

SUPPLEMENTAL COOL TYPE- Used to specify the central plant cooling unit type. Options are COMPRESSION and TOWER. COMPRESSION selects any of the central plant units in BLAST and TOWER employs a integrated closed loop cooling tower in the fan system simulation. If COMPRESSION is selected, the cooling loads required by the water loop are passed to the central plant simulation. If TOWER is selected, the cooling loads are handled by a cooling tower in the fan system simulation and the cooling tower electric consumption is passed to the central plant simulation.

NOMINAL FLOW RATE- Used to specify the nominal flow rate of the water loop heat pump units (See technical reference). This value is the design flow rate of the heat pump divided by the design capacity and is assumed constant for all units. Units: kg/kJ or lbm/kBTU

NOMINAL PRESSURE DROP- The nominal or base rated pressure drop across the heat pump units (See technical reference). Units: inches H20 or N/m^2

LOOP MASS- Used to specify the total mass in the loop. Units: kg or lb

LOOP CONTROL- Used to select the control option for the loop.

FIXED TEMPERATURE (fixed control)

DEAD BAND (free floating loop between limits)

HOURLY SCHEDULE (defined by hourly control schedule). See Equipment Schedules.

TOWER CAPACITY- Used to specify the capacity of the integrated cooling tower when cooling type TOWER is employed. Units: kW or kBtu / hr

TOWER ELECTRIC COEFFICIENT- Used to specify the amount of energy used by the fans in the integrated cooling tower when cooling type TOWER is employed. Units: Dimensionless

TOWER PUMP COEFFICIENT- Used to specify the amount of energy consumed by the integrated cooling tower pump. Units: Dimensionless.

PUMP TYPE- Used to specify the type of pump used by the water loop heat pump system. VARIABLE FLOW for a variable volume pump or CONSTANT FLOW for a constant volume pump.

WLHPS COOLING COIL DESIGN PARAMETERS DATA BLOCK

```
COOLING COIL DESIGN PARAMETERS
    COIL TYPE = CHILLED WATER;
    AIR VOLUME FLOW RATE = 0.00001 (0.00001);
    BAROMETRIC PRESSURE = 405.489 (101000.0);
    AIR FACE VELOCITY = 492.126 (2.5);
    ENTERING AIR DRY BULB TEMPERATURE = 84.92 (29.4);
    ENTERING AIR WET BULB TEMPERATURE = 64.04 (17.8);
    LEAVING AIR DRY BULB TEMPERATURE = 55.04 (12.8);
    LEAVING AIR WET BULB TEMPERATURE = 52.7 (11.5);
    ENTERING WATER TEMPERATURE = 44.96 (7.22);
    LEAVING WATER TEMPERATURE = 55.04 (12,8);
    WATER VOLUME FLOW RATE = 0.0017879111 (0.00000084);
    WATER VELOCITY = 275.59 (1.4);
END COOLING COIL DESIGN PARAMETERS;
```

NOTE-CHILLED WATER COIL SHOWN ABOVE, SEE COOLING COIL PARAMETERS IN THE QUICK REFERENCE FOR DX COIL OPERATION.

COIL TYPE- Used to define the type of cooling coil that is utilized by the system. The options are direct expansion (DX) or chilled water (CW).

AIR VOLUME FLOW RATE- Used to specify the volumetric flow rate of the air over the cooling coil. Units: ft^3/min or m^3/s

BAROMETRIC PRESSURE- Used to specify the barometric pressure of the air. Units: inches H20 or N/m^2

AIR FACE VELOCITY- Used to specify the velocity of the air over the cooling coil. Units: ft/min or m/s

ENTERING AIR DRY BULB TEMPERATURE- Used to specify the entering air dry bulb temperature. Units: °F or °C

ENTERING AIR WET BULB TEMPERATURE- Used to specify the entering air wet bulb temperature. Units: °F or °C

LEAVING AIR DRY BULB TEMPERATURE- Used to specify the leaving air dry bulb temperature. Units: °F or °C

LEAVING AIR WET BULB TEMPERATURE- Used to specify the leaving air wet bulb temperature. Units: °F or °C

ENTERING WATER TEMPERATURE- Used to specify the entering cooling water temperature for chilled water coils. Units: °F or °C

LEAVING WATER TEMPERATURE- Used to specify the leaving cooling water temperature for chilled water coils. Units: °F or °C

WATER VOLUME FLOW RATE- Used to specify the volumetric flow rate of the chilled water through the cooling coil. Units: ft^3/min or m^3/s

WATER VELOCITY- Used to specify the velocity of the chilled water through the cooling coil. Units: ft/min or m/s

WLHPS HEAT RECOVERY PARAMETERS DATA BLOCK

```
HEAT RECOVERY PARAMETERS:
   HTREC1(0.85,0.0,0.0);
   HTREC2(0.0,0.0,0.0);
   HTREC3(0,0,0);
   HTREC4(0,0,0);
   HTREC5(0,0,0);
   HTREC6(0,0,0);
   HEAT RECOVERY CAPACITY = 3412000.0 (1000000.0);
END HEAT RECOVERY PARAMETERS;
```

HTREC1- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC2- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC3- Coefficient used to calculate the effectiveness of sensible heat recovery process in the air to air heat recovery device.

HTREC4- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC5- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HTREC6- Coefficient used to calculate the effectiveness of latent heat recovery process in the air to air heat recovery device.

HEAT RECOVERY CAPACITY- Used to specify the capacity of the heat recovery heat exchanger. Units: kBTU/hr or kW

WLHPS PUMP PARAMETERS DATA BLOCK

```
WATER SOURCE HEAT PUMP PARAMETERS:
    HHCP(-3.6975,4.3374,0.0745);
    HCCP(3.1175,-2.07,0.07459);
    HCOP(-1.1105,1.93,0.107);
    HEER(7.5,-6.3,0.216337);
    PRSURE(0.0,0.0,0.0);
    WLPT(0.0,1.0,0.0);
END WATER SOURCE HEAT PUMP PARAMETERS;
```

HHCP- Used to calculate the heat pump heating capacity.

HCCP- Used to calculate the heat pump cooling capacity.

HCOP- Used to calculate the heat pump COP.

HEER- Used to calculate the heat pump EER.

PRSURE- Used to calculate the heat pump pressure drop.

WLPT- Used to calculate the cooling tower pump energy usage.

WLHPS EQUIPMENT SCHEDULES DATA BLOCK

```
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATON=ON,FROM 01JAN THRU 31DEC;
    TSAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
    WLHPS STORAGE TANK OPERATION=OFF,FROM 01JAN THRU 31DEC;
    WLHPS VENTILATION SYSTEM OPERATION=DAYVENT,FROM 01JAN THRU
31DEC;
    WLHPS LOOP CONTROL SCHEDULE=TEMP1,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
```

SYSTEM OPERATION- Used to schedule the water loop heat pump system operation by means of a previously defined operation schedule and the dates for which this schedule will apply.

EXHAUST FAN OPERATION- Used to schedule the exhaust fan operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for fan operation can be defined by applying the following syntax:

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC,392 MAXIMUM TEMPERATURE,-328 MINIMUM TEMPERATURE;

HEATING COIL OPERATION- Used to schedule the heating coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

COOLING COIL OPERATION- Used to schedule the cooling coil operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heating coil operation can be defined by using optional user syntax (see exhaust fan operation).

TSTAT BASEBOARD HEAT OPREATION- Used to schedule the thermostatically controlled baseboard heater by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for baseboard operation can be defined by using optional user syntax (see exhaust fan operation).

HEAT RECOVERY OPERATION- Used to schedule the air to air heat recovery operation by means of a previously defined operation schedule and dates for which this schedule will apply. The minimum and maximum temperature ranges for heat recovery operation can be defined by using optional user syntax (see exhaust fan operation).

MINIMUM VENTILATION SCHEDULE- Used to schedule the minimum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

MAXIMUM VENTILATION SCHEDULE- Used to schedule the maximum fraction of outside air (see mixed air control) by means of a previously defined operation schedule and dates for which this schedule will apply.

SYSTEM ELECTRICAL DEMAND SCHEDULE- Used to schedule the parasitic or optional system electrical requirement by means of a previously defined operation schedule and dates for which this schedule will apply.

WLHPS STORAGE TANK OPERATION SCHEDULE- Used to schedule the operation of a closed loop storage tank for the water loop heat pump system by means of a previously defined operation schedule and dates for which this schedule will apply.

WLHPS VENTILATION SYSTEM OPERATION SCHEDULE- Used to schedule the operation of a ventilation system for a water loop heat pump system by means of a previously defined operation schedule and dates for which this schedule will apply. This schedule controls induced ventilation by the heat pump units or a separate ventilation system depending on which type is specified.

WLHPS LOOP CONTROL SCHEDULE- Used to schedule the hourly loop control temperatures for a water loop heat pump system by means of a previously defined operation schedule and dates for which this schedule will apply. These schedule values are actual fixed temperature values and can be either metric or English depending on the input deck type.

Example

```
Temporary Schedule (TEMP1):
        Monday Thru Friday (33, 33, 33, 33, 33, 31, 29, 27, 25, 23, 21,
                19, 17, 15, 15, 15, 15, 17, 20, 23, 26, 29, 31, 33);
```

Well-Water Condenser

EQUIPMENT DESCRIPTION:

The BLAST well-water condenser exchanges heat with cool well water. The heat rejected from the condenser is absorbed by water that is returning from the well-water condenser. The heated water then flows into the well-water condenser and returns to the chiller as chilled water. The capacity of the well is infinite and thus the exiting water from the well-water condenser is at the same temperature as the water in the well.

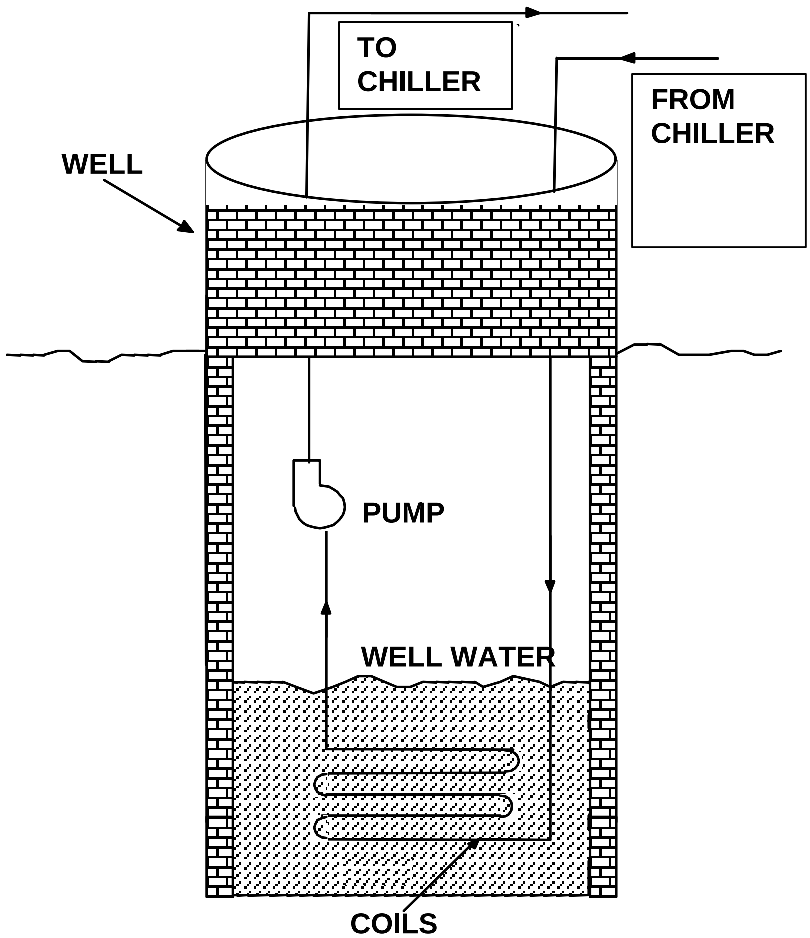


Figure 111. Diagram of a BLAST Well-Water Condenser

USING THE BLAST WELL-WATER CONDENSER:

Specifying a Well-Water Condenser in HBLC

To specify a well-water condenser as one of the operating components in the central energy plant, the user must first select any chiller using the procedure outlined in Central Plants.

Once the plant has been created, and a chiller added, select the chiller and click on "Edit" equipment. A Well Water Condenser may be chosen from the "Condenser Tower" pull down menu. The user also must specify the number and unit capacity of the Well Water Condenser(s) once back in the main Plants form.

Adjusting the Performance Parameters of the Well-Water Condenser

Once the well-water condenser has been added using HBLC, the user must specify operating rules and parameters for the well-water condenser. The user should edit these parameters by either clicking on "Edit" Condenser Tower in the chiller parameters form, or else by selecting the condenser in the main Plants form. If the user does not specify these rules, default parameters will be used. The default parameters specified by HBLC will allow a valid simulation for a well-water condenser that has the following operating parameter:

Well Temperature = 55 °F

The default parameters have been devised so that the default well-water condenser operates independently of the capacity.

PARAMETER DEFINITIONS AND SAMPLE SYNTAX:

Parameter Description:

WCPUMP- Used to determine the power consumption of the well-water condenser pump.

PELWWC- The ratio of well-water condenser pump electrical energy required to condenser load. Units: Dimensionless

TWWC- Minimum allowable temperature for water leaving the well.
Units: °F or °C

Syntax Description:

EQUIPMENT SELECTION- Type and capacity of plant selected.

PLANT ELECTRICAL DEMAND- Specifies Plant demand not otherwise accounted for.

PART LOAD RATIOS- Used to specify the part load performance of the plant.

REPORT VARIABLES- Used to select Report Writer variables.

SAMPLE SYNTAX WITH PARAMETER DEFAULT VALUES:

In the following topics, the well-water condenser syntax is shown in the context of a complete central plant description with both English and Metric default values. The central plant syntax shown in these figures is sufficient to completely model the well-water condenser. HBLC will generate the appropriate syntax for each equipment type along with user customized values. In the following examples, bold text denotes applicable parameters, if not italicized, these are defaults as well.

WELL WATER CONDENSER BLAST INPUT FILE SYNTAX, ENGLISH UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "CHILLER WITH WELL WATER CONDENSER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH WELL WATER CONDENSER:
1 OF SIZE 100;
WELL WATER CONDENSER:
1 OF SIZE 100;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=100, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
WELL WATER CONDENSER(MIN=0.0,MAX=1.00,ELECTRICAL=0.012);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
WCPUMP(1,0,0);
ADJT1C(95,2.77,44);
RCAV1C(1.006,-0.019,0.002);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PELWWC=0.012;
TWWC=32.49;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
WELL WATER TEMPERATURES=(55,55,55,55,55,55,55,55,55,55,55,55);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

WELL WATER CONDENSER BLAST INPUT FILE SYNTAX, SI UNIT DEFAULTS

```
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "CHILLER WITH WELL WATER CONDENSER" SERVING ALL SYSTEMS;
EQUIPMENT SELECTION:
CHILLER WITH WELL WATER CONDENSER:
1 OF SIZE 24;
WELL WATER CONDENSER:
1 OF SIZE 24;
END EQUIPMENT SELECTION;
SCHEDULE:
PLANT ELECTRICAL DEMAND=24, CONSTANT, FROM 01JAN THRU 31 DEC;
.   .   .
END SCHEDULE;
PART LOAD RATIOS:
CHILLER(MIN=0.1,MAX=1.05,BEST=.65,ELECTRICAL=0.2275);
WELL WATER CONDENSER(MIN=0.0,MAX=1.00,ELECTRICAL=0.012);
.   .   .
END PART LOAD RATIOS;
EQUIPMENT PERFORMANCE PARAMETERS:
WCPUMP(1,0,0);
ADJT1C(35,2.77,6.67);
RCAV1C(1.006,-0.019,0.002);
ADJE1C(3.158,-3.313,1.540);
RPWR1C(0.1607,0.3164,0.5198);
END EQUIPMENT PERFORMANCE PARAMETERS;
SPECIAL PARAMETERS:
TCOOL=44.006;
PELWWC=0.012;
TWWC=0.227;
END SPECIAL PARAMETERS;
OTHER PLANT PARAMETERS:
REPORT VARIABLES=(1,2);
WELL WATER TEMPERATURES=(13,13,13,13,13,13,13,13,13,13,13,13);
END OTHER PLANT PARAMETERS;
FOR SYSTEM 1:
SYSTEM MULTIPLIER=1;
END SYSTEM;
END PLANT;
END CENTRAL PLANT DESCRIPTION;
```

Wings and Overhangs

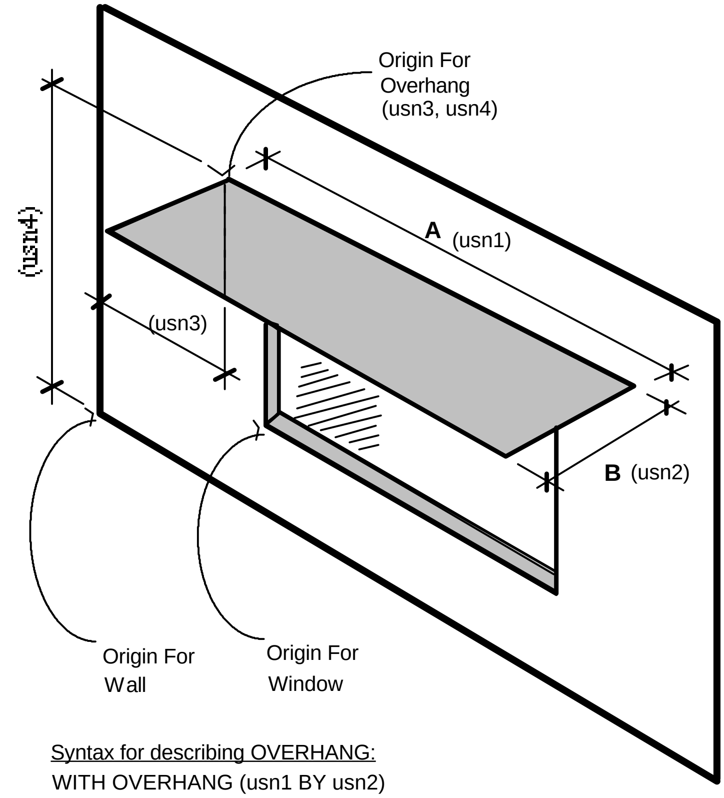
Wings and overhangs are rectangular, attached subsurfaces which project outward form the surface and shade only the surface (and its subsurfaces) to which they are attached. Thus, if a wall has an overhang, the overhang can only cast shadows onto the wall to which it is attached and onto doors and windows in that wall.

If it is assumed that all surfaces are X-Y planes, then overhangs must *always* run parallel to the X axis (e.g., the length dimension of a wall); wings must run parallel to the Y axis (e.g., up and down a wall). To avoid confusion, the AT specification for wings and overhangs should contain the X and Y coordinates on the wall of the bottom-left corner of the wing or overhang. To specify the dimensions of wings and overhangs, first list the dimension along the surface (usually the long dimension), then list the distance the wing or overhang projects outward from the surface (see figures for examples of origins and dimensions).

One zone surface can cast a shadow(s) on another zone surface(s). However, users need not worry about the effects of one wall shading another (e.g., an L-shaped zone). BLAST will automatically check for possible shadowing and perform the proper calculations. Also, since surfaces can only cast shadows in the hemisphere towards which they face, a roof or ceiling which faces *upward* will not cast a shadow *downward*. (Thus, specifying an oversized roof in an attempt to account for the shading effects of overhangs will *not* work). Interior surfaces do not cast shadows of any kind. Thus, partitions, ceilings, and floors that divide conditioned spaces cannot cast shadows.

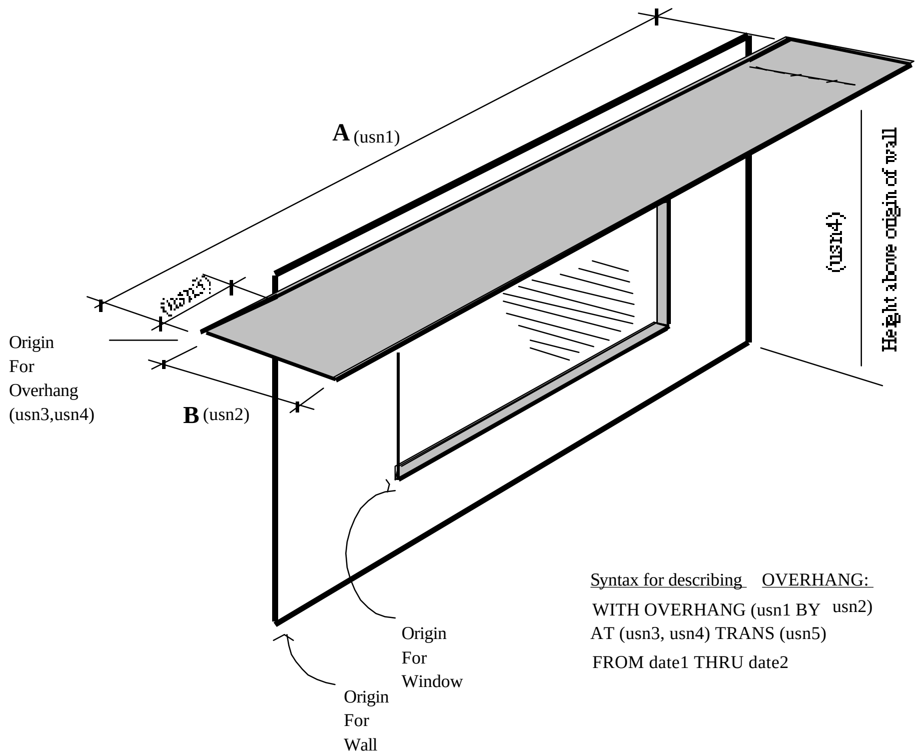
A wing can only shade in one direction. Therefore, when a wing is somewhere between the two ends of a surface, BLAST will create a second wing surface so that shading can take place both to the left and right of the wing. BLAST creates the second surface automatically, and this is why there are two shading surfaces indicated in some of the output reports.

When a wing is specified, it will *only* cast shadows on its base surface and other subsurfaces of that base surface. So, if a wing will in fact cast a shadow on more than one surface, a wing must be specified for each surface that will receive the shading, or the wing should be described as DETACHED SHADING.



<u>Syntax for describing OVERHANG:</u>
WITH OVERHANG (usn1 BY usn2)
AT (usn3, usn4) TRANS (usn5)
FROM date1 THRU date2

Note: TRANS (usn5) defines the transmittanceof the OVERHANG. The default is zero, which is opaque. Total transparency is 1. The dates allow seasonal scheduling of these shading features



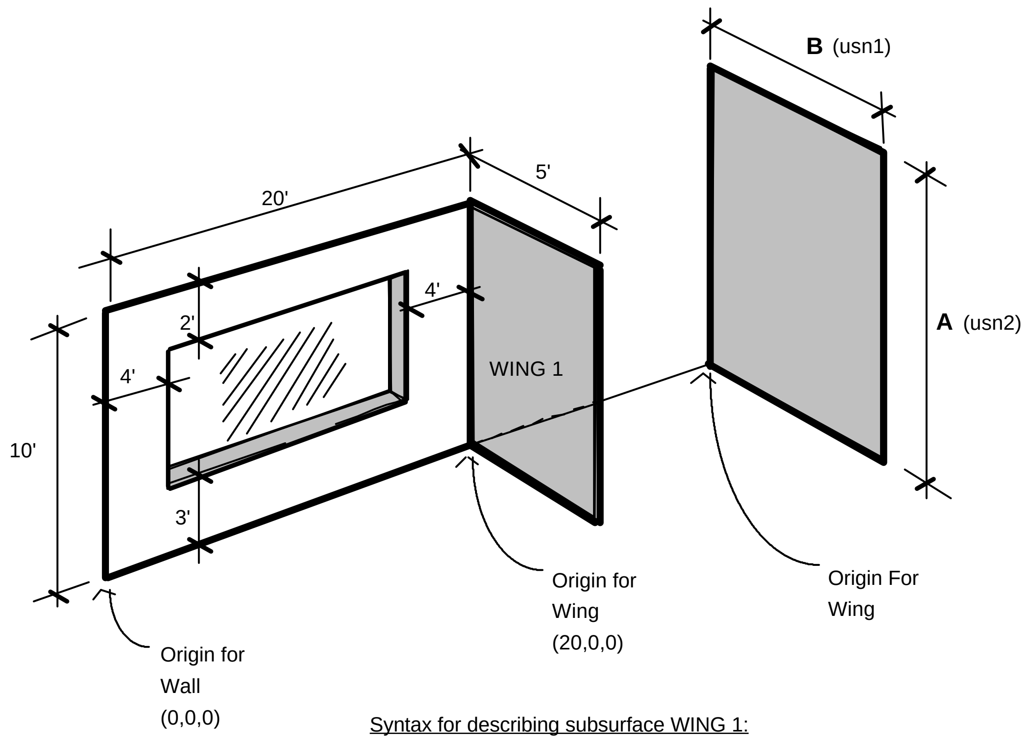
Note: TRANS (usn5) defines the transmittance of the OVERHANG. The default is zero, which is opaque. Total transparency is 1. The dates allow seasonal scheduling of these shading features.

Program execution will be faster if the seasonal scheduling (start and stop) dates are chosen from the following list:

START Dates	STOP Dates
1 Jan	31 Jan
1 Feb	20 Feb
21 Feb	12 Mar
13 Mar	31 Mar
1 Apr	20 Apr
21 Apr	15 May
16 May	31 Jul
1 Aug	24 Aug
25 Aug	12 Sep
13 Sep	30 Sep
1 Oct	20 Oct
21 Oct	15 Nov
16 Nov	15 Dec
16 Dec	31 Dec

Shadow patterns are normally computed for the 14 time periods above. These groups were selected to give the smallest maximum error in solar position for any given day. Shading features that do not use these dates will increase the number of time periods required for computations. A shading feature may be scheduled over several time periods, e.g. FROM 16 MAY THRU 30 SEP.

With solar distribution set to -1 BLAST gives a warning when wings or overhangs are specified. Warning is a reminder that surfaces with wings or overhangs are not allowed to have overlapping subsurfaces.



Syntax for describing subsurface WING 1:
STARTING AT (0,0,0) FACING (180)
WALL NAME (20,10)
WITH WINDOWS OF TYPE
WINDOW NAME (12,5) AT (4,3)
WITH WING (usn1, usn2)
AT (20,0) TRANS (usn3)
FROM date1 THRU date2;

Note: TRANS (usn3) defines the transmittance of the WING. The default is zero, which is opaque. Total transparency is 1. The dates allow seasonal scheduling of these shading features.

Specifying Wings and Overhangs in HBLC

As stated in the previous paragraph, wings and overhangs are considered subsurfaces in BLAST and must be associated with a surface. Thus, in order to define a wing or overhang in HBLC, the surface to which it is attached must already exist. For more information on surfaces and their definition, see *Surface Types* in the *BLAST Quick Reference*.

To add subsurfaces in HBLC, select the desired surface and do any of: double click, press ‘w’, or go to “Wall Subsurfaces” under the “Geometry” tab of the menu bar. An overhang can be added by clicking on “Overhang” at the top of the form. HBLC does not currently support wings. The user is advised to write it manually following the syntax in the above figures.

Zone Data Block

As a minimum, this block must indicate the supply air volume to each zone on the fan system being simulated. For example:

```
FOR ZONE 1:
    SUPPLY AIR VOLUME=500;
END ZONE;
```

The following example shows format and defaults for a zone data block. Up to 20 distinct zones may be specified for each system (one zone data block per zone).

```
FOR ZONE usn1:
    SUPPLY AIR VOLUME=usn2;
    MINIMUM AIR FRACTION=0.1;
    EXHAUST AIR VOLUME=0.0;
    REHEAT CAPACITY=0.0;
    REHEAT ENERGY SUPPLY=HOT WATER;
    BASEBOARD HEAT CAPACITY=0.0;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
    RECOOL CAPACITY=0.0;
    INDUCED AIR FRACTION=2.0;
    ZONE MULTIPLIER=1;
END ZONE;
```

SUPPLY AIR VOLUME- Used to specify the supply air flow rate to the zone under peak conditions. Units: ft^3/min or m^3/s

EXHAUST AIR VOLUME- Used to specify the amount of air which will be removed from the zone any time the fan system is in operation and which will be exhausted directly without heat recovery.   If the exhaust air volume is specified greater than the supply air volume, BLAST will adjust the supply air volume to equal the exhaust air volume. Units: ft^3/min or m^3/s

MINIMUM AIR FRACTION- Used to specify is the minimum fraction of the zone's design supply air volume which will be delivered to the space any time a VAV fan system is running.

REHEAT CAPACITY- Used to specify the capacity of the reheat coils. Units: kBtu/hr or kW

REHEAT ENERGY SUPPLY- Used to specify the reheat coil energy type. The options are hot water, gas, steam and electric. Hot water is the default.

BASEBOARD HEAT CAPACITY- Used to specify a thermostatically controlled baseboard heat. It differs from reheat in that it does not require air flow through the fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY *and* REHEAT CAPACITY cannot be specified for the same zone. Units: kBtu/hr or kW

BASEBOARD HEAT ENERGY SUPPLY- Used to specify the baseboard energy type. The options are hot water, gas, steam and electric. Hot water is the default.

RECOOL CAPACITY- Used to specify the capacity of the recool coils. Currently, recool coils are allowed only for induction systems and are assumed to be chilled water coils that accomplish sensible cooling only.

INDUCED AIR FRACTION- Used to specify the ratio of induced room air flow to supply air flow. This applies only to induction systems.

ZONE MULTIPLIER- Used to simulate identical or nearly identical spaces. The zone multiplier avoids the need for redundant load calculations by accounting for the zone's impact on electric power demand, coil energy demands, and fan energy demand N times, where N is the zone multiplier..

Examples

Introduction

This section of the manual set contains examples of BLAST input and output files. Copies of the input files may be found in the C:\blastsys\examples (default) or in the “examples” directory under the root BLASTSYS directory.

All examples found in this section are referenced from the *Getting Started* section of the manual.

Ft. Monmouth One Zone Model

```
####                 ####                                          ####
####                 ####                                          ####
####                 ####                                          ####
####   <#####>       ####       <#####>   ####      <#######>      ####
#### <#########>     ####     <#########> ####    <###     ###>  ########
####<# ! ! ! ! #>    ####    <# ! ! ! ! #>####   <###      ####  ########
#####! ! ! ! ! ##>   ####   <## ! ! ! ! !#####   ####              ####
#### ! ! ! ! ! ###>  ####  <### ! ! ! ! ! ####   <###>             ####
####----------------------------------------####   <#########>     ####
####          #<! ! ! ! ! ! ! !>#         ####     <#########>     ####
####          ##< ! ! ! ! ! ! >##         ####            >###>    ####
#####         ##><! ! ! ! ! !><##        #####             ####    ####
####<#        #>   <!_!_!_!>   <#        #>####   ####      ###>    ####
#### <#########>     ####     <#########> ####   <###     ###>     <#####
####   <#####>       ####       <#####>   ####     <#######>        <####
                                                                          TRADEMARK
                                                                            APPLIED FOR
```

```
****************************************************
*                                                  *
*   A U.S. ARMY CORPS OF ENGINEERS PROGRAM         *
*                                                  *
*                      BY                          *
*                                                  *
*   CONSTRUCTION ENGINEERING RESEARCH LABORATORY   *
*        P.O. BOX 4005                             *
*        CHAMPAIGN, ILLINOIS  61824-4005           *
*                                                  *
****************************************************
```

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```
****************************************************************************************************
**                                                                                                **
**                              INPUT ECHO AND USER SPECIFIED REPORTS                             **
**                                                                                                **
****************************************************************************************************
BEGIN INPUT;
  RUN CONTROL:
    NEW ZONES,
    NEW AIR SYSTEMS,
    PLANT,
    REPORTS(ZONE LOADS,ZONE SUMMARY,HOURLY PROFILES,ZONE GROUP,96),
    UNITS(IN = ENGLISH, OUT = ENGLISH);
    TEMPORARY WALLS:
```

```
    CONST1
      = (A2 - 4 IN DENSE FACE BRICK               ,
         C8 - 8 IN HW CONCRETE BLOCK              ,
         INS - MINERAL FIBER FIBROUS 6 IN         ,
         PLASTER - GYPSUM LWA 5 / 8 IN           );
    CONST2
      = (PLASTER - GYPSUM LWA 5 / 8 IN            ,
         A2 - 4 IN DENSE FACE BRICK               ,
         C8 - 8 IN HW CONCRETE BLOCK              ,
         PLASTER - GYPSUM LWA 5 / 8 IN           );
    CONST3
      = (PLASTER - GYPSUM LWA 5 / 8 IN            ,
         B1 - AIRSPACE RESISTANCE                 ,
         PLASTER - GYPSUM LWA 5 / 8 IN           );
  END;
  TEMPORARY ROOFS:
    CONST5
      = (ROOFING - BUILT UP ROOFING - 3 / 8 IN   ,
         INS - EXPANDED EXT POLYSTYRENE R12 2 IN ,
         E4 - CEILING AIRSPACE                    ,
         BLBD - ACOUSTIC TILE 3 / 4 IN           );
  END;
  TEMPORARY FLOORS:
    CONST6
      = (DIRT 12 IN                               ,
         CONCRETE - DRIED SAND AND GRAVEL 4 IN   ,
         FINISH FLOORING - TILE 1 / 16 IN        );
  END;
  PROJECT="


                                (HBLC) 2000 2000 ";
  LOCATION=NYC                                     ;
  DESIGN DAYS=NYC SUMMER                              ,
              NYC WINTER                              ;
  GROUND TEMPERATURES=(55.00,55.00,55.00,56.00,61.00,66.00,70.00,
      68.00,66.00,64.00,61.00,58.00);
BEGIN BUILDING DESCRIPTION;
  BUILDING="FT. MONMONTH EDUCATION CENTER           ";
    NORTH AXIS=195.00;
    SOLAR DISTRIBUTION=-1;
    ZONE 1 "ZONE 1                                 ":
      ORIGIN:(17.00,63.09,0.00);
      NORTH AXIS =0.00;
      EXTERIOR WALLS:
        STARTING AT(0.00,0.00,0.00)
        FACING(180.00)
        TILTED(90.00)
        CONST1(50.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DOUBLE PANE WINDOW(8.90 BY 6.80)
            REVEAL(0.00)
            AT (5.60,2.20),
        STARTING AT(50.00,0.00,0.00)
        FACING(90.00)
        TILTED(90.00)
        CONST1(16.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DOUBLE PANE WINDOW(5.80 BY 7.20)
            REVEAL(0.00)
            AT (0.60,2.50),
        STARTING AT(50.00,16.00,0.00)
        FACING(180.00)
```

```
TILTED(90.00)
CONST1(113.00 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(37.00 BY 9.80)
    REVEAL(0.00)
    AT (0.60,0.10),
STARTING AT(163.00,16.00,0.00)
FACING(90.00)
TILTED(90.00)
CONST1(43.30 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(10.70 BY 9.50)
    REVEAL(0.00)
    AT (0.60,0.40),
STARTING AT(163.00,59.30,0.00)
FACING(0.00)
TILTED(90.00)
CONST1(34.00 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(8.50 BY 9.60)
    REVEAL(0.00)
    AT (0.60,0.30),
STARTING AT(129.00,59.30,0.00)
FACING(90.00)
TILTED(90.00)
CONST1(65.00 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(13.80 BY 8.20)
    REVEAL(0.00)
    AT (0.60,1.70),
STARTING AT(129.00,124.30,0.00)
FACING(0.00)
TILTED(90.00)
CONST1(39.00 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(7.90 BY 7.80)
    REVEAL(0.00)
    AT (0.60,2.10),
STARTING AT(90.00,124.30,0.00)
FACING(270.00)
TILTED(90.00)
CONST1(65.00 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(19.40 BY 9.80)
    REVEAL(0.00)
    AT (0.60,0.10),
STARTING AT(90.00,59.30,0.00)
FACING(0.00)
TILTED(90.00)
CONST1(20.00 BY 10.00)
  WITH WINDOWS OF TYPE
  DOUBLE PANE WINDOW(6.40 BY 7.90)
    REVEAL(0.00)
    AT (0.60,1.80),
STARTING AT(70.00,59.30,0.00)
FACING(270.00)
TILTED(90.00)
CONST1(10.00 BY 10.00),
STARTING AT(70.00,49.30,0.00)
FACING(0.00)
TILTED(90.00)
CONST1(20.00 BY 10.00)
  WITH WINDOWS OF TYPE
```

```
            DOUBLE PANE WINDOW(5.70 BY 7.00)
              REVEAL(0.00)
              AT (0.60,2.70),
          STARTING AT(50.00,49.30,0.00)
          FACING(90.00)
          TILTED(90.00)
          CONST1(75.30 BY 10.00)
            WITH WINDOWS OF TYPE
            DOUBLE PANE WINDOW(21.30 BY 9.80)
              REVEAL(0.00)
              AT (0.60,0.10),
          STARTING AT(50.00,124.60,0.00)
          FACING(0.00)
          TILTED(90.00)
          CONST1(50.00 BY 10.00)
            WITH WINDOWS OF TYPE
            DOUBLE PANE WINDOW(10.50 BY 8.00)
              REVEAL(0.00)
              AT (0.60,1.90),
          STARTING AT(0.00,124.60,0.00)
          FACING(270.00)
          TILTED(90.00)
          CONST1(124.60 BY 10.00)
            WITH WINDOWS OF TYPE
            DOUBLE PANE WINDOW(34.10 BY 9.80)
              REVEAL(0.00)
              AT (0.60,0.10);
        SLAB ON GRADE FLOORS:
          STARTING AT(0.00,0.00,0.00)
          FACING(90.00)
          TILTED(180.00)
          CONST6(116.00 BY 116.00);
        ROOFS:
          STARTING AT(0.00,0.00,10.00)
          FACING(180.00)
          TILTED(0.00)
          CONST5(116.00 BY 116.00);
        INTERNAL MASS: CONST2
          (5.00 BY 2060.00);
        INTERNAL MASS: CONST3
          (3784.00 BY 5.00);
        PEOPLE=205,OFFICE OCCUPANCY,
          AT ACTIVITY LEVEL 0.45,70.00 PERCENT RADIANT,
          FROM 01JAN THRU 31DEC;
        LIGHTS=90.00,OFFICE LIGHTING,
          0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
          20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
          FROM 01JAN THRU 31DEC;
        INFILTRATION=1570.000000,CONSTANT,
          WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
          FROM 01JAN THRU 31DEC;
        CONTROLS=SETBACK WITH DUAL THROTTLING RANGES,
          3412000.0 HEATING, 3412000.0 COOLING,
          0.00 PERCENT MRT,
          FROM 01JAN THRU 31DEC;
      END ZONE;
  END BUILDING DESCRIPTION;
END INPUT;
```

```
End Input Parsing, Begin Simulations
```

```
  REPORTING WILL BE DONE IN ENGLISH UNITS

  SIMULATIONS WILL BE ALLOWED FOR TYPES: ZONES      SYSTEMS    PLANTS

         1 BUILDING SIMULATIONS WILL BE ATTEMPTED

       SIMULATIONS WILL BE ATTEMPTED FOR   1 ZONES

       SIMULATIONS WILL BE ATTEMPTED FOR   0 SYSTEMS

       SIMULATIONS WILL BE ATTEMPTED FOR   0 PLANTS

NEW BLDFL AND AHLDFL FILES WILL BE CREATED
     FROM USER INPUT, AS NECESSARY

 * * * * *
 BLDFL FOR



                         (HBLC) 2000 2000
 LOCATION NEW YORK CITY NEW YORK                   LAT=    40.770 LONG=    73.900 TIME ZONE= 5.0
 DATE OF FILE CREATE/UPDATE 24 JUL 98 NUMBER OF ENVIRONMENTS  2
 NUMBER OF ZONES  1 WITH ZONE NUMBERS
  1
   ENVIRONMENT NUMBER  1 FOR BLDFL  TITLE IS NEW YORK CITY NEW YORK WINTER
    DESIGN DAY 21 JAN WITH GROUND TEMPERATURE  55.000  MAKE UP WATER TEMPERATURE  55.004
   ENVIRONMENT NUMBER  2 FOR BLDFL  TITLE IS NEW YORK CITY NEW YORK SUMMER
    DESIGN DAY 21 JUL WITH GROUND TEMPERATURE  70.000  MAKE UP WATER TEMPERATURE  55.004

    TEMPERATURE CONTROL PROFILES --

  1 --                40        50        60        70        80        90       100
                      +         +         +         +         +         +         +

( 67.00/ 1.00)   +1.0  XXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +1.0
( 69.00/ 0.00)         XXXXXXXXXXXXXXXXXXXXXXXXXXX
( 77.00/ 0.00)   +0.8  XXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +0.8
( 79.00/-1.00)         XXXXXXXXXXXXXXXXXXXXXXXXXXX
                 +0.6  XXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +0.6
                 HEAT  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  HEAT
                 +0.4  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +0.4
                       XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                 +0.2  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +0.2
                       XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                  0.0  ------------------------------------------------------------   0.0
                                                            XXXXXXXXXXXXXXXXXXXXXXX
                 -0.2                                       XXXXXXXXXXXXXXXXXXXXXXX  -0.2
                                                            XXXXXXXXXXXXXXXXXXXXXXX
                 -0.4                                       XXXXXXXXXXXXXXXXXXXXXXX  -0.4
                 COOL                                       XXXXXXXXXXXXXXXXXXXXXXX  COOL
                 -0.6                                        XXXXXXXXXXXXXXXXXXXXXX  -0.6
                                                             XXXXXXXXXXXXXXXXXXXXXX
                 -0.8                                        XXXXXXXXXXXXXXXXXXXXXX  -0.8
                                                             XXXXXXXXXXXXXXXXXXXXXX
                 -1.0                                        XXXXXXXXXXXXXXXXXXXXXX  -1.0
                      +         +         +         +         +         +         +


  2 --                40        50        60        70        80        90       100
                      +         +         +         +         +         +         +

( 60.00/ 1.00)   +1.0  XXXXXXXXXXXXXXXXXXXX                                          +1.0
```

```
( 62.00/ 0.00)         XXXXXXXXXXXXXXXXXXXX
                 +0.8  XXXXXXXXXXXXXXXXXXXX                                          +0.8
                       XXXXXXXXXXXXXXXXXXXX
                 +0.6  XXXXXXXXXXXXXXXXXXXX                                          +0.6
                 HEAT  XXXXXXXXXXXXXXXXXXXXX                                         HEAT
                 +0.4  XXXXXXXXXXXXXXXXXXXXX                                         +0.4
                       XXXXXXXXXXXXXXXXXXXXX
                 +0.2  XXXXXXXXXXXXXXXXXXXXX                                         +0.2
                       XXXXXXXXXXXXXXXXXXXXX
                  0.0  ------------------------------------------------------------   0.0

                 -0.2                                                                -0.2

                 -0.4                                                                -0.4
                 COOL                                                                COOL
                 -0.6                                                                -0.6

                 -0.8                                                                -0.8

                 -1.0                                                                -1.0
                      +         +         +         +         +         +         +

    GENERAL SCHEDULE PROFILES --

  1 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

  100 +                                 XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 + 100
      +                                 XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +
   80 +                                 XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +  80
      +                                 XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +
   60 +                                 XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +  60
      +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
   40 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  40
      +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
   20 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  20
      +                         XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
    0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

          0   0   0   0   0   0  10  50 100 100 100 100  50 100 100 100  50  10   0   0   0   0   0   0

  3 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

  100 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             + 100
      +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
   80 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  80
      +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
   60 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  60
      +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
   40 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +  40
      +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
   20 +                         XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +  20
      +                         XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
    0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

          5   5   5   5   5   5  20 100 100 100 100 100 100 100 100 100 100  50   5   5   5   5   5   5

  4 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

  100 +                                                                                                  + 100
      +                                                                                                  +
```

```
  80 +                                                                                                  +  80
     +                                                                                                  +
  60 +                                                                                                  +  60
     +                                                                                                  +
  40 +                                                                                                  +  40
     +                                                                                                  +
  20 +                                                                                                  +  20
     +                                                                                                  +
   0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

         5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5


 5 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

 100 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX + 100
     + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  80 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  80
     + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  60 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  60
     + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  40 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  40
     + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  20 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  20
     + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
   0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

      100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100
```

DESCRIPTION OF ZONE 1: ZONE 1 FT. MONMONTH EDUCATION CENTER

SURF NUMBER	HTS NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
1	1	EXTERIOR WALL	439.5	0.046	15.0	90.0	CONST1
2	2	WINDOW	60.5	0.553			DOUBLE PANE WINDOW
3	3	EXTERIOR WALL	118.2	0.046	285.0	90.0	CONST1
4	4	WINDOW	41.8	0.553			DOUBLE PANE WINDOW
5	5	EXTERIOR WALL	767.4	0.046	15.0	90.0	CONST1
6	6	WINDOW	362.6	0.553			DOUBLE PANE WINDOW
7	7	EXTERIOR WALL	331.4	0.046	285.0	90.0	CONST1
8	8	WINDOW	101.6	0.553			DOUBLE PANE WINDOW
9	9	EXTERIOR WALL	258.4	0.046	195.0	90.0	CONST1
10	10	WINDOW	81.6	0.553			DOUBLE PANE WINDOW
11	11	EXTERIOR WALL	536.8	0.046	285.0	90.0	CONST1
12	12	WINDOW	113.2	0.553			DOUBLE PANE WINDOW
13	13	EXTERIOR WALL	328.4	0.046	195.0	90.0	CONST1
14	14	WINDOW	61.6	0.553			DOUBLE PANE WINDOW
15	15	EXTERIOR WALL	459.9	0.046	105.0	90.0	CONST1
16	16	WINDOW	190.1	0.553			DOUBLE PANE WINDOW
17	17	EXTERIOR WALL	149.4	0.046	195.0	90.0	CONST1
18	18	WINDOW	50.6	0.553			DOUBLE PANE WINDOW
19	19	EXTERIOR WALL	100.0	0.046	105.0	90.0	CONST1
20	20	EXTERIOR WALL	160.1	0.046	195.0	90.0	CONST1
21	21	WINDOW	39.9	0.553			DOUBLE PANE WINDOW
22	22	EXTERIOR WALL	544.3	0.046	285.0	90.0	CONST1
23	23	WINDOW	208.7	0.553			DOUBLE PANE WINDOW
24	24	EXTERIOR WALL	416.0	0.046	195.0	90.0	CONST1
25	25	WINDOW	84.0	0.553			DOUBLE PANE WINDOW
26	26	EXTERIOR WALL	911.8	0.046	105.0	90.0	CONST1
27	27	WINDOW	334.2	0.553			DOUBLE PANE WINDOW
28	28	SLAB ON GRADE FLOOR	13456.0	0.089	285.0	180.0	CONST6

29	29	ROOF	13456.0	0.069	15.0	0.0	CONST5
30	30	INTERNAL MASS	10300.0				CONST2
31	31	INTERNAL MASS	18920.0				CONST3

EXTERIOR SURFACE AREA = 20708.00 AVERAGE U-VALUE = 0.103

ZONE FLOOR AREA= 13456.00 FT**2

APPROXIMATE ZONE VOLUME = 134553. FT**3 AIR HEAT CAPACITY = 20368.950 BTU/DEG F

GENERAL SCHEDULES DATA:			SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE:	2.050E+02	FROM 1JAN THRU 31DEC	2	1	1	1	1	1	2	2	2	2	2	2
4.500E+02 BTUH ACTIVITY LEVEL, 70.0% RADIANT														
LIGHTS:	9.000E+04 BTUH	FROM 1JAN THRU 31DEC	4	3	3	3	3	3	4	4	4	4	4	4
0.0% RETURN AIR, 20.0% RADIANT, 20.0% VISIBLE, 0.0% REPLACEABLE														
INFILTRATION:	1.570E+03 CFM	FROM 1JAN THRU 31DEC	5	5	5	5	5	5	5	5	5	5	5	5
MODIFIER = 0.60600 + 0.02020*DT + 0.00060*V + 0.00000*V**2														

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.412E+09 BTUH COOLING CAPACITY = 3.412E+09 BTUH 0.0% MRT, 0.0% RADIANT HEAT,
0.000E+00 1/FT**2 RADIANT FLUX FACTOR, 0.0% LOST, 0.0% LATENT,
FROM 1JAN THRU 31DEC

BECAUSE THIS IS NOT A RADIANT HEATER, RADIANT FLUX FACTOR, % LOST AND % LATENT
HAVE NO MEANING. THESE VARIABLES ALSO HAVE NO MEANING WHEN COOLING.

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
MON	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
TUE	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
WED	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
THU	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
FRI	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
SAT	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
HOL	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SP1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SP2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SP3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SP4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

ZONE GROUP LOADS FOR NEW YORK CITY NEW YORK WINTER

DATE 21 JAN (MONDAY)

NUMBER		NAME	MULTIPLIER
1	1	ZONE 1	1

ZONE	TOTAL CONVECTIVE HEATER LOAD	TOTAL RADIANT HEATER LOAD	TOTAL SENSIBLE COOLING LOAD	PEAK CONVECTIVE HEATER LOAD	PEAK RADIANT HEATER LOAD	PEAK SENSIBLE COOLING LOAD	MAX TEMP	MIN TEMP
	1000BTU	1000BTU	1000BTU	1000BTU/HR	1000BTU/HR	1000BTU/HR	DEG. F	DEG. F
1	6.447E+03	0.000E+00	0.000E+00	3.633E+02	0.000E+00	0.000E+00	69.00	62.00

GROUP:	6.447E+03	0.000E+00	0.000E+00	3.633E+02	0.000E+00	0.000E+00	69.00	62.00
PEAK DATES (MO/DY/HR):				1/21/ 8	1/21/ 1	1/21/ 1	1/21/16	1/21/ 6

TOTAL ITERATIONS = 207
DID NOT CONVERGE = 0
ZONE GROUP LOADS FOR NEW YORK CITY NEW YORK SUMMER

DATE 21 JUL (MONDAY)

NUMBER		NAME	MULTIPLIER
1	1	ZONE 1	1

ZONE	TOTAL CONVECTIVE HEATER LOAD	TOTAL RADIANT HEATER LOAD	TOTAL SENSIBLE COOLING LOAD	PEAK CONVECTIVE HEATER LOAD	PEAK RADIANT HEATER LOAD	PEAK SENSIBLE COOLING LOAD	MAX TEMP	MIN TEMP
	1000BTU	1000BTU	1000BTU	1000BTU/HR	1000BTU/HR	1000BTU/HR	DEG. F	DEG. F
1	0.000E+00	0.000E+00	2.460E+03	0.000E+00	0.000E+00	2.738E+02	85.95	77.00
GROUP:	0.000E+00	0.000E+00	2.460E+03	0.000E+00	0.000E+00	2.738E+02	85.95	77.00
PEAK DATES (MO/DY/HR):				7/21/ 1	7/21/ 1	7/21/16	7/21/18	7/21/ 8

TOTAL ITERATIONS = 190
DID NOT CONVERGE = 0

ZONE LOADS REPORT

(HBLC) 2000 2000

LOCATION: NEW YORK CITY NEW YORK

ZONE: 1 ZONE 1 FT. MONMONTH EDUCATION CENTER

ENVIRONMENT NEW YORK CITY NEW YORK WINTER 1 DAYS

DATE 21 JAN (MONDAY)

HR	HEATING LOAD 1000BTU	COOLING LOAD 1000BTU	LATENT LOAD 1000BTU	RETURN AIR HEAT GAIN 1000BTU	BASEBOARD LOAD 1000BTU	ELECTRIC LOAD 1000BTU	GAS LOAD 1000BTU	INFILT HEAT LOSS 1000BTU	INFILT HEAT GAIN 1000BTU	TEMPERATURES MAT DEG. F	ODB DEG. F	OWB DEG. F
1	2.607E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
2	2.622E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
3	2.644E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
4	2.664E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
5	2.683E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
6	2.701E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
7	2.575E+02	0.000E+00	2.095E+00	0.000E+00	0.000E+00	1.800E+01	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
8	3.633E+02	0.000E+00	1.047E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
9	3.137E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
10	3.021E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
11	2.931E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
12	2.879E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00

13	3.011E+02	0.000E+00	1.572E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
14	2.825E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
15	2.787E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
16	2.749E+02	0.000E+00	3.145E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
17	2.891E+02	0.000E+00	1.572E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	2.464E+02	0.000E+00	69.00	15.00	15.00
18	1.443E+02	0.000E+00	2.095E+00	0.000E+00	0.000E+00	4.500E+01	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
19	2.213E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
20	2.373E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
21	2.441E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
22	2.504E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
23	2.550E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
24	2.588E+02	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	2.028E+02	0.000E+00	62.00	15.00	15.00
TOT	6.447E+03	0.000E+00	2.662E+02	0.000E+00	0.000E+00	1.017E+03	0.000E+00	5.303E+03	0.000E+00			

HEATING LOAD = 4.791E-01 1000BTU /FT**2 COOLING LOAD = 0.000E+00 1000BTU /FT**2 ZONE FLOOR AREA = 1.346E+04 FT**2

PEAK LOADS AND TEMPERATURES:
    MAX HEATING LOAD = 3.633E+02 1000BTU/HR AT HOUR 8 WITH ZONE AIR TEMP OF 69.00 DEG. F
    MAX COOLING LOAD = 0.000E+00 1000BTU/HR AT HOUR 0 WITH ZONE AIR TEMP OF 0.00 DEG. F
    MAX ZONE AIR TEMP = 69.00 DEG. F AT HOUR 16
    MIN ZONE AIR TEMP = 62.00 DEG. F AT HOUR 6

ZONE LOADS REPORT

(HBLC) 2000 2000

LOCATION: NEW YORK CITY NEW YORK

ZONE: 1 ZONE 1 FT. MONMONTH EDUCATION CENTER

ENVIRONMENT NEW YORK CITY NEW YORK SUMMER 1 DAYS

DATE 21 JUL (MONDAY)

HR	HEATING LOAD 1000BTU	COOLING LOAD 1000BTU	LATENT LOAD 1000BTU	RETURN AIR HEAT GAIN 1000BTU	BASEBOARD LOAD 1000BTU	ELECTRIC LOAD 1000BTU	GAS LOAD 1000BTU	INFILT HEAT LOSS 1000BTU	INFILT HEAT GAIN 1000BTU	TEMPERATURES MAT DEG. F	ODB DEG. F	OWB DEG. F
1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	81.23	73.34	68.40
2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	80.94	72.44	68.13
3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	80.67	71.72	67.90
4	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	80.42	71.18	67.73
5	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	80.21	71.00	67.68
6	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	80.41	71.36	67.79
7	0.000E+00	0.000E+00	5.314E+00	0.000E+00	0.000E+00	1.800E+01	0.000E+00	0.000E+00	0.000E+00	81.86	72.26	68.07
8	0.000E+00	2.013E+02	2.814E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	0.000E+00	77.00	73.88	68.57
9	0.000E+00	2.243E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	0.000E+00	77.00	76.22	69.28
10	0.000E+00	2.352E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	3.543E+00	77.00	78.92	70.09
11	0.000E+00	2.436E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	9.613E+00	77.00	81.98	71.00
12	0.000E+00	2.499E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	1.579E+01	77.00	84.86	71.83
13	0.000E+00	2.436E+02	2.303E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	2.072E+01	77.00	87.02	72.44
14	0.000E+00	2.625E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	2.414E+01	77.00	88.46	72.85
15	0.000E+00	2.708E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	2.545E+01	77.00	89.00	73.00
16	0.000E+00	2.738E+02	4.606E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	2.414E+01	77.00	88.46	72.85
17	0.000E+00	2.551E+02	2.303E+01	0.000E+00	0.000E+00	9.000E+01	0.000E+00	0.000E+00	2.114E+01	77.00	87.20	72.49
18	0.000E+00	0.000E+00	5.863E+00	0.000E+00	0.000E+00	4.500E+01	0.000E+00	0.000E+00	0.000E+00	85.95	85.22	71.93
19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	84.48	82.88	71.26
20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	83.44	80.54	70.57
21	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.500E+00	0.000E+00	0.000E+00	0.000E+00	82.89	78.56	69.99

```
 22    0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  4.500E+00  0.000E+00  0.000E+00  0.000E+00   82.36   76.76   69.45
 23    0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  4.500E+00  0.000E+00  0.000E+00  0.000E+00   81.97   75.32   69.01
 24    0.000E+00  0.000E+00  0.000E+00  0.000E+00  0.000E+00  4.500E+00  0.000E+00  0.000E+00  0.000E+00   81.63   74.24   68.68

TOT    0.000E+00  2.460E+03  4.078E+02  0.000E+00  0.000E+00  1.017E+03  0.000E+00  0.000E+00  1.445E+02

HEATING LOAD = 0.000E+00 1000BTU   /FT**2    COOLING LOAD = 1.828E-01 1000BTU   /FT**2    ZONE FLOOR AREA = 1.346E+04 FT**2

PEAK LOADS AND TEMPERATURES:
    MAX HEATING LOAD =  0.000E+00 1000BTU/HR AT HOUR 24 WITH ZONE AIR TEMP OF  81.63 DEG. F
    MAX COOLING LOAD =  2.738E+02 1000BTU/HR AT HOUR 16 WITH ZONE AIR TEMP OF  77.00 DEG. F
    MAX ZONE AIR TEMP =   85.95 DEG. F     AT HOUR 18
    MIN ZONE AIR TEMP =   77.00 DEG. F     AT HOUR  8
```

Ft. Monmouth Seven Zone Model: Workshop 2

```
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                                                                        APPLIED FOR
             ****************************************************
             *                                                  *
             *   A U.S. ARMY CORPS OF ENGINEERS PROGRAM         *
             *                                                  *
             *                    BY                            *
             *                                                  *
             *   CONSTRUCTION ENGINEERING RESEARCH LABORATORY   *
             *        P.O. BOX 4005                             *
             *        CHAMPAIGN, ILLINOIS  61824-4005           *
             *                                                  *
             ****************************************************
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```
****************************************************************************************************
**                                                                                                **
**                               INPUT ECHO AND USER SPECIFIED REPORTS                            **
**                                                                                                **
****************************************************************************************************
BEGIN INPUT;
  RUN CONTROL:
    NEW ZONES,
    NEW AIR SYSTEMS,
    PLANT,
```

```
  REPORTS(SYSTEM LOADS,PLANT LOADS,SYSTEM,96),
  UNITS(IN = ENGLISH, OUT = ENGLISH);
  TEMPORARY WALLS:
    CON1
      = (A2 - 4 IN DENSE FACE BRICK              ,
         C8 - 8 IN HW CONCRETE BLOCK             ,
         INS - MINERAL FIBER FIBROUS 6 IN        ,
         PLASTER - GYPSUM LWA 5 / 8 IN           );
    CON3
      = (PLASTER - GYPSUM LWA 5 / 8 IN           ,
         B1 - AIRSPACE RESISTANCE                ,
         PLASTER - GYPSUM LWA 5 / 8 IN           );
    CON2
      = (PLASTER - GYPSUM LWA 5 / 8 IN           ,
         A2 - 4 IN DENSE FACE BRICK              ,
         C8 - 8 IN HW CONCRETE BLOCK             ,
         PLASTER - GYPSUM LWA 5 / 8 IN           );
  END;
  TEMPORARY ROOFS:
    CON5
      = (ROOFING - BUILT UP ROOFING - 3 / 8 IN   ,
         INS - PREFORMED ROOF INSULATION 1.5 IN  ,
         E4 - CEILING AIRSPACE                   ,
         BLBD - ACOUSTIC TILE 3 / 4 IN           );
  END;
  TEMPORARY FLOORS:
    CON6
      = (DIRT 12 IN                              ,
         CONCRETE - DRIED SAND AND GRAVEL 4 IN   ,
         FINISH FLOORING - TILE 1 / 16 IN        );
  END;
  PROJECT="FORT MONMOUTH, NJ
           EDUCATION CENTER
           SEVEN ZONE HBLC WORKSHOP
                                  (HBLC) 2500 1600 ";
  LOCATION=NYC                                     ;
  DESIGN DAYS=NYC SUMMER                              ,
              NYC WINTER                              ;
  GROUND TEMPERATURES=(55.00,55.00,55.00,56.00,61.00,66.00,70.00,
      68.00,66.00,64.00,61.00,58.00);
BEGIN BUILDING DESCRIPTION;
  BUILDING="FORT MONMOUTH EDUCATION CENTER          ";
    NORTH AXIS=165.00;
    SOLAR DISTRIBUTION=-1;
    ZONE 1 "ZONE 1                                  ":
      ORIGIN:(42.71,4.60,0.00);
      NORTH AXIS =0.00;
      EXTERIOR WALLS:
        STARTING AT(0.00,0.00,0.00)
        FACING(180.00)
        TILTED(90.00)
        CON1(50.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DOUBLE PANE TINTED WINDOW(8.70 BY 7.00)
            REVEAL(0.00)
            AT (1.10,1.30),
        STARTING AT(50.00,0.00,0.00)
        FACING(90.00)
        TILTED(90.00)
        CON1(16.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DOUBLE PANE TINTED WINDOW(7.00 BY 7.00)
            REVEAL(0.00)
```

```
        AT (0.60,2.70),
    STARTING AT(24.60,125.00,0.00)
    FACING(0.00)
    TILTED(0.00)
    CON1(24.60 BY 10.00)
      WITH WINDOWS OF TYPE
      DOUBLE PANE TINTED WINDOW(6.80 BY 6.00)
        REVEAL(0.00)
        AT (0.60,0.90)
      WITH DOORS OF TYPE
      ALUMINUM DOOR(3.50 BY 3.00)
        REVEAL(0.00)
        AT (9.70,1.10),
    STARTING AT(0.00,125.00,0.00)
    FACING(270.00)
    TILTED(0.00)
    CON1(125.00 BY 10.00)
      WITH WINDOWS OF TYPE
      DOUBLE PANE TINTED WINDOW(44.60 BY 7.50)
        REVEAL(0.00)
        AT (0.40,1.30)
      WITH DOORS OF TYPE
      ALUMINUM DOOR(4.10 BY 4.00)
        REVEAL(0.00)
        AT (11.40,0.30);
  PARTITIONS:
    STARTING AT(50.00,29.00,0.00)
    FACING(90.00)
    TILTED(0.00)
    CON3(3.70 BY 10.00),
    STARTING AT(49.70,32.70,0.00)
    FACING(0.00)
    TILTED(0.00)
    CON3(25.10 BY 10.00),
    STARTING AT(24.60,32.70,0.00)
    FACING(90.00)
    TILTED(0.00)
    CON3(92.30 BY 10.00);
  INTERZONE PARTITIONS:
    STARTING AT(50.00,16.00,0.00)
    FACING(90.00)
    TILTED(90.00)
    CON2(13.00 BY 10.00)
    ADJACENT TO ZONE (3);
  SLAB ON GRADE FLOORS:
    STARTING AT(0.00,0.00,0.00)
    FACING(90.00)
    TILTED(180.00)
    CON6(93.10 BY 93.20);
  ROOFS:
    STARTING AT(0.00,0.00,10.00)
    FACING(180.00)
    TILTED(0.00)
    CON5(93.20 BY 93.10);
  INTERNAL MASS: CON3
    (238.00 BY 10.00);
  PEOPLE=100,OFFICE OCCUPANCY,
    AT ACTIVITY LEVEL 0.47,60.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=26.90,OFFICE LIGHTING,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
```

```
    INFILTRATION=470.000000,CONSTANT,
      WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
      FROM 01JAN THRU 31DEC;
    CONTROLS=NWS2,
      305.5 HEATING, 97.6 COOLING,
      0.00 PERCENT MRT,
      FROM 01JAN THRU 31DEC;
  END ZONE;
  ZONE 2 "ZONE 2                                  ":
    ORIGIN:(67.65,37.57,0.00);
    NORTH AXIS =0.00;
    EXTERIOR WALLS:
      STARTING AT(24.80,16.70,0.00)
      FACING(180.00)
      TILTED(0.00)
      CON1(0.20 BY 10.00),
      STARTING AT(25.00,16.70,0.00)
      FACING(90.00)
      TILTED(0.00)
      CON1(75.30 BY 10.00)
        WITH WINDOWS OF TYPE
        DOUBLE PANE TINTED WINDOW(27.80 BY 7.50)
          REVEAL(0.00)
          AT (0.10,1.70),
      STARTING AT(25.00,92.00,0.00)
      FACING(0.00)
      TILTED(0.00)
      CON1(25.00 BY 10.00)
        WITH WINDOWS OF TYPE
        DOUBLE PANE TINTED WINDOW(7.00 BY 7.00)
          REVEAL(0.00)
          AT (0.60,0.90)
        WITH DOORS OF TYPE
        ALUMINUM DOOR(2.90 BY 3.60)
          REVEAL(0.00)
          AT (9.30,1.10);
    PARTITIONS:
      STARTING AT(0.00,0.00,0.00)
      FACING(180.00)
      TILTED(90.00)
      CON3(24.80 BY 10.00),
      STARTING AT(24.80,0.00,0.00)
      FACING(90.00)
      TILTED(90.00)
      CON3(3.70 BY 10.00),
      STARTING AT(0.00,92.00,0.00)
      FACING(270.00)
      TILTED(0.00)
      CON3(92.00 BY 10.00);
    INTERZONE PARTITIONS:
      STARTING AT(24.80,3.70,0.00)
      FACING(90.00)
      TILTED(90.00)
      CON2(13.00 BY 10.00)
      ADJACENT TO ZONE (3);
    SLAB ON GRADE FLOORS:
      STARTING AT(0.00,0.00,0.00)
      FACING(90.00)
      TILTED(180.00)
      CON6(47.90 BY 47.90);
    ROOFS:
      STARTING AT(0.00,0.00,10.00)
      FACING(180.00)
```

```
      TILTED(0.00)
      CON5(47.90 BY 47.90);
    INTERNAL MASS: CON3
      (88.00 BY 10.00);
    PEOPLE=55,OFFICE OCCUPANCY,
      AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=15.00,OFFICE LIGHTING,
      0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
      20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
    INFILTRATION=262.000000,CONSTANT,
      WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
      FROM 01JAN THRU 31DEC;
    CONTROLS=NWS2,
      195.1 HEATING, 62.3 COOLING,
      0.00 PERCENT MRT,
      FROM 01JAN THRU 31DEC;
  END ZONE;
  ZONE 3 "ZONE 3                                  ":
    ORIGIN:(92.86,20.74,0.00);
    NORTH AXIS =0.00;
    EXTERIOR WALLS:
      STARTING AT(0.00,0.00,0.00)
      FACING(180.00)
      TILTED(90.00)
      CON1(67.00 BY 10.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW(18.30 BY 9.80)
          REVEAL(0.00)
          AT (0.60,0.10)
        WITH DOORS OF TYPE
        ALUMINUM DOOR(7.80 BY 4.50)
          REVEAL(0.00)
          AT (13.20,0.20),
      STARTING AT(20.00,33.30,0.00)
      FACING(0.00)
      TILTED(0.00)
      CON1(20.00 BY 10.00)
        WITH WINDOWS OF TYPE
        DOUBLE PANE TINTED WINDOW(5.70 BY 7.00)
          REVEAL(0.00)
          AT (0.60,2.70);
    PARTITIONS:
      STARTING AT(0.00,20.30,0.00)
      FACING(270.00)
      TILTED(0.00)
      CON3(7.30 BY 10.00);
    INTERZONE PARTITIONS:
      STARTING AT(67.00,0.00,0.00)
      FACING(90.00)
      TILTED(90.00)
      CON3(20.30 BY 10.00)
      ADJACENT TO ZONE (6),
      STARTING AT(67.00,20.30,0.00)
      FACING(0.00)
      TILTED(90.00)
      CON3(27.00 BY 10.00)
      ADJACENT TO ZONE (6),
      STARTING AT(40.00,20.30,0.00)
      FACING(0.00)
      TILTED(0.00)
      CON3(20.00 BY 10.00)
```

```
    ADJACENT TO ZONE (4),
    STARTING AT(20.00,20.30,0.00)
    FACING(90.00)
    TILTED(0.00)
    CON3(13.00 BY 10.00)
    ADJACENT TO ZONE (4),
    STARTING AT(0.00,33.30,0.00)
    FACING(270.00)
    TILTED(0.00)
    CON2(13.00 BY 10.00)
    ADJACENT TO ZONE (2),
    STARTING AT(0.00,13.00,0.00)
    FACING(270.00)
    TILTED(0.00)
    CON2(13.00 BY 10.00)
    ADJACENT TO ZONE (1);
  SLAB ON GRADE FLOORS:
    STARTING AT(0.00,0.00,0.00)
    FACING(90.00)
    TILTED(180.00)
    CON6(46.30 BY 46.20);
  ROOFS:
    STARTING AT(0.00,0.00,10.00)
    FACING(180.00)
    TILTED(0.00)
    CON5(46.20 BY 46.30);
  INTERNAL MASS: CON3
    (322.00 BY 10.00);
  PEOPLE=10,OFFICE OCCUPANCY,
    AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=9.90,OFFICE LIGHTING,
    0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
  INFILTRATION=172.000000,CONSTANT,
    WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
    FROM 01JAN THRU 31DEC;
  CONTROLS=NWS2,
    108.9 HEATING, 34.8 COOLING,
    0.00 PERCENT MRT,
    FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 4 "ZONE 4                                  ":
  ORIGIN:(112.88,41.04,0.00);
  NORTH AXIS =0.00;
  EXTERIOR WALLS:
    STARTING AT(20.00,23.00,0.00)
    FACING(0.00)
    TILTED(90.00)
    CON1(20.00 BY 10.00)
      WITH WINDOWS OF TYPE
      DOUBLE PANE TINTED WINDOW(4.60 BY 5.70)
        REVEAL(0.00)
        AT (0.60,4.00)
      WITH DOORS OF TYPE
      ALUMINUM DOOR(4.10 BY 5.10)
        REVEAL(0.00)
        AT (7.40,1.40),
    STARTING AT(0.00,23.00,0.00)
    FACING(270.00)
    TILTED(90.00)
    CON1(10.00 BY 10.00);
```

```
  INTERZONE PARTITIONS:
    STARTING AT(0.00,0.00,0.00)
    FACING(180.00)
    TILTED(90.00)
    CON3(20.00 BY 10.00)
    ADJACENT TO ZONE (3),
    STARTING AT(20.00,0.00,0.00)
    FACING(90.00)
    TILTED(90.00)
    CON3(23.00 BY 10.00)
    ADJACENT TO ZONE (6),
    STARTING AT(0.00,13.00,0.00)
    FACING(270.00)
    TILTED(0.00)
    CON3(13.00 BY 10.00)
    ADJACENT TO ZONE (3);
  SLAB ON GRADE FLOORS:
    STARTING AT(0.00,0.00,0.00)
    FACING(90.00)
    TILTED(180.00)
    CON6(21.40 BY 21.50);
  ROOFS:
    STARTING AT(0.00,0.00,10.00)
    FACING(180.00)
    TILTED(0.00)
    CON5(21.50 BY 21.40);
  INTERNAL MASS: CON3
    (28.00 BY 10.00);
  PEOPLE=0,CONSTANT,
    AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=3.30,OFFICE LIGHTING,
    0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
  INFILTRATION=58.000000,CONSTANT,
    WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
    FROM 01JAN THRU 31DEC;
  CONTROLS=NWS2,
    16.0 HEATING, 0.0 COOLING,
    0.00 PERCENT MRT,
    FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 5 "ZONE 5                                  ":
  ORIGIN:(133.17,116.31,0.00);
  NORTH AXIS =0.00;
  EXTERIOR WALLS:
    STARTING AT(9.00,13.20,0.00)
    FACING(0.00)
    TILTED(90.00)
    CON1(9.00 BY 10.00),
    STARTING AT(0.00,13.20,0.00)
    FACING(270.00)
    TILTED(90.00)
    CON1(13.00 BY 10.00)
      WITH DOORS OF TYPE
      ALUMINUM DOOR(4.10 BY 5.10)
        REVEAL(0.00)
        AT (0.60,4.60);
  INTERZONE PARTITIONS:
    STARTING AT(0.00,0.20,0.00)
    FACING(180.00)
    TILTED(90.00)
```

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      CON3(9.00 BY 10.00)
      ADJACENT TO ZONE (7),
      STARTING AT(9.00,0.20,0.00)
      FACING(90.00)
      TILTED(90.00)
      CON3(13.00 BY 10.00)
      ADJACENT TO ZONE (7);
    SLAB ON GRADE FLOORS:
      STARTING AT(0.00,0.00,0.00)
      FACING(90.00)
      TILTED(180.00)
      CON6(13.00 BY 9.00);
    ROOFS:
      STARTING AT(0.00,0.00,10.00)
      FACING(180.00)
      TILTED(0.00)
      CON5(9.00 BY 13.00);
    PEOPLE=0,CONSTANT,
      AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=0.80,OFFICE LIGHTING,
      0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
      20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
    INFILTRATION=14.000000,CONSTANT,
      WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
      FROM 01JAN THRU 31DEC;
    CONTROLS=NWS2,
      10.0 HEATING, 0.0 COOLING,
      0.00 PERCENT MRT,
      FROM 01JAN THRU 31DEC;
  END ZONE;
  ZONE 6 "ZONE 6                                  ":
    ORIGIN:(133.17,20.79,0.00);
    NORTH AXIS =0.00;
    EXTERIOR WALLS:
      STARTING AT(27.00,0.00,0.00)
      FACING(180.00)
      TILTED(90.00)
      CON1(45.80 BY 10.00)
        WITH WINDOWS OF TYPE
        DOUBLE PANE TINTED WINDOW(18.70 BY 9.80)
          REVEAL(0.00)
          AT (0.60,0.10),
      STARTING AT(72.80,0.00,0.00)
      FACING(90.00)
      TILTED(90.00)
      CON1(43.30 BY 10.00)
        WITH WINDOWS OF TYPE
        DOUBLE PANE TINTED WINDOW(10.70 BY 9.50)
          REVEAL(0.00)
          AT (0.70,0.30)
        WITH DOORS OF TYPE
        ALUMINUM DOOR(6.30 BY 5.60)
          REVEAL(0.00)
          AT (12.50,0.00),
      STARTING AT(72.80,43.30,0.00)
      FACING(0.00)
      TILTED(90.00)
      CON1(33.80 BY 10.00)
        WITH WINDOWS OF TYPE
        DOUBLE PANE TINTED WINDOW(8.50 BY 9.60)
          REVEAL(0.00)
```

```
        AT (4.50,0.30);
  INTERZONE PARTITIONS:
    STARTING AT(39.00,43.30,0.00)
    FACING(0.00)
    TILTED(0.00)
    CON2(39.00 BY 10.00)
    ADJACENT TO ZONE (7),
    STARTING AT(0.00,43.30,0.00)
    FACING(270.00)
    TILTED(0.00)
    CON3(23.00 BY 10.00)
    ADJACENT TO ZONE (4),
    STARTING AT(0.00,20.30,0.00)
    FACING(180.00)
    TILTED(0.00)
    CON3(27.00 BY 10.00)
    ADJACENT TO ZONE (3),
    STARTING AT(27.00,20.30,0.00)
    FACING(270.00)
    TILTED(0.00)
    CON3(20.30 BY 10.00)
    ADJACENT TO ZONE (3);
  SLAB ON GRADE FLOORS:
    STARTING AT(0.00,0.00,0.00)
    FACING(90.00)
    TILTED(180.00)
    CON6(44.50 BY 44.60);
  ROOFS:
    STARTING AT(0.00,0.00,10.00)
    FACING(180.00)
    TILTED(0.00)
    CON5(44.60 BY 44.50);
  INTERNAL MASS: CON3
    (124.00 BY 10.00);
  PEOPLE=20,OFFICE OCCUPANCY,
    AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=17.60,OFFICE LIGHTING,
    0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
  INFILTRATION=307.000000,CONSTANT,
    WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
    FROM 01JAN THRU 31DEC;
  CONTROLS=NWS2,
    177.0 HEATING, 56.6 COOLING,
    0.00 PERCENT MRT,
    FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 7 "ZONE 7                                  ":
  ORIGIN:(133.07,64.34,0.00);
  NORTH AXIS =0.00;
  EXTERIOR WALLS:
    STARTING AT(39.00,0.00,0.00)
    FACING(90.00)
    TILTED(90.00)
    CON1(65.00 BY 10.00)
      WITH WINDOWS OF TYPE
      DOUBLE PANE TINTED WINDOW(13.90 BY 8.20)
        REVEAL(0.00)
        AT (4.40,0.70)
      WITH DOORS OF TYPE
      ALUMINUM DOOR(6.00 BY 3.50)
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            REVEAL(0.00)
            AT (0.90,6.40),
        STARTING AT(39.00,65.00,0.00)
        FACING(0.00)
        TILTED(90.00)
        CON1(30.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DOUBLE PANE TINTED WINDOW(7.10 BY 8.80)
            REVEAL(0.00)
            AT (0.60,1.00),
        STARTING AT(0.00,52.00,0.00)
        FACING(270.00)
        TILTED(0.00)
        EXTERIOR(52.00 BY 10.00)
          WITH WINDOWS OF TYPE
          DOUBLE PANE TINTED WINDOW(19.30 BY 9.80)
            REVEAL(0.00)
            AT (0.60,0.10);
      INTERZONE PARTITIONS:
        STARTING AT(0.00,0.00,0.00)
        FACING(180.00)
        TILTED(90.00)
        CON2(39.00 BY 10.00)
        ADJACENT TO ZONE (6),
        STARTING AT(9.00,65.00,0.00)
        FACING(270.00)
        TILTED(90.00)
        CON3(13.00 BY 10.00)
        ADJACENT TO ZONE (5),
        STARTING AT(9.00,52.00,0.00)
        FACING(0.00)
        TILTED(0.00)
        CON3(9.00 BY 10.00)
        ADJACENT TO ZONE (5);
      SLAB ON GRADE FLOORS:
        STARTING AT(0.00,0.00,0.00)
        FACING(90.00)
        TILTED(180.00)
        CON6(49.20 BY 49.10);
      ROOFS:
        STARTING AT(0.00,0.00,10.00)
        FACING(180.00)
        TILTED(0.00)
        CON5(49.10 BY 49.20);
      INTERNAL MASS: CON3
        (238.00 BY 10.00);
      PEOPLE=20,OFFICE OCCUPANCY,
        AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
        FROM 01JAN THRU 31DEC;
      LIGHTS=16.50,OFFICE LIGHTING,
        0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
        20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
        FROM 01JAN THRU 31DEC;
      INFILTRATION=287.000000,CONSTANT,
        WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
        FROM 01JAN THRU 31DEC;
      CONTROLS=NWS2,
        191.1 HEATING, 61.1 COOLING,
        0.00 PERCENT MRT,
        FROM 01JAN THRU 31DEC;
    END ZONE;
END BUILDING DESCRIPTION;
BEGIN FAN SYSTEM DESCRIPTION;
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```
FOUR PIPE FAN COIL SYSTEM  1
"FOUR PIPE FAN COIL #1" SERVING ZONES
    1, 2;
  FOR ZONE  1:
    SUPPLY AIR VOLUME=4000.0;
    EXHAUST AIR VOLUME=0;
    BASEBOARD HEAT CAPACITY=0;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
    ZONE MULTIPLIER=1;
  END ZONE;
  FOR ZONE  2:
    SUPPLY AIR VOLUME=2700.0;
    EXHAUST AIR VOLUME=0.0;
    BASEBOARD HEAT CAPACITY=0.0;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
    ZONE MULTIPLIER=1;
  END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=0.49783;
    SUPPLY FAN EFFICIENCY=0.7;
    EXHAUST FAN PRESSURE=1.00396;
    EXHAUST FAN EFFICIENCY=0.7;
    GAS BURNER EFFICIENCY=0.8;
    SYSTEM ELECTRICAL DEMAND=0.0;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=3412000.0;
    MIXED AIR CONTROL=FIXED PERCENT;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
    OUTSIDE AIR VOLUME=0.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=55.04;
    COLD DECK THROTTLING RANGE=7.2;
    COLD DECK CONTROL SCHEDULE=(55 AT 90, 65 AT 70);
    HOT DECK CONTROL=FIXED SET POINT;
    HOT DECK TEMPERATURE=140.0;
    HOT DECK THROTTLING RANGE=7.2;
    HOT DECK CONTROL SCHEDULE=(140 AT 0, 70 AT 70);
  END OTHER SYSTEM PARAMETERS;
  EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    FAN COIL HEATING OPERATION=ON,FROM 01OCT THRU 30APR;
    FAN COIL COOLING OPERATION=ON,FROM 01MAY THRU 30SEP;
    FAN COIL HEATING OPERATION=OFF,FROM 01MAY THRU 30SEP;
    FAN COIL COOLING OPERATION=OFF,FROM 01OCT THRU 30APR;
  END EQUIPMENT SCHEDULES;
  COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER;
    AIR VOLUME FLOW RATE=6700.0;
    BAROMETRIC PRESSURE=405.489;
    AIR FACE VELOCITY=492.126;
    ENTERING AIR DRY BULB TEMPERATURE=84.92;
    ENTERING AIR WET BULB TEMPERATURE=64.04;
    LEAVING AIR DRY BULB TEMPERATURE=55.04;
    LEAVING AIR WET BULB TEMPERATURE=52.7;
    ENTERING WATER TEMPERATURE=44.96;
    LEAVING WATER TEMPERATURE=55.04;
    WATER VOLUME FLOW RATE=5.65346;
    WATER VELOCITY=275.59;
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    END COOLING COIL DESIGN PARAMETERS;
  END SYSTEM;
  SINGLE ZONE DRAW THRU SYSTEM  2
  "SINGLE ZONE DRAW THROUGH #1" SERVING ZONES
      3;
    FOR ZONE  3:
      SUPPLY AIR VOLUME=2500.0;
      EXHAUST AIR VOLUME=0;
      BASEBOARD HEAT CAPACITY=0;
      BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
      ZONE MULTIPLIER=1;
    END ZONE;
    OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      SUPPLY FAN EFFICIENCY=0.7;
      EXHAUST FAN PRESSURE=1.00396;
      EXHAUST FAN EFFICIENCY=0.7;
      GAS BURNER EFFICIENCY=0.8;
      SYSTEM ELECTRICAL DEMAND=0.0;
      RETURN FAN PRESSURE=0.0;
      RETURN FAN EFFICIENCY=0.7;
      HEATING COIL ENERGY SUPPLY=HOT WATER;
      HEATING COIL CAPACITY=3412000.0;
      MIXED AIR CONTROL=FIXED PERCENT;
      DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
      OUTSIDE AIR VOLUME=0.0;
      PREHEAT COIL LOCATION=NONE;
      PREHEAT TEMPERATURE=46.4;
      PREHEAT ENERGY SUPPLY=HOT WATER;
      PREHEAT COIL CAPACITY=3412000.0;
      HUMIDIFIER TYPE=NONE;
      HUMIDISTAT SET POINT=50.0;
    END OTHER SYSTEM PARAMETERS;
    EQUIPMENT SCHEDULES:
      SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
      TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
      SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
      PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
      HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      COOLING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
      HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
      MINIMUM VENTILATION SCHEDULE=MINIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
      MAXIMUM VENTILATION SCHEDULE=MAXIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    END EQUIPMENT SCHEDULES;
    COOLING COIL DESIGN PARAMETERS:
      COIL TYPE=CHILLED WATER;
      AIR VOLUME FLOW RATE=600.0668;
      BAROMETRIC PRESSURE=405.489;
      AIR FACE VELOCITY=492.126;
      ENTERING AIR DRY BULB TEMPERATURE=84.92;
      ENTERING AIR WET BULB TEMPERATURE=64.04;
      LEAVING AIR DRY BULB TEMPERATURE=55.04;
      LEAVING AIR WET BULB TEMPERATURE=52.7;
      ENTERING WATER TEMPERATURE=44.96;
      LEAVING WATER TEMPERATURE=55.04;
      WATER VOLUME FLOW RATE=0.5063364;
      WATER VELOCITY=275.59;
    END COOLING COIL DESIGN PARAMETERS;
    HEAT RECOVERY PARAMETERS:
      HTREC1( 0.85 , 0 , 0 );
      HTREC2( 0 , 0 , 0 );
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    HTREC3( 0 , 0 , 0 );
    HTREC4( 0 , 0 , 0 );
    HTREC5( 0 , 0 , 0 );
    HTREC6( 0 , 0 , 0 );
    HTPWR( 0 , 0 , 0 );
    HEAT RECOVERY CAPACITY=3412000.0;
  END HEAT RECOVERY PARAMETERS;
END SYSTEM;
SINGLE ZONE DRAW THRU SYSTEM  3
"SINGLE ZONE DRAW THROUGH #2" SERVING ZONES
    6;
  FOR ZONE  6:
    SUPPLY AIR VOLUME=2250.0;
    EXHAUST AIR VOLUME=0;
    BASEBOARD HEAT CAPACITY=0;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
    ZONE MULTIPLIER=1;
  END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783;
    SUPPLY FAN EFFICIENCY=0.7;
    EXHAUST FAN PRESSURE=1.00396;
    EXHAUST FAN EFFICIENCY=0.7;
    GAS BURNER EFFICIENCY=0.8;
    SYSTEM ELECTRICAL DEMAND=0.0;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=0.7;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=3412000.0;
    MIXED AIR CONTROL=FIXED PERCENT;
    DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
    OUTSIDE AIR VOLUME=0.0;
    PREHEAT COIL LOCATION=NONE;
    PREHEAT TEMPERATURE=46.4;
    PREHEAT ENERGY SUPPLY=HOT WATER;
    PREHEAT COIL CAPACITY=3412000.0;
    HUMIDIFIER TYPE=NONE;
    HUMIDISTAT SET POINT=50.0;
  END OTHER SYSTEM PARAMETERS;
  EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
    TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
    HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=MAXIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
  COOLING COIL DESIGN PARAMETERS:
    COIL TYPE=CHILLED WATER;
    AIR VOLUME FLOW RATE=600.0668;
    BAROMETRIC PRESSURE=405.489;
    AIR FACE VELOCITY=492.126;
    ENTERING AIR DRY BULB TEMPERATURE=84.92;
    ENTERING AIR WET BULB TEMPERATURE=64.04;
    LEAVING AIR DRY BULB TEMPERATURE=55.04;
    LEAVING AIR WET BULB TEMPERATURE=52.7;
    ENTERING WATER TEMPERATURE=44.96;
    LEAVING WATER TEMPERATURE=55.04;
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      WATER VOLUME FLOW RATE=0.5063364;
      WATER VELOCITY=275.59;
    END COOLING COIL DESIGN PARAMETERS;
    HEAT RECOVERY PARAMETERS:
      HTREC1( 0.85 , 0 , 0 );
      HTREC2( 0 , 0 , 0 );
      HTREC3( 0 , 0 , 0 );
      HTREC4( 0 , 0 , 0 );
      HTREC5( 0 , 0 , 0 );
      HTREC6( 0 , 0 , 0 );
      HTPWR( 0 , 0 , 0 );
      HEAT RECOVERY CAPACITY=3412000.0;
    END HEAT RECOVERY PARAMETERS;
  END SYSTEM;
  SINGLE ZONE DRAW THRU SYSTEM  4
  "SINGLE ZONE DRAW THROUGH #3" SERVING ZONES
      7;
    FOR ZONE  7:
      SUPPLY AIR VOLUME=2450.0;
      EXHAUST AIR VOLUME=0;
      BASEBOARD HEAT CAPACITY=0;
      BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
      ZONE MULTIPLIER=1;
    END ZONE;
    OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      SUPPLY FAN EFFICIENCY=0.7;
      EXHAUST FAN PRESSURE=1.00396;
      EXHAUST FAN EFFICIENCY=0.7;
      GAS BURNER EFFICIENCY=0.8;
      SYSTEM ELECTRICAL DEMAND=0.0;
      RETURN FAN PRESSURE=0.0;
      RETURN FAN EFFICIENCY=0.7;
      HEATING COIL ENERGY SUPPLY=HOT WATER;
      HEATING COIL CAPACITY=3412000.0;
      MIXED AIR CONTROL=FIXED PERCENT;
      DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
      OUTSIDE AIR VOLUME=0.0;
      PREHEAT COIL LOCATION=NONE;
      PREHEAT TEMPERATURE=46.4;
      PREHEAT ENERGY SUPPLY=HOT WATER;
      PREHEAT COIL CAPACITY=3412000.0;
      HUMIDIFIER TYPE=NONE;
      HUMIDISTAT SET POINT=50.0;
    END OTHER SYSTEM PARAMETERS;
    EQUIPMENT SCHEDULES:
      SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
      TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
      SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
      PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
      HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      COOLING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
      HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
      MINIMUM VENTILATION SCHEDULE=MINIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
      MAXIMUM VENTILATION SCHEDULE=MAXIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    END EQUIPMENT SCHEDULES;
    COOLING COIL DESIGN PARAMETERS:
      COIL TYPE=CHILLED WATER;
      AIR VOLUME FLOW RATE=600.0668;
      BAROMETRIC PRESSURE=405.489;
      AIR FACE VELOCITY=492.126;
```

```
    ENTERING AIR DRY BULB TEMPERATURE=84.92;
    ENTERING AIR WET BULB TEMPERATURE=64.04;
    LEAVING AIR DRY BULB TEMPERATURE=55.04;
    LEAVING AIR WET BULB TEMPERATURE=52.7;
    ENTERING WATER TEMPERATURE=44.96;
    LEAVING WATER TEMPERATURE=55.04;
    WATER VOLUME FLOW RATE=0.5063364;
    WATER VELOCITY=275.59;
  END COOLING COIL DESIGN PARAMETERS;
  HEAT RECOVERY PARAMETERS:
    HTREC1( 0.85 , 0 , 0 );
    HTREC2( 0 , 0 , 0 );
    HTREC3( 0 , 0 , 0 );
    HTREC4( 0 , 0 , 0 );
    HTREC5( 0 , 0 , 0 );
    HTREC6( 0 , 0 , 0 );
    HTPWR( 0 , 0 , 0 );
    HEAT RECOVERY CAPACITY=3412000.0;
  END HEAT RECOVERY PARAMETERS;
END SYSTEM;
UNIT HEATER SYSTEM  5
"UNIT HEATER #1" SERVING ZONES
    4;
  FOR ZONE  4:
    SUPPLY AIR VOLUME=300.0;
    BASEBOARD HEAT CAPACITY=0;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
    ZONE MULTIPLIER=1;
    REHEAT CAPACITY=0;
    REHEAT ENERGY SUPPLY=HOT WATER;
  END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=2.49783;
    SUPPLY FAN EFFICIENCY=0.7;
    EXHAUST FAN PRESSURE=1.00396;
    EXHAUST FAN EFFICIENCY=0.7;
    GAS BURNER EFFICIENCY=0.8;
    SYSTEM ELECTRICAL DEMAND=0.0;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=3412000.0;
    REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
    REHEAT TEMPERATURE LIMIT=140.0;
    REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70);
  END OTHER SYSTEM PARAMETERS;
  EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
    REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
END SYSTEM;
UNIT HEATER SYSTEM  6
"UNIT HEATER #2" SERVING ZONES
    5;
  FOR ZONE  5:
    SUPPLY AIR VOLUME=220.0;
    BASEBOARD HEAT CAPACITY=0;
    BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
    ZONE MULTIPLIER=1;
    REHEAT CAPACITY=0;
    REHEAT ENERGY SUPPLY=HOT WATER;
  END ZONE;
  OTHER SYSTEM PARAMETERS:
```

```
      SUPPLY FAN PRESSURE=2.49783;
      SUPPLY FAN EFFICIENCY=0.7;
      EXHAUST FAN PRESSURE=1.00396;
      EXHAUST FAN EFFICIENCY=0.7;
      GAS BURNER EFFICIENCY=0.8;
      SYSTEM ELECTRICAL DEMAND=0.0;
      HEATING COIL ENERGY SUPPLY=HOT WATER;
      HEATING COIL CAPACITY=3412000.0;
      REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
      REHEAT TEMPERATURE LIMIT=140.0;
      REHEAT CONTROL SCHEDULE=(140 AT 0, 70 AT 70);
    END OTHER SYSTEM PARAMETERS;
    EQUIPMENT SCHEDULES:
      SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
      SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
      REHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    END EQUIPMENT SCHEDULES;
  END SYSTEM;
END FAN SYSTEM DESCRIPTION;
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "PLANT #1" SERVING SYSTEM
  1, 2, 3, 4, 5, 6;
 EQUIPMENT SELECTION:
   BOILER:
       1  OF SIZE  674 ;
   CHILLER:
       1  OF SIZE  553 ;
 END EQUIPMENT SELECTION;
 PART LOAD RATIOS:
   BOILER (MIN=.01, MAX=1, BEST=.87, ELECTRICAL=0);
   CHILLER (MIN=.1, MAX=1.05, BEST=.65, ELECTRICAL=.2275);
 END PART LOAD RATIOS;
 SCHEDULE:
   PLANT ELECTRICAL DEMAND=0, CONSTANT,FROM 01JAN THRU 31DEC;
   PROCESS WASTE HEAT=0, CONSTANT,FROM 01JAN THRU 31DEC, AT LEVEL 5;
   HOT WATER= 0 , CONSTANT,FROM 01JAN THRU 31DEC,
             AT  125  SUPPLIED BY BOILER;
 END SCHEDULE;
 SPECIAL PARAMETERS:
   TCOOL=44.006;
   STEAM=1168.678;
   PSTEAM=284.4099;
   TSATUR=241.5302;
   HFUELB=20013.0;
   RFLASH=0.071;
   RHFLASH=0.5;
   SRATB=17.0;
   TLEAVE=550.04;
 END SPECIAL PARAMETERS;
 EQUIPMENT PERFORMANCE PARAMETERS:
   CPUMP ( 1.0, 0.0, 0.0);
   HPUMP ( 1.0, 0.0, 0.0);
   RFUELB ( 0.6, 0.8888889, -0.4938272);
   ADJE1C ( 2.3201, -1.46175, 0.181487);
   ADJT1C ( 95.0, 2.5, 44.0);
   RCAV1C ( 1.01846, -0.03075, -0.0001442);
   RPWR1C ( 0.18717, 0.122387, 0.67436);
 END EQUIPMENT PERFORMANCE PARAMETERS;
 FOR SYSTEM 1 :
   SYSTEM MULTIPLIER= 1 ;
 END SYSTEM;
 FOR SYSTEM 2 :
```

```
        SYSTEM MULTIPLIER= 1 ;
      END SYSTEM;
      FOR SYSTEM 3 :
        SYSTEM MULTIPLIER= 1 ;
      END SYSTEM;
      FOR SYSTEM 4 :
        SYSTEM MULTIPLIER= 1 ;
      END SYSTEM;
      FOR SYSTEM 5 :
        SYSTEM MULTIPLIER= 1 ;
      END SYSTEM;
      FOR SYSTEM 6 :
        SYSTEM MULTIPLIER= 1 ;
      END SYSTEM;
    END PLANT;
     END CENTRAL PLANT DESCRIPTION;
   END INPUT;


End Input Parsing, Begin Simulations


  REPORTING WILL BE DONE IN ENGLISH UNITS

  SIMULATIONS WILL BE ALLOWED FOR TYPES: ZONES      SYSTEMS    PLANTS

         1 BUILDING SIMULATIONS WILL BE ATTEMPTED

       SIMULATIONS WILL BE ATTEMPTED FOR   7 ZONES

       SIMULATIONS WILL BE ATTEMPTED FOR   6 SYSTEMS

       SIMULATIONS WILL BE ATTEMPTED FOR   1 PLANTS

NEW BLDFL AND AHLDFL FILES WILL BE CREATED
     FROM USER INPUT, AS NECESSARY

 * * * * *
 BLDFL FOR
  FORT MONMOUTH, NJ
  EDUCATION CENTER
  SEVEN ZONE HBLC WORKSHOP
                        (HBLC) 2500 1600
 LOCATION NEW YORK CITY NEW YORK                   LAT=    40.770 LONG=    73.900 TIME ZONE= 5.0
 DATE OF FILE CREATE/UPDATE 24 JUL 98 NUMBER OF ENVIRONMENTS  2
 NUMBER OF ZONES  7 WITH ZONE NUMBERS
  1    2    3    4    5    6    7

 * * * * *
 AHLDFL FOR
  FORT MONMOUTH, NJ
  EDUCATION CENTER
  SEVEN ZONE HBLC WORKSHOP
                        (HBLC) 2500 1600
 LOCATION NEW YORK CITY NEW YORK                   LAT=    40.770 LONG=    73.900 TIME ZONE= 5.0
 DATE OF FILE CREATE/UPDATE 24 JUL 98 NUMBER OF ENVIRONMENTS  2
 NUMBER OF SYSTEMS  6 WITH SYSTEM NUMBERS
  1    2    3    4    5    6
   ENVIRONMENT NUMBER  1 FOR BLDFL  TITLE IS NEW YORK CITY NEW YORK WINTER
    DESIGN DAY 21 JAN WITH GROUND TEMPERATURE  55.000  MAKE UP WATER TEMPERATURE  55.004
   ENVIRONMENT NUMBER  1 FOR AHLDFL TITLE IS NEW YORK CITY NEW YORK WINTER
    DESIGN DAY 21 JAN WITH GROUND TEMPERATURE  55.000  MAKE UP WATER TEMPERATURE  55.004
   ENVIRONMENT NUMBER  2 FOR BLDFL  TITLE IS NEW YORK CITY NEW YORK SUMMER
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     DESIGN DAY 21 JUL WITH GROUND TEMPERATURE  70.000  MAKE UP WATER TEMPERATURE  55.004
    ENVIRONMENT NUMBER  2 FOR AHLDFL TITLE IS NEW YORK CITY NEW YORK SUMMER
     DESIGN DAY 21 JUL WITH GROUND TEMPERATURE  70.000  MAKE UP WATER TEMPERATURE  55.004
***************************************************************************
**                                                                       **
**     A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N     **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         1, FOUR PIPE FAN COIL #1

  TYPE SYS = FOUR PIPE FAN COIL         NO. DISTINCT ZONES ON SYS. =    2



  TOTAL SUPPLY  FAN PRESSURE =    0.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70

  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    0.00000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER

  COLD DECK CONTROL = FIXED SET POINT
  COLD DECK THROTTLING RANGE =    0.00000     DEG. F
  COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                            ZONE DATA SUMMARY

  ZONE      ZONE       ZONE       ZONE       ZONE       ZONE       ZONE       ZONE
 NUMBER    SUPPLY     EXHAUST    REHEAT     REHEAT    TSTAT BB   TSTAT BB     MULT
           AIR VOL    AIR VOL    CAPCTY     ENERGY     CAPCTY     ENERGY
     1   4.000E+03  0.000E+00  0.000E+00  HOT WATER  0.000E+00  HOT WATER      1.0
     2   2.700E+03  0.000E+00  0.000E+00  HOT WATER  0.000E+00  HOT WATER      1.0

  TOTAL DESIGN SUPPLY AIR VOLUME =  6.700E+03
***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y     **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         1, FOUR PIPE FAN COIL #1
  DESIGN DAY NEW YORK CITY NEW YORK WINTER

  SIMULATION DATE 21JAN1998 (MONDAY   )

                          TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                              1000BTU         1000BTU/HR        MO/DY/HR
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SUM OF ZONE SENSIBLE
HEATING LOADS                3.77236E+03        1.97338E+02       1/21/ 8

TOTAL HEATING PROVIDED
BY SYSTEM                    5.00370E+03        2.52880E+02       1/21/ 8


SUM OF ZONE SENSIBLE
COOLING LOADS                0.00000E+00        0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM           0.00000E+00        0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM           0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                    0.00000E+00        0.00000E+00       0/ 0/ 0


TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    5.52307E+03    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.09713E+04  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     5.03409E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.

 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                         15.00          15.00          15.00               24                          24
(MO/DY/HR):                        1/21/ 1                       1/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!

         *****************************************************************************************************************
         **                                                                                                             **
         **                            S U M M A R Y  U N M E T  L O A D S  R E P O R T                                 **
         **                                                                                                             **
         *****************************************************************************************************************


          SYSTEM NUMBER=        1, FOUR PIPE FAN COIL #1
          DESIGN DAY NEW YORK CITY NEW YORK SUMMER                         SIMULATION DATE 21JUL1998 (MONDAY   )

ZONE #  UNDER HEAT          UNDER COOL          OVER HEAT           OVER COOL           HEAT W/O DMD        COOL W/O DMD
          1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS

    1   0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    4.186E+01 (  12)
    2   0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    4.063E+01 (  14)
        =========           =========           =========           =========           =========           =========
 TOTAL  0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    8.249E+01 (  26)
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**                                                                        **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y     **
**                                                                        **
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  SYSTEM NUMBER=         1, FOUR PIPE FAN COIL #1
  DESIGN DAY NEW YORK CITY NEW YORK SUMMER

  SIMULATION DATE 21JUL1998 (MONDAY   )

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                               1000BTU         1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                0.00000E+00         0.00000E+00       0/ 0/ 0

TOTAL HEATING PROVIDED
BY SYSTEM                    0.00000E+00         0.00000E+00       0/ 0/ 0



SUM OF ZONE SENSIBLE
COOLING LOADS                1.14125E+03         1.34670E+02       7/21/15

SENSIBLE COOLING
PROVIDED BY SYSTEM           1.21627E+03         1.47725E+02       7/21/15

LATENT COOLING
PROVIDED BY SYSTEM           4.97572E+02         5.54399E+01       7/21/12

TOTAL COOLING PROVIDED
BY SYSTEM                    1.71384E+03         2.02171E+02       7/21/15



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    2.23321E+03    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.09713E+04  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     2.03549E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.

 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                         15.00          15.00          15.00                24                        24
(MO/DY/HR):                        7/21/ 1                       7/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!

****************************************************************************
**                                                                        **
**     A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N     **
**                                                                        **
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  SYSTEM NUMBER=         2, SINGLE ZONE DRAW THROUGH #1

  TYPE SYS = SINGLE ZN DRAW THRU        NO. DISTINCT ZONES ON SYS. =    1


  TOTAL SUPPLY  FAN PRESSURE =    2.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70

  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    7.20000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER

  COLD DECK CONTROL = FIXED SET POINT
  COLD DECK THROTTLING RANGE =    7.20000     DEG. F
  COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                            ZONE DATA SUMMARY

  ZONE      ZONE       ZONE       ZONE       ZONE       ZONE       ZONE       ZONE
 NUMBER    SUPPLY     EXHAUST     REHEAT     REHEAT    TSTAT BB   TSTAT BB     MULT
          AIR VOL     AIR VOL     CAPCTY     ENERGY     CAPCTY     ENERGY
      3  2.500E+03  0.000E+00  0.000E+00  HOT WATER  0.000E+00  HOT WATER      1.0

  TOTAL DESIGN SUPPLY AIR VOLUME =  2.500E+03
****************************************************************************
**                                                                        **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y     **
**                                                                        **
****************************************************************************


  SYSTEM NUMBER=         2, SINGLE ZONE DRAW THROUGH #1
  DESIGN DAY NEW YORK CITY NEW YORK WINTER

  SIMULATION DATE 21JAN1998 (MONDAY   )

                           TOTAL DEMAND      PEAK DEMAND     TIME OF PEAK
                               1000BTU        1000BTU/HR       MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS               1.03450E+03        5.70047E+01      1/21/ 8

TOTAL HEATING PROVIDED
BY SYSTEM                   1.42354E+03        7.47566E+01      1/21/ 8
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SUM OF ZONE SENSIBLE
COOLING LOADS              0.00000E+00        0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM         0.00000E+00        0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM         0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                  0.00000E+00        0.00000E+00       0/ 0/ 0



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    1.62134E+03    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        2.13906E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     7.57970E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.

 FRACTION OF OUTSIDE AIR           MAX [%]       AVG [%]       MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                         15.00         15.00         15.00              24                          24
(MO/DY/HR):                        1/21/ 1                     1/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!

***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                       **
***************************************************************************

  SYSTEM NUMBER=         2, SINGLE ZONE DRAW THROUGH #1
  DESIGN DAY NEW YORK CITY NEW YORK SUMMER

  SIMULATION DATE 21JUL1998 (MONDAY   )

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                               1000BTU          1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS              0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL HEATING PROVIDED
BY SYSTEM                  0.00000E+00        0.00000E+00       0/ 0/ 0



SUM OF ZONE SENSIBLE
COOLING LOADS              2.41283E+02        2.84008E+01       7/21/15

SENSIBLE COOLING
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```
PROVIDED BY SYSTEM          3.12058E+02        3.61581E+01       7/21/15

LATENT COOLING
PROVIDED BY SYSTEM          8.22759E+01        1.23597E+01       7/21/12

TOTAL COOLING PROVIDED
BY SYSTEM                   3.94333E+02        4.72046E+01       7/21/14



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    5.92138E+02    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        2.13906E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     2.76822E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.

 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                         15.00          15.00          15.00                24                         24
(MO/DY/HR):                        7/21/ 1                       7/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!

***************************************************************************
**                                                                       **
**     A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N     **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         3, SINGLE ZONE DRAW THROUGH #2

  TYPE SYS = SINGLE ZN DRAW THRU        NO. DISTINCT ZONES ON SYS. =    1


  TOTAL SUPPLY  FAN PRESSURE =    2.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70

  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    7.20000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER
```

```
  COLD DECK CONTROL = FIXED SET POINT
  COLD DECK THROTTLING RANGE =    7.20000     DEG. F
  COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                            ZONE DATA SUMMARY

  ZONE      ZONE        ZONE        ZONE        ZONE        ZONE        ZONE        ZONE
 NUMBER    SUPPLY     EXHAUST      REHEAT      REHEAT     TSTAT BB    TSTAT BB      MULT
          AIR VOL     AIR VOL      CAPCTY      ENERGY      CAPCTY      ENERGY
      6   2.250E+03   0.000E+00   0.000E+00   HOT WATER   0.000E+00   HOT WATER       1.0

  TOTAL DESIGN SUPPLY AIR VOLUME =  2.250E+03
***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         3, SINGLE ZONE DRAW THROUGH #2
  DESIGN DAY NEW YORK CITY NEW YORK WINTER

  SIMULATION DATE 21JAN1998 (MONDAY   )

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU         1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                1.34717E+03         6.69647E+01       1/21/ 8

TOTAL HEATING PROVIDED
BY SYSTEM                    1.69867E+03         8.30467E+01       1/21/ 8


SUM OF ZONE SENSIBLE
COOLING LOADS                0.00000E+00         0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM           0.00000E+00         0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM           0.00000E+00         0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                    0.00000E+00         0.00000E+00       0/ 0/ 0


TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    1.97489E+03    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.98470E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     9.95059E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.
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 FRACTION OF OUTSIDE AIR          MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                        15.00          15.00          15.00               24                        24
(MO/DY/HR):                       1/21/ 1                       1/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y     **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         3, SINGLE ZONE DRAW THROUGH #2
  DESIGN DAY NEW YORK CITY NEW YORK SUMMER

  SIMULATION DATE 21JUL1998 (MONDAY   )

                             TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU         1000BTU/HR         MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                 0.00000E+00        0.00000E+00      0/ 0/ 0

TOTAL HEATING PROVIDED
BY SYSTEM                     0.00000E+00        0.00000E+00      0/ 0/ 0


SUM OF ZONE SENSIBLE
COOLING LOADS                 2.96235E+02        3.56930E+01      7/21/16

SENSIBLE COOLING
PROVIDED BY SYSTEM            3.60448E+02        4.26133E+01      7/21/16

LATENT COOLING
PROVIDED BY SYSTEM            1.55833E+02        1.90957E+01      7/21/14

TOTAL COOLING PROVIDED
BY SYSTEM                     5.16281E+02        6.13450E+01      7/21/15



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    7.92503E+02    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.98470E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     3.99306E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.

 FRACTION OF OUTSIDE AIR          MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                        15.00          15.00          15.00               24                        24
```

```
(MO/DY/HR):                        7/21/ 1                        7/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


***************************************************************************
**                                                                      **
**     A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N    **
**                                                                      **
***************************************************************************


  SYSTEM NUMBER=         4, SINGLE ZONE DRAW THROUGH #3

  TYPE SYS = SINGLE ZN DRAW THRU        NO. DISTINCT ZONES ON SYS. =    1



  TOTAL SUPPLY  FAN PRESSURE =    2.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70

  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    7.20000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER

  COLD DECK CONTROL = FIXED SET POINT
  COLD DECK THROTTLING RANGE =    7.20000     DEG. F
  COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                            ZONE DATA SUMMARY

  ZONE      ZONE        ZONE        ZONE        ZONE        ZONE        ZONE        ZONE
 NUMBER    SUPPLY     EXHAUST      REHEAT      REHEAT     TSTAT BB    TSTAT BB      MULT
          AIR VOL     AIR VOL      CAPCTY      ENERGY      CAPCTY      ENERGY
      7  2.450E+03   0.000E+00   0.000E+00   HOT WATER   0.000E+00   HOT WATER       1.0

  TOTAL DESIGN SUPPLY AIR VOLUME =  2.450E+03
***************************************************************************
**                                                                      **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                      **
***************************************************************************


  SYSTEM NUMBER=         4, SINGLE ZONE DRAW THROUGH #3
  DESIGN DAY NEW YORK CITY NEW YORK WINTER

  SIMULATION DATE 21JAN1998 (MONDAY   )

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                               1000BTU         1000BTU/HR        MO/DY/HR
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```
SUM OF ZONE SENSIBLE
HEATING LOADS             1.38672E+03        7.15878E+01      1/21/ 8

TOTAL HEATING PROVIDED
BY SYSTEM                 1.76974E+03        8.91022E+01      1/21/ 8


SUM OF ZONE SENSIBLE
COOLING LOADS             0.00000E+00        0.00000E+00      0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM        0.00000E+00        0.00000E+00      0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM        0.00000E+00        0.00000E+00      0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                 0.00000E+00        0.00000E+00      0/ 0/ 0



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =   2.04041E+03   1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =       2.41572E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =    8.44638E-01   1000BTU /FT**2/DAY


NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.


 FRACTION OF OUTSIDE AIR          MAX [%]       AVG [%]       MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                        15.00         15.00         15.00                24                        24
(MO/DY/HR):                       1/21/ 1                     1/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=        4, SINGLE ZONE DRAW THROUGH #3
  DESIGN DAY NEW YORK CITY NEW YORK SUMMER

  SIMULATION DATE 21JUL1998 (MONDAY   )

                            TOTAL DEMAND      PEAK DEMAND      TIME OF PEAK
                               1000BTU         1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS             0.00000E+00        0.00000E+00      0/ 0/ 0
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```
TOTAL HEATING PROVIDED
BY SYSTEM                   1.59808E+00       4.02448E-01      7/21/ 4


SUM OF ZONE SENSIBLE
COOLING LOADS               3.88733E+02       4.62665E+01      7/21/15

SENSIBLE COOLING
PROVIDED BY SYSTEM          4.52977E+02       5.39152E+01      7/21/15

LATENT COOLING
PROVIDED BY SYSTEM          2.09256E+02       2.40233E+01      7/21/12

TOTAL COOLING PROVIDED
BY SYSTEM                   6.62232E+02       7.72496E+01      7/21/15


TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    9.34496E+02    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        2.41572E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     3.86840E-01    1000BTU /FT**2/DAY


NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.


 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                         15.00          15.00          15.00                24                        24
(MO/DY/HR):                        7/21/ 1                       7/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


***************************************************************************
**                                                                       **
**     A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N     **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         5, UNIT HEATER #1

  TYPE SYS = UNIT HEATER                NO. DISTINCT ZONES ON SYS. =    1


  TOTAL SUPPLY  FAN PRESSURE =    2.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70
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  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    7.20000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER

  COLD DECK CONTROL = FIXED SET POINT
  COLD DECK THROTTLING RANGE =    0.00000     DEG. F
  COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                            ZONE DATA SUMMARY

  ZONE      ZONE       ZONE       ZONE       ZONE       ZONE       ZONE       ZONE
 NUMBER    SUPPLY     EXHAUST     REHEAT     REHEAT    TSTAT BB   TSTAT BB    MULT
          AIR VOL     AIR VOL     CAPCTY     ENERGY     CAPCTY     ENERGY
     4   3.000E+02   0.000E+00   3.412E+09  HOT WATER  0.000E+00  HOT WATER      1.0

  TOTAL DESIGN SUPPLY AIR VOLUME =  3.000E+02
***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         5, UNIT HEATER #1
  DESIGN DAY NEW YORK CITY NEW YORK WINTER

  SIMULATION DATE 21JAN1998 (MONDAY   )

                             TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU          1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                 2.59676E+02        1.36958E+01       1/21/ 8

TOTAL HEATING PROVIDED
BY SYSTEM                     2.49363E+02        1.32661E+01       1/21/ 8



SUM OF ZONE SENSIBLE
COOLING LOADS                 0.00000E+00        0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM            0.00000E+00        0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM            0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                     0.00000E+00        0.00000E+00       0/ 0/ 0



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    2.96965E+02    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        4.60100E+02  FT**2
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ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     6.45437E-01    1000BTU /FT**2/DAY


NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.


 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                          0.00           0.00           0.00               24                        24
(MO/DY/HR):                        0/ 0/ 0                       1/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


         *********************************************************************************************************
         **                                                                                                     **
         **                           S U M M A R Y   U N M E T   L O A D S   R E P O R T                       **
         **                                                                                                     **
         *********************************************************************************************************


          SYSTEM NUMBER=         5, UNIT HEATER #1
          DESIGN DAY NEW YORK CITY NEW YORK SUMMER                                   SIMULATION DATE 21JUL1998 (MONDAY   )

ZONE #  UNDER HEAT          UNDER COOL          OVER HEAT           OVER COOL           HEAT W/O DMD        COOL W/O DMD
          1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS

    4   0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    1.031E+01 (  24)    0.000E+00 (   0)
        =========           =========           =========           =========           =========           =========
 TOTAL  0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    1.031E+01 (  24)    0.000E+00 (   0)


****************************************************************************
**                                                                        **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                        **
****************************************************************************


  SYSTEM NUMBER=         5, UNIT HEATER #1
  DESIGN DAY NEW YORK CITY NEW YORK SUMMER

  SIMULATION DATE 21JUL1998 (MONDAY   )

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU         1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                0.00000E+00         0.00000E+00       0/ 0/ 0

TOTAL HEATING PROVIDED
BY SYSTEM                    0.00000E+00         0.00000E+00       0/ 0/ 0



SUM OF ZONE SENSIBLE
COOLING LOADS                0.00000E+00         0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
```

```
PROVIDED BY SYSTEM          0.00000E+00        0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM          0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                   0.00000E+00        0.00000E+00       0/ 0/ 0



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    4.76022E+01    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        4.60100E+02  FT**2



ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     1.03461E-01    1000BTU /FT**2/DAY


NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.


 FRACTION OF OUTSIDE AIR           MAX [%]       AVG [%]       MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                          0.00          0.00          0.00                24                         24
(MO/DY/HR):                        0/ 0/ 0                     7/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


***************************************************************************
**                                                                       **
**     A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N     **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         6, UNIT HEATER #2

  TYPE SYS = UNIT HEATER                NO. DISTINCT ZONES ON SYS. =    1



  TOTAL SUPPLY  FAN PRESSURE =    2.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70

  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    7.20000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER
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```
  COLD DECK CONTROL = FIXED SET POINT
  COLD DECK THROTTLING RANGE =    0.00000     DEG. F
  COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                              ZONE DATA SUMMARY

  ZONE      ZONE        ZONE        ZONE        ZONE        ZONE        ZONE        ZONE
 NUMBER    SUPPLY     EXHAUST      REHEAT      REHEAT     TSTAT BB    TSTAT BB      MULT
          AIR VOL     AIR VOL      CAPCTY      ENERGY      CAPCTY      ENERGY
      5   2.200E+02   0.000E+00   3.412E+09   HOT WATER   0.000E+00   HOT WATER       1.0

  TOTAL DESIGN SUPPLY AIR VOLUME =  2.200E+02
***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         6, UNIT HEATER #2
  DESIGN DAY NEW YORK CITY NEW YORK WINTER

  SIMULATION DATE 21JAN1998 (MONDAY   )

                             TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU          1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                7.75885E+01         4.20379E+00       1/21/ 8

TOTAL HEATING PROVIDED
BY SYSTEM                    7.00263E+01         3.88870E+00       1/21/ 8


SUM OF ZONE SENSIBLE
COOLING LOADS                0.00000E+00         0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM           0.00000E+00         0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM           0.00000E+00         0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                    0.00000E+00         0.00000E+00       0/ 0/ 0



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    8.66285E+01    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.17000E+02  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     7.40415E-01    1000BTU /FT**2/DAY

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.
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```
 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                          0.00           0.00           0.00                24                         24
(MO/DY/HR):                        0/ 0/ 0                       1/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!


         ******************************************************************************************************************
         **                                                                                                              **
         **                            S U M M A R Y   U N M E T   L O A D S   R E P O R T                               **
         **                                                                                                              **
         ******************************************************************************************************************


          SYSTEM NUMBER=         6, UNIT HEATER #2
          DESIGN DAY NEW YORK CITY NEW YORK SUMMER                                  SIMULATION DATE 21JUL1998 (MONDAY   )

ZONE #  UNDER HEAT          UNDER COOL          OVER HEAT           OVER COOL           HEAT W/O DMD        COOL W/O DMD
          1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS      1000BTU  HOURS

    5   0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    7.562E+00 (  24)    0.000E+00 (   0)
        =========           =========           =========           =========           =========           =========
 TOTAL  0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    0.000E+00 (   0)    7.562E+00 (  24)    0.000E+00 (   0)


****************************************************************************
**                                                                        **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                        **
****************************************************************************


  SYSTEM NUMBER=         6, UNIT HEATER #2
  DESIGN DAY NEW YORK CITY NEW YORK SUMMER

  SIMULATION DATE 21JUL1998 (MONDAY   )

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU         1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL HEATING PROVIDED
BY SYSTEM                    0.00000E+00        0.00000E+00       0/ 0/ 0


SUM OF ZONE SENSIBLE
COOLING LOADS                0.00000E+00        0.00000E+00       0/ 0/ 0

SENSIBLE COOLING
PROVIDED BY SYSTEM           0.00000E+00        0.00000E+00       0/ 0/ 0

LATENT COOLING
PROVIDED BY SYSTEM           0.00000E+00        0.00000E+00       0/ 0/ 0

TOTAL COOLING PROVIDED
BY SYSTEM                    0.00000E+00        0.00000E+00       0/ 0/ 0
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TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    1.66023E+01    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.17000E+02  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     1.41900E-01    1000BTU /FT**2/DAY


NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.


 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]      HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
MX/MN DATES                          0.00           0.00           0.00                24                          24
(MO/DY/HR):                        0/ 0/ 0                       7/21/ 1

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!

          *********************************************************************************************************
          **                                                                                                     **
          **             P L A N T   E Q U I P M E N T   E N E R G Y   I N P U T   B R E A K D O W N             **
          **                                                                                                     **
          *********************************************************************************************************


          PLANT NUMBER=         1, PLANT #1



          DESIGN DAY NEW YORK CITY NEW YORK WINTER                            SIMULATION DATE 21JAN1998 (MONDAY   )


                                          CHILLED WATER EQUIPMENT ENERGY INPUT BREAKDOWN
```

HOUR	DIESEL CHILLER 1000BTU	GAS TURBINE CHILLER 1000BTU	ELECTRIC CHILLER 1000BTU	ABSORBER CHILLER HW/STEAM 1000BTU	ABSORBER PARASITIC ELECTRIC 1000BTU	CONDENSER/ TOWER ELECTRIC 1000BTU	CHILLED WATER PUMPS 1000BTU	TOTAL CW INPUT 1000BTU
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PEAK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR
	1/21/24	1/21/24	1/21/24	1/21/24	1/21/24	1/21/24	1/21/24	1/21/24

HOT WATER/STEAM AND SOLAR EQUIPMENT ENERGY INPUT BREAKDOWN ++ ELECTRIC GENERATOR ENERGY INPUT BREAKDOWN

HOUR	ELECTRIC BOILER 1000BTU	FUEL BOILER 1000BTU	FUEL BOILER ELECTRIC 1000BTU	HOT WATER PUMPS 1000BTU	SOLAR PUMP ELECTRIC 1000BTU	TOTAL HW/STEAM INPUT 1000BTU	++	DIESEL FUEL 1000BTU	GAS TURBINE FUEL 1000BTU	STEAM 1000BTU	TOTAL GENERATOR INPUT 1000BTU
1	0.00E+00	5.90E+02	0.00E+00	4.04E+00	0.00E+00	5.94E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	5.92E+02	0.00E+00	4.04E+00	0.00E+00	5.97E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	5.95E+02	0.00E+00	4.04E+00	0.00E+00	5.99E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	5.97E+02	0.00E+00	4.04E+00	0.00E+00	6.01E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	5.98E+02	0.00E+00	4.04E+00	0.00E+00	6.03E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	6.00E+02	0.00E+00	4.04E+00	0.00E+00	6.04E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	5.87E+02	0.00E+00	4.04E+00	0.00E+00	5.91E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	7.19E+02	0.00E+00	4.04E+00	0.00E+00	7.23E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	6.62E+02	0.00E+00	4.04E+00	0.00E+00	6.66E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	6.51E+02	0.00E+00	4.04E+00	0.00E+00	6.55E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	6.43E+02	0.00E+00	4.04E+00	0.00E+00	6.47E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	6.38E+02	0.00E+00	4.04E+00	0.00E+00	6.42E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	6.56E+02	0.00E+00	4.04E+00	0.00E+00	6.60E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	6.33E+02	0.00E+00	4.04E+00	0.00E+00	6.37E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	6.29E+02	0.00E+00	4.04E+00	0.00E+00	6.33E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	6.26E+02	0.00E+00	4.04E+00	0.00E+00	6.30E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	6.45E+02	0.00E+00	4.04E+00	0.00E+00	6.49E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	4.87E+02	0.00E+00	4.04E+00	0.00E+00	4.91E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	5.56E+02	0.00E+00	4.04E+00	0.00E+00	5.60E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	5.73E+02	0.00E+00	4.04E+00	0.00E+00	5.77E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	0.00E+00	5.79E+02	0.00E+00	4.04E+00	0.00E+00	5.83E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	0.00E+00	5.83E+02	0.00E+00	4.04E+00	0.00E+00	5.87E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	5.87E+02	0.00E+00	4.04E+00	0.00E+00	5.91E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	5.89E+02	0.00E+00	4.04E+00	0.00E+00	5.93E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	0.00E+00	1.46E+04	0.00E+00	9.71E+01	0.00E+00	1.47E+04	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PEAK	0.00E+00	7.19E+02	0.00E+00	4.04E+00	0.00E+00	7.23E+02	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	++	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR
	1/21/24	1/21/ 8	1/21/24	1/21/24	1/21/24	1/21/ 8	++	1/21/24	1/21/24	1/21/24	1/21/24

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***********************************************************************************************************
**                                                                                                       **
**           P L A N T   E Q U I P M E N T   E N E R G Y   I N P U T   B R E A K D O W N                 **
**                                                                                                       **
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PLANT NUMBER= 1, PLANT #1

DESIGN DAY NEW YORK CITY NEW YORK SUMMER SIMULATION DATE 21JUL1998 (MONDAY)

CHILLED WATER EQUIPMENT ENERGY INPUT BREAKDOWN

HOUR	DIESEL CHILLER 1000BTU	GAS TURBINE CHILLER 1000BTU	ELECTRIC CHILLER 1000BTU	ABSORBER CHILLER HW/STEAM 1000BTU	ABSORBER PARASITIC ELECTRIC 1000BTU	CONDENSER/ TOWER ELECTRIC 1000BTU	CHILLED WATER PUMPS 1000BTU	TOTAL CW INPUT 1000BTU
1	0.00E+00	0.00E+00	2.44E+01	0.00E+00	0.00E+00	6.35E-01	9.95E+00	3.50E+01
2	0.00E+00	0.00E+00	2.44E+01	0.00E+00	0.00E+00	6.24E-01	9.95E+00	3.50E+01
3	0.00E+00	0.00E+00	2.43E+01	0.00E+00	0.00E+00	6.17E-01	9.95E+00	3.49E+01
4	0.00E+00	0.00E+00	2.43E+01	0.00E+00	0.00E+00	6.11E-01	9.95E+00	3.49E+01
5	0.00E+00	0.00E+00	2.43E+01	0.00E+00	0.00E+00	6.14E-01	9.95E+00	3.48E+01
6	0.00E+00	0.00E+00	2.43E+01	0.00E+00	0.00E+00	6.22E-01	9.95E+00	3.48E+01
7	0.00E+00	0.00E+00	2.43E+01	0.00E+00	0.00E+00	6.26E-01	9.95E+00	3.49E+01
8	0.00E+00	0.00E+00	3.14E+01	0.00E+00	0.00E+00	5.54E+00	9.95E+00	4.69E+01
9	0.00E+00	0.00E+00	3.65E+01	0.00E+00	0.00E+00	7.10E+00	9.95E+00	5.36E+01
10	0.00E+00	0.00E+00	4.16E+01	0.00E+00	0.00E+00	8.36E+00	9.95E+00	5.99E+01
11	0.00E+00	0.00E+00	4.64E+01	0.00E+00	0.00E+00	9.38E+00	9.95E+00	6.57E+01
12	0.00E+00	0.00E+00	5.07E+01	0.00E+00	0.00E+00	1.02E+01	9.95E+00	7.08E+01
13	0.00E+00	0.00E+00	5.12E+01	0.00E+00	0.00E+00	1.02E+01	9.95E+00	7.13E+01
14	0.00E+00	0.00E+00	5.38E+01	0.00E+00	0.00E+00	1.06E+01	9.95E+00	7.44E+01
15	0.00E+00	0.00E+00	5.65E+01	0.00E+00	0.00E+00	1.11E+01	9.95E+00	7.76E+01
16	0.00E+00	0.00E+00	5.53E+01	0.00E+00	0.00E+00	1.08E+01	9.95E+00	7.61E+01
17	0.00E+00	0.00E+00	4.99E+01	0.00E+00	0.00E+00	9.79E+00	9.95E+00	6.97E+01
18	0.00E+00	0.00E+00	2.50E+01	0.00E+00	0.00E+00	8.01E-01	9.95E+00	3.58E+01
19	0.00E+00	0.00E+00	2.49E+01	0.00E+00	0.00E+00	7.91E-01	9.95E+00	3.57E+01
20	0.00E+00	0.00E+00	2.48E+01	0.00E+00	0.00E+00	7.67E-01	9.95E+00	3.56E+01
21	0.00E+00	0.00E+00	2.47E+01	0.00E+00	0.00E+00	7.39E-01	9.95E+00	3.54E+01
22	0.00E+00	0.00E+00	2.46E+01	0.00E+00	0.00E+00	6.98E-01	9.95E+00	3.53E+01
23	0.00E+00	0.00E+00	2.46E+01	0.00E+00	0.00E+00	6.68E-01	9.95E+00	3.52E+01
24	0.00E+00	0.00E+00	2.45E+01	0.00E+00	0.00E+00	6.48E-01	9.95E+00	3.51E+01
TOTAL	0.00E+00	0.00E+00	8.17E+02	0.00E+00	0.00E+00	1.03E+02	2.39E+02	1.16E+03
PEAK	0.00E+00	0.00E+00	5.65E+01	0.00E+00	0.00E+00	1.11E+01	9.95E+00	7.76E+01
AT	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/DY/HR 7/21/15	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/DY/HR 7/21/15	MO/DY/HR 7/21/24	MO/DY/HR 7/21/15

HOT WATER/STEAM AND SOLAR EQUIPMENT ENERGY INPUT BREAKDOWN ++ ELECTRIC GENERATOR ENERGY INPUT BREAKDOWN

ELECTRIC BOILER	FUEL BOILER	FUEL BOILER ELECTRIC	HOT WATER PUMPS	SOLAR PUMP ELECTRIC	TOTAL HW/STEAM INPUT	++	DIESEL FUEL	GAS TURBINE FUEL	STEAM	TOTAL GENERATOR INPUT

HOUR	1000BTU	1000BTU	1000BTU	1000BTU	1000BTU	1000BTU	++	1000BTU	1000BTU	1000BTU	1000BTU
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	4.95E-01	0.00E+00	4.04E+00	0.00E+00	4.54E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	7.83E-01	0.00E+00	4.04E+00	0.00E+00	4.83E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	9.17E-01	0.00E+00	4.04E+00	0.00E+00	4.96E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	7.81E-01	0.00E+00	4.04E+00	0.00E+00	4.82E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	3.50E-01	0.00E+00	4.04E+00	0.00E+00	4.39E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	3.16E-01	0.00E+00	4.04E+00	0.00E+00	4.36E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOTAL	0.00E+00	3.64E+00	0.00E+00	2.43E+01	0.00E+00	2.79E+01	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
							++				
PEAK	0.00E+00	9.17E-01	0.00E+00	4.04E+00	0.00E+00	4.96E+00	++	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	++	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR
	7/21/24	7/21/ 4	7/21/24	7/21/ 7	7/21/24	7/21/ 4	++	7/21/24	7/21/24	7/21/24	7/21/24

Technical Reference

Technical Reference Introduction

For ease of reference, BLAST program information is presented under four separate tabs:

1. The *Quick Reference* defines BLAST syntax.
2. The *User Reference* is an encyclopedic listing of user information.
3. The *Output* section explains all BLAST output reports.
4. The *Technical Reference* contains engineering, modelling and advanced user information.

The *Technical Referenc*e contains an encyclopedic listing of detailed information on advanced topics not covered in *Getting Started* or the *Quick Reference*. In *Getting Started* and *Quick Reference*, general information was presented to enable the user to develop a working BLAST model. The *Technical Reference* takes the user one step further by providing advanced topics that enable the user to customize the BLAST model. Each listing in the BLAST technical reference contains information on advanced user topics, such as modeling and derivation of equations, and enables the user to develop more complete and accurate BLAST models.

More specifically, each listing in this section contains a subject description, detailed derivation of equations used in calculations, and in some cases examples of the subject use in BLAST. This section also contains information on and sample performance curves for central plants such as chillers and boilers. In addition, this section contains extensive summaries for Controls, DX Condensing Unit, Generators, and Interaction of Loads and Systems.

Absorption Chillers

Single-stage, two-stage absorption chillers, and two-stage absorption chillers with economizers are modeled using the equipment performance parameter sets REN1A, REN2A, and REN2AE, respectively. In each case, the heat power consumed by the absorber is:

```
Heat Power = CL * (A1/PLR) + A2 + A3 * PLR
```

where:

CL = chiller load

PLR = part-load ratio

A1, A2, and A3 = appropriate performance coefficients of the REN1A, REN2A or REN2AE sets.

Thus, the REN1A, REN2A, and REN2AE coefficient sets establish the ratio of heat power in-to-cooling effect produced as a function of part load. The ratio of heat-power-in to cooling-effect-produced is the *inverse* of the coefficient of performance.

To generate the coefficients, the Heat Power equation can be rearranged as follows:

[Heat Power/CL] * PLR = A1 + A2 * (PLR) + A3 * $(PLR)^2$

For single-stage absorption chillers, which are to be driven by solar collectors, the CAVL1A coefficient set is used to specify the maximum part-load ratio as a function of the difference between the full-capacity temperature (TSATUR from SPECIAL PARAMETERS) and the temperature of the solar tank.

PLR_{max} = B1 + B2 * (ΔT) + B3 * $(\Delta T)^2$

where:

PLR_{max} = the maximum allowable PLR (a capacity limit)

ΔT = TSATUR - T_{tank}

Example

This example illustrates how manufacturer's data can be transformed to yield the appropriate REN1A coefficients.

According to the manufacturer of a single-stage absorber without economizer, the heat input at full load is 17800 Btu/hr-ton or 1.483 Btu/hr. This is the full load Heat Power/CL.

FFL	PLR
1.00	1.0
0.90	0.9
0.79	0.8
0.68	0.7
0.59	0.6
0.42	0.4
0.26	0.2
0.18	0.1

Table 25. Data from Manufacturer's Part-Load Curve

To convert the data for curve-fitting, the heat power per unit cooling load is 1.483 (FFL/PLR) for part load. The table below lists the results of [Heat Power/CL] * PLR = 1.483 * FFL.

[Heat Power/CL] * PLR	PLR
1.483	1.0
1.335	0.9

1.172	0.8
1.008	0.7
0.875	0.6
0.623	0.4
0.386	0.2
0.287	0.1

*Table 26. Inverse COP * PLR vs. PLR*

From a curve-fitting:

[Heat Power/CL] * (PLR) = 0.191 + 0.910 * (PLR) + 0.388 * $(PLR)^2$

The performance coefficients for this single-stage absorber can be specified by:

REN1A (0.191, 0.910, 0.388);

Values for the REN2A and REN2AE sets of coefficients can be determined in the same way.

Example 2

This example illustrates how manufacturer's data can be transformed to yield the appropriate CAVL1A coefficients for a solar driven absorption chiller.

A manufacturer states that the maximum PLR of an absorber for solar application is 0.15 at 170°F and 1.0 at 240°F and that its change in PLR_{max} is roughly proportional to temperature. Thus,the *change* in PLR as a function of ΔT is:

$$\frac{1.0 - 0.15}{170 - 240} = -0.0121$$

Thus:

$PLR_{max} = 1 - 0.0121 * (\Delta T)$

The term B3 is zero, since for this absorber, a straight-line relationship exists.

The parameter for this example is:

CAVL1A (1, -0.0121, 0);

Summary

A complete set of parameters for the example solar driven single-stage absorption chiller is:

REN1A (0.191, 0.910, 0.388);

CAVL1A (0.1184, -0.0121, 0);

Accuracy Verification for BLAST Family of Software

The numerical accuracy of any simulation like BLAST is dependent on the precision of the computer on which the program is run. The BLAST family of software is now available on a number of computers with varying CPU and coprocessor accuracy. It was, therefore, of interest to the BSO to compare BLAST and WIFE output generated on the most popular BLAST machines.

The comparison was done with the test files *dental.blin* and *youth.blin* using the *try.dat* weather file. For this test, the Macintosh, the IBM 386-PC, the Apollo workstation with a 9.7 Unix Domain operating system, and the Apollo workstation with a 10.2 Unix Domain operating system were used.

Machine type (compiler)	**CPU number storage (significant numbers)**	**Coprocessor storage (significant numbers)**
Macintosh (Language systems)	Real * 10 (80 bits) 19- 20 digits	Real * 12 (96 bits) 23 - 24 digits
PC-386 (NDP Fortran-386)	Real * 8 (64 bits) 15 - 16 digits	Real * 10 (80 bits) 19- 20 digits
9.7 Apollo (Domain Fortran)	Real * 8 (64 bits) 15 - 16 digits	Real * 8 (64 bits) 15 - 16 digits
10.2 Apollo (Domain Fortran)	Real * 8 (64 bits) 15 - 16 digits	Real * 8 (64 bits) 15 - 16 digits

Table 27. Comparison of various machine accuracies

The table "Comparison of various machine accuracies" shows the differences in the precision of the four systems tested. Macintosh BLAST was taken as a reference since the Language Systems Fortran Compiler, used to compile BLAST on the Macintosh, has the best precision. The 386-PC, with a math coprocessor is next in line since floating point coprocessor calculations are carried out to four more significant digits than the Apollo systems. Relative error is therefore defined by equation 1.

$$\text{Relative error} = \frac{\text{OtherVersionValue} - \text{MacValue}}{\text{MacValue}} \times 100 \qquad [1]$$

The focus of the BLAST runs was on total values since the maximum differences show up in the summation of the values for an annual run. The error is small for each hour, but as these errors are summed over 8760 hours, the differences become more apparent.

The table below shows results for total zone loads that were produced by running the example file *dental.blin,* which is distributed as a test file with the BLAST package.

	Total Heating load 1000 BTU	**Total Cooling load 1000 BTU**
Mac	61,390	446,200
10.2	61,410	446,100
9.7	61,410	446,100
386	61,390	446,200

Table 28. Differences in Dental.bin on various machines

From the previous table, we see that, for the significant digits shown, the Mac and the 386 have the same values and the results from the Apollos were consistent. By using equation [1], the relative error was calculated for total heating and total cooling loads and was found to vary from 0.0326% to -0.0224%, respectively.

A BLAST user from the Fort Worth District of the U.S. Army Corps of Engineers, created a BLAST input file called *youth.blin*. This file is well suited for detailed testing since it incorporates many important features of BLAST. Twenty zones, sixteen fan systems, and eight different plants are modeled in this file. Each Plant serves four fan systems. The fan systems are numbered 1 through 16. Plants 1,5 and 7 serve systems 1 through 4, plants 2, 6 and 8 serve systems 5 through 8, plant 3 serves the next four systems, and plant 4 serves systems 13 through 16.

The table below lists the relative error for total chilled water consumption based on an annual run for all eight plants. The Mac was again used as the reference machine. It should be noted that the chilled water consumption was the only value for an annual run that showed any significant difference between the four machines. The numbers in the table are the maximum relative error (using equation [1]) for the chilled water consumption for an annual run (8760 hours). Notice that the Mac and the 386 consistently gave similar results and that the Apollo with the 10.2 and the 9.7 operating systems showed the same accuracy.

	Plant #1	**Plant #2**	**Plant #3**	**Plant #4**	**Plant #5**	**Plant #6**	**Plant #7**	**Plant #8**
10.2	0.27%	0.23%	N/A	N/A	0.27%	0.23%	0.27%	0.23%
9.7	0.27%	0.23%	N/A	N/A	0.27%	0.23%	0.27%	0.23%
386	0.0%	0.0%	N/A	N/A	0.0%	0.0%	0.0 %	0.0%

Table 29. Relative error of total chilled water consumption of fan systems served by the eight plants.

* N/A - Direct expansion cooling

Results from the WIFE program with the test file *try.wea* (also distributed with the BLAST package) showed the same trends as the results from the BLAST runs. The Macintosh and the 386 PC gave the same precision, and the difference between them and the Apollos was 0.135%.

The results from all machines were as expected. The relative error was found to be much, much smaller than the overall accuracy of the simulations. Further differences would show up between the versions if more significant digits were shown in the reports, but there is no need to extend the number of significant digits currently displayed in BLAST output files. If someone is running BLAST on more than one machine, slight numeric differences in the output files might be seen, but these differences are not significant in the context of the overall simulation.

Bermed Buildings in BLAST

A study to determine a suitable method or methods for modeling bermed buildings with BLAST has been completed by the BLAST Support Office. A fairly simple model was developed that should be sufficient for most applications. This model consists of substituting a thick berm section for the section of an exterior wall that is bermed. The thermal properties of the berm material should be used for this construction. In order to account for the mass of the berm, the maximum possible thickness should be used for the new section of wall. The following formula was developed to determine the maximum allowable thickness for a construction in BLAST based on the thermal properties of the material in the construction:

$$L\sqrt{\frac{1}{\alpha}} < 50 \qquad \text{(SI units)}$$

or

$$L\sqrt{\frac{1}{\alpha}} < 27 \qquad \text{(English units)}$$

where α is the thermal diffusivity of the material defined by

$$\alpha = \frac{k}{\rho c_p}$$

where

k is the thermal conductivity $\frac{W}{m \cdot {}^{o}C}$ or $\frac{Btu}{hr \cdot ft \cdot {}^{o}F}$, ρ is the density $\frac{kg}{m^3}$ *or* $\frac{lbm}{ft^3}$, and c_p is the specific heat $\frac{kJ}{kg \cdot {}^{\circ}C}$ or $\frac{Btu}{lbm \cdot {}^{\circ} F}$

This formula is valid only for homogeneous walls. The figure below "Bermed Construction Details" illustrates the substitution of a thick berm section for the bermed section of an exterior wall.

A detailed report explaining berm modeling in BLAST is now available from the BLAST Support Office. The report includes a discussion of the heat transfer phenomena in ground heat transfer as well as results and recommendations for a variety of other more detailed berm models that were considered.

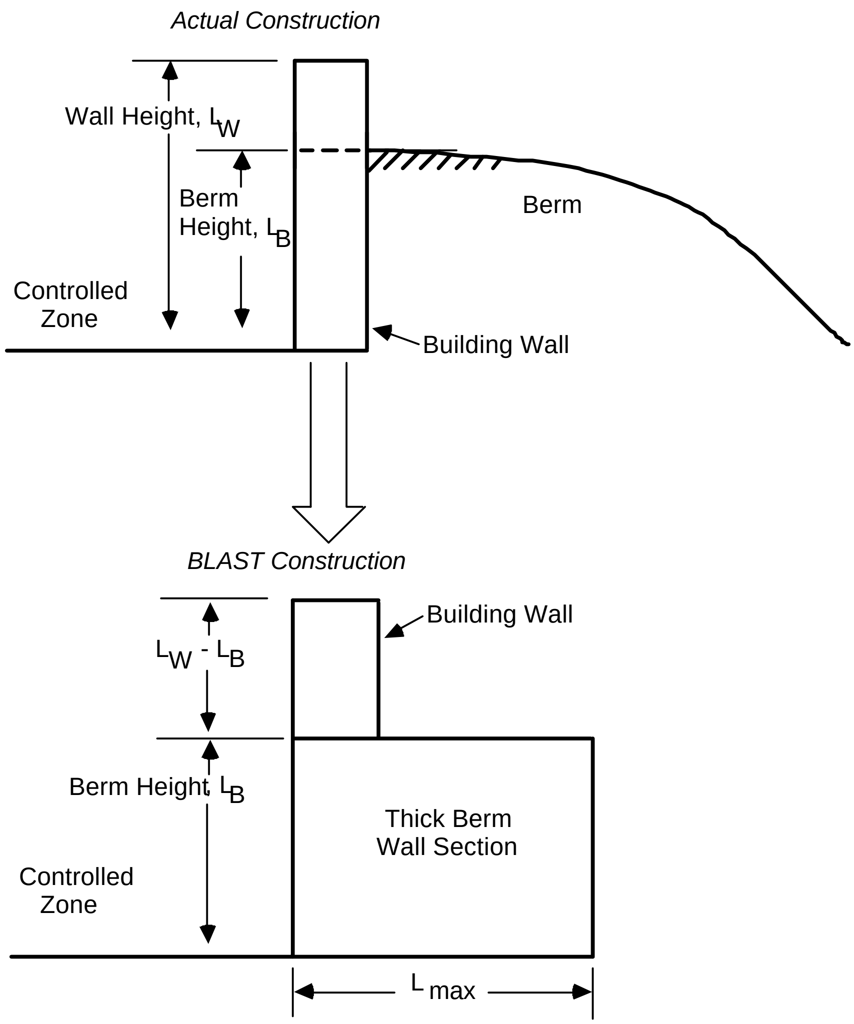

Figure 112. Bermed Building Construction Details

BLDFL and AHLDFL Files

Fine tuning a large BLAST run can be very time consuming, especially when annual runs are being made. If the same building description is being used to compare a number of fan systems or central plants, using existing BLDFL or AHLDFL files can save a tremendous amount of time. Since BLAST independently simulates the building, fan system and central plant, it is possible to simulate the building only one time and use the results of the building simulation (the BLDFL) to perform additional fan system and central plant simulations. Likewise, it is possible to save the results of the fan system simulation (the AHLDFL) and use these results to perform additional central plant simulations.

There is one drawback to using the BLDFL and AHLDFL in your BLAST simulations: these scratch files are very large and use a large amount of disk space. A typical BLDFL for a six zone building will take approximately 2.6 Megs of disk space.

Presently, BLDFLs and AHLDFLs can be used on the PC with a DoBLAST interface and on the Apollo with BLAST Level 130 or greater.

What is a BLDFL or AHLDFL File?

BLDFL, BLAST Scratch Files for Building Loads

A BLDFL is a random access file created by the load-determining subprogram containing hourly zone loads and other data. It is a required input to the air distribution system simulation program and by the load-determining program itself whenever the ADD ZONES or REPLACE ZONES run control parameters are specified.

AHLDFL, BLAST Scratch Files for Systems Loads

The AHLDFL is a random access file created by the air distribution system simulation subprogram containing hourly electrical power, heating and cooling coil energy demand, and other data. It is required as an input file by the central energy plant simulation subprogram and by the air distribution system simulation program itself any time the ADD AIR SYSTEMS or REPLACE AIR SYSTEMS run control parameters are specified.

How Does BLAST Create BLDFL and AHLDFL Files?

BLAST creates a BLDFL or an AHLDFL file whenever the NEW ZONES or NEW AIR SYSTEMS statements are used in the run control block.

The NEW ZONES statement tells BLAST to calculate loads for the zones described in the building description input block. All previous load calculations, if any, are disregarded. If NEW ZONES is not specified, no loads will be calculated. The NEW ZONES statement appears in the RUN CONTROL BLOCK as shown below:

```
BEGIN INPUT;
RUN CONTROL:
NEW ZONES,
NEW AIR SYSTEMS,
PLANT,
REPORTS(ZONE LOADS,SYSTEM LOADS,SYSTEM),
UNITS(IN=ENGLISH, OUT=ENGLISH);
.
.
.
```

The NEW AIR SYSTEMS tells BLAST to calculate system loads for the fan systems described in the fan system description input block. If NEW AIR SYSTEMS is not specified, no fan system simulation will be performed. Any fan system simulation requires that zone loads data be available. Under normal usage this requires that NEW ZONES be specified.

Why Reuse a BLDFL or an AHLDFL File?

Reuse of the building loads or air handling loads scratch files can take place when the BLAST run is created in a three-step process. The first step is creating the building description and lead input. When this portion is complete and runs without error for a design day, then the fan system simulation can be added. If the loads simulation is complete, then all the loads simulation information that is passed on to the fan system simulation can be stored and reused. The file that stores this information is the BLDFL file. This file can be stored permanently for use in additional simulations without recalculating the building loads. The second step is to input the fan systems; they can be added and debugged by reusing the BLDFL file. The third step is to add the central plants simulation after the fan systems are complete. The same procedure can be followed in reusing the AHLDFL file, which contains the air handling loads data needed for the central plant simulation. The reuse of the BLDFL and AHLDFL files can save the user a tremendous amount of time since it avoids resimulating elements to which no changes have been made.

How to Reuse a BLDFL or AHLDFL File

The BLDFL or the AHLDFL files can be used in later BLAST runs by keeping the loads files from being deleted at the end of the BLAST run. On the Apollo, the option can be added at the end of the runblast command to save the loads files. On the IBM PC (with the DoBLAST Interface version 2.0), the user has the option to save the BFLDFL or the AHLDFL files during the setup of each BLAST run.

Reusing Existing Loads Files

There are three things that must be done to reuse a loads file:

1.) Setup the scripts, or batch files, to save the proper loads file at the end of the initial BLAST run.

2.) Change the input file so that BLAST knows to reuse an old loads file.

3.) When the saved loads file is to be reused, the script, or batch file, is modified to make a copy of the loads file so BLAST can access it.

Remember that the BLAST program accesses the files bldfl.scr and ahldfl.scr with read and write commands directly from the program. The only statement in the BLAST input that tells whether to create a new loads file or reuse an old loads file is in the run control block of input.

The majority of the work that needs to be done to reuse loads files is manipulating the loads files before and after the BLAST runs so that they are in the correct place at the right time. The main thing that has to be done to the script or batch file is to make sure they do not delete the loads files upon completion of the BLAST run. Every step after this could be done by hand. The DoBLAST interface carries this a few steps further by copying these files with a different extension so additional BLAST runs will not impact those saved loads files. The last step for the scripts or batch files is to copy the loads files to be reused back to their original file names (bldfl.scr and ahldfl.scr) so BLAST can access these files for reuse.

Changing the Input File

The only change to the input file when the entire building description is reused, is to simply put two asterisks in front of the NEW ZONES line.

```
BEGIN INPUT;
    RUN CONTROL:
**  NEW ZONES,
    NEW AIR SYSTEMS,
    PLANT,
    REPORTS    etc.....
```

Remember that two asterisks in front of any line in a BLAST input will comment the line out. This completes the changes to the input file and allows the reuse of the building loads simulation results without having to delete any of the input.

Apollo RunBLAST Scripts

On the Apollo (level 130 or greater), the option to save the loads files can be added at the end of the runblast command.

runblast <input file name> <weather file, if an annual run> **-savefl**

While the IBM PC (with the DoBLAST interface) and the Vax are more "hands off" implementation for reusing the loads files, the Apollo needs more input by the user to effectively reuse the files. The runblast command only keeps the scratch files from being deleted. The runblast script does not change the file name and associate it with the project name as the other interfaces. To do this the loads file should be renamed to a different file name which represents the project that is being worked on, this will make the file accessible run after run. An example would be to copy the bldfl.scr to *project_name*.bld, which would represent the building loads file. Then a small script could be written which would copy the *project_name*.bld to bldfl.scr, then execute the runblast command for every run that reuses the loads files. This same type of procedure could be done for the air handling loads file.

DoBLAST Interface

The DoBLAST interface Level 2.0 is setup to allow saving and reuse of the loads files. Upon executing a BLAST run there are two screens which ask if you would like to save the BLDFL or the AHLDFL files. If you answer yes to either of the questions the batch file will not delete the loads files at the end of the BLAST run. The DoBLAST interface will save the loads files as:

1.) BLDFL as *project_name*.BLD

2.) AHLDFL as *project_name*.AHL

To reuse this information a *project_name*.BLD or *project_name*.AHL must exist at the start of execution, and at that time the interface will ask you if you would like to reuse this file.

HBLC Interface

HBLC is not explicitly set up to allow a user to automatically save BLDFL and AHLDFL files. In fact, it deletes them at the end of each run. However, there is an option to save the "RUNBLAST" script. An advanced user can use this feature to create the proper commands to reuse the BLDFL/AHLDFL files as previously discussed.

We'd suggest you follow similar procedures to the DOBLAST description and create your own set of batch files. You will, however, have to perform all the BLAST runs directly from the MS-DOS prompt rather than within HBLC.

Building and Air Handling Loads ADD or REPLACE

There are other options available in the Run Control block of BLAST input, these options are to add and replace zones or fan systems. To use either of these options you must still have a saved BLDFL or AHLDFL loads files. To add or replace a zone or a fan system, only the zone or fan system to be added or replaced can be in the input file. All the rest of the building description or other fan systems must be deleted, or commented out. This requirement severely limits the usefulness of the ADD and REPLACE options.

ADD ZONES tells BLAST that:

1.) The user has saved previously calculated loads data for one or more zones and now wishes to add calculated loads for new zones to the same load data file.

2.) The zones to be added, and only these zones, are described in the building description input block. Interzone partitions can not be specified since interaction between zones can not be taken into account.

3.) Every zone has a zone number assigned by the user, the added zones must be assigned different numbers from any zone numbers previously used.

4.) The loads that are to be calculated for the described zones and the hourly results are added to the loads data file.

*NOTE if previously assigned zone numbers are used, BLAST will stop after processing the input.

REPLACE ZONES tells BLAST that:

1.) The user has saved previously calculated loads data for one or more zones, but one or more of these zones have changed.

2.) Only zones for which loads are to be recalculated are described in the building description input block. Interzone partitions can not be specified since interaction between zones can not be taken into account.

3.) The replaced zones must have the same zone number as one of the previously simulated zones.

4.) The loads are to be recalculated for the described zones and the hourly results are to replace the previously calculated results on the loads data file. (Hourly results for previously calculated zone loads for zones not described in the building description block are not changed.)

*NOTE if a replaced zone is not assigned the same zone number as a previously simulated zone, BLAST will stop after processing the input.

Fan Systems have similar statements as zone loads:

ADD AIR SYSTEMS

REPLACE AIR SYSTEMS.

Each phrase serves a function analogous to the ADD and REPLACE ZONES. These statements modify previously saved fan system simulation results and require appropriate system descriptions in the fan system description input data block. Like zones, each fan system is assigned a number by the user. (HBLC automatically assigns numbers to zones and systems.) Any fan system simulation requires that zone load data be available either as a result of zone load calculations performed during the same BLAST run or by attaching saved results from a previous load calculation.

One User's Experience with BLDFL/AHLDFL Files

Editor's Note: The following letter was received by the BLAST Support Office via electronic mail. For comparison, the BLAST benchmark simulation, Dental Clinic, requires 45 minutes to complete on the Apollo. Using the BLDFL file, the same simulation requires only 5 minutes.

"I received the April [1990] issue of BLASTnews this morning. I would like to let you know [of] my experience [using the] BLDFL and AHLDFL files.

"Last night I started [on a 386/20] a set of simulations using BLDFL and AHLDFL files:

SET # 1: 20 ZONES

SET # 2: 20 ZONES

SET # 3: 12 ZONES

SET # 4: 4 SYSTEMS

SET # 5: 10 SYSTEMS

SET # 6: 20 SYSTEMS

SET # 7: 20 SYSTEMS

SET # 8: 3 PLANTS.

"The size of the BLDFL [representing a 52 zone simulation] is 21 MB. The size of the AHLDFL [representing a 54 system simulation] is 22 MB. The output [report] represents 8 MB.

"I performed the simulation for 3 design days and one TRY year. The simulation started at 9:30 pm and ended at 5:40 am the following day . . ."

Conclusion

For each machine that BLAST runs on, there is a slightly different procedure to save the building and system loads files. Some versions (such as the IBM PC) have fully automated the procedure; others require user implementation of each step in the procedure. There does not seem to be as much utility in using the ADD or REPLACE options in the run control block due to the large amount of change needed in the input file and the restrictions on zone interaction (ie. interzone partitions may not be used). The main things to remember to reuse the loads files are:

1.) Ensure that the loads file exists in the correct form at the beginning of the BLAST run.

2.) Modify the BLAST input file to indicate that you are reusing the loads file/files.

3.) Remember that the BLDFL and AHLDFL **consume large amounts of disk space**, use these options as necessary and then eliminate the loads files after the project is finished.

4.) Remember that this is an advanced option for BLAST use, and should be used carefully.

Boiler

The program calculates boiler performance in two steps. First, the air/fuel ratio, heat content of the fuel, and the stack temperature (all SPECIAL PARAMETERS) are used along with the ambient temperature and humidity ratio to compute the theoretical full-load boiler efficiency and theoretical fuel required to meet the load. The following semi-empirical relationship is used to compute theoretical efficiency (efficiency is expressed as a fraction from 0 to 1);

η = [0.87 - 1.25 *(STRATB/HFUELB) [TLEAVE - TAIR] * $c_{p,ex}$)]

where:

η	= efficiency
STRATB	= air to fuel ratio in lb/lb
HFUELB	= heating value of fuel as fired in Btu/lb
TLEAVE	= boiler stack leaving temperature in °F
TAIR	= ambient air temperature °9F (air is assumed to be dry)
$c_{p, ex}$	= specific heat of exhaust (assumed constant at .24 Btu/lb * °F)

Boiler Example 1

First consider a high-pressure steam boiler whose stack temperature is 550°F (the default). Hypothetical part-load data at standard conditions (dry air and 77°F) might be:

Hypothetical Part-Load Data

PLR	Actual Efficiency
1.1	0.720
1.0	0.730
0.8	0.725
0.6	0.716
0.4	0.700
0.2	0.650

The theoretical efficiency at these conditions is 0.749. Note that

$$\frac{\text{theoretical fuel consumption}}{\text{actual fuel consumption}} = \frac{\text{actual efficiency}}{\text{theoretical efficiency}}$$

The table below, which is necessary to calculate the RFUELB coefficients, can be generated. For 0.8 PLR, for example, the actual/theoretical is 0.725/0.749 = 0.968.

actual η/theoretical η	PLR
0.961	1.1

0.975	1.0
0.968	0.8
0.956	0.6
0.935	0.4
0.868	0.2

Table 30. Data For Finding RFUELB Coefficients

After curve-fitting:

$$\frac{\text{actual efficiency}}{\text{theoretical efficiency}} = \frac{\text{theoretical fuel consumption}}{\text{actual fuel consumption}} = 0.801 + (0.405)\text{PLF}$$

To simulate this boiler, the user must specify:

RFUELB (0.801, 0.405, -0.235);

Boiler Example 2

This example is perhaps more typical of a low-temperature hot water boiler. In this case, the stack temperature is 300°F (the special parameter TLEAVE defaults to 550°F, so it must be changed) and the resulting theoretical efficiency is 0.813 for the same air/fuel ratio and fuel heating value as before. The actual full-load efficiency is 0.79, and the test data are:

PLR	Fraction of Full-Load Fuel Input (FFLF Input)
1.0	1.00
0.8	0.81
0.6	0.63
0.4	0.45
0.2	0.27

Table 31. Boiler Part-Load Performance

The actual efficiency at part load is computed from the data in the above table as follows:

$$\text{actual efficiency} = 0.79\frac{\text{PLR}}{\text{FFLF Input}}$$

The table below shows the ratio of actual efficiency-to-theoretical efficiency for various loads.

actual/theoretical	PLR
0.972	1.0
0.960	0.8
0.925	0.6
0.864	0.4
0.720	0.2

Table 32. Ratio of Actual Efficiency to Theoretical Efficiency for Part Loads

After curve-fitting:

$$\frac{\text{actual efficiency}}{\text{theoretical efficiency}} = 0.563 + 0.921 * (PLR) - 0.518 * (PLR)^2$$

For this boiler, the specification is

RFUELB (0.563, 0.921, -0.518);

The curves in the following figure illustrate the default RFUELB curve as well as the RFUELB curve for the above examples.

Actual-to-theoretical Efficiency Ratio vs. KPLR for Boiler.

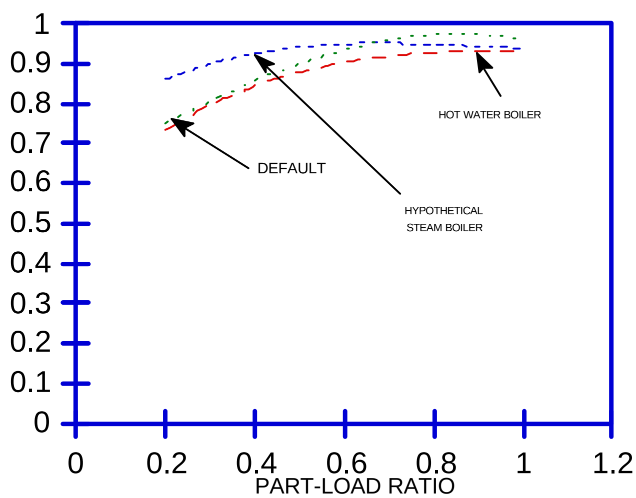

Figure 113. Efficiency vs PLR Curves

Summary

The parameter sets for the examples will be specified by:

RFUELB (0.801, 0.405, -0.235);

or

RFUELB (0.563, 0.921, -0.518);

Clothing Insulation

The thermal resistance of clothing has been measured for many typical items, and a listing has been included in the figure below. Note that the *ASHRAE Handbook of Fundamentals* suggests multiplying the summation of individual clothing items by a factor of 0.82 for clothing ensembles. In other words, for a man wearing a T-shirt, briefs, ankle socks, oxfords, a light short sleeve shirt, and light trousers, the maximum clothing insulation would be:

$$0.82*(0.09+0.05+0.04+0.04+0.14+0.26)=0.5084$$

The BLAST default value is 1.0.

Men		Women	
Clothing	**clo**	**Clothing**	**clo**
Underwear			
Sleeveless	0.06	Bra and Panties	0.05
T Shirt	0.09	Half Slip	0.13
Briefs	0.05	Full Slip	0.19
Long underwear upper	0.35	Long underwear lower	0.35
Torso			
Shirt		*Blouse*	
Light, short sleeve	0.14	Light	0.20
long sleeve	0.22	Heavy	0.29
Heavy, short sleeve	0.25		
long sleeve	0.29	*Dress*	
(Plus 5% for tie or turtleneck)		Light	0.22
		Heavy	0.70
Vest		*Skirt*	
Light	0.15	Light	0.10
Heavy	0.29	Heavy	0.22
Trousers		*Slacks*	
Light	0.26	Light	0.26
Heavy	0.32	Heavy	0.44
Sweater		*Sweater*	
Light	0.20	Light	0.17
Heavy	0.37	Heavy	0.37
Jacket		*Jacket*	
Light	0.22	Light	0.17
Heavy	0.49	Heavy	0.37
Footwear			
Socks		*Stockings*	
Ankle Length	0.04	Any length	0.01
Knee Length	0.1	Panty Hose	0.01
Shoes		*Shoes*	
Sandals	0.02	Sandals	0.02
Oxfords	0.04	Pumps	0.04
Boots	0.08	Boots	0.08

Table 33. Clo Units for Individual Items of Clothing§

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Controls

The following sections detail control profiles for various fan systems. The general format will include a brief description of the system, a nomenclature section defining the appropriate parameters and variables, the equations used to determine the control profile points, an example, and a discussion of the limitations of the formulations.

There are several different methods of developing control profiles. The method described and used in this guide is algebraic in nature and all variables and parameters will be carried through to the final equation. This may appear more formidable than substituting known values as you go, but it is more practical for cookbook solutions. All the user will need to do is to substitute the appropriate parameters into some simple equations to find each point of a control profile.

The method used here begins with writing an energy balance for the zone air. The terms in the energy balance equation that vary depending on zone air temperature are identified. Equations for these terms as functions of zone air temperature are written and substituted into the energy balance equation. Generally, several equations that are each applicable over a different range of zone temperatures will be needed.

Having developed the appropriate equation or equations, we will know the amount of heating or cooling provided to the zone as a function of temperature. We then calculate the maximum heating and maximum cooling provided to the zone and the zone temperature at which no heating or cooling is provided (T_0). The energy balance equation is divided by the maximum heating capacity for temperatures below T_0 and by the maximum cooling capacity for temperatures above T_0. This is essentially the control profile.

The control profile is then described to BLAST as a set of points. The points are determined by evaluating the function at the endpoint of each range of zone temperatures. Ideally, the equations for each range of zone temperatures are linear. In practice, this is not always true, but we use a linear approximation because this is the form required by BLAST.

Control Profile Macros for Lotus and Symphony on the PC are available from the BLAST Support Office. These macros can aid the creation of control profiles. For more information, please contact the Blast Support Office.

Overview of Control Variations between Fan System Types

Discussion of SZD

SZD with DX Unit

System type can subtly affect room temperature control strategies. For example, assume that a package DX condensing unit with electric heat has been selected to serve the zone whose control strategy is shown in the figure below. Further assume that the unit delivers 3850 cfm (1.82 m³/s) to the space and that the cooling coil was selected to allow 55 °F (12.8 °C) air to be delivered at the design sensible load of 100 kBtu/hr (23.4 kW). In this case the below figure closely approximates the achieved room temperature control. The room thermostat will modulate the condensing unit from "off" to "full" capacity through as many capacity control steps as are available on the unit. This modulation will occur in roughly linear fashion as the balance point room temperature varies from 77 to 79°F (25 to 26.1°C). The heating will be similarly modulated between 69 and 67°F (20.6 and 19.4°C), and both heating and cooling will be "off" between 69 and 77°F (20.6 and 25.0°C). Since the condensing unit's maximum heating and cooling capacity are approximately constant, the unit adds or removes fixed quantities of heat whenever the room temperature is below 67°F (19.4°C) or above 79°F (26.1°C).

SZD with Hot and Chilled Water

If a single-zone drawthrough unit served by hot and chilled water is selected instead of a package DX unit, the control strategy of the figure below may require a slight revision. If room temperature remains between 67 and 79°F below is correct. However, as long as the boiler and chiller serving the coils in the fan unit can deliver constant temperature hot and chilled water, the maximum capacity of the heating and cooling coils is *not* independent of room temperature. For example, as the room temperature rises toward 79°F (26.1°C), the room thermostat opens the cooling coil's chilled water valve until the valve is fully opened at 79°F (26.1°C). If room heat gains are sufficient, the room air temperature will continue to rise; but as it rises, the temperature of the air entering the coil also rises. As a result, the cooling capacity of the coil gradually increases. The dotted lines on the figure below show this trend for both the heating and cooling coils. Coil catalog data can be used to determine the change in coil capacity that occurs with changing entering air conditions.

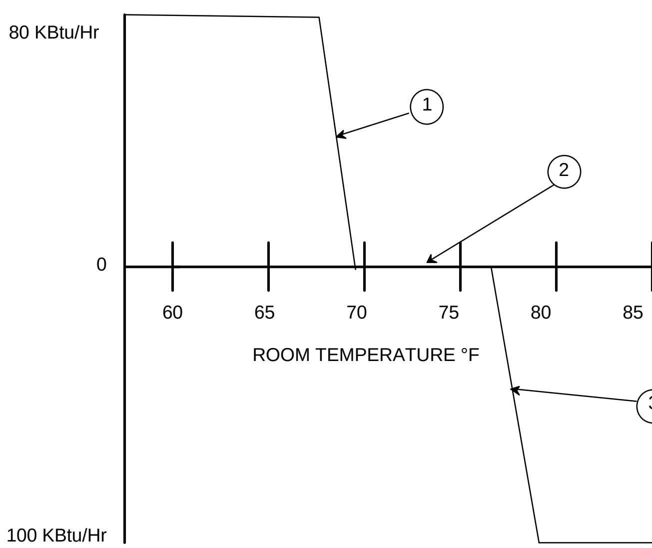


Figure 114. Capacity as a function of temperature for package DX unit

In the case of the single-zone drawthrough unit, the thermostat is in control of the heating and cooling capacity as long as sufficient capacity is available to keep the room temperature within the range of the thermostat (67 through 79°F [19.4 through 26.1°C] in the single-zone drawthrough example). Fortunately, most systems are designed with sufficient capacity to maintain comfort conditions, and users need only be concerned about room temperature control characteristics which are outside the range of the thermostat when the heating or cooling system has been inadvertently or deliberately undersized.

Multizone (3-Deck)

The figure below shows the equivalent HEATANDCOOL control profile that should be used if a three-deck multizone unit is selected to serve several zones with the same thermostat throttling ranges and deadband. The rationale for selecting this profile is:

1. Range 3 is the thermostat deadband in which almost all air delivered to the zone passes through the bypass deck of the three-deck multizone system and is neither heated nor cooled.
2. In Range 2, air from the hot deck and the bypass deck of the fan system are mixed to meet heating requirements in the zone. This is the heating throttling range for the thermostat. At its lower end (67°F [19.4°C]), all air to the zone comes from the hot deck and the air delivered to the zone is approximately at the hot deck temperature (87.7°F [31°C], for example).
3. If heat losses are severe, the room temperature may continue to fall into Range 1. In this range, air entering the zone emanates from the hot deck only. As long as the fan system heating coil is not overloaded, the air is supplied to the zone at constant temperature. *However, the amount of heat added to the room air continues to increase as the room air temperature falls.* The amount of heat added per hour can be calculated from the following formula:

$$Q = mC_P (T_S - T_R) \qquad [1]$$

where:

m = mass flow rate of air supplied by the fan system to the room,

C_P = specific heat of air,

T_S = supply air temperature to the room (in this case the hot deck temperature),

T_R = air temperature in the room.

For this system, m and C_P are constant and T_S is constant for Range 1. Therefore, as the room temperature (T_R) falls, the heat added to the room increases linearly as shown in the figure below.

4. Ranges 4 and 5 are analogous to Ranges 2 and 1 but are for cooling.

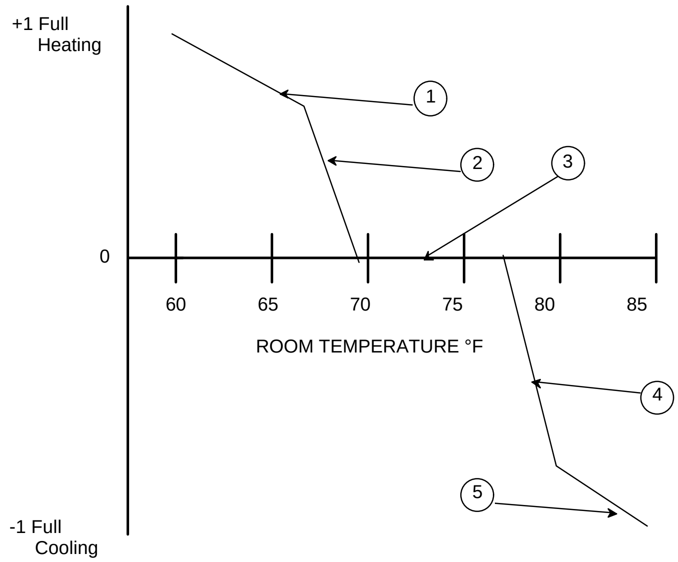


Figure 115. Capacity vs Temperature for a three-deck multizone system

General Discussion

When defining a control profile like the one shown in the figure above, users should select arbitrarily low and high room temperatures to establish the full heating and full cooling (+1 and -1) points on this profile. In the example, 60 and 85°F (15.6 and 29.4°C) were selected. When specifying corresponding heating and cooling capacities for each zone (refer to the workshop in the *Getting Started* section), the "design" capacity generally should not be used. The capacities should correspond with the selected low and high temperatures.

In the DX condensing unit, single-zone drawthrough, and three-deck multizone examples, load calculations will yield identical results when the control profile shown in the figure above or the figure below is used, *providing* that the temperature in the space stays between 67 and 79°F (19.4 and 26.1°C) during the hours of the day when the control profile is in effect.

The same reasoning used for the three-deck multizone system can be used to construct control profiles for spaces served by conventional multizone, dual duct, or reheat systems (see the figure "Control profile for systems with no deadband"). Ranges 1 and 3 correspond to Ranges 1 and 5 of the figure for the three deck multizone (above), respectively. Range 2 covers the temperature range where the mixing box, zone dampers, or reheat coils are modulated by the room thermostat. No deadband is possible with these systems.

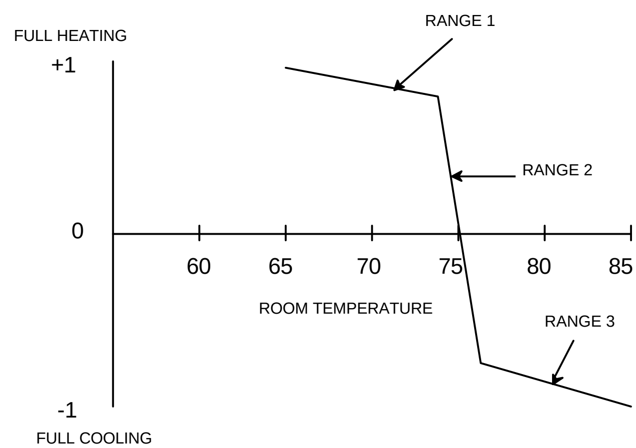


Figure 116. Control profile for systems with no deadband

The figure below shows a typical control profile for a variable volume system with reheat. It was constructed based on the assumption that 3850 cfm (1.82 m³/s) of 55°F (12.8°C) delivery air is to be supplied to the zone with the VAV dampers fully open at 79°F (26.1°C) and closed to their minimum of 20 percent at 77°F (25°C). Reheat is to operate between 69 and 67°F (20.6 and 19.4°C), and the reheat coil will deliver air at 140°F (60°C) when fully energized. The figure below shows the calculation made to arrive at the control profile.

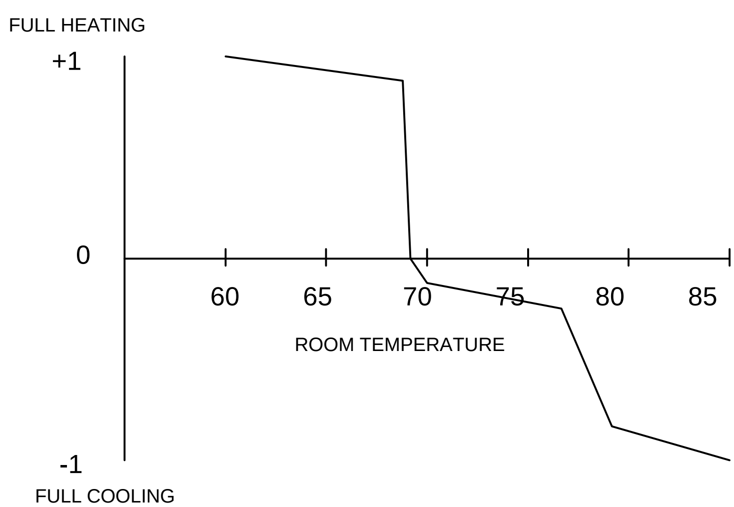


Figure 117. Profile for a VAV system with reheat

The following three sections will discuss the Multizone, VAV, and Terminal Reheat System types and the calculation of control profiles for them in greater detail.

Temperature [°F (°C)]	Capacity [kBtu/hr (kW)]	Normalized Capacity
85.0 (29.4)	-125 (-36.6)	-1.00
79.0 (26.1)	-100 (-29.3)	-0.80

77.0 (25.0)	- 18 (- 5.3)	-0.15
69.0 (20.6)	- 12 (- 3.5)	-0.09
68.7 (20.4)	0 (0.0)	0.00
67.0 (19.4)	61 (17.9)	0.91
60.0 (15.6)	66 (19.3)	1.00

Table 34 Calculation of Control Profile
Multizone, VAV and Terminal Reheat

Multizone Controls

System Description

The control profiles developed in this section apply to multizone systems. The typical features of a multizone system include hot and cold decks and separate mixing dampers for each zone. The total air flow to each room is kept constant while the proportion of hot air to cold air is adjusted to maintain the temperature in each zone at the desired level.

In order to develop a generic control profile, it is necessary to use certain approximations and assumptions that may or may not be appropriate for all multizone systems. It is up to the user to determine the applicability of the control profile developed here to a particular system. Assumptions and approximations that are made here include the following:

1.) Constant deck temperatures (i.e. PI (proportional-integral) control of coils).

2.) Density (ρ), specific heat (C_p) and the total volumetric flow rate (V_{TOT}) are assumed to be constant.

3.) We assume that over a given throttling range, the dampers mix the air in a linear fashion. For example, if we have 100% cold air when the zone temperature is 72°F, and 100% hot air when the zone temperature is 68°F, then we expect that at 70°F, we have 50% hot air and 50% cold air. Likewise, at 69°F, we have 75% hot air and 25% cold air. This is the best approximation that can be made without taking into account specific damper characteristics.

Nomenclature

C_p = Specific heat of the air. (BTU/lbm °F)

m = Mass flow rate. (lbm/s)

Q = Zone heating load; Q < 0 implies a cooling load. (kBtu/hr)

Q_{MAXH} = Maximum heating provided to zone when $T_Z = T_{ZMIN}$. (kBtu/hr)

Q_{MAXC} = Maximum cooling provided to zone when $T_Z = T_{Z,MAX}$. (kBtu/hr)

T_{COLD} = Cold deck temperature. (°F)

T_{HOT} = Hot deck temperature. (°F)

T_S = Supply air (mixed air) temperature. (°F)

T_Z = Zone air temperature. (°F)

$T_{Z,0}$ = Zone air temperature at which $T_S=T_Z$, where the system is not providing heating or cooling to the zone. (°F)

T_{ZC} = Zone air temperature above which $V_{COLD}=V_{TOT}$, $V_{HOT}=0$. (°F)

T_{ZH} = Zone air temperature below which $V_{HOT}=V_{TOT}$, $V_{COLD}=0$. (°F)

$T_{Z,MAX}$ = Maximum zone air temperature that is likely to occur. (°F)

$T_{Z,MIN}$ = Minimum zone air temperature that is likely to occur. (°F)

V_{HOT} = Volumetric flow rate of air from hot deck. (CFM)

V_{COLD} = Volumetric flow rate of air from cold deck. (CFM)

V_{TOT} = Total volumetric flow rate. (CFM)

ρ = Density of air. (lbm/ft³)

Derivation

A first law of thermodynamics energy balance on a zone gives:

$$Q = m * C_p * (T_S - T_Z)$$

$$Q = \rho * C_p * V_{TOT} * (T_S - T_Z) \quad [1a]$$

As previously discussed, ρ, V_{TOT} and C_p are all assumed to be constant. T_S is a function of the flow and temperature from each deck:

$$T_S = (\rho * Cp * V_{HOT} * T_{HOT} + \rho * Cp * V_{COLD} * T_{COLD}) / \rho * Cp * V_{HOT} \quad [1b]$$

Factoring out $\rho * C_p$, which is assumed to be constant, we have:

TS = (VHOT ∗ THOT + VCOLD ∗ TCOLD)/VTOT [2]

T_{HOT} and T_{COLD} are fixed. V_{HOT} and V_{COLD} are dependent on how the mixing dampers are controlled. We can specify V_{HOT} and V_{COLD} as functions of T_Z for each of three different regions of zone temperatures.

For $T_Z > T_{ZC}$:

$V_{COLD} = V_{TOT}$, $V_{HOT} = 0$, and $T_S = T_{COLD}$. [3a]

For $T_Z < T_{ZH}$:

$V_{HOT} = V_{TOT}$, $V_{COLD} = 0$, and $T_S = T_{HOT}$. [3b]

For $T_{ZH} - T_Z - T_{ZC}$:

Based on our "linear-mixing" assumption,

$V_{HOT} = V_{TOT} * (T_{ZC} - T_Z)/(T_{ZC} - T_{ZH})$,

and

VCOLD = VTOT ∗ (TZ - TZH)/(TZC - TZH).

Substituting these two equations for V_{HOT} and V_{COLD} into [2], we obtain:

$$T_S = \frac{(T_{ZC} - T_Z) * T_{HOT} + (T_Z - T_{ZH}) * T_{COLD}}{(T_{ZC} - T_{ZH})} \quad [3c]$$

Now, substituting [3a-c] into [1] yields the following set of equations:

For $T_Z > T_{ZC}$: $Q = \rho * C_p * V_{TOT} * (T_{COLD} - T_Z)$. [4a]

For $T_Z < T_{ZH}$: $Q = \rho * Cp * V_{TOT} * (T_{HOT} - T_Z)$. [4b]

For $T_{ZH} – T_Z – T_{ZC}$:

$$Q = \rho * C_p * V_{TOT} * \left(\frac{(T_{ZC} - T_Z) * T_{HOT} + (T_Z - T_{ZH}) * T_{COLD}}{T_{ZC} - T_{ZH}} - T_Z \right).$$

[4c]

In order to cast equations [4a-c] in forms that will be useful for writing control profiles, one more piece of information needs to be determined. We need the temperature at which the system provides neither heating nor cooling to the zone by virtue of $T_S=T_Z$. To find this zone air temperature, $T_{Z,0}$, set the left hand side of [4c] to zero and solve for T_Z.

$T_{Z,0} = (T_{ZC} * T_{HOT} - T_{ZH} * T_{COLD})/(T_{HOT}-T_{COLD} + T_{ZC} - T_{ZH})$
[5]

Now, divide [4a-c] by Q_{MAXH} for $T_Z < T_{Z,0}$ and by Q_{MAXC} for $T_Z > T_{Z,0}$ where

$Q_{MAXH} = \rho * Cp * V_{TOT} * (T_{HOT} - T_{Z,MIN})$ [6a]

$Q_{MAXC} = \rho * Cp * V_{TOT} * (T_{Z,MAX} - T_{COLD})$ [6b]

For $T_Z > T_{ZC}$:

$Q/Q_{MAXC} = (T_{COLD} - T_Z)/(T_{Z,MAX} - T_{COLD})$ [7a]

For $T_{Z,0} – T_Z – T_{ZC}$:

$$Q/Q_{MAXC} = \frac{(T_{ZC} - T_Z) * T_{HOT} + (T_Z - T_{ZH}) * T_{COLD}}{(T_{ZC} - T_{ZH}) * (T_{Z,MAX} - T_{COLD})} - \frac{T_Z}{(T_{Z,MAX} - T_{COLD})}$$

[7b]

For $T_{ZH} – T_Z – T_{Z,0}$:

$$Q/Q_{MAXH} = \frac{(T_{ZC} - T_Z) * T_{HOT} + (T_Z - T_{ZH}) * T_{COLD}}{(T_{ZC} - T_{ZH}) * (T_{HOT} - T_{Z,MIN})} - \frac{T_Z}{(T_{HOT} - T_{Z,MIN})}$$

[7c]

For $T_Z < T_{ZH}$:

$Q/Q_{MAXH}= (T_{HOT} - T_Z)/(T_{HOT} - T_{Z,MIN})$ [7d]

Now, we can determine equations for each point on the control profile by substituting the desired zone temperatures into [7a-d].

$T_{Z,MAX}$ $Q/Q_{MAXC} = -1.$ [8a]

T_{ZC} $Q/Q_{MAXC} = (T_{COLD} - T_{ZC})/(T_{Z,MAX} - T_{COLD})$ [8b]

$T_{Z,0}$ $Q/Q_{MAXC} = Q/Q_{MAXH} = 0$ [8c]

T_{ZH} $Q/Q_{MAXH} = (T_{HOT} - T_{ZH})/(T_{HOT} - T_{Z,MIN})$ [8d]

$T_{Z,MIN}$ $Q/Q_{MAXH} = 1.$ [8e]

Together, [8a-e] and [5] are a complete description of the points on a control profile. Exactly how to use them will be summarized in the "Procedure" section, and an example will be given in the "Example" section below. In addition, appropriate heating and cooling capacities must be calculated for each zone that the system serves. The capacities can be easily calculated with equations [6a-b].

Procedure for Constructing a Multizone Control Profile

1. Determine T_{COLD}, T_{HOT}, T_{ZC}, T_{ZH}, $T_{Z,MAX}$, and $T_{Z,MIN}$ for the building and system you wish to simulate. (Note that in many cases, $T_{ZC}=T_{Z,MAX}$ and $T_{ZH}=T_{Z,MIN}$.) These are values that must be selected by the designer.

2. Calculate $T_{Z,0}$ using:

   $T_{Z,0} = (T_{ZC} * T_{HOT} - T_{ZH} * T_{COLD})/(T_{HOT} - T_{COLD} + T_{ZC} - T_{ZH})$ [5]

3. Calculate Q/Q_{MAXC} for T_{ZC} using:

   $Q/Q_{MAXC} = (T_{COLD} - T_{ZC})/(T_{Z,MAX} - T_{COLD})_p$ [8b]

4. Calculate Q/Q_{MAXH} for T_{ZH} using:

   $Q/Q_{MAXH} = (T_{HOT} - T_{ZH})/(T_{HOT} - T_{Z,MIN})$ [8d]

5. Remember that $Q/Q_{MAXC} = -1$ for $T_Z = T_{Z,MAX}$ and $Q/Q_{MAXH} = 1$ for $T_Z = T_{Z,MIN}$. All points necessary for a BLAST control profile have now been determined.

6. Write the control profile in BLAST syntax.

7. Determine the required flow rate (V_{TOT}) from the peak zone loads.

8. Determine the heating and cooling capacities for each zone the system serves using

   $Q_{MAXH} = \rho * Cp * V_{TOT} * (T_{HOT} - T_{Z,MIN})$ [6a]

   $Q_{MAXC} = \rho * Cp * V_{TOT} * (T_{Z,MAX} - T_{COLD})$ [6b]

Example Multizone Control Profile

You wish to design a multizone system with a cooling capacity of 10,000 BTU/hr (@72°F) and a heating capacity of 5,000 BTU/hr (@68°F) for a given zone. PI controllers will allow the hot deck to be maintained at 115°F and the cold deck to be maintained at 55°F. The dampers will be controlled to provide 100% hot air at 68°F (and below) and 100% cold air at 72°F (and above). Between 68°F and 72°F, the dampers will be modulated linearly. (This is an approximation, of course.)

Furthermore, you use setback at night and on weekends so that the building temperature may be as high as 95°F or as low as 55°F when the system starts up in the morning. Assume that the chiller/coil combination has enough capacity to maintain the specified deck temperatures over the full range of indoor/outdoor environmental conditions.

1. From the problem statement, we see that:

T_{HOT} = 115

T_{COLD} = 55

$T_{Z,MAX}$ = 95

$T_{Z,MIN}$ = 55

T_{ZH} = 68

T_{ZC} = 72

2. $T_{Z,0}$ = (72 ∗ 115 - 68 ∗ 55)/(115 - 55 + 72 - 68)

= 70.9°F

3. For T_{ZC} = 72°F

Q/Q_{MAXC} = (55 - 72)/(95 - 55) = -.425

4. For T_{ZH} = 68°F

Q/Q_{MAXH} = (115 - 68)/(115 - 55) = .783

5. For $T_{Z,MAX}$ = 95, Q/Q_{MAXC} = -1

For $T_{Z,MIN}$ = 55, Q/Q_{MAXH} = 1

We can now make a table showing Q/Qmax vs. Zone Temp.

Zone temp.	**Q/Q_{MAX}**
55.0	1.0
68.0	0.78
70.9	0.0
72.0	-0.43
95.0	-1.0

Table 35. Q/Qmax vs. Zone Temp

A graph of this control profile is shown in the figure below.

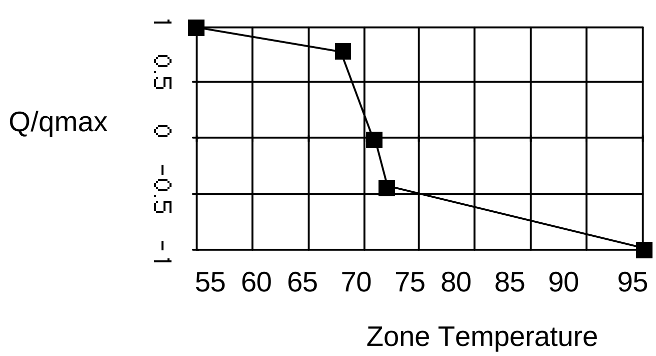


Figure 118. Graph of example control profile

6. If we assume some typical scheduling, the following control schedule results.

```
TEMPORARY CONTROLS (MULTIZONE WITH SETBACK):
PROFILES:
    MZ = (1.0 AT 55, 0.78 AT 68, 0.0 AT 70.9,
         -0.43 AT 72, -1.0 AT 95);
    SB = (1.0 AT 54.9, 0.0 AT 55);
SCHEDULES:
    MONDAY THRU FRIDAY = (07 TO 17 - MZ, 17 TO 07 - SB),
    SATURDAY THRU SUNDAY = (00 TO 24 - SB),
    HOLIDAY = SUNDAY;
END CONTROLS;
```

7. The next task is to determine the required flow rate (V_{TOT}). In this system, the flow rate will be determined by the cooling requirement. The standard equation is:

$$Q = 1.08 * V_{TOT} * (\Delta T), \text{ where } \Delta T = (T_{ZC} - T_{COLD})$$

$$V_{TOT} = \frac{Q}{1.08\ \Delta T} = \frac{10,000}{1.08\,(72 - 55)} = 545 \text{ CFM}$$

A supply air volume of 600 CFM is chosen to allow a slight safety factor.

8. Now that we know the total supply air volumetric flow rate, we can calculate Q_{MAXC} and Q_{MAXH}.

Q_{MAXH} = 1.08 ∗ 600 ∗ (115 - 55) = 38,880 BTU/hr

= 38.9 kBtu/hr

Q_{MAXC} = 1.08 ∗ 600 ∗ (95 - 55) = 25,920 BTU/hr

= 25.9 kBtu/hr

The BLAST controls syntax will be:

CONTROLS = MULTIZONE WITH SETBACK, 38.9 HEATING, 25.9 COOLING;

VAV Controls

System Description

The control profiles developed below apply to VAV systems. Air flows through a main cooling coil and exits at a constant cold deck temperature. The air is then split off and sent to each separate zone. A VAV box, or terminal unit in each zone, modulates the amount of air sent to the zone with a damper. If the zone requires heating, a reheat coil heats the air just before entering the zone.

In order to develop a control profile for this kind of system, it is necessary to use certain approximations that may or may not be appropriate for all VAV systems. It is up to the user to determine if these assumptions apply for the system in question. The assumptions used include the following:

1.) Constant cold deck temperature (i.e. PI (proportional-integral) control of coil).

2.) Density (ρ) and specific heat (c_p) are constant.

3.) The damper modulates linearly over the throttling range of the VAV box. Below the range of the VAV box, the damper stays at its minimum fraction (see the figure "Flow Rate vs Zone Temperature for a VAV system" below).

4.) The reheat coil modulates linearly between two temperatures. At the lower temperature, the reheat coil is adding the maximum amount of energy to the air. At the higher temperature, the coil is just beginning to turn on (shown in figure "Heat Added vs Zone Temperature by a reheat coil in a VAV system"). Since the temperature entering the reheat box is constant, the exit temperature is a linear function of zone temperature (see figure "Supply Temperature vs Zone Temperature for a VAV system").

Nomenclature

c_p = Specific heat of the air. (BTU/lbm°F)

ρ = Density of air. (lbm/ft^3)

Q = Zone heating load; Q< 0 implies a cooling load. (BTU/hr)

T_{cold} = Cold deck temperature set point. (°F)

T_{hot} = Maximum temperature leaving the reheat coil. (°F)

T_s = Air temperature supplied to the zone. (°F)

T_z = Zone air temperature. (°F)

$T_{z,0}$ = Zone temperature where heating (or cooling) supplied to the zone is zero. (°F)

$T_{z,max}$ = Maximum zone air temperature that is likely to occur. (°F)

$T_{z,min}$ = Minimum zone air temperature that is likely to occur. (°F)

$T_{rh,h}$ = Zone temperature at which the reheat begins to turn on. (°F)

$T_{rh,l}$ = Zone temperature at which the reheat is fully on. (°F)

$T_{vav,h}$ = Temperature when the VAV damper is fully open. (°F)

$T_{vav,l}$ = Temperature when the VAV damper is at minimum fraction. (°F)

V = Volumetric flow rate. (CFM)

V_{max} = Maximum volumetric flow rate. (CFM)

f_{min} = The minimum fraction of the VAV box.

$Q_{rh,cap}$ = The capacity of the reheat coil. (BTU/hr)

Q_{maxh} = The maximum heating capacity. (BTU/hr)

Q_{maxc} = The maximum cooling capacity (this number is negative). (BTU/hr)

F = Units conversion factor used in the First Law of Thermodynamics to convert minutes to hours (60 min/1 hr)

Derivation

Using a First Law of Thermodynamics energy balance on the zone, we get the basic equation:

$$Q = F\rho c_p V(T_s - T_z) \qquad [1]$$

Note that the product $F\rho c_p$ in English Units is equal to 1.08. This number is commonly used in the equation

Q[BTU/hr] = 1.08*CFM*ΔT[F]

The reheat coil at full capacity can be expressed as:

$$Q_{rh,cap} = F\rho c_p f_{min} V_{max} (T_{hot} - T_{cold}) \quad [2]$$

T_{hot} can then be found by rearranging [2]:

$$T_{hot} = \; + T_{cold} \quad [3]$$

In some cases, the reheat coil capacity will be specified; in some cases, T_{hot} will be specified. Take whichever is known and use equation [2] or [3] to calculate the other.

From [1], the maximum cooling rate is then:

$$Q_{maxc} = F\rho c_p V_{max} (T_{cold} - T_{z,max}) \quad [4]$$

Likewise, the maximum heating rate is:

$$Q_{maxh} = F\rho c_p f_{min} V_{max} (T_{hot} - T_{z,min}) \quad [5]$$

Algebraically, the volumetric flow rate can be represented by three regions.

For T_z _ $T_{vav,h}$:

$$V = V_{max} \quad [6a]$$

For $T_{vav,l}$ _ T_z _ $T_{vav,h}$:

$$V = \left[f_{min} + \frac{(T_z - T_{vav,1}) - (1.0 - f_{min})}{(T_{vav,h} - T_{vav,1})} \right] = V_{max}$$

[6b]

For T_z _ $T_{vav,l}$:

$$V = f_{min} V_{max} \quad [6c]$$

Similarly, the supply temperature can be expressed for three regions.

For T_z _ $T_{rh,h}$:

$$T_s = T_{cold} \quad [7a]$$

For $T_{rh,l}$ _ T_z _ $T_{rh,h}$:

$$T_s = T_{hot} - \frac{(T_{hot} - T_{cold})(T_z - T_{rh,1})}{(T_{rh,h} - T_{rh,1})} \quad [7b]$$

For T_z _ $T_{rh,l}$:

$$T_s = T_{hot} \quad [7c]$$

Substituting [6] and [7] into [1] gives five different regions.

For $T_{vav,h}$ _ T_z _ $T_{z,max}$:

$$Q = F\rho c_p V_{max} (T_{cold} - T_z) \quad [8a]$$

For Tvav,l _T_z _ Tvav,h:

$$Q = F\rho c_p V_{max}$$

$$\left[f_{min} + \frac{(1.0 - f_{min})(T_z - T_{vav,1})}{(T_{vav,h} - T_{vav,1})}\right](T_{cold} - T_z)$$

For $T_{rh,h}$ _ T_z _ $T_{vav,l}$:

$$Q = F\rho c_p f_{min} V_{max} (T_{cold} - T_z) \quad [8c]$$

For $T_{rh,l}$ _ T_z _ $T_{rh,h}$:

$$Q = F\rho c_p f_{min} V_{max}$$

$$\left[(T_{hot} - T_z) - \frac{(T_{hot} - T_{cold})(T_z - T_{rh,1})}{(T_{rh,h} - T_{rh,1})}\right]$$

For $T_{z,min}$ _ T_z _ $T_{rh,l}$:

$$Q = F\rho c_p f_{min} V_{max} (T_{hot} - T_z) \quad [8e]$$

Next we must find the zone temperature where Q equals zero. This point is found to be:

$$T_{z,0} \; \frac{T_{rh,h} * T_{hot} - T_{rh,1} * T_{cold}}{T_{hot} - T_{cold} + T_{rh,h} - T_{rh,1}} \quad [9]$$

BLAST Control Profile

A point on the BLAST control profile is defined as Q /$|Q_{max}|$ where $|Q_{max}|$ is the absolute value of Q_{maxc} if in the cooling range or Q_{maxh} if in the heating range. The control profile is simply the fraction of peak cooling or heating at a specific zone temperature. We must divide by the absolute value in order to keep the correct sign in the profile (negative for cooling and positive for heating).

Each point on the control profile then becomes (linearizing the points in between):

Temperature	Normalized Capacity	
$T_{z,max}$	$\frac{Q}{\lvert Q_{maxc}\rvert} = -1$	[10a]
$T_{vav,h}$	$\frac{Q}{\lvert Q_{maxc}\rvert} = \frac{(T_{cold} - T_{vav,h})}{(T_{z,max} - T_{cold})}$	[10b]
$T_{vav,l}$	$\frac{Q}{\lvert Q_{maxc}\rvert} = \frac{f_{min}(T_{cold} - T_{vav,1})}{(T_{z,max} - T_{cold})}$	[10c]
$T_{rh,h}$	$\frac{Q}{\lvert Q_{maxc}\rvert} = \frac{f_{min}(T_{cold} - T_{rh,h})}{(T_{z,max} - T_{cold})}$	[10d]
$T_{z,0}$	$\frac{Q}{\lvert Q_{max\,h}\rvert} = 0$	[10e]

$T_{rh,l}$ $$\frac{Q}{\left|Q_{max\,h}\right|} = \frac{(T_{hot} - T_{rh,1})}{(T_{hot} - T_{z,min})} \quad [10f]$$

$T_{z,min}$ $$\frac{Q}{\left|Q_{max\,h}\right|} = 1 \quad [10g]$$

Procedure for Constructing a VAV Control Profile

1. Determine T_{cold}, T_{hot}, $T_{vav,h}$,$T_{vav,l}$, $T_{rh,l}$, $T_{rh,h}$, $T_{z,max}$, $T_{z,min}$, and f_{min} for the building and system you wish to simulate. These are values that must be selected by the designer.

2. Determine the maximum flow rate (V_{max}) from the cooling specification.

3. Calculate $Q_{rh,cap}$ knowing T_{hot} or calculate T_{hot}, knowing $Q_{rh,cap}$:

   Qrh,cap = FρcpfminVmax (Thot - Tcold) [2]

   $$Thot = \frac{Q_{rh,cap}}{F\rho c_p f_{min} V_{max}} + Tcold \quad [3]$$

4. Determine $T_{z,0}$ using the following equation:

   $$Tz,0 = \frac{T_{rh,h} * T_{hot} - T_{rh,1} * T_{cold}}{T_{hot} - T_{cold} + T_{rh,h} - T_{rh,1}} \quad [9]$$

5. Calculate Q/ $|Q_{maxc}|$for $T_{vav,h}$ using:

   $$\frac{Q}{\left|Q_{max\ c}\right|} = \frac{(T_{cold} - T_{vav,h})}{(T_{z,max} - T_{cold})} \quad [10b]$$

6. Calculate Q /$|Q_{maxc}|$ for $T_{vav,l}$ using:

   $$\frac{Q}{\left|Q_{maxc}\right|} = \frac{f_{min}(T_{cold} - T_{vav,1})}{(T_{z,max} - T_{cold})} \quad [10c]$$

7. Calculate Q /$|Q_{maxc}|$ for $T_{rh,h}$ using:

   $$\frac{Q}{\left|Q_{maxc}\right|} = \frac{f_{min}(T_{cold} - T_{rh,h})}{(T_{z,max} - T_{cold})} \quad [10d]$$

8. Calculate Q/Q_{maxh} for $T_{rh,l}$ using:

   $$\frac{Q}{\left|Q_{max\,h}\right|} = \frac{(T_{hot} - T_{rh,1})}{(T_{hot} - T_{z,min})} \quad [10f]$$

9. Remember that:

$$\frac{Q}{|Q_{maxc}|} = -1 \text{ for } T_z = T_{z,max}, \quad [10a]$$

$$\frac{Q}{|Q_{maxc}|} = 0 \text{ for } T_z = T_{z,0}, \text{ and} \quad [10e]$$

$$\frac{Q}{|Q_{maxh}|} = 1 \text{ for } T_z = T_{z,min}. \quad [10g]$$

All the points necessary for a BLAST control profile have now been determined.

10. Write the control profile in BLAST syntax.
11. Determine the heating and cooling capacities for each zone the system serves using:

$$Q_{maxc} = F\rho c_p V_{max} (T_{cold} - T_{z,max}) \text{ and} \quad [4]$$

$$Q_{maxh} = F\rho c_p V_{max} f_{min} (T_{hot} - T_{z,min}). \quad [5]$$

Example VAV Control Profile

You wish to design a VAV system that can provide 40,000 BTU/hr of cooling (@76°F) for a given zone. PI control will keep the cold deck at 50°F. The VAV box controller will keep the box fully open at 76°F and above; the box will be at its minimum fraction of 0.4 at 72°F. Reheat comes on at 70°F and is at full capacity at 67°F. The reheat coil can supply 30,000 BTU/hr of heating.

Furthermore, you use setback at night and on weekends so that the building temperature may be as high at 90°F or as low as 55°F when the system starts up in the morning. Assume that the chiller/reheat combination has enough capacity to maintain the specified deck temperatures over the full range of indoor/outdoor environmental conditions.

1. From the problem statement, we see that:

   $T_{z,max}$ = 90°F

   $T_{z,min}$ = 55°F

   $T_{rh,h}$ = 70°F

   $T_{rh,l}$ = 67°F

   $T_{vav,h}$ = 76°F

   $T_{vav,l}$ = 72°F

   T_{cold} = 50°F

   $Q_{rh,cap}$ = 30,000 BTU/hr

   f_{min} = 0.4

2. The next task is to determine the required flow rate, V_{max}. In this system, the flow rate will be determined by the cooling requirement.

   The properties of air at standard conditions are:

   ρ= 0.075 lbm/ft^3

c_p= 0.24 BTU/lbm·°F

Therefore, $Fc_p\rho$ = 0.075 * 0.24 * 60 = 1.08 BTU/hr·CFM·°F

V_{max} is then calculated as:

$$V_{max} = \frac{40,000}{1.08 * (76 - 50)} = 1425 \text{ CFM}$$

3. Calculate T_{hot}:

$$T_{hot} = \frac{30,000}{(1.08 * 1425 * 0.4) + 50} = 98.7\ °F$$

4. $T_{z,0} = \frac{(70 * 98.7 - 67 * 50)}{(98.7 - 50 + 70 - 67)} = 68.8\ °F$

5. At $T_{vav,h}$: Q /|Q_{maxc}| = (50-76)/(90-50) = -0.65

6. At $T_{vav,l}$: Q /|Q_{maxc}| = 0.4(50-72)/(90-50) = -0.22

7. At $T_{rh,h}$: Q /|Q_{maxc}| = 0.4(50-70)/(90-50) = -0.2

8. At $T_{rh,l}$: Q /|Q_{maxh}| = (98.7-67)/(98.7-55) = 0.73

9. At $T_{z,min}$: Q /|Q_{maxh}| = 1

   At $T_{z,max}$: Q /|Q_{maxc}| = -1

   At $T_{z,0}$: Q /|Q_{maxc}| = 0

   We can now make a table showing Q / |Qmax| vs. zone temperature.

Zone Temperature ºF	Q / |Q_{max}|
55.0	1.00
67.0	0.73
68.8	0.00
70.0	-0.20
72.0	-0.22
76.0	-0.65
90.0	-1.00

Table 36. Table showing Q ratio and zone temperature

A graph of this control profile is shown in the figure below.

10. Assuming typical scheduling, the following BLAST syntax results.

```
TEMPORARY CONTROLS (VAV SYSTEM WITH SETBACK):
PROFILES:
    VAV = (1.0 AT 55, 0.73 AT 67,0.0 AT 68.8,-0.2 AT 70,
         -0.22 AT 72,-0.65 AT 76,-1.0 AT 90);
    SB = (1.0 AT 54.9, 0.0 AT 55);
SCHEDULES:
    MONDAY THRU FRIDAY = (07 TO 17 -VAV,17 TO 07 - SB),
    SATURDAY THRU SUNDAY = (00 TO 24 - SB),
    HOLIDAY = SUNDAY;
END CONTROLS;
```

11. Now that we know the total supply air volumetric flow rate, we can calculate Q_{maxc} and Q_{maxh}.

    Calculate Q_{maxh} and Q_{maxc}:

    Q_{maxh} = 1.08 * 0.4 * 1425 * (98.7 - 55) = 26,900 BTU/hr

    Q_{maxc} = 1.08 * 1425 * (50-90) = -61,600 BTU/hr

    The BLAST controls syntax will be:

    CONTROLS = VAV SYSTEM WITH SETBACK, 26.9 HEATING, 61.6 COOLING;

Discussion of Example VAV Control Profile

In this example, we assumed that the "chiller/reheat combination has enough capacity to maintain the specified deck temperatures over the full range of indoor/outdoor environmental conditions." This is, of course, an approximation, since control profiles are based on indoor environmental conditions and can not be modified to explicitly account for outdoor environmental conditions. The best we can do is to pick $T_{z,max}$ and $T_{z,min}$ such that the system is likely to maintain its deck temperatures under the indoor/outdoor environmental conditions that are likely to cause those zone temperatures.

A more conservative approximation would be to assume that the chiller is not oversized and that there is no extra capacity when the zone temperature exceeds $T_{vav,h}$, i.e. 76 °F in this example. In this case, one would set $T_{z,max}$ equal to $T_{vav,h}$. This would have the effect of having constant capacity above 76 °F. One would do likewise for the $T_{z,min}$, setting it to 67 °F.

This problem stems from the separation of the BLAST loads simulation and the system simulation. The BSO is currently researching ways to combine the simulations that would solve this and other problems.

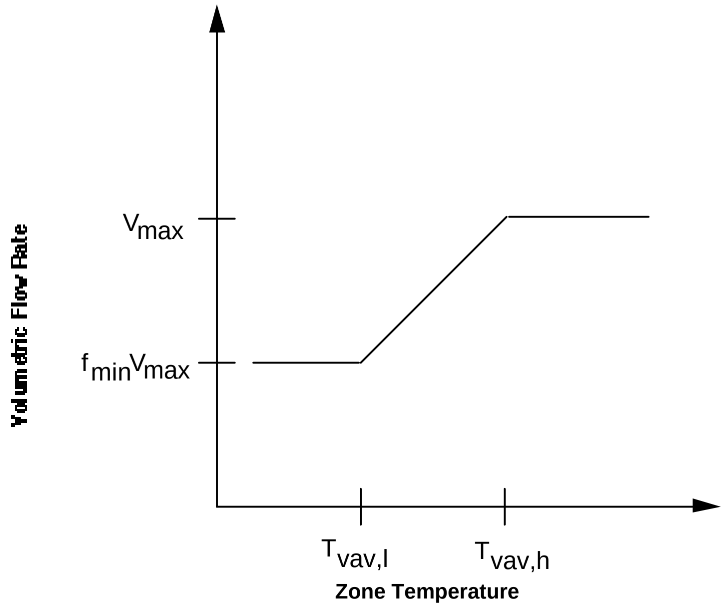


Figure 119. Flow Rate vs Zone Temperature for a VAV system

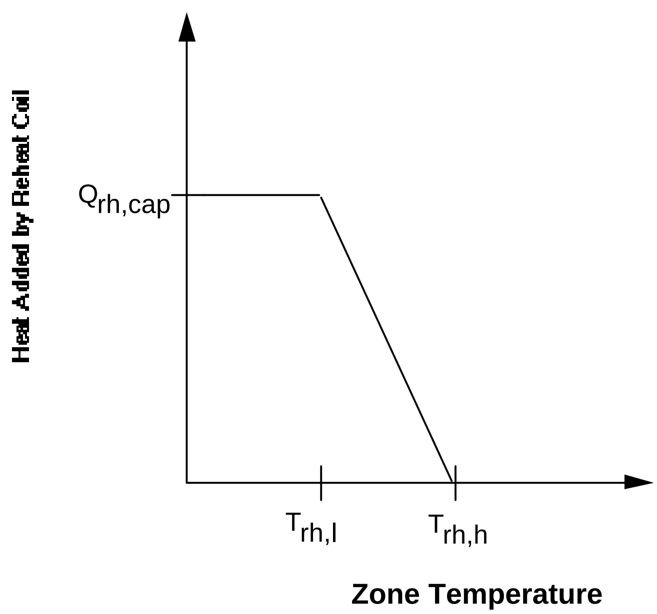


Figure 120. Heat Added vs Zone Temperature by a reheat coil in a VAV system

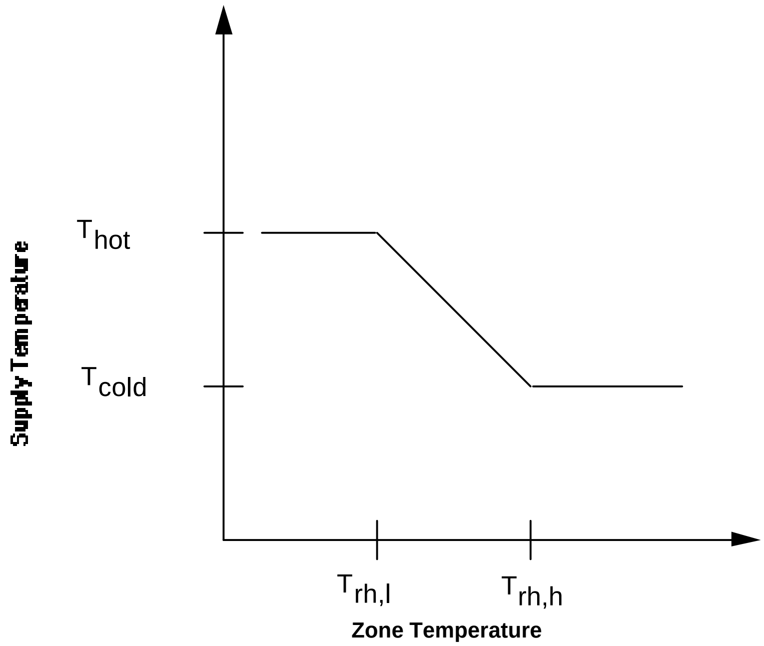


Figure 121. Supply Temperature vs Zone Temperature for a VAV system

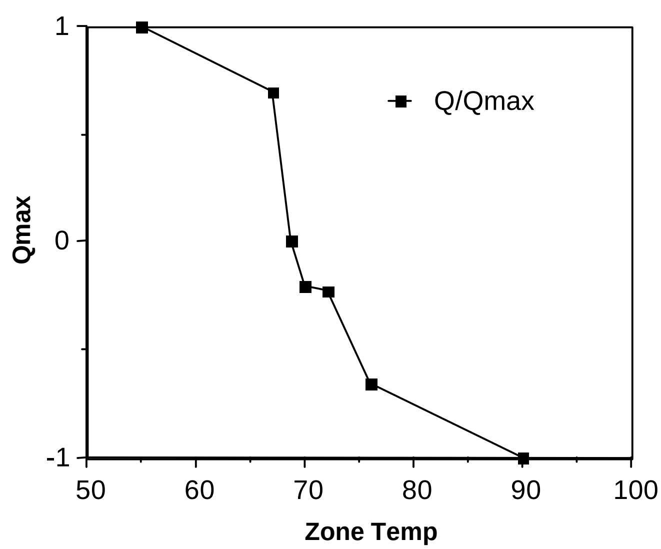


Figure 122. Control profile for a VAV system

Terminal Reheat Controls

System Description

The control profiles developed below apply to Terminal Reheat (TRH) systems. Air flows through a main cooling coil and exits at a constant cold deck temperature. The air is then split off and sent to each separate zone. If the zone requires heating, then the air is heated by a reheat coil just before entering the zone.

In order to develop a control profile for this kind of system, it is necessary to use certain approximations that may or may not be appropriate for all TRH systems. It is up to the user to determine if these assumptions apply for the system in question. The assumptions used include the following:

1.) Constant cold deck temperature (i.e. PI (proportional-integral) control of coil).

2.) Density (ρ) and specific heat (c_p) are assumed to be constant.

3.) The reheat coil modulates linearly between two temperatures. At the lower temperature, the reheat coil is adding the maximum amount of energy to the air. At the higher temperature, the coil is just beginning to turn on (reference figure "Heat Added vs Zone Temperatures by Reheat Coil"). Since the temperature entering the reheat box is constant, the exit temperature is a linear function of zone temperature (reference figure "Supply Temperatures vs Zone Temperatures").

Nomenclature

c_p = Specific heat of the air. (BTU/lbm °F)

ρ = Density of air. (lbm/ft^3)

Q = Zone heating load; Q< 0 implies a cooling load. (BTU/hr)

T_{cold} = Cold deck temperature set point. (°F)

T_{hot} = Maximum temperature leaving the reheat coil. (°F)

T_s = Air temperature supplied to the zone. (°F)

T_z = Zone air temperature. (°F)

$T_{z,0}$ = Zone temperature where heating (or cooling) supplied to the zone is zero. (°F)

$T_{z,max}$ = Maximum zone air temperature that is likely to occur. (°F)

$T_{z,min}$ = Minimum zone air temperature that is likely to occur. (°F)

$T_{rh,h}$ = Zone temperature at which the reheat begins to turn on. (°F)

$T_{rh,l}$ = Zone temperature at which the reheat is fully on. (°F)

V = Volumetric flow rate. This is a constant. (CFM)

$Q_{rh,cap}$ = The capacity of the reheat coil. (BTU/hr)

Q_{maxh} = The maximum heating capacity. (BTU/hr)

Q_{maxc} = The maximum cooling capacity (This number is negative). (BTU/hr)

F = Units conversion factor used in the First Law of Thermodynamics to convert minutes to hours (60 min/1 hr)

Derivation

Using a First Law of Thermodynamics energy balance on the zone, we get the basic equation:

$$Q = F\rho c_p V(T_s - T_z) \qquad [1]$$

Note that the product $F\rho c_p$ in English Units is equal to

$$1.08\left[\frac{BTU}{hr * CFM * {}^\circ F}\right]$$

This number is commonly used in the equation

$Q[BTU/hr] = 1.08*CFM*\Delta T[{}^\circ F]$

The reheat coil at full capacity can be expressed as:

$$Q_{rh,cap} = F\rho c_p V\,(T_{hot} - T_{cold}) \quad [2]$$

T_{hot} can then be found by rearranging [2]:

$$T_{hot} = \frac{Q_{rh,cap}}{F_{\rho}\,cp} + T_{cold} \quad [3]$$

In some cases, the reheat coil capacity will be specified; in some cases, T_{hot} will be specified. Take whichever is known and use equation [2] or [3] to calculate the other.

From [1], the maximum cooling rate is then:

$$Q_{maxc} = F\rho c_p V\,(T_{cold} - T_{z,max}) \quad [4]$$

The maximum heating rate occurs when:

$$Q_{maxh} = F\rho c_p V\,(T_{hot} - T_{z,min}) \quad [5]$$

The supply temperature can be expressed for three regions (reference figure "Heat Added vs Zone Temperatures by Reheat Coil").

For T_z _ $T_{rh,h}$:

$$T_s = T_{cold} \quad [6a]$$

For $T_{rh,l}$ _ T_z _ $T_{rh,h}$:

$$T_s = T_{hot} - \frac{(T_{hot} - T_{cold})(T_z - T_{rh,1})}{(T_{rh,h} - T_{rh,1})} \quad [6b]$$

For T_z _ $T_{rh,l}$:

$$T_s = T_{hot} \quad [6c]$$

Substituting [6] into [1] gives three different regions.

For $T_{rh,h}$ _ T_z _ $T_{z,max}$:

$$Q = F\rho c_p V\,(T_{cold} - T_z). \quad [7a]$$

For $T_{rh,l}$ _ T_z _ $T_{rh,h}$:

$$Q = F\rho c_p V\left[(T_{hot} - T_z) - \frac{(T_{hot} - T_{cold})(T_z - T_{rh,1})}{(T_{rh,h} - T_{rh,1})}\right.$$

[7b]

For $T_{z,min}$ _ T_z _ $T_{rh,l}$:

$$Q = F\rho c_p V(T_{hot\mathbf{b}} - T_z). \quad [7c]$$

Next we must find the zone temperature where Q equals zero. This point is found to be:

$$T_{z,0} = \frac{T_{rh,h} * T_{hot} - T_{rh,1} * T_{cold}}{T_{hot} - T_{cold} + T_{rh,h} - T_{rh,1}} \quad [8]$$

BLAST Control Profile

A point on the BLAST control profile is defined as Q /$|Q_{max}|$ where $|Q_{max}|$ is the absolute value of Q_{maxc} if in the cooling range or Q_{maxh} if in the heating range. The control profile is simply the fraction of peak cooling or heating at a specific zone temperature. We must divide by the absolute value in order to keep the correct sign in the profile (negative for cooling and positive for heating).

Each point on the control profile then becomes (linearizing the points in between):

Temperature	Normalized Capacity
$T_{z,max}$	$\frac{Q}{\lvert Q_{maxc}\rvert} = -1$ [9a]
$T_{rh,h}$	$\frac{Q}{\lvert Q_{maxc}\rvert} = \frac{(T_{cold} - T_{rh,h})}{(T_{z,max} - T_{cold})}$ [9b]
$T_{z,0}$	$\frac{Q}{\lvert Q_{maxh}\rvert} = 0$ [9c]
$T_{rh,l}$	$\frac{Q}{\lvert Q_{maxh}\rvert} = \frac{(T_{hot} - T_{rh,1})}{(T_{hot} - T_{z,min})}$ [9d]
$T_{z,min}$	$\frac{Q}{\lvert Q_{maxh}\rvert} = 1$ [9e]

Procedure for Constructing a TRH Control Profile

1. Determine T_{cold}, T_{hot}, $T_{rh,l}$, $T_{rh,h}$, $T_{z,max}$, and $T_{z,min}$ for the building and system you wish to simulate. These are values that must be selected by the designer.
2. Determine the flow rate, V, from the cooling specification.
3. Calculate $Q_{rh,cap}$ knowing T_{hot} or calculate T_{hot} knowing $Q_{rh,cap}$:

   $$Q_{rh,cap} = F_{\rho cp}V\,(T_{hot} - T_{cold}) \quad [1]$$

   $$Tb_{hot} = \frac{Qrh,cap}{FpcpV} + Tcold \quad [2]$$

4. Determine $T_{z,0}$ using the following equation:

$$T_{z,0} = \frac{T_{rh,h} * T_{hot} - T_{rh,1} * T_{cold}}{T_{hot} - T_{cold} + T_{rh,h} - T_{rh,1}} \qquad [3]$$

5. Calculate $Q/|Q_{maxc}|$ for $T_{rh,h}$ using:

$$\frac{Q}{|Q_{max\,c}|} = \frac{(T_{cold} - T_{rh,h})}{(T_{z,max} - T_{cold})} \qquad [4]$$

6. Calculate $Q/|Q_{maxh}|$ for $T_{rh,1}$ using:

$$\frac{Q}{|Q_{max\,h}|} = \frac{(T_{hot} - T_{rh,1})}{(T_{hot} - T_{z,min})} \qquad [5]$$

7. Remember that:

$$\frac{Q}{|Q_{max\,c}|} = -1 \text{ for } T_z = T_{z,max}, \qquad [6a]$$

$$\frac{Q}{|Q_{max\,c}|} = 0 \text{ for } T_z = T_{z,0}, \text{ and} \qquad [6b]$$

$$\frac{Q}{|Q_{max\,h}|} = 1 \text{ for } T_z = T_{z,min}. \qquad [6c]$$

All the points necessary for a BLAST control profile have now been determined.

8. Write the control profile in BLAST syntax.

9. Determine the heating and cooling capacities for each zone the system serves, using:

$Q_{maxc} = F\rho c_p V (T_{cold} - T_{z,max})$ and [7]

$Q_{maxh} = F\rho c_p V (T_{hot} - T_{z,min})$. [8]

Example TRH Control Profile

You wish to design a TRH system that can provide 40,000 BTU/hr of cooling (@76°F) for a given zone. PI control will keep the cold deck at 50 °F. Reheat comes on at 70 °F and is at full capacity at 67 °F. The reheat coil can supply 50,000 BTU/hr of heating.

Furthermore, you use setback at night and on weekends so that the building temperature may be as high at 90 °F or as low as 55 °F when the system starts up in the morning. Assume that the chiller/reheat combination has enough capacity to maintain the specified deck temperatures over the full range of indoor/outdoor environmental conditions.

1. From the problem statement, we see that:

$T_{z,max}$ = 90°F

$T_{z,min}$ = 55°F

$T_{rh,h}$ = 70°F

F

V is then calculated as:

$V = 40,000 / 1.08*(76-50) = 1425$ CFM

3. Calculate T_{hot}:

   $T_{hot} = 50,000/(1.08*1425) + 50 = 82.5°F$

4. $T_{z,0} = (70 * 82.5 - 67 * 50)/(82.5 - 50 + 70 - 67) = 68.3$

5. At $T_{rh,h}$: $Q /|Q_{maxc}| = (50-70)/(90-50) = -0.5$

6. At $T_{rh,l}$: $Q /|Q_{maxh}| = (82.5-67)/(82.5-55) = 0.56$

7. At $T_{z,min}$: $Q /|Q_{maxh}| = 1$

   At $T_{z,max}$: $Q /|Q_{maxc}| = -1$

   At $T_{z,0}$: $Q /|Q_{maxc}| = 0$

We can now make a table showing Q / |Qmax| vs. zone temperature.

Zone Temperature ºF	**Q / |Q_{max}|**
55.0	1.00
67.0	0.56
68.3	0.00
70.0	-0.50
90.0	-1.00

Table 37. Q ratio and zone temp

A graph of this control profile is shown in the figure below.

8. Assuming typical scheduling, the following BLAST syntax results.

```
TEMPORARY CONTROLS (TRH SYSTEM WITH SETBACK):
PROFILES:
    TRH = (1.0 AT 55, 0.56 AT 67,0.0 AT 68.3,
        -0.5 AT 70, ,-1.0 AT 90);
    SB = (1.0 AT 54.9, 0.0 AT 55);
SCHEDULES:
    MONDAY THRU FRIDAY = (07 TO 17 -TRH,17 TO 07 - SB),
    SATURDAY THRU SUNDAY = (00 TO 24 - SB),
    HOLIDAY = SUNDAY;
END CONTROLS;
```

9. Now that we know the total supply air volumetric flow rate, we can calculate Q_{maxc} and Q_{maxh}.

Q_{maxh} = 1.08*1425*(82.5 - 55) = 42,300 BTU/hr

Q_{maxc} = 1.08*1425*(50-90) = -61,600 BTU/hr

The BLAST controls syntax will be:

```
CONTROLS = TRH SYSTEM WITH SETBACK, 42.3 HEATING,
            61.6 COOLING;
```

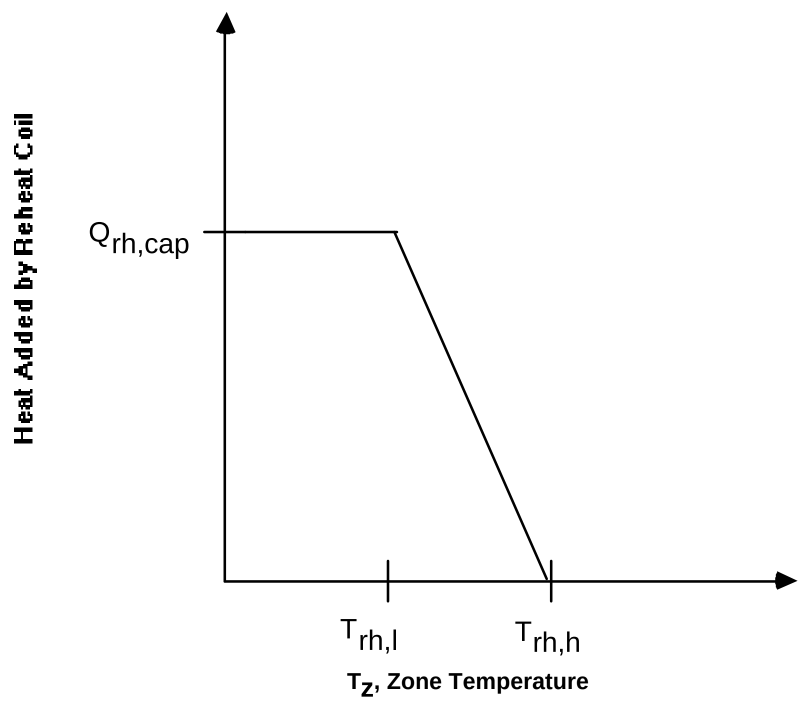


Figure 123. Heat Added vs Zone Temperatures by Reheat Coil

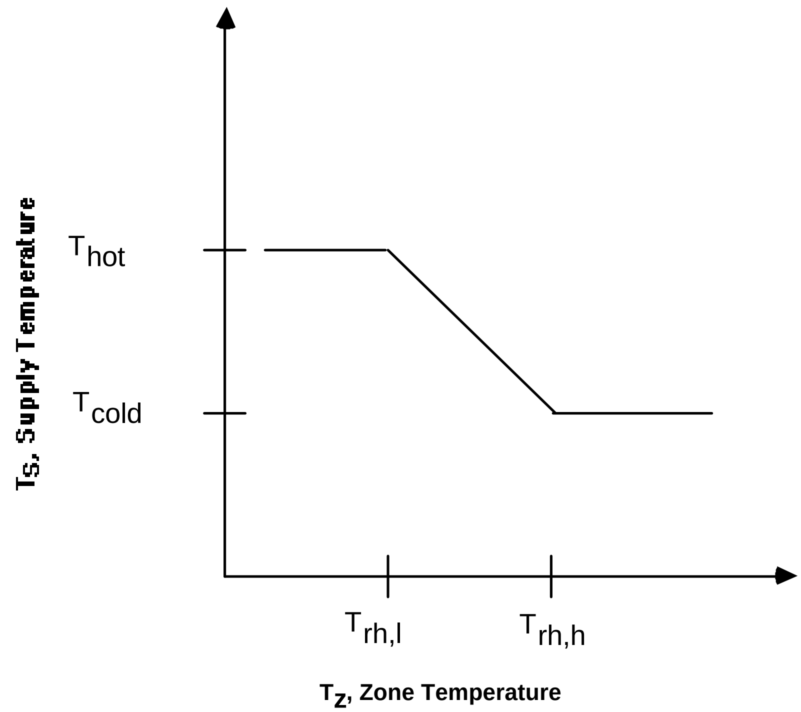


Figure 124. Supply Temperatures vs Zone Temperatures for a Terminal Reheat system

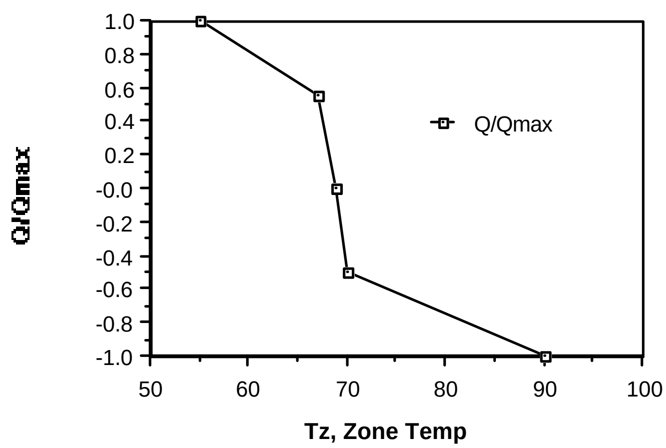


Figure 125. Control Profile for a Terminal Reheat System

Cooling Coil Design Parameters

The COOLING COIL DESIGN PARAMETERS input data block allows the user to specify a cooling coil of his choice by inputting data for one coil operating unit. The table below shows the data necessary for each of the four types of coils BLAST can simulate.

∗ indicates parameter affects system

	DX PACKAGE COILS	DIRECT EXPANSION COILS	WATER COILS IN FAN COIL UNITS	ALL OTHER CHILLED WATER COILS
Coil Type		•		•
Air Volume Flow Rate		•	•	•
Barometric Pressure		•	•	•
Air Face Velocity		•		•
Entering Air Dry-Bulb Temperature		•	•	•
Entering Air Wet-Bulb Temperature		•	•	•
Leaving Air Dry-Bulb Temperature		•	•	•
Leaving Air Wet-Bulb Temperature		•		•
Entering Water Temperature			•	•
Leaving Water Temperature			•	•
Water Volume Flow Rate			•	•
Water Velocity				•
Entering Refrigerant Temperature		•		
Leaving Refrigerant Temperature		•		
Total Cooling Load		•		
Number of Tube Circuits		•		
DXCOIL1	•			
DXCOIL2	•			
DXCOIL3	•			

Table 38. Cooling Coil Design Parameters Applicability

NOTES:

1. All temperatures are in °F [or °C]
2. All capacities are in kBtu/hr [or kW]
3. All velocities are in ft/min [or m/sec]
4. All flow rates are in ft^3/min [or m^3/sec]
5. All pressures are in inches H20 [or N/m^2]

   1 GPM (gallon per minute) = 0.1338 ft^3/min

   407 $inches\ H_2O$ = 1 atmosphere = 101330. N/m^2

The following sections are sample descriptions of each of the four major coil types. Each sample includes default values.

Coil Capacities

When performing a fan system simulation, BLAST does not limit the capacity of the preheat coil, cooling coil, heating coil, recool coils, reheat coils, thermostatic baseboard heat, fan coil cooling coils, and fan coil heating coils. These coils will provide as much heating or cooling as desired unless they have been completely turned off. Any coil may be turned off by specifying the appropriate schedule in the EQUIPMENT SCHEDULES block. In addition, reheat coils, recool coils, and baseboard heat may be turned off by specifying CAPACITY = 0.0 in the zone data block (this is the default condition). To determine if any coils have exceeded their capacity, the user must request the COIL LOADS report.

Packaged DX Coil

If and only if a user specifies a DX PACKAGED UNIT as the system type, a special packaged DX coil model is used and only these COOLING COIL DESIGN PARAMETERS apply. The COIL TYPE is DIRECT EXPANSION regardless of user input.

```
COOLING COIL DESIGN PARAMETERS:
 DXCOIL1 (4589.14, 1.63, -0.02011);
 DXCOIL2 (-25.342, 0.02492, 0.00461);
 DXCOIL3 (0.01715, -0.000051, -1.715E-8);
END COOLING COIL DESIGN PARAMETERS;
```

The DXCOIL1, DXCOIL2, and DXCOIL3 coefficients are used to determine the total cooling load on the DX package unit cooling coil as shown in the following equations:

$$QSQT=DXCOIL1(1) + DXCOIL1(2) * EDBT + DXCOIL1(3) * EDBT^2 + DXCOIL2(1) * EWBT + DXCOIL2(2) * EWBT * EDBT + DXCOIL2(3) * EDBT^2 * EWBT + DXCOIL3(1) * EWBT^2 + DXCOIL3(2) * EDBT * EWBT^2 + DXCOIL3(3) * EDBT^2 * EWBT^2$$

$$QCC=(1000*SMASS*(EDBT-LDBT))/QSQT$$

Where

: EDBT=Entering dry bulb temperature

EWBT=Entering wet bulb temperature

LDBT=Leaving dry bulb temperature

SMASS=Mass flow rate of supply air

QCC=Load on cooling coil

Water Coils in Fan Coil Units

If a user selects a two or four pipe fan coil system, only these COOLING COIL DESIGN PARAMETERS apply. COIL TYPE for fan coil systems is always CHILLED WATER.

```
COOLING COIL DESIGN PARAMETERS:
 AIR VOLUME FLOW RATE=600;
 BAROMETRIC PRESSURE=406.8;
 ENTERING AIR DRY BULB TEMPERATURE=80;
 ENTERING AIR WET BULB TEMPERATURE=67;
 LEAVING AIR DRY BULB TEMPERATURE=60.4;
 ENTERING WATER TEMPERATURE=45;
 LEAVING WATER TEMPERATURE=54.6;
 WATER VOLUME FLOW RATE=0.5348;
END COOLING COIL DESIGN PARAMETERS;
```

Direct Expansion Coil Design Parameters

Direct Expansion cooling coils can be selected for all system types, with the exception of FAN COIL systems, by overriding the default coil type (CHILLED WATER).

```
COOLING COIL DESIGN PARAMETERS:
 COIL TYPE = DX;
 AIR VOLUME FLOW RATE = 12000;
 BAROMETRIC PRESSURE = 405;
 AIR FACE VELOCITY = 600;
 ENTERING AIR DRY BULB TEMPERATURE = 80;
 ENTERING AIR WET BULB TEMPERATURE = 67;
 LEAVING AIR DRY BULB TEMPERATURE = 55;
 LEAVING AIR WET BULB TEMPERATURE = 54;
 ENTERING REFRIGERANT TEMPERATURE = 40;
 LEAVING REFRIGERANT TEMPERATURE = 40;
 TOTAL COOLING LOAD = 487.33;
 NUMBER OF TUBE CIRCUITS = 20;
END COOLING COIL DESIGN PARAMETERS;
```

All Other Chilled Water Coils

Default COIL TYPE for all systems except DX PACKAGED UNIT is CHILLED WATER. Defaults correspond to a typical four row coil. This is the only coil type which is automatically scaled by BLAST based on total system air volume flow rate. If the user enters 0 for both AIR VOLUME FLOW RATE and WATER VOLUME FLOW RATE, BLAST will automatically calculate them.

```
COOLING COIL DESIGN PARAMETERS:
 COIL TYPE = CHILLED WATER;
 AIR VOLUME FLOW RATE =
 BAROMETRIC PRESSURE = 407;
 AIR FACE VELOCITY = 490;
 ENTERING AIR DRY BULB TEMPERATURE = 85;
 ENTERING AIR WET BULB TEMPERATURE = 64;
 LEAVING AIR DRY BULB TEMPERATURE = 55;
 LEAVING AIR WET BULB TEMPERATURE = 52.7;
 ENTERING WATER TEMPERATURE = 45;
 LEAVING WATER TEMPERATURE = 55;
 WATER VOLUME FLOW RATE = ;
 WATER VELOCITY = 275;
END COOLING COIL DESIGN PARAMETERS;
```

AIR VOLUME FLOW RATE: the sum of all the zone air flow rates (supply air volume)

WATER VOLUME FLOW RATE: (.00085 times the AIR VOLUME FLOW RATE)

Except for DX PACKAGED UNITS and FAN COIL UNITS, the COOLING COIL PARAMETERS (user specified or default) are used to compute an equivalent heat transfer area and overall heat transfer coefficient for the coil. These values become the basis for a precise simulation of coil performance under actual hourly entering and leaving air conditions and flow rates encountered during the simulation period.

Direct expansion coils in DX PACKAGED UNITS and chilled water coils in FAN COIL UNITS are modeled somewhat differently (and the input is somewhat different) from their counterparts in other types of systems because

(1) catalog data for these coils are usually presented in a different form and (2) the air temperature leaving the coil is not usually controlled.

Whenever a DX or packaged DX coil is specified, a DX CONDENSING UNIT to serve the coil is automatically simulated (one for each fan system served by a DX coil; see DX CONDENSING UNIT PARAMETERS).

Cooling Tower

If a cooling tower capacity is not specified in the input and a chiller capacity is specified, BLAST will automatically determine the electrical consumption and leaving water temperature of the tower using a simplified model. This simplified model is as follows:

Electrical power consumed = TLOAD * (PELTWR + ELECTRICAL)

Leaving water temperature = MAX (TTOWR, TWET + 1.11 °C)

where:

TLOAD = current hours load on cooling tower kW

PELTWR = pump electrical consumption for condensing water for SPECIAL PARAMETERS input sequence

ELECTRICAL = fan electrical consumption per unit load on the cooling tower from PART LOAD RATIOS input sequence for tower

TTOWR = minimum leaving water temperature from tower from SPECIAL PARAMETERS

TWET = current hour wet bulb temperature

When a tower is specified, tower pump power is:

Tower pump power = TCAP * PETLWR (A1 + A2 * HPLR) + A3 * $HPLR^2$

where:

TCAP = tower capacity

A1, A2, A3 = coefficients of the TPUMP set

HPLR = TLOAD/TCAP

If a tower(s) is selected,

Electric power = TLOAD * ELECTRICAL + tower pump power

Daylight

The DAYLIGHT statement is used if artificial lighting levels may be reduced at certain times in the zone to take advantage of natural light ("daylighting"). BLAST uses the parameters specified in the daylight statement in the following manner. For each hour of the simulation:

Daylighting = (Beam Usable) + (Diffuse Usable)

Where:

Daylighting = The amount of usable solar lighting that replaces artificial lighting up to the maximum amount specified by the usn5 PERCENT REPLACEABLE entry in the LIGHTS statement.

Beam Usable = (Visible beam radiation entering zone) x (PERCENT BEAM USABLE) x (Schedule value)

Diffuse Usable = (Visible diffuse radiation entering zone) x (PERCENT DIFFUSE USABLE)

The figure below illustrates the above.

The Percent/Diffuse Usable is based on the glass transmissivity and shades, and the part of total radiation used in the calculation only includes the visible spectrum. The schedule on beam radiation simply allows the user flexibility in modeling angle dependent obstructions within the zone. For example, a skylight located far above a workspace may cast a direct beam into the work space during one part of the day, and be completely obstructed during another part. The user supplied percentage of beam and diffuse account for the non-angle dependent aspects of natural lighting. For example, a room that is "black" to the visible spectrum should be specified with a low percentage of usable beam and diffuse.

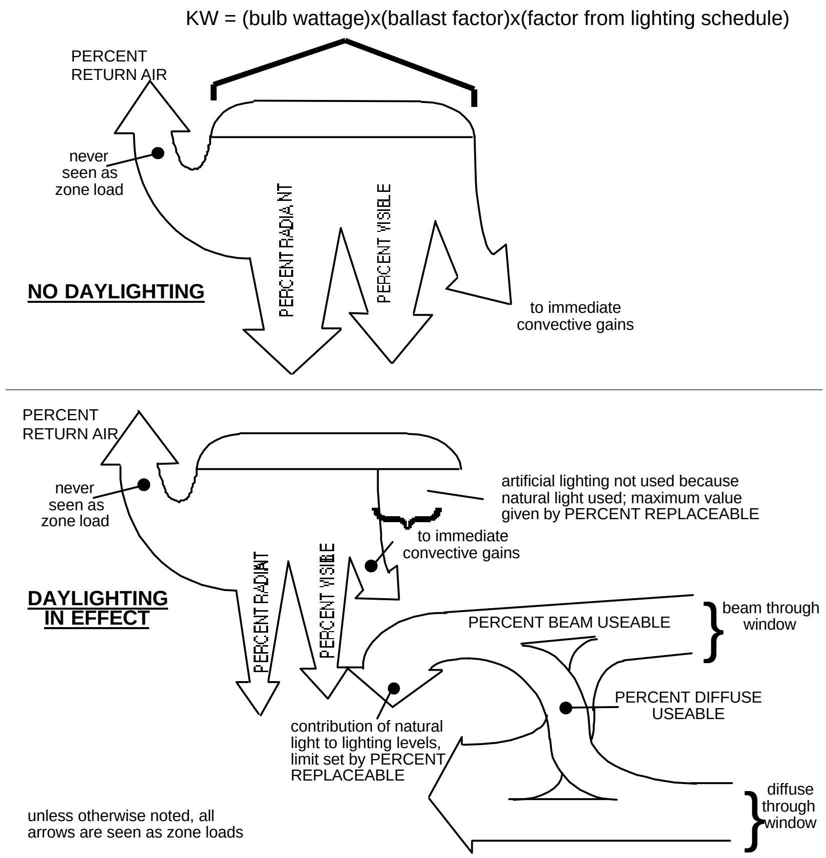


Figure 126. BLAST Relationship Between Lighting and Daylighting

Design Week

One practice that is frequently used in the ice storage industry is the sizing of ice storage systems based upon a design week instead of a design day. When using a design day to select an ice storage system, chillers must be sized so that enough ice is stored during the charging cycle to meet the demands during the next on-peak period. A design week would take into account an entire week's load profile. Since many buildings operate based on a weekend setback mode, no heating or cooling is required over the weekend. As a result, any energy stored over the weekend can be used to supplement the ice which can be built during the week. Each day of the week, the ice left in storage after the on-peak period decreases until, ideally, there is no ice left at the end of the on-peak period on Friday. Thus, during any week, there are five discharging cycles and seven charging periods. The end result is that chiller sizes can be decreased; this may allow substantial initial equipment cost savings.

In practice, the designer would like to have the flexibility to specify seven design days which would comprise the design week. These design days would be simulated consecutively so that any stored energy left over from the previous days could be taken into account. While it is possible to select a week from a weather tape, this offers the designer almost no flexibility in the definition of the design week characteristics. The Design Week Creation Program is a menu-driven program that allows users to quickly specify an entire week of weather data.

Though the Design Week Creation program was developed to suit the Thermal Storage applications, it can be used to create a week of weather data for any application the user might wish to look at in detail.

The user is prompted for standard design day information such as maximum dry bulb temperature, wet bulb temperature, minimum temperature, etc. for each day of the week. The program will allow each day to have different data, if desired. Thus, the user is allowed total flexibility to specify seven identical days or seven distinct days. The program creates a special one-week weather file that must be processed by WIFE prior to using it in BLAST. The program creates both the raw weather data file and the WIFE input file (*proj.win*) so that WIFE can be executed easily. WIFE will create the processed weather data file (*proj.wea*) which can be read by BLAST during BLAST execution.

Detailed Geometry

To accurately account for shading, solar gain, and the effects of wind on exterior walls, windows, and roofs, a fairly careful description of the building's geometry is required. Similarly, details about the building's construction are required to fully account for the time lag and heat flow through walls and for the heat stored in the building. These construction details are made available to the program by naming the appropriate wall, roof, or floor sections from the library.

In addition to geometric information, certain non-geometric data that affect the heat loss and gain in each zone must be provided. This includes information about such energy-influencing factors as lighting, equipment, people, and infiltration levels, and the appropriate schedule from the library that will be used in apportioning these factors each hour of each day.

BLAST uses the Cartesian coordinate system for describing buildings and zones. The Y axis points due north, the X axis due east, and the Z axis points upward at right angles to the Y and X axes. Directions are specified as degrees clockwise from due north (the same as the compass); thus, east is either 90 or -270 degrees, south is ±180 degrees, and west is 270 or -90 degrees. For the purpose of calculating the effects of shading, sun, and wind, the direction toward which a wall faces must be accurately described.

TILTED specifies the angle from the Z axis (the upward pointing axis) to the outward pointing normal of the surface. If TILTED is omitted, tilts take on the following defaults: Roofs and ceilings = 0°, walls = 90°, and floors = 180°.

Building, Zone, Surface, and Subsurface Origins

When describing a building, an origin (usually the southwest corner of the building) is designated as the building origin. Origins are designated by either *starting at* or *at* statements in the BLAST input file. When describing zones, the location (origin) relative to this building origin is specified. Once a zone origin has been described, the user can ignore the rest of the building and give the coordinates of the surfaces bounding the zone relative to the zone origin.

The starting point of a surface is its lower left-hand corner, looking at it from the outside. In the figure below, for example, the starting point is relative to the zone origin, which is (15,0,10). Once the user has established the starting point of a surface, the rest of the zone can be ignored and the surface treated as an XY plane with its starting point as (0,0). Thus, for example, the east-facing wall of the zone in the figure below starts at (15,0,0) relative to the zone origin. Viewing the wall as an XY plane, the window starts at (2,3). This window is actually 30 ft east, 2 ft north, and 13 ft above the building origin (9.1 m east, 0.6 m north, and 4.0 m above the building origin); however, the user never has to compute these distances -- BLAST does it.

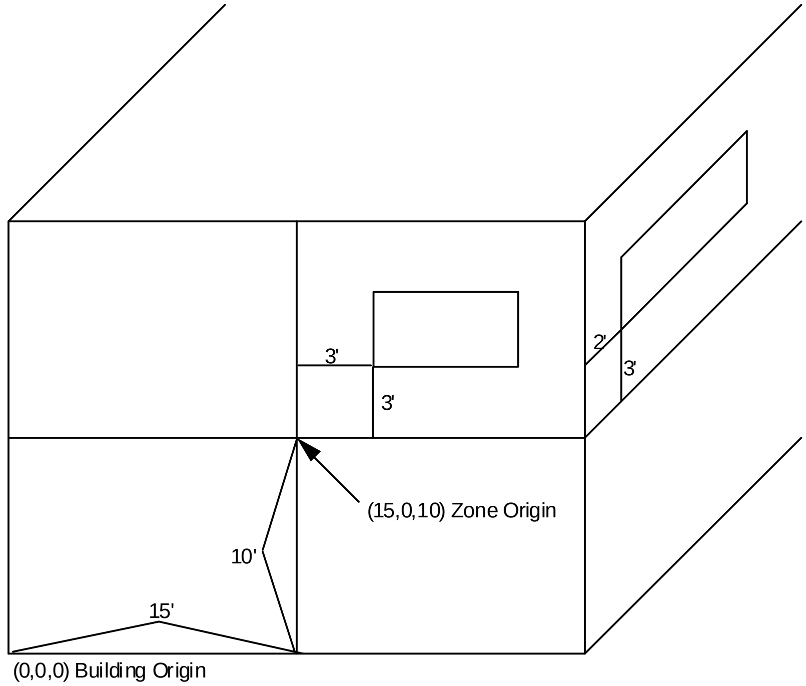


Figure 127. Building and Zone Origins

In summary, users begin with the building origin, locate and specify the zone origin, and describe the lower-left corner of each surface bounding the zone relative to the zone origin. Finally, viewing the lower-left corner of the surface as its origin, windows, doors, overhangs, and wings are described relative to that origin.

Facing Angle

FACING indicates the direction towards which the surface faces; i.e., the direction of the outward pointing normal to the surface. The angle towards which a surface faces is the same one that would usually be used to describe the room, i.e., the north wall is the wall which faces northward. The facing angle will default to 0.

If a roof or ceiling is flat, the angle towards which it is "facing" must be specified if the roof origin and dimensions are to have meaning. If a roof is peaked, it is easy to choose the facing direction and lower-left corners (see the figure below). To specify the angle for a flat roof, the user pretends that it is slightly tilted in one direction or another. Then, by arbitrarily choosing an imaginary tilt, the user can find the lower-left corner of the roof and establish its facing angle. The same procedure is used to specify floor angles. The figures "Flat Roof Facing and Origin", "Peaked Floor Facing Angle and Origin" illustrate proper origins, facing angles, and dimensions for roofs, ceilings, and floors. The figures "Alternate Flat Roof Facing Angle and Origin" and "Alternate Floor Facing Angle and Origin" show how the user may choose different origins, facing angles, and dimensions to describe the same roof and floor as those of previous figures.

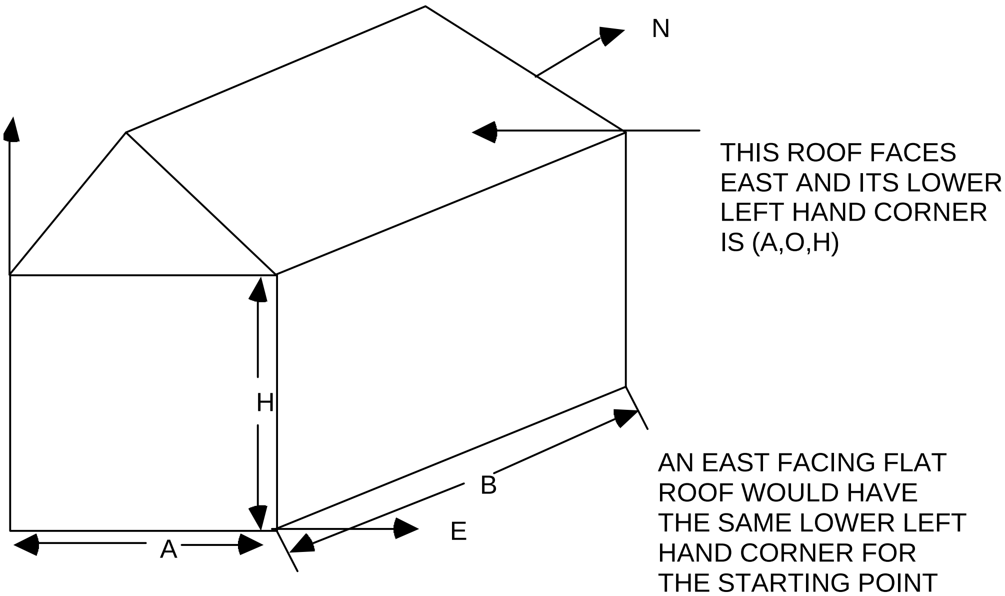


Figure 128. Peaked Roof Facing Angle and Origin

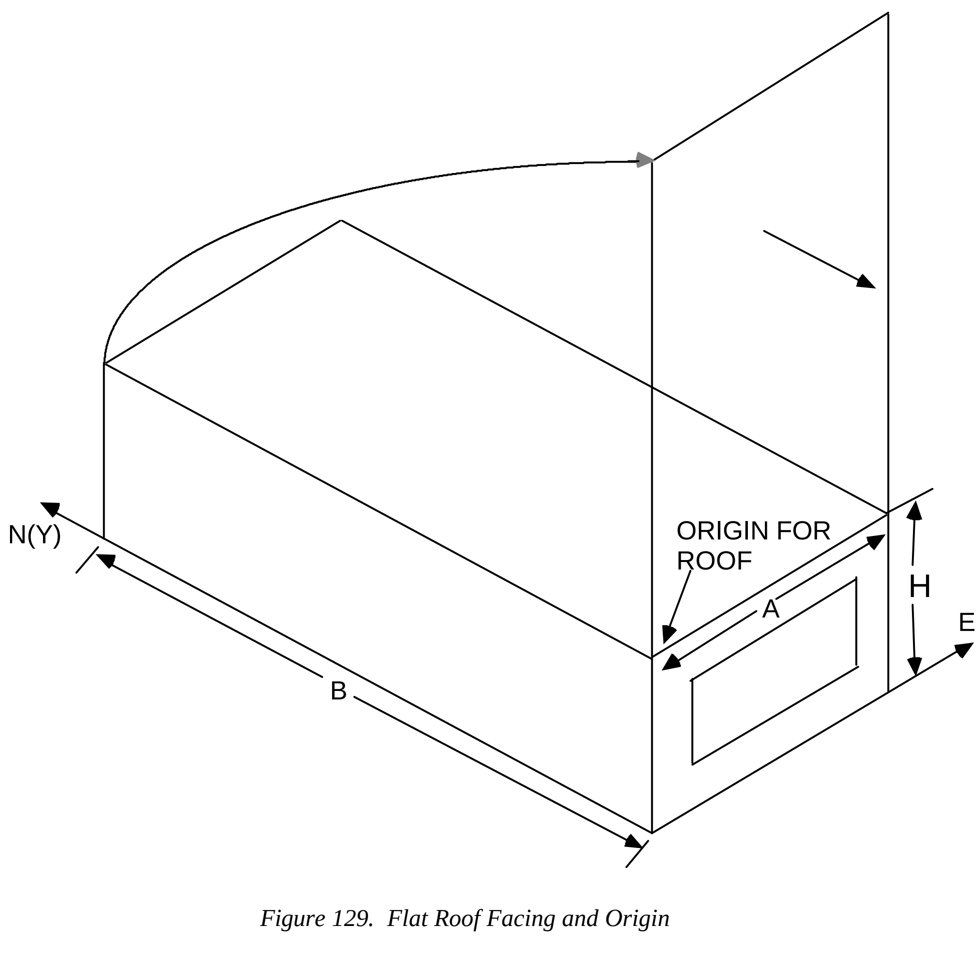


Figure 129. Flat Roof Facing and Origin

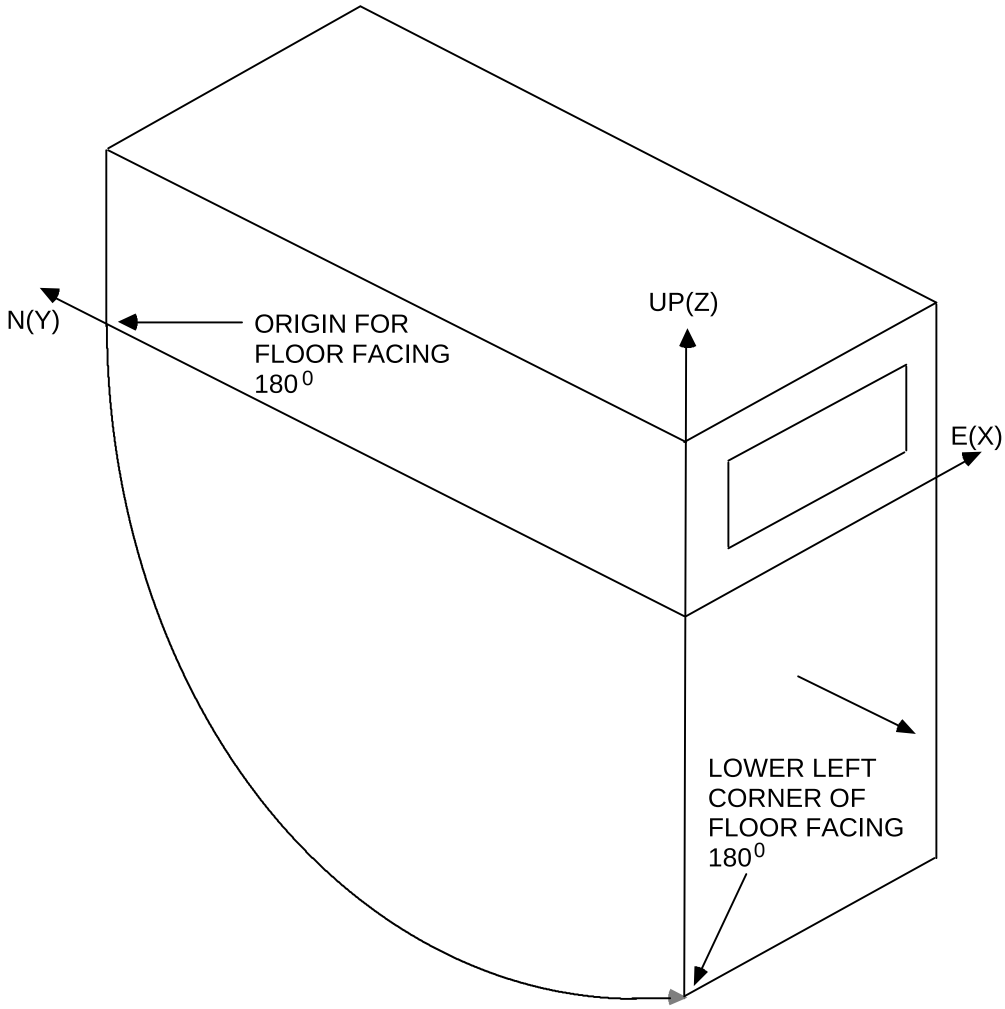


Figure 130. Floor Facing Angle and Origin

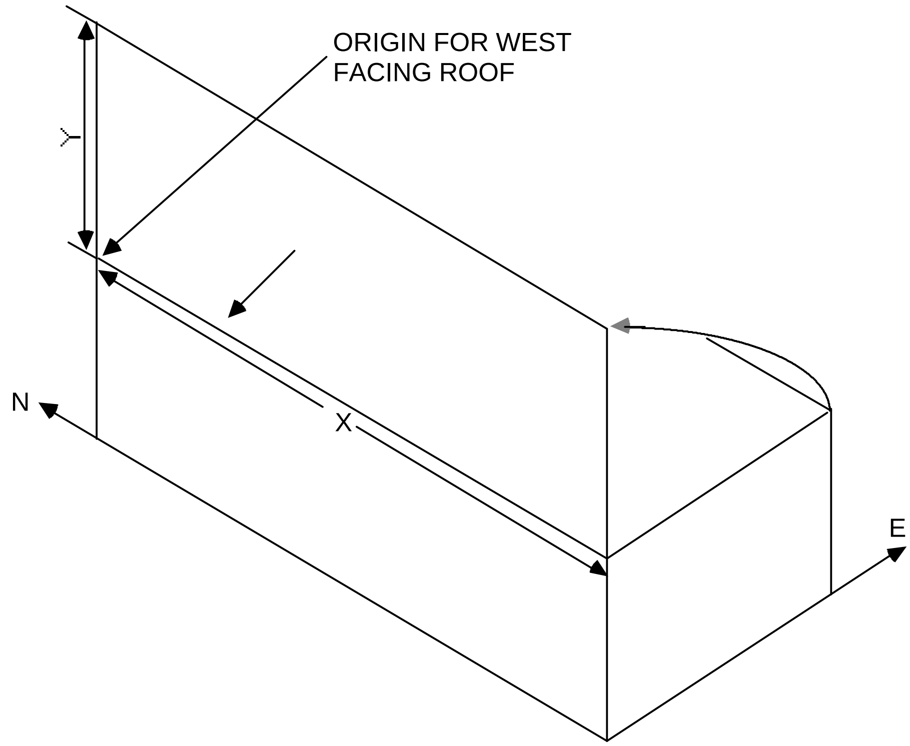


Figure 131. Alternate Flat Roof Facing Angle and Origin

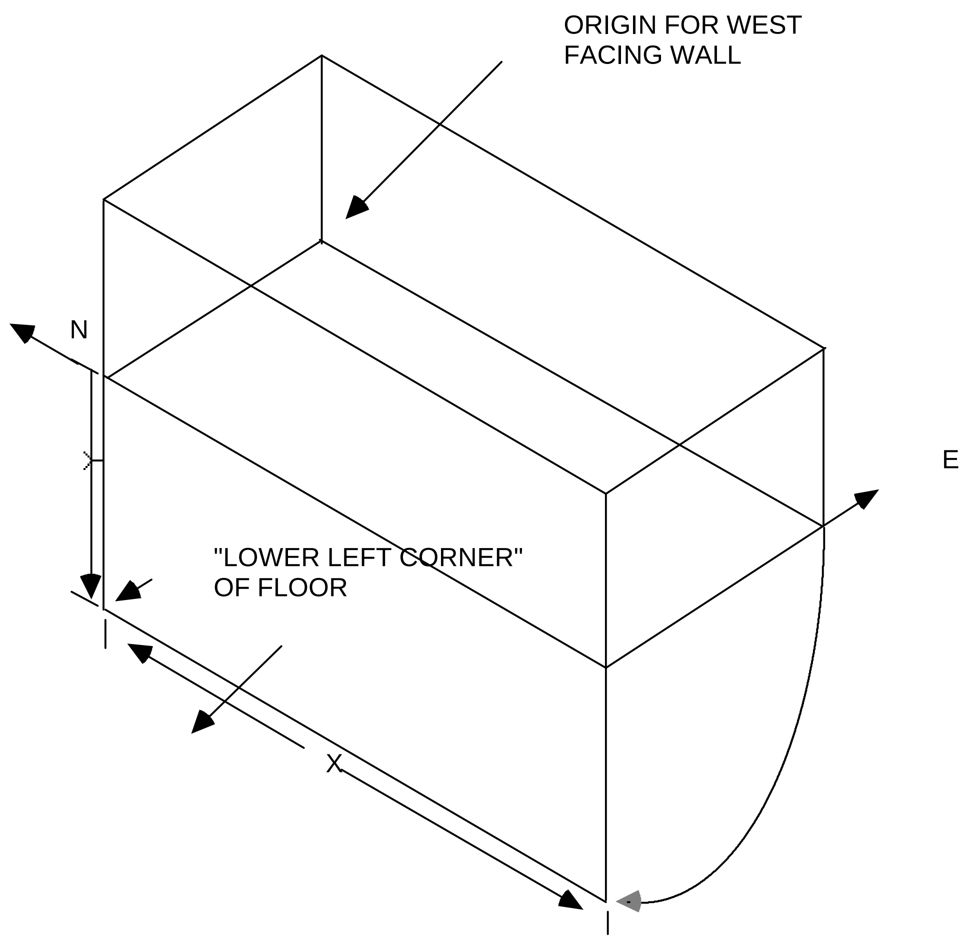
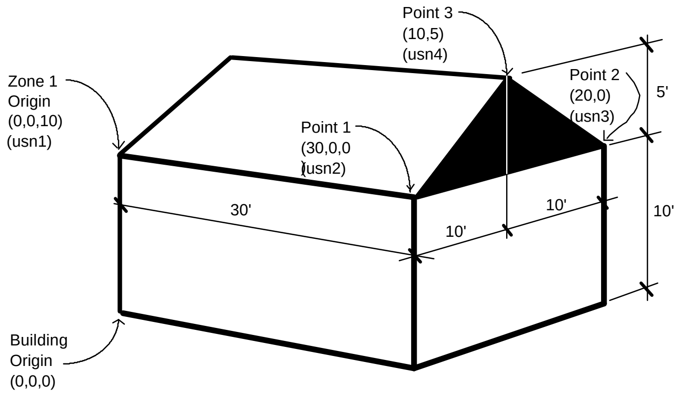


Figure 132. Alternate Floor Facing Angle and Origin

Non-Rectangular Surfaces

So far, all the surfaces have been described as rectangles (length by height). Many buildings have non-rectangular surfaces, such as attic gables. BLAST provides an alternate method of describing a surface to handle these situations.

In the figure below, the STARTING AT point represents the origin of the X,Y plane (point 1) and one of the vertices of the surface. The rest of the surface description is the same as it was for rectangular surfaces. Notice, however, that vertices are always specified in the plane for the surface being described and require extra care in calculating the vertices relative to the surface origin whenever a TILT is specified for a surface. Also, consecutive points *must* be described moving *counterclockwise* around the surface.



Generic Syntax for End Wall of Attic

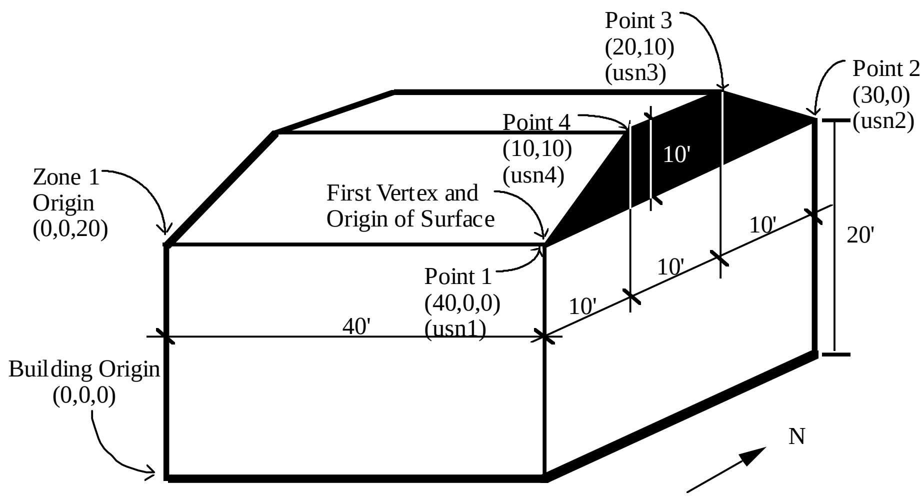
ZONE 1 "HOUSE ATTIC"
ORIGIN: (usn1);
EXTERIOR WALLS:
STARTING AT (usn2)
WALL NAME ((usn3),(usn4))
FACING (90)

Syntax for Shaded Area

ZONE 1 "HOUSE ATTIC"
ORIGIN: (0,0,10);
EXTERIOR WALLS:
STARTING AT (30,0,0)
WALL NAME ((20,0),(10,5))
FACING (90)

Note: Vertices must be specified in a counterclockwise direction

BLAST also allows a fourth vertex so that the user can describe any four-sided surface as long as it is *not concave*; concave surfaces must be broken down into allowable convex shapes and described as more than one surface (see figures below).



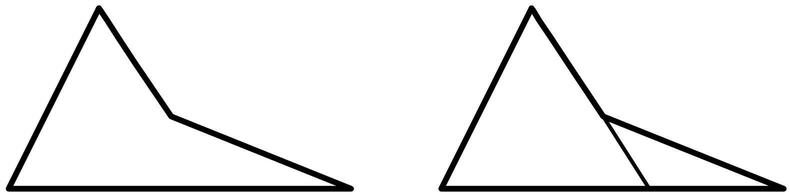
Generic Syntax for End Wall of Attic

ZONE 1 "ATTIC SPACE":
EXTERIOR WALLS:
STARTING AT (usn1)
wallname ((usn2) , (usn3) , (usn4))
FACING (90)

Syntax for Shaded Area

ZONE 1 "ATTIC SPACE":
EXTERIOR WALLS:
STARTING AT (40,0,0)
EXTERIOR((30,0) , (20,10) , (10,10))
FACING (90)

Note: Vertices must be specified in a counterclockwise direction



This surface is concave and will not work

This would be one solution for breaking one concave surface into two convex surfaces

Double Bundle Chiller

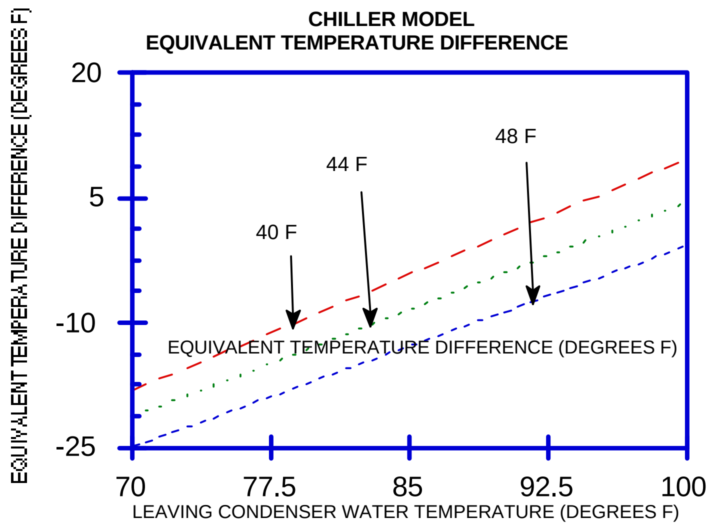
All reciprocating and centrifugal chillers, water to water heat pumps, and double-bundle chillers are modeled in the same way. Taking the double-bundle chiller as an example, first the chiller capacity is adjusted to reflect the change in condenser water temperature using the RCAVDB and ADJTDB equipment performance parameters. The ADJTDB coefficients are used to define an equivalent temperature difference between leaving chilled water and leaving condenser water. The first and last coefficients are the rating point temperatures for condenser water leaving and chilled water leaving, respectively. The second coefficient is the number of degrees that the temperature of the leaving chilled water rises or falls from the rating point to maintain the same rated capacity. The equivalent temperature difference is zero at the rated conditions. Next, the full-load power consumption is adjusted using the ADJEDB parameter set. Finally, the fraction of full-load power, FFL, is determined for part-load operation using the RPWRDB parameter set.

Example

At the rating point, the catalog showing capacity vs. leaving condenser water and chilled water temperature shows a capacity of 1073 tons at 95°F and 44°F. Thus, the first and last coefficients of ADJTDB set are 95 and 44, respectively. At 97.37°F and 46°F, the unit has a capacity of 1073 tons (its nominal capacity). The condenser water is 2.37°F higher than at the rating point, while the chilled water is 2°F higher. The second coefficient of the ADJTDB set is 2.37/2 or 1.19. Thus, the ADJTDB parameter set is:

ADJTDB (95, 1.19, 44);

The following figure shows ΔT for various condenser water and leaving chilled water temperature for the above ADJTDB coefficients.



The ratio of available-capacity to nominal-capacity is adjusted by using the equivalent temperature difference and the RCAVDC parameter set so that

$$\frac{\text{available capacity}}{\text{nominal capacity}} = B1 + B2 * (\Delta T) + B3 * (\Delta T)^2$$

where: B1, B2, and B3 are the parameters of the RACVDB set.

In this example:

$$\Delta T = [(T_{cond} - 95)/1.19] - [T_{cw} - 44]$$

where: T_{cw} is the actual temperature of the leaving chilled water

T_{cond} is the actual temperature of the leaving condenser water.

To find the RCAVDB coefficients for this example chiller, use the same manufacturer's table of available capacity vs. condenser and chilled water temperature. Several values have been selected and listed in the table below.

Leaving Condenser Water Temperature	**Leaving Chilled Water Temperature**	**ΔT**	**Available* Capacity**	**Available Capacity/Nominal Capacity**
95	40	+4	1000	0.932
95	42	+2	1053	0.981
95	46	-2	1127	1.050
100	40	+8.202	923	0.860
100	42	+6.202	970	0.904
100	46	+2.202	1027	0.957
100	48	+0.202	1063	0.991

Table 39. Data for Computing the RCAVDB Coefficients

* in tons

After curve-fitting:

$$\frac{\text{available capacity}}{\text{nominal capacity}} = 1.006 - 0.019 * \Delta T + 0.00022 * (\Delta T)^2$$

The parameter values are:

RCAVDB (1.006, -0.019,0.00022);

The figure below shows the available-capacity to nominal-capacity ratio vs. ΔT for the RCAVDB coefficients listed above.

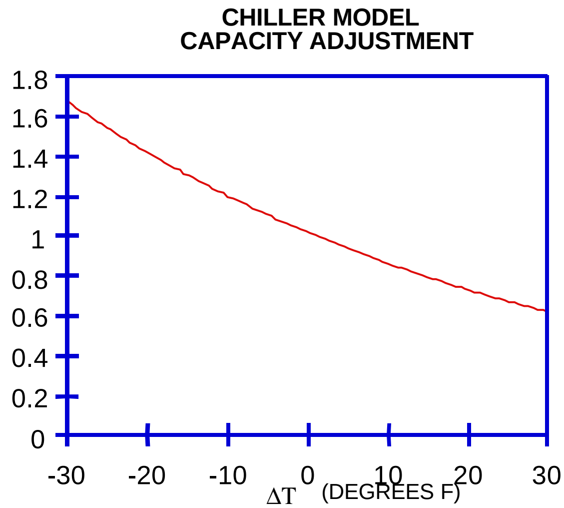


Figure 133. Capacity ratio vs DT

In double-bundle chillers, FLPR, the full-load power ratio, changes as the available capacity-to-nominal capacity ratio changes. Thus, FLPR is adjusted as a function of available-to-nominal capacity ratio, using the ADJEDB parameter set as follows:

$$FLPR = NFLPR * [C1 + C2 * (ANCR) + C3 * (ANCR)^2]$$

where: FLPR = Actual full-load power ratio

NFLPR = nominal full-load power ratio (default or user-specified, using the PART LOAD RATIOS sequence)

ANCR = available capacity to nominal capacity ratio

C1,C2,C3 = parameters of the ADJEDB set.

In this example, the full-load power is constant for each of the available capacities shown. However, since the capacities are changing, the full-load power *ratio* is changing. Data from the tableabove and the default nominal full-load power ratio (the catalog value is nearly the same as this default) were used to create the table below. This table can be used to find the ADJEDB set.

Available Capacity (tons)	**Power Consumption (kW)**	**FLPR***	**FLPR / NFLPR**	**Available Capacity / Nominal Capacity**
1000	858	0.244	1.073	0.932

1053	858	0.232	1.019	0.981
1127	858	0.216	0.952	1.050
923	858	0.264	1.163	0.860
970	858	0.251	1.106	0.904
1027	858	0.238	1.045	0.957
1063	858	0.299	1.009	0.991

Table 40. Example Data for Computing ADJEDB Coefficients

*FLPR = (kW/ton) * .2843 (tons/kW).

From curve-fitting:

$$\frac{FLPR}{NFLPR} = 3.158 - 3.313 * (ANCR) + 1.154 * (ANCR)^2$$

The parameter values are

ADJEDB (3.158, -3.313, 1.154);

The figure below shows actual-to-nominal FLPR vs. available-to-nominal-capacity ratio for the ADJEDB coefficients listed above.

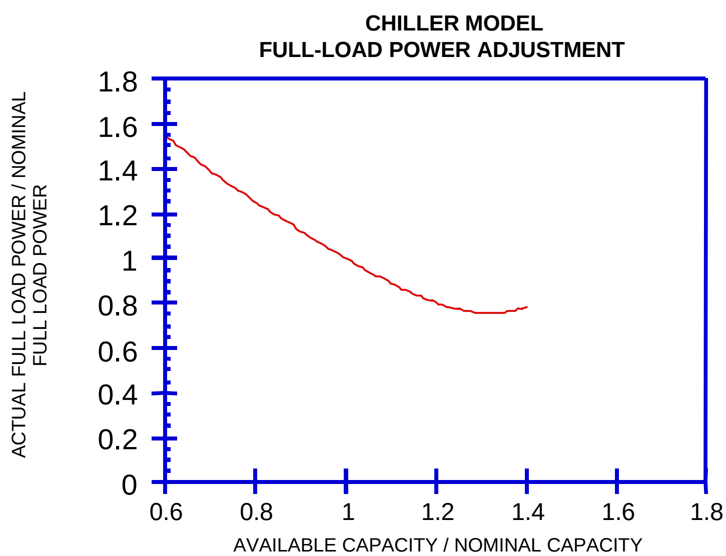


Figure 134. Full Load ratio vs Capacity ratio

The double-bundle chiller simulation must be able to calculate part-load performance. This is accomplished by computing FFL, the fraction of full-load power, as a function of PLR (PLR is the cooling load divided by the actual, not nominal, capacity) using the RPWRDB parameter set.

$$FFL = A1 + A2 * (PLR) + A3 * (PLR)^2$$

where: A1, A2, A3 are the parameters of the RPWRDB set.

This example uses a double-bundle chiller with the same part-load curve and coefficients used for a centrifugal chiller (the same centrifugal compressor is used). Thus:

FFL	PLR
1.00	1.0
0.89	0.9
0.78	0.8
0.68	0.7
0.59	0.6
0.51	0.5
0.42	0.4
0.34	0.3
0.27	0.2
0.20	0.1

Table 41. Part-Load Power Data

After curve-fitting:

$$FFL = 0.140 + 0.593 * (PLR) + 0.265 * (PLR)^2$$

The parameter values are:

RPWRDB (0.140, 0.593, 0.265);

The following figure shows the FFL as a function of the cooling load to actual capacity ratio for the RPWRDB coefficients listed above.

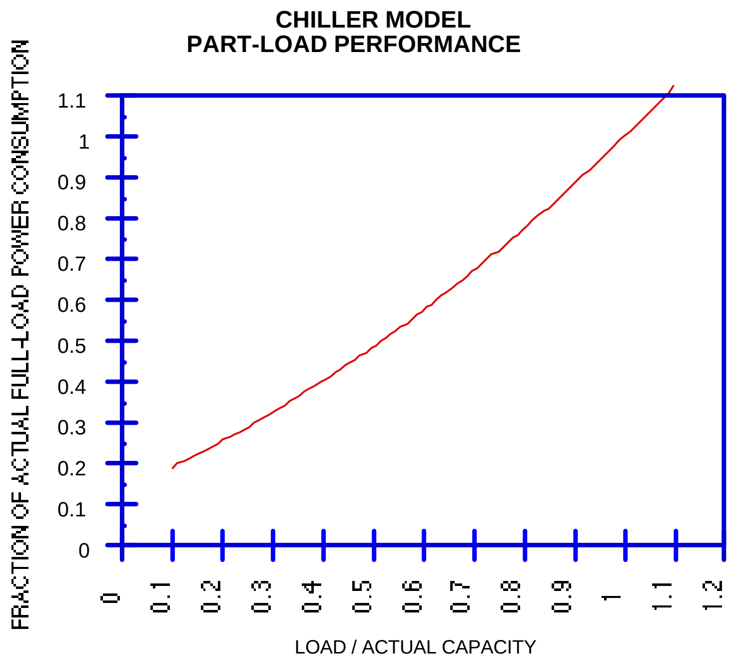


Figure 135. FFL Power vs Load/Capacity ratio

The final power demand calculation for double-bundle chillers has the same form as the equation for compression chillers:

Power = FLPR * CAP * FFL

CAP is the adjusted available capacity based on the equivalent condenser water to chilled water temperature difference; FLPR is adjusted on the basis of the ratio of available to nominal capacity, and the FFL is adjusted on the basis of the ratio of the load to the *available* capacity (i.e., PLR = Cooling Load/Available Capacity).

The following figure shows the full- and part-load power consumption that would be calculated for various leaving condenser and leaving chilled water temperatures using the above equipment performance parameters.

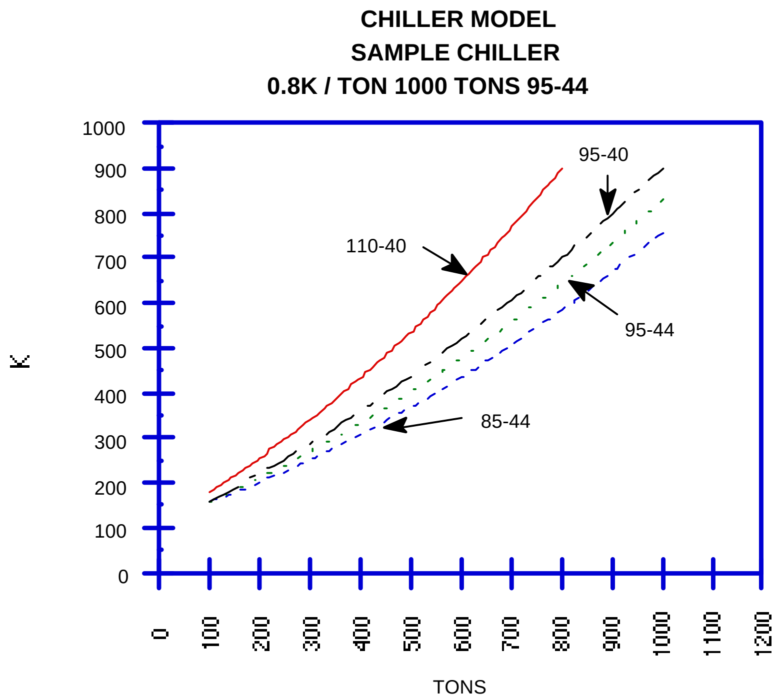


Figure 136. Relationships between Temperature, Power, and Equipment Parameters

Summary

To change the performance parameters for double bundle chillers, input:

```
EQUIPMENT PERFORMANCE PARAMETERS:
    . . .
    ADJTDB (95,1.19,44);
    RCAVDB (1.006,-0.019,.00022);
    ADJEDB (3.158,-3.313,1.154);
    RPWRDB (.140,.593,.265);
    . . .
END;
```

DX Condensing Unit Parameters

If a DX Packaged Unit is selected or if a DX coil is used in one of the other system types, a special group of parameters is involved. For these parameters, the default values supplied by the program in absence of user input and the format of the statements which allow the user to override the defaults are:

```
DX CONDENSING UNIT PARAMETERS:
    DX CONDENSING UNIT CAPACITY=487.3 (142.8);
    DESIGN SATURATED SUCTION TEMPERATURE=40 (4.4);
    DESIGN SATURATED CONDENSING TEMPERATURE=122 (50)
    MINIMUM SATURATED CONDENSING TEMPERATURE=100 (37.8);
    UNLOADER THROTTLING RANGE=4 (2.2)
    CONDENSOR UA=27.43 (14.5)
    SCT TEMPERATURE RISE COEFFICIENT=2.63
    DESIGN FULL LOAD POWER RATIO=0.326
    RCAVCD (0.98772,-0.02288,0.00027);
    RPWRCD (0.1456,0.9554,-0.10476);
    ADJECD (0.2984,0.1334,34.603);
    CONDENSING UNIT TYPE=AIR COOLED
                =WATER COOLED
END DX CONDENSING UNIT PARAMETERS;
```

In the following descriptions, the parameters are abbreviated:

Parameter	Abbreviation
DX CONDENSING UNIT CAPACITY	NOMCAP
DESIGN SATURATED SUCTION TEMPERATURE	DSST
DESIGN SATURATED CONDENSING TEMPERATURE	DSCT
MINIMUM SATURATED CONDENSING TEMPERATURE	MSCT
UNLOADER THROTTLING RANGE	UTR
CONDENSOR UA	CUA
SCT TEMPERATURE RISE COEFFICIENT	SCTTR
DESIGN FULL LOAD POWER RATIO	DFLPR
RCAVCD(1,2,3)	RCAVCD(1),(2),(3)
RPWRCD(1,2,3)	RPWRCD(1),(2),(3)
ADJECD(1,2,3)	ADJECD(1),(2),(3)

BLAST uses the above parameters in the following way:

Estimate SST:

SST = DSST - CPLR * UTR

where:

SST is the actual saturated suction temperature

CPLR is the cooling part-load ratio, calculated by coil modeling

DSST is the design saturated suction temperature

UTR is the unloader throttling range

Estimate SCT:

$$SCT = MAX\left(MSCT, OADB + \frac{LOAD * (1 + DFLPR)}{CUA}\right.$$

Where:

SCT is the actual saturated condenser temperature

OADB is the outdoor dry bulb temperature

LOAD is the total load on condensing unit calculated by coil modeling

MSCT is the minimum saturated condenser level

DFLPR is the design full-load power ratio

CUA is condenser U-factor-area product

Determine equivalent temperature difference (ΔT):

$$\Delta T = (SCT - DSCT)/SCTTR - (SST - DSST)$$

where:

DSCT is the design saturated condensing temperature

SCTTR is the SCT temperature rise coefficient

Calculate available capacity (AVAIL CAP):

$$AVAILCAP = NOMCAP * (RCAVCD(1) + RCAVCD(2)\,\Delta T + RCAVCD(3)\,\Delta T^2)$$

where: NOMCAP is the user-specified cooling capacity of the DX coil being served by the

condensing unit

Compute Carnot efficiency:

$$\eta_C = \frac{SCT - SST}{SCT + T_{BASE}}$$

where: the addition of T_{BASE} makes the denominator degrees absolute °R or

Compute actual full-load power ratio (FLPR):

$$FLPR = DFLPR * (ADJECD(1) + ADJECD(2)\,\eta_C + ADJECD(3)\,\eta_C^2)$$

Compute part-load ratio (PLR):

$$PLR = \frac{LOAD}{AVAIL\ \ CAP}$$

Compute fraction of full-load power (FFL):

$$FFL = RPWRCD(1) + RPWRCD(2)PLR + RPWRCD(3)PLR^2$$

Compute power consumed:

$$Power = (AVAIL\ CAP) * (FLPR) * (FFL)$$

Example

The SST is estimated by dividing the total cooling load on the cooling coil by the total design capacity of the cooling coil. This coil part-load ratio (CPLR) is used with the unloader throttling range (UTR) and the DSST according to the following:

$$SST = DSST - (CPLR * UTR)$$

For example, if the DSST is 40°F (4°C), the coil is operating at 60 percent capacity, and the unloader throttling range is 4°F (-15°C), the estimated actual saturated suction temperature is:

$$SST = 40 - 0.6 * 4 = 37.6°F\ (.55°C)$$

To estimate SCT, use CUA, OADB, LOAD, and DFLPR. The DFLPR is the inverse of coefficient of performance and is the dimensionless ratio of power supplied to the compressor divided by cooling effect supplied by the condensing unit. Thus, the heat rejected to the condenser is (as a first estimate):

$$Q_C = LOAD + DFLPR * LOAD = CUA * (SCT - OADB)$$

Note that DFLPR times LOAD is an estimate of the power into the compressor which must be rejected along with the cooling effect (the load). (A more refined estimate will be made later when power requirements are more precisely calculated.) Rearranging the equation yields:

$$SCT = OADB + \frac{Q_C}{CUA}$$

Additionally, SCT is constrained so as not to be lower than the minimum saturated condensing temperature (MSCT).

The condenser U-factor-area product (CUA) is a user-supplied or default parameter which can be calculated from full-load catalog data by writing the approximate heat balance as:

$$Q_C = LOAD + DPOWER = CUA\ (SCT - OADB)$$

where: DPOWER is the specified power input to the compressor.

The log-mean temperature difference could also be used in this equation; however, this approximation is used to define an effective UA based on inlet air temperature.

Since full load data are usually used, load becomes the capacity of the unit at specified OADB and SST. An average UA can be computed for several data points as shown below (The table below provides basic catalog data):

$$UA = \frac{NOM\ \ CAP\ \ +\ \ DPOWER}{SCT\ \ -\ \ OADB}\ \text{kBtu/hr - °F or (kW/°C)}$$

Table 42. Condensing Unit Capacities Performance Data

SST (°F)		30	35	40	45	50
85	Cap	501	553	607	664	723
	SCT	109	111	114	116	119
	kW	47.7	48.4	51.0	53.7	56.4
90	Cap	463	512	563	618	673
	SCT	118	120	122	125	127
	kW	48.0	50.9	53.8	56.8	59.8
100	Cap	444	492	542	595	650
	SCT	122	124	127	129	131
	kW	49.2	52.2	55.3	58.3	61.4
105	Cap	426	472	521	573	626
	SCT	127	129	131	133	136
	kW	50.3	53.5	56.7	59.9	63.1
115	Cap	391	434	480	528	578
	SCT	136	138	140	142	144
	kW	52.4	55.8	59.3	62.8	66.3

Several catalog points produce the following UA estimates:

= (°F-32) x 5/9)

Capacity (Btu/hr)	SST (°F)	SCT (°F)
563,000	40	122
563,000	45	135

Table 43. Data for Calculating SCT Temperature Rise Coefficient

SCTTR = (SCT - DSCT)/(SST - DSST)

= (135 - 122)/(45 - 40) = 2.60

Since SCTTR is expected to be independent of the selected design point, any other design point should produce the same value. For example, from the performance data, the capacity is 501,000 Btu/hr, DSST = 30°F, DSCT = 109°F. Using this as the design point:

Capacity (Btu/hr)	SST (°F)	SCT (°F)
501,000	30	109
501,000	35	122.2
501,000	40	135.4

Table 44. Data Used to Check SCT Temperature Rise Coefficient

$$SCTTR = \frac{12.2 - 109}{35 - 30} = 2.64$$

$$SCTTR = \frac{135.4 - 109}{40 - 30} = 2.64$$

The average value for SCTTR is 2.63.

Condensing units usually operate at other than nominal capacity (ΔT _ 0). The second step in determining the actual capacity is to use the calculated value for ΔT and the empirical coefficients called RCAVCD parameters to adjust the nominal capacity according to the following:

$$AVAIL\ CAP = NOM\ CAP * (A_1 + A_2\ \Delta T + A_3\ \Delta T^2)$$

where: A_1, A_2, and A_3 are the empirical RCAVCD parameters.

Curve-fitting procedures can be used to establish A_1, A_2, A_3 by fitting AVAIL CAP/NOM CAP to ΔT. (See figures at end of DX Condensing Unit Parameters section.)

Various SCTs and SSTs are calculated because only one part-load performance curve is used regardless of the SCT and SST. To use only one curve, the condensing unit part-load ratio (PLR) is defined as the ratio of load to *actual* capacity. Actual power consumption will be determined by multiplying full-load power consumption by a part-load correction factor (FFL), which is a function of PLR. The full-load power consumption is determined first, however, since it will vary from the nominal as the suction and condensing temperatures change.

Nominal Capacity=563,000 Btu/hr			
SCT	**SST**	**AVAIL CAP/NOM CAP**	**ΔT**
109	30	0.89	5.05
111	35	0.98	0.81
114	40	1.08	-3.05
116	45	1.18	-7.28
119	50	1.28	-11.14
122	30	0.79	10.00
124	35	0.87	5.76
127	40	0.96	1.90
129	45	1.05	-2.34
131	50	1.15	-6.57
136	30	0.69	15.33
138	35	0.77	11.09
140	40	0.85	6.85
142	45	0.94	-1.62

Table 45. Data for Computing RCAVCD Coefficients

$$\frac{\text{AVAIL} \quad \text{CAP}}{\text{NOM CAP}} = 0.98772 + (-0.02288)\ \Delta T + 0.00027\ \Delta T^2$$

A convenient way to consider power in modeling a condensing unit is to consider the power ratio, which is the ratio of power-in to cooling-effect produced. A further normalization occurs by dividing by the nominal power ratio. For the full-load condition, the full-load power ratio, FLPR, the nominal full-load power ratio, DFLPR, and the ratio of the two are used. Note the FLPR is the inverse of COP, and that since DFLPR is a constant (the full-load power ratio at the nominal condensing unit capacity), the ratio FLPR/DFLPR is proportional to COP. It has been shown that even though the refrigeration cycle is not a Carnot cycle, the COP of the actual cycle can be related to the theoretical Carnot efficiency. That is:

$$\frac{\text{FLPR}}{\text{DFLPR}} = A_1 + A_2\eta_c + A_3\eta_c^2$$

where: η_c =Carnot cycle efficiency operating between SCT and SST

A_1, A_2, A_3 are empirical coefficients (ADJECD)

If SCT and SST are in °F, then:

$$\eta_c = \frac{\text{SCT} - \text{SST}}{\text{SCT - T}_{\text{BASE}}}$$

where: the addition of T_{BASE} makes the denominator degrees absolute (°R or

The table below was constructed to find A_1, A_2, and A_3.

SST	SCT	η_c	Capacity (1000 BTU/hr)	Power (kW)	FLPR/ DFLPR
30	109	0.139	501	45.7	0.955
35	111	0.133	553	48.4	0.916
40	114	0.129	607	51.0	0.879
45	116	0.123	664	53.7	0.846
50	119	0.119	723	56.4	0.816
30	122	0.158	444	49.2	1.760
35	124	0.152	492	52.2	1.110
40	127	0.148	542	55.3	1.068
45	129	0.143	595	58.3	1.025
50	131	0.137	650	61.4	0.989
30	136	0.178	391	52.4	1.402
35	138	0.172	434	55.8	1.345
40	140	0.167	480	59.3	1.293
45	142	0.161	528	62.8	1.245
50	144	0.156	578	66.3	1.200
40	122	0.141	563	53.8	1.000

		2.356			17.249

Table 46. Data for Determining ADJECD Coefficients (DFLPR = 0.326)

After curve-fitting: $\frac{FLPR}{DFLPR} = 0.2984 + 0.1334\eta_C + 34.603\eta_C^2$ (see following figure)

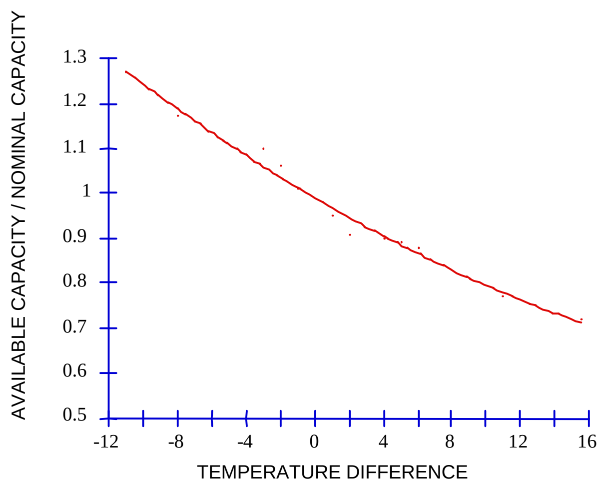


Figure 137. Available Capacity / Nominal Capacity vs DT

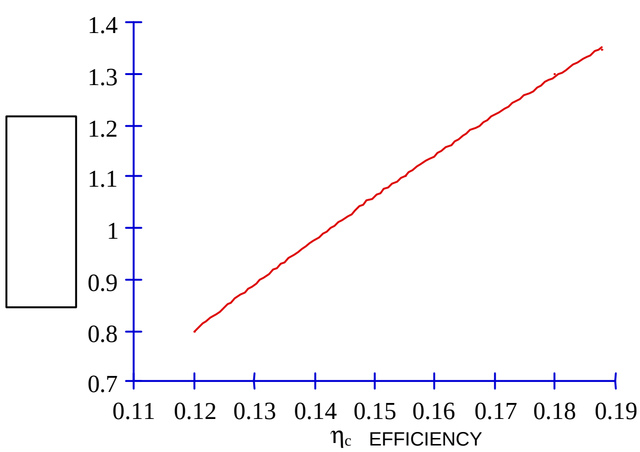


Figure 138. FLPR/DFLPR vs Efficiency

The last step in determining part-load performance coefficients that relate the fraction of full-load power to the PLR is:

$$FFL = A_1 + A_2 * PLR + A_3 * PLR^2$$

where: FFL is the fraction of full-load power

PLR is the part-load ratio on the condensing unit (LOAD/AVAIL CAP)

A_1, A_2, A_3 are coefficients of the RPWRCD set.

The table below lists data showing the compressor performance under part-load conditions.

FFL	PLR
1.00	1.0
0.86	0.833
0.74	0.666
0.60	0.500
0.45	0.333

Table 47. Data for Determining RPWRCD Coefficients

After curve-fitting: FFL = 0.1456 + 0.9554 (PLR) + (-0.10476) $(PLR)^2$

Note that even though the compressor unloads in "steps", if the PLR does not correspond exactly to an unloading point, the compressor will cycle between steps and the FFL will closely follow a smooth curve. For example, if the PLR for a given hour is 0.75, then, for the above data, the compressor will operate at 0.833 part load for 50.3 percent of the hour, and at 0.666 part load 49.7 percent of the hour. It will consume about 80.3 percent of the FFL.

Power consumption is:

Power = (AVAIL CAP) * (FLPR) * (FFL)

Evaporative Cooler

The evaporative cooler model has five configurations for simulation in BLAST:

1. Direct stage
2. Dry coil indirect stage
3. Wet coil indirect stage
4. Dry coil indirect with the direct stage
5. Wet coil indirect with the direct stage

There are two major types of evaporative coolers:

1. Direct, where water is evaporated directly into the supply air simultaneously cooling and humidifying the air (adiabatic cooling).
2. Indirect, where a secondary stream of air is humidified and used to cool the supply air through a heat exchanger separating the streams, therefore only sensibly cooling the supply air.

Direct Stage

The direct stage, shown in the figure below, consists of a rigid media evaporative pad, with water recirculated from a reservoir. The water is pumped from the reservoir to a water distribution header, for water feed by gravity from above the media. The evaporative pad provides the area for the adiabatic saturation of the air. While the process provides a lower dry bulb temperature, the moisture content of the leaving air is higher than the entering condition. The direct stage is used for comfort cooling in a building where adding humidity to the air can be tolerated.

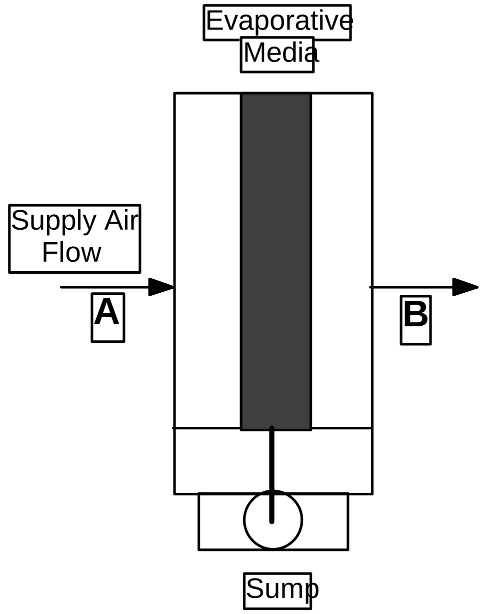


Figure 139. Direct Stage Evaporative Cooler

The thermodynamic process is a simultaneous heat and mass transfer, or adiabatic cooling, and follows a constant enthalpy line on the psychrometric chart, it is shown in the figure below as a process from A to B. Since the deviation of the constant wet-bulb line and the constant enthalpy line is small, it is assumed that the wet bulb temperature is constant across the direct evaporative stage.

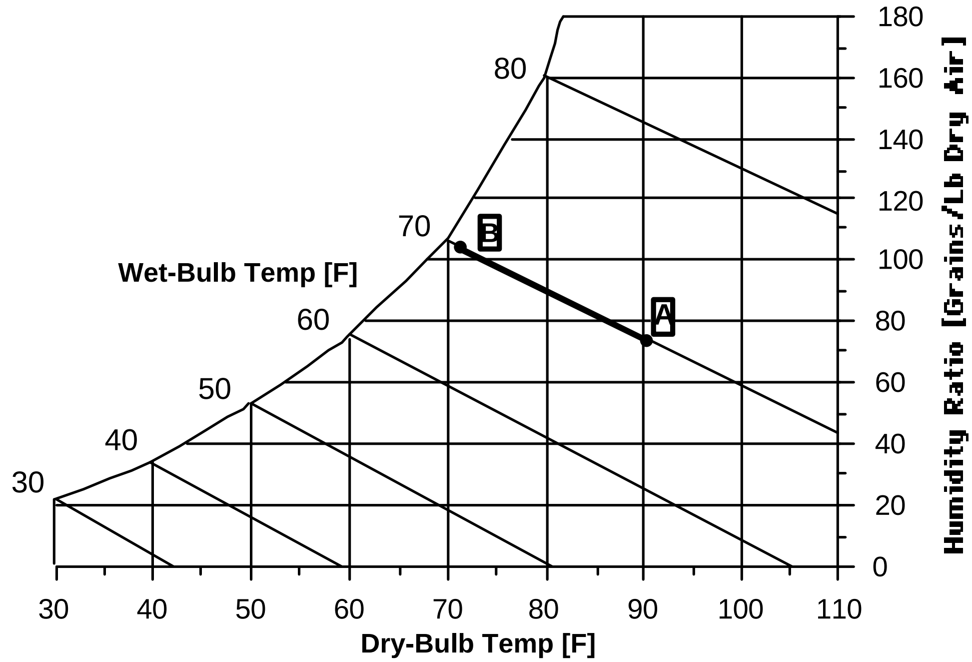


Figure 140. Adiabatic Cooling

If the direct evaporative process were 100% efficient the leaving dry bulb temperature would equal the entering wet bulb temperature. The efficiency of the direct evaporative process is less than 100% and by defining a saturation efficiency (ε_{se}) for the direct stage or evaporative pad, the leaving dry bulb temperature can be expressed by Equation 1.

$$T_{db\ sup\ out} = T_{db\ sup\ in} - \varepsilon_{se}*(T_{odb} - T_{owb}) \qquad [1]$$

Indirect Stage

The indirect evaporative coolers, shown in figures "Dry Coil Indirect Stage evaporative cooling process" and "Wetted Coil Indirect Stage evaporative cooling process", have an air to air heat exchanger that separates the supply air flow from the secondary air flow. The only difference between the previous figures is where the secondary air undergoes adiabatic cooling, either on the heat exchanger tube or in the evaporative media before the heat exchanger. The supply air flows in the tube side of the heat exchanger and only undergoes sensible cooling, lowering both the dry bulb and the wet bulb temperatures at a constant humidity ratio. The secondary air stream undergoes direct evaporative cooling, which in turn cools the supply air. The indirect stage can be used for comfort cooling of a building, or pre-cooling for a refrigeration coil.

The effectiveness of the heat exchanger and the saturation efficiency both come into play to lower the overall efficiency of the indirect stage below that of the direct stage. The trade off with the lowered efficiency is that the dry bulb temperature of the supply air is reduced without increasing the moisture content. The thermodynamic process for the supply air is shown in the figure below, going from A to B.

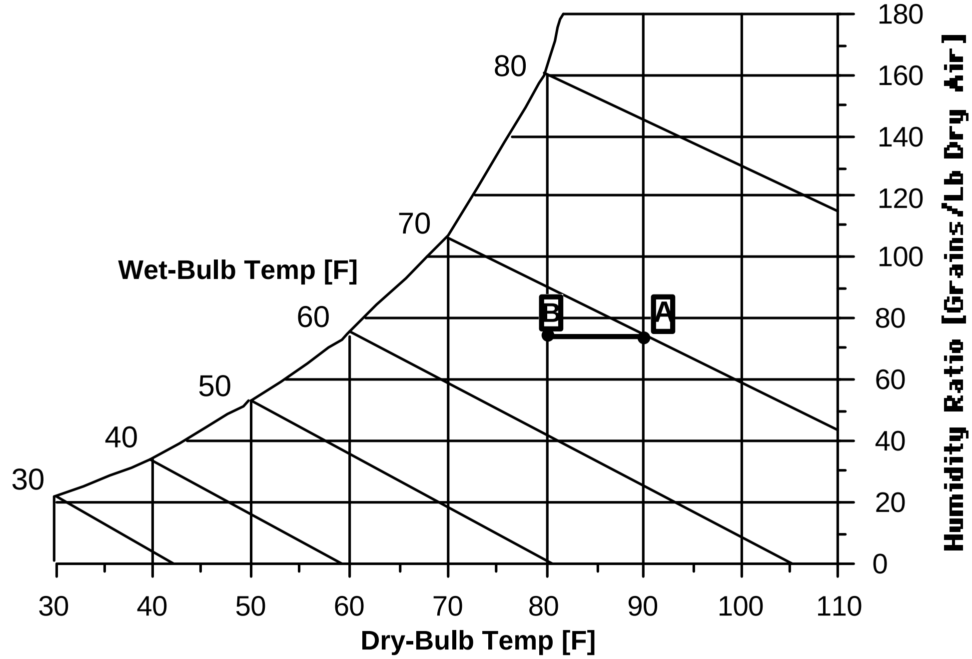


Figure 141. Cooling at a constant humidity ratio

Dry Coil Indirect Evaporative Cooler

The dry coil indirect evaporative cooler, shown in the figure below, has a rigid media pad, similar to the direct evaporative stage, where the adiabatic cooling takes place. The secondary air leaves the rigid media pad and enters an air-to-air heat exchanger where it cools the supply air flowing through the heat exchanger tubes. The moist secondary air is then exhausted to the environment. The secondary air stream has its own fan.

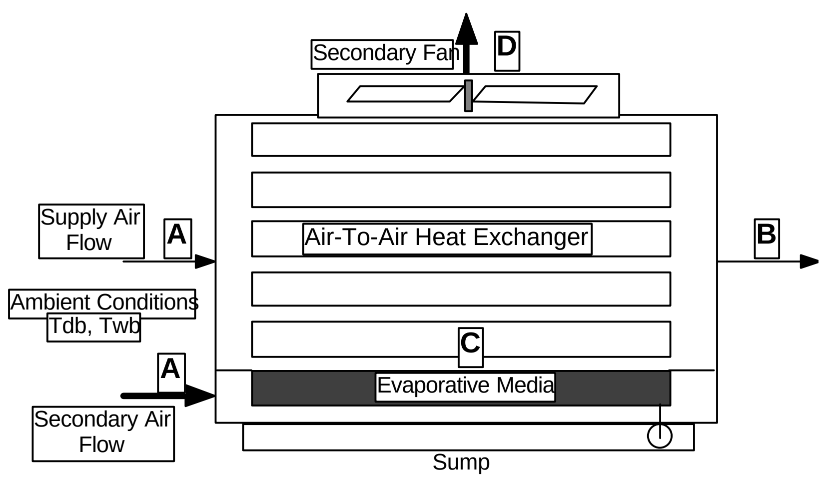


Figure 142. Dry Coil Indirect Stage Evaporative Cooler

The process that the secondary air goes through, A to C to D, is shown by the dashed lines in the figure below. Process A to C is adiabatic cooling in the rigid media pad. Then the air enters the shell side of the heat exchanger and is sensibly heated from C to D by the warm supply air passing through the tube side.

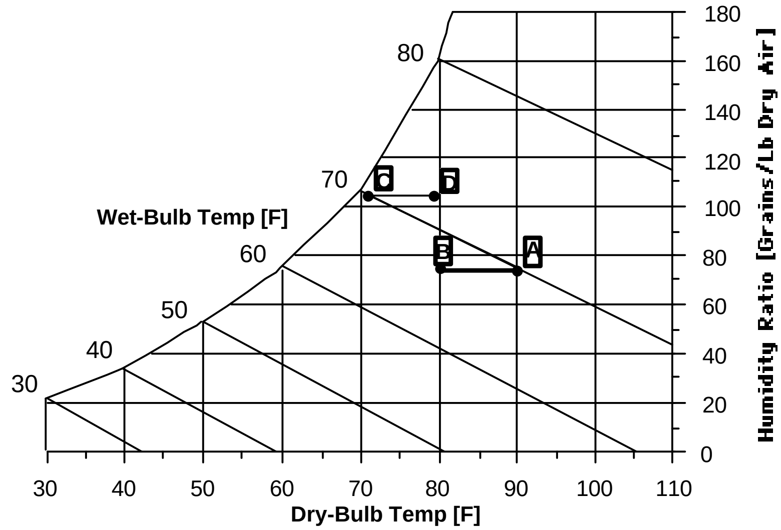


Figure 143. Dry Coil Indirect Stage evaporative cooling process

The advantage of the dry coil heat exchanger is that the heat exchanger does not have the evaporation taking place on the outside of the tubes, thus no mineral deposits are left on the heat exchange surface to reduce the efficiency of the heat exchanger. The rigid media pads are designed to flush the mineral deposits to the sump, so the saturation efficiency of the pad stays relatively constant.

Wetted Coil Indirect Evaporative Cooler

The wetted coil evaporative cooler, shown in the figure below, has water sprayed directly on the tubes of the heat exchanger where latent cooling takes place. The vaporization of the water on the outside of the heat exchanger tubes allows the simultaneous heat and mass transfer which removes heat from the supply air on the tube side. Then the moist secondary air is exhausted. The secondary air stream has its own fan.

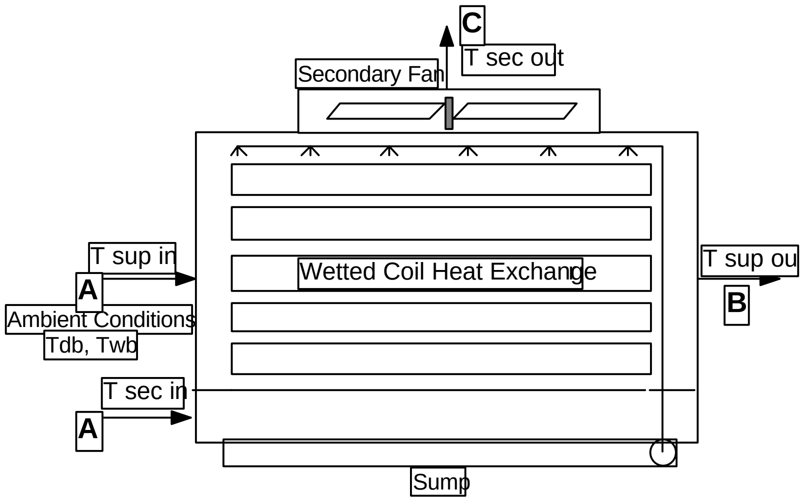


Figure 144. Wetted Coil Indirect Stage Evaporative Cooler

The process that the secondary air goes through, A to C on the figure above, is a path of simultaneous heat and mass transfer, but it does not follow a line of constant enthalpy as in the direct stage. The process is not adiabatic due to the heat gain from the supply air flowing through the tubes of the heat exchanger.

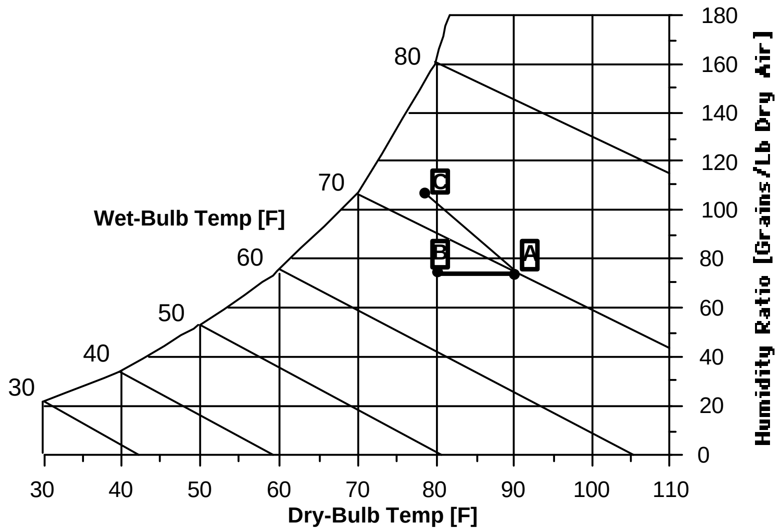


Figure 145. Wetted Coil Indirect Stage evaporative cooling process

The wet coil heat exchanger can have a higher stage efficiency than the dry coil due to a higher heat transfer rate on the outside of the heat exchanger tubes. Over the operating lifetime of the heat exchanger, the vaporization taking place on the heat exchange surface can leave mineral deposits which will decrease the effectiveness of the heat exchanger.

Two Stage Indirect Staged with a Direct

The two stage can be either a wet coil or the dry coil indirect evaporative cooler staged with a direct evaporative cooler. It is shown with a dry coil indirect evaporative cooler in the figure below. This configuration is mainly used for total comfort cooling for a building and would not normally be used as a pre-cooler for a refrigeration coil, since the direct stage would increase the latent load on a refrigeration coil.

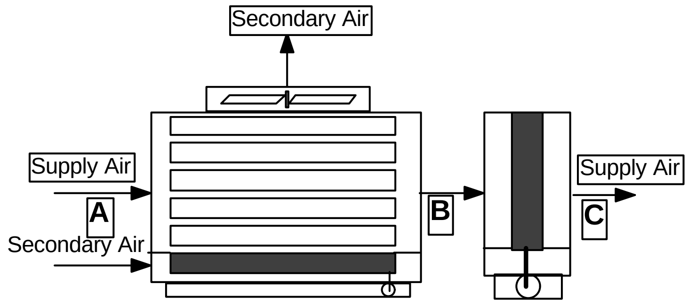


Figure 146. Two Stage Evaporative Cooler

The thermodynamic process for the supply air is shown in the figure below, going from A to B to C. The process from A to B is sensible cooling in the indirect stage. The process from B to C is simultaneous heat and mass transfer following a constant enthalpy line. The air leaving the final stage has a lower dry bulb and wet bulb temperature, and an increase in moisture from the direct stage.

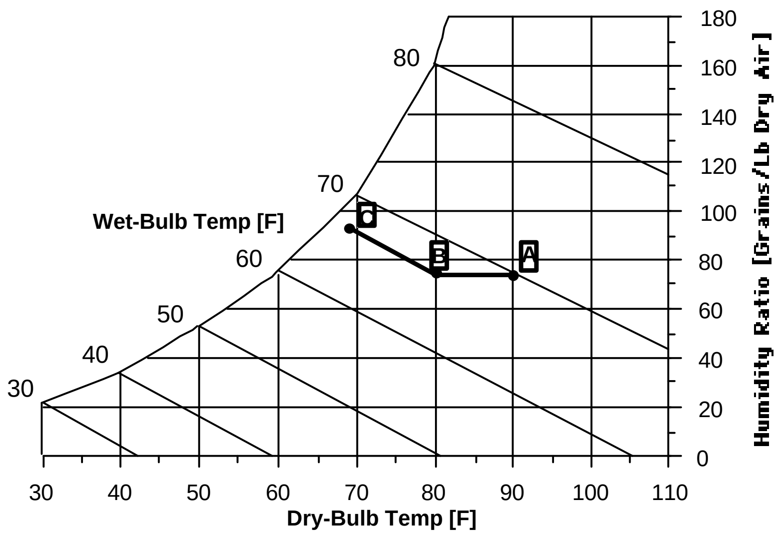


Figure 147. Two Stage evaporative cooling process

These models should cover the basic configurations that a designer might encounter. The evolution of new evaporative combinations and configurations is occurring at a rapid rate due to the emphasis on indoor air quality and displacement of CFC's, but equivalent capacities can be calculated and simulated by these five configurations.

Evaporative Cooler Controls

With many of the BLAST fan systems, the evaporative coolers can take advantage of the outside air damper in the mixed air box to control evaporative cooler capacity. Two control methods have been implemented, one where the outside air damper is full open with continuous operation, and the other with the outside air damper modulating to control the capacity of the evaporative cooler.

Continuous operation at 100% capacity

Scheme I

Evaporative cooler operates at 100% when specified, and while the supply fan operates.

When the evaporative coolers are specified in the fan system, 100% outside air is used and the evaporative cooler operates continuously while the supply fan operates. This scheme is used with fan systems that have a mixed air box, the outside air damper is set to 100% outside air flow with 100% relief air. The supply fan can be scheduled OFF, which in the BLAST program means that it will only operate when a demand in the zone exists, this allows the evaporative cooler to cycle on and off for an hour, depending on zone demand. While the evaporative cooler is operating there is no attempt to try to meet the desired mixed air temperature, and the evaporative cooler operates continuously for that hour. This control scheme can be used for any of the evaporative cooler configurations, for the two stage configuration both stages will operate.

Damper Control to Meet Desired Mixed Air Temperature

The desired mixed air temperature is the temperature of the supply air that will meet the entire heating/cooling load in the zone for that hour. If the desired mixed air temperature is met, additional heating/cooling is not required to meet zone demand.

Scheme II

- Continuous operation of the supply air fan.
- Evaporative cooler operates with a modulated air flow to meet demand.

The basic idea of this control scheme is to try to meet the zone demand with outside air first, then the evaporative coolers, and then, if available, by a cooling coil. The sequence is:

- If the outside air is cooler then the desired mixed air temperature, then the outside air damper will control the amount of outside air to meet demand until the damper is full open.
- Once the outside air damper reaches 100% open and can no longer meet the desired mixed air temperature, then the pumps, or pumps and fans activate for the first evaporative stage (if this is a two stage configuration, the indirect stage will start first to minimize the latent load on the zone).
- Once again the outside air dampers will modulate to meet the desired mixed air temperature until the dampers reach 100% open (full cooling capacity of the stage).
- If another evaporative stage is available, the pumps will start for the second stage and the outside air damper will modulate to meet

the desired mixed air temperature until they reach 100% open (for the two stage configuration this will be the direct stage).

- When the dampers reach 100% outside air, with all the evaporative coolers running and additional cooling is still needed, the dampers stay at 100% outside air and the cooling coils are used to provide the extra cooling capacity. If cooling coils are not available, then the evaporative coolers would maintain whatever temperature possible in the zone.

The first control scheme is commonly used on smaller systems, like the direct evaporative coolers used in residences in the southwest. The second control scheme is used on more elaborate systems where there is staging of evaporative coolers with each other and with cooling coils. Installation of more elaborate systems is becoming more common as evaporative cooling replaces, or partially displaces refrigeration cooling.

Other Systems Parameters

Other System Parameters in the BLAST input for a fan system give the user the ability to specify different outside air controls, cooling and heating coil deck temperatures, coil parameters, etc. To use the evaporative cooler models with the default BLAST fan systems some changes need to be made to a few of the default parameters.

The temperature leaving an evaporative cooler is a function of flow. As the flow is increased the saturation efficiency is reduced and the dry bulb temperature leaving the cooler increases. As the flow decreases the saturation efficiency increases and the dry bulb temperature leaving the evaporative cooler decreases. The evaporative cooler can supply a lot of air at a fairly cool temperature, depending on the wet bulb temperature depression, but can not produce temperatures comparable to refrigeration coils. The BLAST cooling coil is set to meet a specified cold deck temperature and will meet this temperature by modulating the cooling capacity to the coil.

The "Cold Deck Control", "Cold Deck Temperature", "Cold Deck Throttling Range", and the "Mixed Air Control" are defaulted from BLAST for use with a refrigeration cooling coil. These BLAST default values need to be changed to values that are reasonable for operation with evaporative coolers. The BLAST default system parameters are shown in the BLAST User Reference section on Evaporative Coolers. These defaults need to be modified for systems that have more control over the cold deck temperature. Changing these parameters is necessary to have the desired mixed air temperature set to the supply air temperature. They need to be changed for the following fan systems:

1. Multizone
2. Three Deck Multizone
3. Variable Volume
4. Dual Duct Variable Volume
5. Terminal Reheat
6. Two Pipe Induction Unit
7. Four Pipe Induction Unit

Other fan systems that will work with the evaporative cooler model, and their desired mixed air temperature is automatically set to the supply air temperature:

1. Sub Zone Reheat
2. Single Zone Draw Thru
3. DX Packaged Unit

For the last three fan systems the cold deck control syntax will not be specified from the HBLC systems form.

Mixed Air Control determines how outside air is going to mix with return air to determine the mixed, supply air flow. Control Scheme I, is set by "EVAP CONTROL NONE". Control Scheme II, is set by "EVAP NO HUMIDITY CONTROL".

Evaporative control scheme II is programmed to meet the desired mixed air temperature. This is the temperature at the mixed air box before fan heat is added. If the evaporative cooler can meet this temperature then the cooling demand is satisfied. If additional cooling is needed and the cooling coil is scheduled "ON", the load will be met by the coil. If the cooling coil is scheduled "OFF" the additional cooling required by the zone will show up under "Fan System Undercooling".

In the case when the weather is mild and the cooling demand is small using control scheme II can result in "Fan System Overcooling". This happens when the evaporative cooler can satisfy the cooling demand if the outside air flow is between zero and the minimum air fraction. The control scheme will determine the actual outside air flow required for the cooling and check to see if the air flow is less than the minimum. If the air flow is below the minimum, the outside air flow will be set to the minimum. This will provide extra cooling which will be reported as overcooling. The magnitude of overcooling will depend on the magnitude of the minimum air fraction. This does not happen with a cooling coil because the cold deck temperature is not a function of the air flow rate.

Efficiencies of the Indirect Stage

In an indirect stage of an evaporative cooler, the wet side air stream acts as a heat sink for the supply air. The efficiency of the indirect stage is given as the effectiveness of the sensible heat exchange, through the air to air heat exchanger, and the saturation efficiency on the wet stream side. These are given as:

$$\varepsilon_{Hx} = \frac{q}{q_{max}} = \frac{C_{sup}(T_{sup\ in} - T_{sup\ out})}{C_{min}(T_{sec\ in} - T_{sec\ out})}$$

where $T_{sup\ in} = T_{sec\ in}$ for the indirect cooler.

$$\varepsilon_{se} = \frac{T_{db\ sec\ in} - T_{db\ sec\ out}}{T_{db} - T_{wb}}$$

The maximum heat transfer rate possible would be obtained when the supply stream is cooled all the way to the wet bulb temperature.

$$\varepsilon_{ind} = \frac{q}{q_{max}} \quad \text{wet side} = \frac{C_{sup}(T_{sup\ in} - T_{sup\ out})}{C_{min}(T_{db} - T_{wb})}$$

The combination of the effectiveness and saturation efficiency equations will give the total efficiency of the indirect stage.

$$\varepsilon_{ind} = \varepsilon_{Hx} \ \varepsilon_{se} \ \frac{C_{sup}}{C_{min}}$$

In many cases Csup = Cmin and the efficiency of the indirect stage would reduce to:

$$\varepsilon_{ind} = \varepsilon_{Hx} \ \varepsilon_{se}$$

Both the effectiveness of the heat exchanger and the saturation efficiency are functions of flow, but both vary differently with flow and need to be considered separately. See the figure below for schematic.

Tdb sec out	dry bulb temperature leaving from secondary stream
Tdb sec in	dry bulb temperature entering the secondary stream
Twb	wet bulb temperature at ambient conditions
Tdb	dry bulb temperature at ambient conditions
Tsup in	dry bulb temperature entering the supply stream
Tsup out	dry bulb temperature leaving from supply stream
ε_{ind}	Overall efficiency of the indirect evaporative cooler
ε_{Hx}	Effectiveness of the air-to-air heat exchanger
ε_{se}	Saturation efficiency of the evaporative cooler
Csup	Heat capacity of the supply stream
Cmin	Minimum heat capacity, supply or secondary air stream

Table 48. Legend of terms used to develop Evaporative Cooler equations

Efficiencies of the Evaporative Media

Saturation efficiencies of the evaporative media are used in both the direct and indirect stages of the evaporative coolers. It was shown above that the overall, indirect evaporative cooler efficiency is made up of two separate efficiencies, the effectiveness of the heat exchanger and the saturation efficiency. In the direct stage, the saturation efficiency is the total efficiency for the stage. Saturation efficiency is a function of air flow, or pad face velocity, and pad thickness. Below is a graph of the curve fit that is used in BLAST to generate saturation efficiencies.

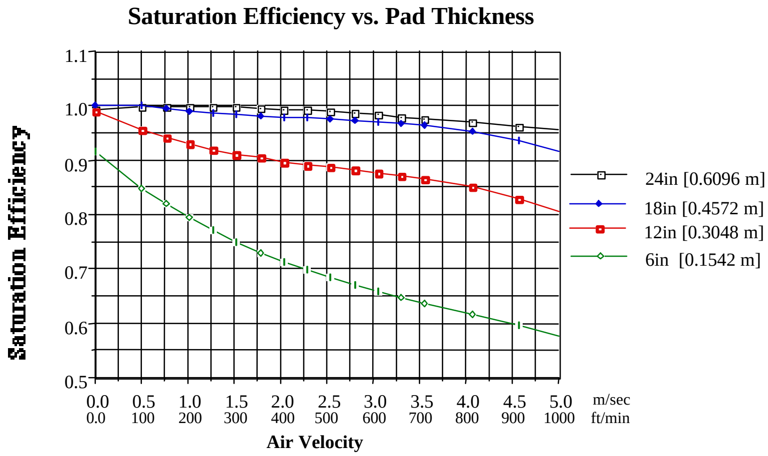


Figure 148. Relationships between efficiency, Pad Thickness, and Air Flow

These are the curve fits for rigid media pads, when aspen pads or other evaporative media are being used, an effective pad depth must be specified equivalent to the rigid media pads. For example, if you have an aspen pad that is 2 inches thick and has an 80% saturation efficiency at 200 ft/min, then you would look at the graph on the x-axis at 200 ft/min and 80% saturation efficiency. You would notice that this corresponds to a rigid media pad thickness of 6 inches, this would be the value you would enter for the pad thickness in the input file. If it landed between to values on the graph, you could do a linear interpolation to find the closest pad thickness. Remember that the curve fits are for the rigid media pads, but the same trends are inherent in all types of pads. The fits should give decent simulation data for other pad material types.

Output Reports for the Evaporative Cooler

The Output Reports which can be used to analyze the performance of the evaporative coolers are:

1. Evaporative Report
2. Humidity Report

They can be added to the Reports statement in the BLAST input file and the reports will appear in the Fan Systems Section of the output file. The output reports can be used for both design day and annual runs. The humidity report can be run for any fan system and can also be used without an evaporative cooler specified. See "BLAST Output Reports" for further descriptions.

Exterior Convection Coefficients

Some confusion exists about the way BLAST calculates outside convection coefficients for the six possible wall roughnesses (i.e. very rough, rough, medium rough, etc.) Since BLAST calculates the heating and/or cooling load for any zone based on the aforementioned convection coefficients, some confusion may also exist about the relationship between zone loads and said outside convection coefficients. It is the purpose of this article to clear up any questions about outside convection coefficients, how they are calculated, and their effect on zone load calculations.

Outside Convection Coefficients

Relationships for convection coefficients developed in the *ASHRAE Handbook of Fundamentals* [1] were used as a basis for this investigation. The ASHRAE values are based on the experiments described below.

Experiments were made on 304.8mm square samples of different materials at a mean temperature of -6.7°C for wind velocities up to 17.9 m/s. The results of these studies are shown in Figure 1 on p. 22.4 of the *1989 ASHRAE Handbook of Fundamentals*. They have been reproduced in the figure below of this article for convenience. The results of these tests are the basis for the way outside convection coefficients are calculated by BLAST. BLAST uses the following equation, which is a curve fit of the ASHRAE data:

h = D(RF) + E(RF) * WS + F(RF) * (WS)2

where:

h = outside convection coefficient (W/m2 * K)

WS = wind velocity (m/s)

D,E,F = coefficient arrays derived from the curve fit

RF = roughness flag (1=very rough,..., 6=very smooth)

The figure below is a graph of h vs. WS which was generated using the equation from BLAST. The graph is essentially identical to the one presented in the *ASHRAE Handbook of Fundamentals.*

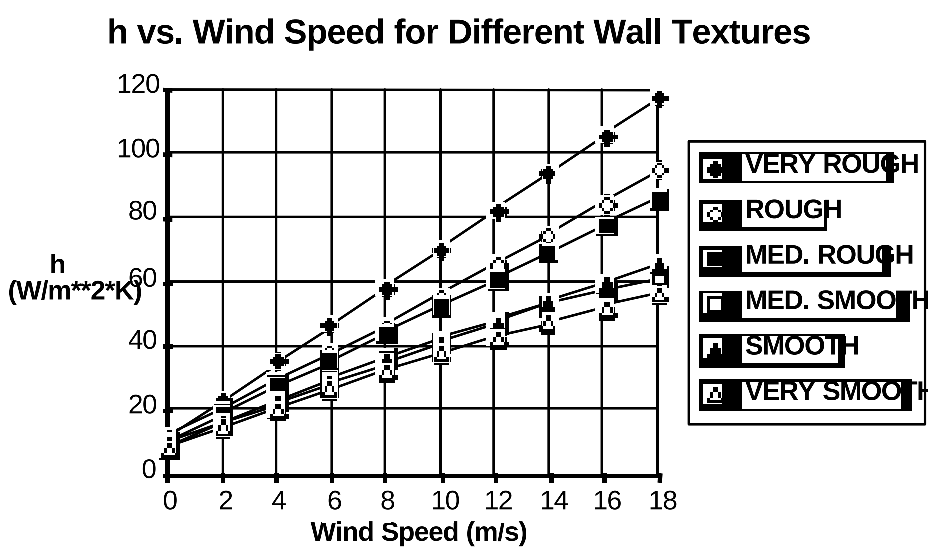


Figure 149. Relationships between h, Wind Speed, and Roughness

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[1] *Handbook of Fundamentals* (American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1985.

Relationship of Outside Convection Coefficients to Zone Loads

Two BLAST input files were created to determine the relationship between the outside convection coefficients and zone loads.

The files contained twelve identical design days, with the exception of the wind speed variable. Each design day had a unique wind speed ranging from 0 to 11 m/s.

The building consisted of six identically dimensioned zones. Each zone had unique walls with one of the possible user specified wall roughnesses. The controls in the zones were the same and were created to insure there would be both heating and cooling loads present for each design day.

There was only one difference between the two BLAST input decks. In one deck the clearness variable was set to 0.0 (no sun), and in the other deck the clearness was set to 1.0 (100% solar flux). This was done to see what effect (if any) solar flux had on the different wall surfaces.

Heating Loads

The steady-state thermal resistance network for any wall in any zone of the test building looks like the following:

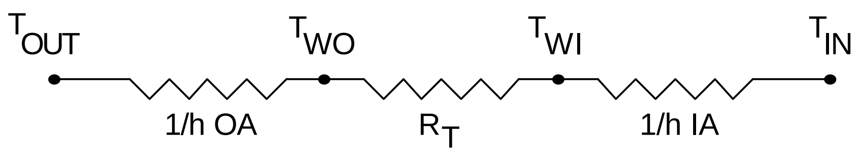

Figure 150. Thermal Resistance Network

where:

T_{OUT} = outside air temperature

T_{WO} = temperature on the outside wall surface

T_{WI} = temperature on the inside wall surface

T_{IN} = inside air temperature

1/hOA = outside convective thermal resistance

R_T = total thermal resistance in wall

1/hIA = inside convective thermal resistance

For the purposes of this study, it is assumed that R_T and 1/hIA are constant. That is, the only variable that will change is hOA (which is the outside convection coefficient).

The heating loads occurred primarily at night, therefore, there was not a dramatic difference in the heating loads between the sun and no sun cases. In general, as the wind velocity increases, h_O also increases and the outside convective thermal resistance decreases. Therefore, we would expect the heating loads to increase. Indeed, this is the result obtained (see the figure below).

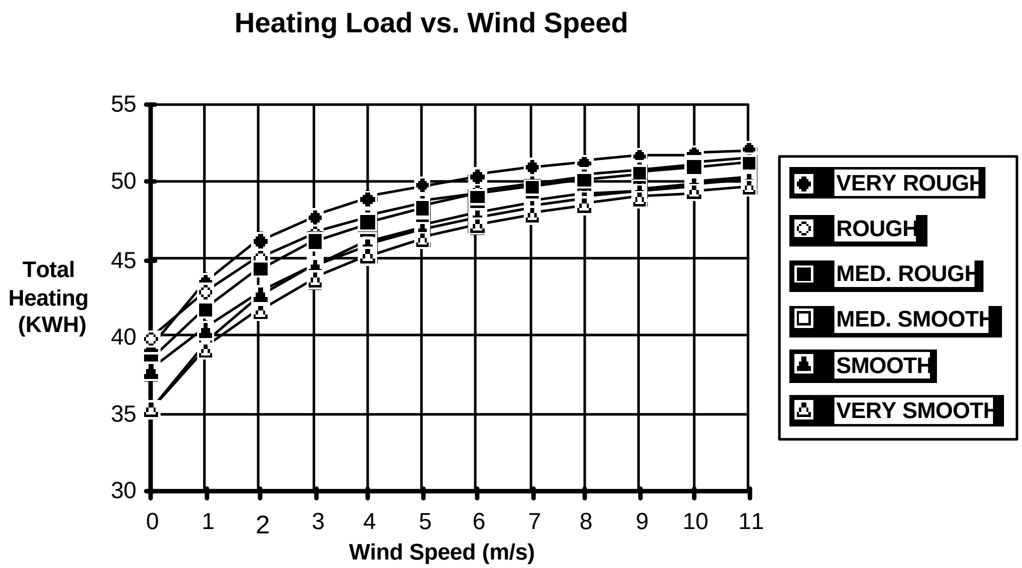

Figure 151. Heating Load vs. Wind Speed

Cooling Loads

The relationships between the cooling loads and wind speed are much more dramatic. At the no sun condition, one would expect the cooling loads to increase with increasing wind speed. The reason for this is clear. As wind speed increases, h_0 also increases and the overall thermal resistance decreases. Therefore, the cooling loads should increase.

When solar flux is added to the building, the relationships between the cooling loads and wind speed are much different. The cooling loads decrease with increasing wind speed.

An exterior wall with a solar flux on it will be at a higher temperature than the outside ambient air. As wind velocity increases, the outside wall temperature approaches the outside ambient air temperature. Hence, less heat is conducted (inward) through the walls and therefore the cooling loads should decrease.

Summary

Heating and cooling loads are a function of outside convection coefficients. The coefficients themselves are a function of wind speed and surface roughness. At the no sun condition, both heating and cooling loads increase with increasing wind speed. The zones with the rougher walls have greater loads than the zones with smoother walls.

When solar flux is added, the relationships change. The heating loads increase with increasing wind speed (as with the no sun condition), but the cooling loads decrease with increasing wind speed, with the rougher walled zones having a lesser load than the smoother walled zones.

For further information about the concepts discussed, see the *ASHRAE Handbook of Fundamentals.*

Fan Power Coefficients

Fan power for fixed volume systems and full-load fan power for VAV systems is computed from default or user-specified fan pressure and fan efficiency using basic fan laws. Note that full-load fan efficiency for VAV fans is usually lower than their fixed volume counterparts. Part-load fan power for VAV systems is computed using VAV VOLUME CONTROL TYPE *or* FAN POWER COEFFICIENTS.

If specified, FAN POWER COEFFICIENTS determine the fraction of full-load fan power consumption for variable volume systems according to the following equation:

$$FFLP = A + B * PLR + C * PLR^2 + D * PLR^3 + E * PLR^4$$

where:

FFLP = the fraction of full-load power

PLR = the part-load ratio defined as the delivered air flow in any one hourdivided by the design air flow rate for the fan

A, B, C, D & E = are the five fan power coefficients specified within the parentheses inFAN POWER COEFFICIENTS. (Any of these coefficients can be zero).

If the user does not specify FAN POWER COEFFICIENTS and is simulating a variable volume fan system, three types of air volume control can be invoked: DISCHARGE DAMPERS, INLET VANES, and VARIABLE FAN SPEED. The full load fan power equation is still used but with default coefficients, depending on the type of fan volume control specified. The following FAN POWER COEFFICIENTS are used if the user specifies INLET VANES, DISCHARGE DAMPERS, or VARIABLE FAN SPEED.

For INLET VANES:

$FFLP = 0.3507123 + 0.3085 \times PLR - 0.54137 \times PLR^2 + 0.871988 \times PLR^3$

For DISCHARGE DAMPERS:

$FFLP = 0.3707 + 0.9725 \times PLR - 0.3424 \times PLR^2$

For VARIABLE FAN SPEED:

$FFLP = 0.00153 + 0.005208 \times PLR + 1.1086 \times PLR^2 - 0.11635563 \times PLR^3$

The following figure shows the default curves for FFLP vs. PLR for these types of volume control.

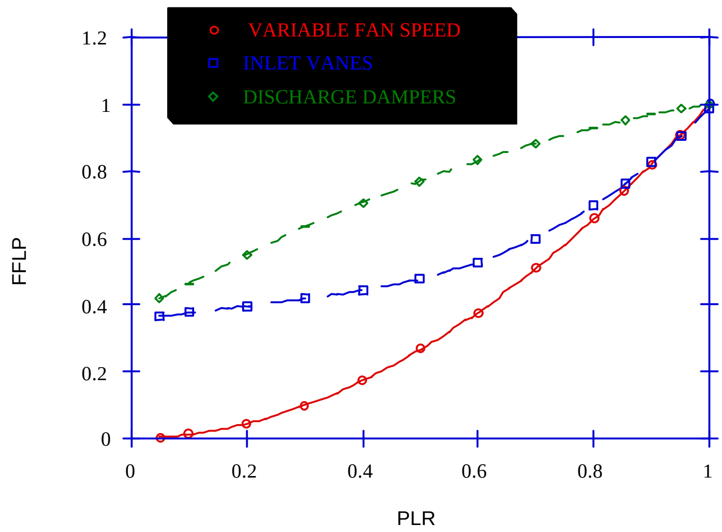

Figure 152. FFLP vs PLR for three types of volume control

The SYSTEM ELECTRICAL DEMAND input along with the SYSTEM ELECTRICAL DEMAND SCHEDULE input from the EQUIPMENT SCHEDULE input block are used to account for miscellaneous system electrical demands such as controls, compressors, etc.

Free Cooling Chiller

The free cooling chiller is an open centrifugal chiller which may obtain cooling with the compressor shut off when the condenser water temperature drops low enough by operating only a small refrigerant pump as well as the chilled water and condenser pumps. Therefore, the free cooling chiller operates in either the regular open chiller mode or the free cooling mode. The actual mode of operation is determined by the SPECIAL PARAMETERS FCCTRL, FCON, FCOFF, and FCTEMP.

If the chiller is operating in the "regular" mode, the chiller performance is described by the EQUIPMENT PERFORMANCE PARAMETERS ADJTFC, RCAVFC, ADJEFC, and RPWRFC. These parameters are defined and used analogously to those for the double-bundle chiller.

If the chiller is operating in the "free cooling" mode, the chiller performance is described by the EQUIPMENT PERFORMANCE PARAMETERS CAVFCM parameter set. Next, the actual amount of free cooling used is computed. Finally, the electrical power consumption for the chiller in the free cooling mode is determined.

The available free cooling chiller capacity is determined by:

$$AVLCAP = OCAP * [A_1 + A_2 * (TCOOL - TECW) + A_3 * (TCOOL - TECW)^2]$$

where: A_1, A_2, A_3 are the parameters of the CAVFCM set

OCAP is the design free cooling chiller capacity operating for that hour

TCOOL is the SPECIAL PARAMETER describing the leaving chilled water temperature

TECW is the chiller temperature of the condenser water entering the chiller

AVLCAP is the actual capacity available

The actual cooling (FCCOOL) is determined by:

FCCOOL = minimum of ECOOL and AVLCAP

where: ECOOL is the actual cooling load for that hour

The electrical consumption for the free cooling chiller in the free cooling mode is computed by:

$$ELEC = B_1 + B_2 * PLR + B_3 * PLR^2$$

where: B_1, B_2, B_3 are the parameters of the PWRFCM set

PLR = FCCOOL/AVLCAP

ELEC = electricity consumed

FFL VS. PLR FOR COMPRESSION CHILLERS

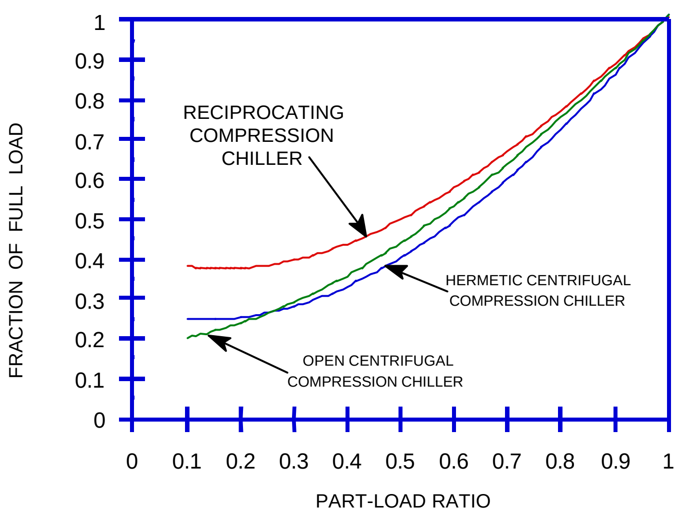

Figure 153. FFL vs PLR for Compression Chillers

Generators

Diesel Generator

Diesel engine generators are modeled using the following equations:

Electric energy output/fuel energy input = A1 + A2 * PLR + A3 * PLR²

where:

PLR = part-load ratio (i.e., electric/load generator capacity)

A1, A2, and A3 = equipment performance parameters of the RELD parameter set.

Recoverable jacket heat/fuel energy = B1 + B2 * PLR + B3 * PLR²

where:

B1, B2, and B3 = equipment performance parameters in the RJACD set.

Recoverable lube oil heat/fuel energy input = C1 + C2 * PLR + C3 * PLR²

where:

C1, C2, and C3 = equipment performance parameters in the RLUBD set.

Total exhaust heat/fuel energy input = D1 + D2 * PLR +D3 * PLR²

where:

D1, D2, and D3 = equipment performance parameters in the REXD set.

Exhaust gas temperature/fuel energy input = E1 + E2 * PLR + E3 * PLR²

where:

E1, E2, and E3 = equipment performance parameters in the TEXD set.

The diesel generator model uses the electrical load and engine generator size to compute part-load ratios (PLR). Fuel energy input and recoverable jacket and lube oil heat are then computed. Finally, the recoverable exhaust heat is calculated. The left sides of the equations indicate the manufacturer's curve or tables that must be obtained for diesel engine generators to derive the equipment performance parameters. Note that simple transformation of the form of the manufacturer's curves may be required. For example, the data required to determine the RELD parameters set may be presented in the form of fuel consumption vs. kilowatt electrical load. In this case, the transformation required is (K is the appropriate units conversion constant):

$$\frac{(\text{electrical load})\,(K)}{(\text{fuel consumption})\,(\text{heat content of fuel})} = \frac{\text{electrical energy output}}{\text{fuel energy input}}$$

and

$$\frac{\text{electrical load}}{\text{generator capacity}} = \text{part-load ratio (PLR)}$$

Example

The following example illustrates the procedure for generating performance coefficients for a specific diesel generator. In the example, data for a 630-kW Ebullient diesel engine generator were obtained from the manufacturer . The following equations were also obtained from the manufacturer:

Lube heat (Btu/min) = 8.4 x horsepower.

Fuel consumption (Btu/min) = 1.1 (exhaust heat + jacket heat + lube heat + aux heat + work).

Percent	Total Exhaust Gas Heat	Recoverable Exhaust Gas	Jacket & Lube Heat	Work	Aux. Heat (Pumps,

Load	Rejected at 90°F (Btu/min)	Heat at 300°F (Btu/min)	(Btu/min)	(Btu/min)	Fans) (Btu/min)
100	31,960	17,650	24,400	35,820	11,128
75	24,380	12,910	18,900	26,870	8,520
50	17,040	8,070	12,300	17,190	6,760
25	10,820	4,020	5,900	8,960	4,470

Table 49. Manufacturer's Data - Diesel Generator

Step 1

Determine exhaust gas temperature. Although the exhaust gas temperature is not given, it can be determined from the following equations:

Total exhaust gas heat at 90°F, $H_{90} = mc_p(T_E\text{-}90)$

Recoverable exhaust gas heat at 300°F, $H_{300}8 = mc_p(T_E\text{-}300)$

where: m = the exhaust gas mass flow rate

c_p = the exhaust gas specific heat

T_E = the exhaust gas temperature in °F.

After dividing and rearranging,

$$T_E = \frac{90(H_{300}) - 300(H_{90})}{H_{300} - H_{90}}$$

where: H_{300} = recoverable exhaust gas heat at 300°F

H_{90} = total exhaust gas heat at 90°F.

For example, at 100 percent load:

$$T_E = \frac{90(17650) - 300(31960)}{17650 - 31960} = 559°F$$

Repeating the process using manufacturer's data for other PLRs gives the following results:

Percent Load	PLR	Exhaust Gas Temperature	
100	1.0	559°F	1019°R
75	.75	536°F	996°R
50	.50	489°F	949°R
25	.25	424°F	884°R

Table 50. Exhaust Gas Temperature for Various PLRs

Step 2

Determine exhaust gas heat. Note that exhaust gas heat is not equal to the total rejected heat at 90°F. The number required is mc_p (T_E-32), since 32°F is the base temperature for enthalpy calculations. Since T_E is known, only mc_p must be found in order to compute exhaust gas heat. For example, at 100 percent load:

$$H_{90} = mc_p\,(559\text{-}90) = 31{,}960$$

or

$$mc_p = \frac{31{,}960}{(559 - 90)} = 68.14 \text{ Btu/(min °F)}$$

and

$$H_{32} = mc_p\,(T_E - 32) = 35{,}912 \text{ Btu/min}$$

Repeating the process for other PLRs gives:

Percent Load	PLR	Exhaust Gas Heat (Btu/min)
100	1.0	35,912
75	0.75	34,345
50	0.50	31,142
25	0.25	26,712

Table 51. Exhaust Gas Heat for Various PLRs

Step 3

Determine lube oil heat. The manufacturer indicates that lube heat is a linear function of load on the engine:

Lube heat (Btu/min) = 8.4 * kW * 1.34 HP/kW

For the 630-kW generator set, this results in:

Percent Load	PLR	kW Load	Lube Heat (Btu/min)
100	1.0	630	7091
75	0.75	472	5313
50	0.50	315	3546
25	0.25	157	1767

Table 52. Lube Heat for Various PLRs

Step 4

Determine jacket heat. The jacket heat is determined by subtracting the lube heat from column 4 of the manufacturer supplied data (lube + jacket heat).

Percent Load	PLR	Jacket Heat (Btu/min)
100	1.0	18,309
75	0.75	13,587

50	0.50	8,754
25	0.25	4,133

Table 53. Jacket Heat for Various PLRs

Step 5

Determine fuel consumption. Having computed the exhaust heat, jacket heat, and lube heat using the auxiliary energy and work energy given by the manufacturer, the fuel consumption can be computed on the basis of the formula provided by the manufacturer:

Fuel consumption = 1.1 (exhaust heat + jacket heat + lube heat + aux heat + work)

The fuel consumed for various PLRs:

Percent Load	PLR	Fuel Energy (Btu/min)
100	1.0	119,086
75	0.75	97,498
50	0.50	74,923
25	0.25	50,646

Table 54. Fuel Consumption for Various PLRs

Step 6

Normalize results. The various heat rates (jacket heat, lube heat, exhaust heat, electrical power) must be divided by the fuel input rate to get data into the form for curve fitting.

$$\text{Electrical power} = \text{kW x 3412 Btu/hr-kW} \frac{1}{60\ \text{min}/\ \text{hr}}$$

Part-Load Ratio	Exhaust Temperature °R	Electric Power (Btu/min)	Electric Power/ Fuel Input Rate	Exhaust Heat Rate/Fuel Input Rate	Jacket Heat Rate/Fuel Input Rate	Lube Heat Rate/Fuel Input Rate
1.0	1019	35,820	0.301	0.032	0.154	0.060
0.75	996	26,870	0.276	0.352	0.139	0.054
0.50	949	17,910	0.239	0.416	0.117	0.047
0.25	884	8,960	0.177	0.527	0.082	0.035

Table 55. Normalized Data

Summary

The results of least squares curve-fitting on the diesel generator examples are the complete parameter set:

RELD (0.09975,0.34860,-0.14800);

RJACD (0.03850,0.19520,-0.0800);

RLUBD (0.021,0.063,-0.024);

REXD (0.660,-0.601,0.224);

TEXD (796,390,-168);

UACD (0,0,0);

The (0,0,0) values for UACD mean that no heat recovery is done on this example diesel generator exhaust gas; when no heat recovery is specified, BLAST will ignore REXD and TEXD. Refer to the Equipment Performance Parameter - Heat Recovery section for a discussion of how to obtain the UACD parameter set.

Gas Turbine

Gas turbine generators use the FUEL1G and FUEL2G performance parameter sets to compute fuel energy consumption as a function of part-load and ambient (entering) air temperature, respectively. The form of the model is:

$$\frac{\text{fuel energy input}}{\text{electric energy output}} = [A1 + A2 * (PLR) + A3 * (PLR)^2] * [B1 + B2 * (\Delta T) + B3 * (\Delta T)^2]$$

where:

PLR = part-load ratio

$\Delta T = T_{air} - 77$, where 77 °F (25 °C) is the fixed rating point temperature at which the capacity of the engine is specified

A1, A2, and A3 = the FUEL1G parameters

B1, B2, and B3 = the FUEL2G parameters (B1 is 1.0 or nearly 1.0.)

Exhaust gas temperature is computed in a similar fashion:

Exhaust gas temperature, °R = $(C1 + C2 * PLR + C3 * PLR^2) * (D1 + D2 * \Delta T + D3 * \Delta T^2)$

where:

PLR and ΔT are as previously defined

C1, C2, and C3 = the TEX1G parameter set

D1, D2, and D3 = the TEX2G parameter set.

The exhaust gas flow rate per unit capacity is computed as a function of the above ΔT as follows:

$$\frac{\text{exhaust gas flow rate (lb / hour)}}{\text{unit capacity (1000 Btu / hour)}} = (E1 + E2 * \Delta T + E3 * \Delta T^2)$$

where:

E1, E2, and E3 = the FEXG parameters.

Example

The table below was constructed from the manufacturer's data for a 2850-kW gas turbine generator. These data were also used to obtain the gas turbine default values.

Table 56. Gas Turbine Generator Data (Output Capacity = 8800 X 10^3 Btu/hr)

Entering Air Temp., Tair °F	45	45	45	77	77	77
Tair - 77	-32	-32	-32	0	0	0
Load (10^3 Btu/hr)	9690	7270	4950	8800	6600	4400
Part-Load Ratio	1.1	0.862	0.562	1	0.75	0.5
Fuel Energy in (10^3 Btu/hr)						
Fuel Input / Energy Out	4.27	4.61	5.49	4.25	4.73	5.75
Exhaust Gas Temp.°R (°F + 460)	1293	1173	1060	1305	1193	1091
Exhaust Gas Flow (lb/hr) / Unit Capacity (1000 Btu/hr)	16.41	16.41	16.41	15.68	15.68	15.68
Entering Air Temp., Tair °F	80	80	80	100	100	100
Tair - 77	3	3	3	23	23	23
Load (10^3 Btu/hr)	8393	6295	4197	7847	5885	3924
Part-Load Ratio	0.954	0.715	0.477	0.892	0.669	0.446
Fuel Energy in (10^3 Btu/hr)	36460	30620	24850	3400	28800	23600
Fuel Input / Energy Out	4.34	4.86	5.92	4.33	4.89	6.01
Exhaust Gas Temp.°R (°F + 460)	1303	1200	1102	1320	1217	1123
Exhaust Gas Flow (lb/hr) / Unit Capacity (1000 Btu/hr)	15.5	15.5	15.5	14.83	14.83	14.83

To begin curve-fitting, take the fuel input to energy output ratio at 77 °F, where$\Delta T = 0$.

$\frac{\text{Fuel Input}}{\text{Energy Output}}$	PLR
4.25	1.00
4.73	0.75
5.75	0.50

Table 57. Data for Determining FUEL1G Parameter Set

After curve-fitting:

$$\frac{\text{fuel input}}{\text{energy output}} = 9.41 - 9.48 * (PLR) + 4.32 * (PLR)^2$$

Thus, the FUEL1G parameters become:

FUEL1G (9.41, -9.48, 4.32);

To determine the adjustment factor for entering air temperature, first define

$$PLRFAC = 9.41 - 9.48 * (PLR) + 4.32 * (PLR)^2$$

and then define

$$\frac{\text{fuel input}}{\text{energy output}} * \frac{1}{\text{PLRFAC}} = B1 + B2 * (\Delta T) + B3 * (\Delta T)^2$$

The table below shows the data necessary for curve-fitting.

$\frac{\textbf{Fuel Input}}{\textbf{Energy Output}} * \frac{\textbf{1}}{\textbf{PLRFAC}}$	**ΔT**
1.014	-32
1.018	-32
1.008	-32
1.0	0
1.0	0
1.0	0
1.010	3
1.004	3
1.008	3
0.986	23
0.978	23
0.995	23

Table 58. Data for Determining FUEL2G Parameter Set

After curve-fitting:

$$\frac{\text{fuel input}}{\text{energy output}} * \frac{1}{\text{PLRFAC}} = 1.0044 - .0008 * (\Delta T) + 0.0 * (\Delta T)^2$$

Thus, FUEL2G(1.0044, -0.0008, 0.0); is the FUEL2G parameter set specification.

The same procedure is used for exhaust gas temperatures:

Exhaust Gas Temperature at T_{air} = 77°F (T_{exh})	**PLR**
1305°R	1.0
1193	0.75
1091	0.50

Table 59. Data for Determining TEX1G Parameter Set

After fitting:

T_{exh} at T_{air} = 77°F = 917 + 308 * (PLR) + 80 * (PLR)^2

or

TEX1G (917,308,80)

If PLRFAC = 917 + 308 (PLR) + 80 * (PLR)^2

then

$$\frac{T_{exh}}{PLRFAC} = D1 + D2 * (\Delta T) + D3 * (\Delta T)^2$$

can be used to create the table below.

$\frac{T_{exh}}{PLRFAC}$	ΔT
0.956	-32
0.957	-32
0.950	-32
1.000	0
1.000	0
1.000	0
1.015	3
1.018	3
1.018	3
1.051	23
1.050	23
1.049	23

Table 60. Data for Determining TEX2G Parameter Set

After fitting:

$$\frac{T_{exh}}{PLRFAC} = 1.0056 + .0018 * (\Delta T) + 0.0 * (\Delta T)^2$$

or

TEX2G (1.0056,.00180,0.0);

Finally, the ratio of exhaust flow rate to generator capacity must be computed as a function of ΔT.

$\frac{\text{Exhaust Gas Flow } (1lb/hr)}{\text{Unit Capacity } (1000\ Btu/h)}$	ΔT
16.41	-32
15.68	0
15.50	3
14.83	23

Table 61. Data for Determining FEXG Parameter Set

After fitting:

$$\frac{\text{Exhaust Gas Flow } (1lb / hr)}{\text{Unit Capacity } (1000\ Btu / hr)} = 15.638 - 0.0306 * (\Delta T) - 0.0002 * (\Delta T)^2$$

or

FUEL1G (9.41, -9.48, 4.32);

FUEL2G (1.0044, -0.0008, 0);

TEX1G (917, 308, 80);

TEX2G (1.0056, 0.0018, 0);

FEXG (15.638, -0.0306, -0.0002);

UACG (0, 0, 0);

where the (0, 0, 0) values for UACG mean that no heat recovery is done on the example gas turbine exhaust gas. BLAST will ignore, TEX1G, TEX2G, and FEXG if no heat recovery is specified. Refer to the next section for a discussion of how to obtain the UACG parameter set.

Heat Recovery

Both gas turbine and diesel engine exhaust gas heat recovery systems use basic heat exchanger effectiveness models to compute the temperature of the gas leaving the heat recovery device and the amount of heat recovered. Under the assumption that the mc_p for the water or steam to which the exhaust heat is being transferred is much larger than the mc_p product for the exhaust gas, the basic heat exchanger effectiveness relationships follow:

$$1 - \varepsilon = \exp(-(UA/mc_p))$$

and

$$\frac{(T_{out} - T_{c\,in})}{(T_{exh} - T_{c\,in})} = \exp(-(UA/mc_p))$$

where: ε = heat exchanger effectiveness

m = exhaust gas mass flow rate in lb/hour

c_p = specific heat of the exhaust gas (24 Btu/lb)

UA = U-factor-times area (A) of the heat exchanger

T_{out} = temperature of the exhaust gas leaving the heat exchanger

T_{exh} = temperature of the exhaust gas entering the heat exchanger

$T_{c\,in}$ = temperature of water entering the heat exchanger or steam saturationtemperature in the heat exchanger (TSATUR of the SPECIAL PARAMETER set)

$(-(UA/mc_p))$ =the number of heat transfer units (NTU).

The BLAST program permits the user to vary the UA product using the performance parameter sets UACG and UACD. UACG applied to gas turbine exhaust heat recovery, while UACD is for diesel engine exhaust recovery. Variations in the UA product are made to be functions of the engine generator unit capacity.

$$UA = A1 * CAP^{A2}$$

where:

A1 and A2 = the first two coefficients of the UACD or UACG parameter sets (the third coefficient is not used)

CAP = the total installed engine capacity in kBtu/hr.

In computing A1 and A2, the equation can be written in linear form as:

n(UA) = ln(A1) + A2 ln(CAP)

Note that since capacity is given in kBtu/hr, the units for UA must be kBtu/hr - °F when determining A1 and A2. Users who wish to change UA for use with only one capacity may wish to change only the appropriate A1 coefficient.

Users who wish to model specific heat exchangers should obtain the heat exchanger effectiveness data for various sizes of interest then find UA as a function of *engine* capacity (mc_p values should be those for the engines running at nominal capacity). Alternately, the temperature difference formulation can be used when effectiveness is not given, but appropriate temperature data is available.

Summary

If heat recovery is to be used, UACG and UACD can be entered in their respective equipment performance parameter sets or defaults will be used. If heat recovery is not to be used, UACG and UACD must appear in their sets as:

UACG (0, 0, 0);

or

UACD (0, 0, 0);

Heat Pump Air Source

Heat pump manufacturers tabulate the heat transfer capability as well as the electric power requirements for an array of operating conditions. With these performance data from representative heat pumps, statistical model coefficients can be calculated. These coefficients can be used in the BLAST program to simulate heat pump performance.

Heating Mode Model

There are two input variables of interest, the outdoor temperature, T_{odb}, and the heating coil entering dry bulb temperature, T_{edb}. The output variables are the heat transfer rate, dQ/dt, and the heat pump power, dW/dt. As T_{edb} and T_{odb} are varied, dQ/dt and dW/dt change.

First, the variables at a reference or design state will be defined for heating:

T_{edbd} is the entering coil dry bulb design temperature

T_{odbd} is the outdoor dry bulb design temperature

$\dot{Q}_d$ is the heating capacity at design conditions

COPd is the coefficient of performance at design conditions

$\dot{W}_d$ is the power input requirement at design conditions

In order to fit the data, a temperature difference will be defined based on the design conditions for the outside dry bulb temperature and entering dry bulb temperature:

$$\Delta T = \frac{T_{edb} - T_{edbd}}{C1} - (T_{odb} - T_{odbd})$$

where C1 is a constant. Then the maximum heat transfer rate can be calculated with a curve fit:

$$\dot{Q} = \dot{Q}_d(A1 + A2*\Delta T + A3*\Delta T^2)$$

where A1, A2, and A3 are constant, defined by QHPH2 in the input file. $\dot{Q}$ must not include the effect of fan heat on the performance. Fan heat will be accounted for separately.

The coefficient of performance, COP is defined as the heat transfer rate divided by the power input to the heat pump, $\dot{W}$. This power input should include the effect of defrosting, and the outdoor fan power along with the compressor power. However the power input should not include the power from the indoor supply fan; this effect will be simulated separately

$$COP = \frac{\dot{Q}}{\dot{W}}$$

Similarly, define a figure of merit, FOM. This is similar to the Carnot efficiency because it includes a constant change in temperature across the heat exchanger. Define the FOM as:

$$FOM = \frac{T_{odb}}{T_{edb} - T_{odb} + C2}$$

where C2 is a constant defined as FOMCH in the input file. COP can then be calculated from the curve fit:

$$COP = COPd(B1 + B2*FOM + B3*FOM^2)$$

where B1, B2, and B3 are constants defined by COPH1 or COPH2 in the input file.

Both the maximum heat transfer rate and the COP drop off quickly as ice begins to form on the outside coil because of changing outdoor dry bulb conditions. Therefore, two sets of values for A1, A2, A3, B1, B2, and B3 are needed, one set below the frosting point (QHPH1 and COPH1) and one set above the frosting point (QHPH2 and COPH2). This outdoor temperature that separates the two regions will be called the heat pump transition temperature, HPTT.

Cooling Mode Model

There are three input variables of interest: the outdoor dry bulb temperature, T_{odb}; the cooling coil entering wet bulb temperature, T_{ewb}; and the cooling coil entering dry bulb temperature, T_{edb}. The output variables are the total heat transfer, $\dot{Q}_{tot}$, the sensible heat transfer rate, $\dot{Q}_{sens}$, and the heat pump power, $\dot{W}$. As T_{ewb} and T_{odb} are varied, $\dot{Q}_{tot}$ changes. However, $\dot{Q}_{sens}$ is also a function of T_{edb} when the coil is wet. As T_{edb} increases the coil becomes dry and $\dot{Q}_{sens}$ is tabulated with $\dot{Q}_{sens}$ greater than $\dot{Q}_{tot}$. These points are marked with an asterisk (*). In this case, the value for $\dot{Q}_{tot}$ is no longer valid the value for $\dot{Q}_{sens}$ should be used instead.

First, the variables at a reference or design state will be defined for cooling:

T_{edbd} is the entering coil dry bulb design temperature

T_{ewbd} is the entering coil wet bulb design temperature

T_{odbd} is the outdoor dry bulb design temperature

$\dot{Q}_{totd}$ is the total cooling capacity (wet coil) at design conditions

COPd is the coefficient of performance at design conditions

$\dot{W}_d$ is the power input requirement at design conditions

In order to fit the data, a temperature difference based on design conditions for the outside temperature, and entering wet bulb temperature will be defined

$$\Delta T = \frac{(T_{ewb} - T_{ewdb})}{C1} - (T_{odb} - T_{odbd})$$

where C_1 is a constant. ΔT does not include T_{edb}. Then the total maximum heat transfer rate (wet coil) can be calculated with the following curve fit:

$\dot{Q}_{tot} = \dot{Q}_{totd}(A1 + A2*\Delta T + A3*\Delta T^2)$

where A1, A2, and A3 are constants defined by QHPC in the input file. $\dot{Q}_{tot}$ must not contain the effect of fan heat on the performance. Fan heat will be accounted for separately.

The coefficient of performance, COP is defined as the heat transfer rate divided by the power input to the heat pump, $\dot{W}$. The power input must include compressor power as well as outdoor fan power. As in the case of heating, the indoor fan power will be simulated separately.

$$COP = \frac{\dot{Q}_{tot}}{\dot{W}}$$

Similarly, define a figure of merit, FOM. This is similar to the Carnot efficiency because it includes a constant change in temperature across the heat exchanger. Define the FOM as:

$$FOM = \frac{T_{ewb}}{T_{odb} - T_{ewb} + C2}$$

where C2 is a constant, defined as FOMCC in the input file. The COP can be calculated from this curve fit:

$COP = COPd(B1 + B2*FOM + B3*FOM^2)$

where B1, B2, and B3 are constants defined by COPC in the input file.

Additionally, it is also necessary to develop an equation that will calculate the sensible load on the system. The ratio between the sensible and the wet coil total heat transfer rate, F_{st}, can be fit as a function of entering wet bulb, entering dry bulb and outdoor dry bulb temperatures. In order to correctly account for a dry coil, it is valid for this ratio to be greater than one. The function is defined as follows:

$$F_{st} = \frac{\dot{Q}_{sens}}{\dot{Q}_{tot}} = D11 + D12 \cdot T_{edb} + D13 \cdot T_{edb}^2$$

$$+ D21 \cdot T_{ewb} + D22 \cdot T_{edb} \cdot T_{ewb} + D23 \cdot T_{edb}^2 \cdot T_{ewb}$$

$$+D31\cdot T_{ewb}^2 + D32\cdot T_{edb}\cdot T_{edb}^2 + D33\cdot T_{odb}$$

where D11 … D33 are constants. This equation is not necessary in heating mode since the coil is always dry and cannot provide any latent cooling or heating.

Transient Effects Model

For units that have a simple control scheme such as small home heat pump units, some transient effects must be taken into account. It has been shown that sensible or total heat transfer rate as a function of time from a residential heat pump can be modelled as a modified first order function:

$$\frac{\dot{Q}}{\dot{Q}_{ss}} = 1 - A\, e^{-t/\tau}$$

where A, τ are constants,

$\dot{Q}$ is the instantaneous heat transfer rate,

$\dot{Q}_{ss}$ is the steady state heat transfer rate,

t is the length of time that the heat pump operates.

It had been experimentally determined that for a residential heat pump, A is 0.5 and the time constant, τ is 1 minute.

Integrated over time the amount of energy transferred from the coil becomes:

$$Q_{coil} = \dot{Q}_{ss}[t - A\tau(1 - e^{-t/\tau})]$$

For t/τ greater than about 4 the exponential term vanishes. For a time constant of about 1 minute, it can be reasonably assumed that this term is approximately zero, then:

$$Q_{coil} = \dot{Q}_{ss}\,(t - A\tau)$$

where:

MAXFLOW = the larger of the relief air mass flows and outside air mass flows forthe current hour

RATFLOW = MAXFLOW divided by the smaller of the relief air mass flows or outside air mass flows for the current hour

Users are advised to find a good "canned" curve-fitting program on the computer they are using if a constant effective heat exchange is not a sufficiently accurate approximation for the system being simulated and HTREC1, HTREC2, and HTREC3 coefficients must be determined. Users are also cautioned to include enough significant figures in the coefficients because the form of equations involve the product of the squares of two flow rates.

The HTPWR coefficients are used to determine the power consumed by the heat recovery unit, as per the equation

$$HTRCPW = HTPWR(1) + ABS(QHTREC)*HTPWR(2) + QHTREC^2 * HTPWR(3)$$

where:

QHTREC = the heat recovered (in kW)

HTRCPW = the power used by the heat recovery unit (in kW).

High Temperature Radiant Heaters

During the testing of radiant BLAST, it was discovered that the convergence of the radiant model was sensitive to several parameters. If these parameters are not set to reasonable values, the model may not converge for a radiant heater. *Be sure to check that convergence criteria were met.* A check of convergence criteria is found in the Zone Group Loads Report (DID NOT CONVERGE = some number). This number is the number of hours that the model did not converge. The following paragraphs outline the parameters to which the radiant model is sensitive and possible solutions to most convergence problems that may be encountered when using this model.

The radiant model was found to be sensitive to the size of the **heating capacity** in the control profile. If the heating capacity is sized too large, the model may not converge. It is suggested that a design day run be performed first without radiant heat turned on in order to obtain a good estimate of the required heating capacity before turning on the radiant options.

Also, a very **steep control profile** may cause the model to not converge. For example, a control profile with a capacity of 1 at 70 and 0 at 70.1 may be much too steep. It may be necessary to change the control profile to 1 at 70 and 0 at 71 in order for the radiant model to converge.

The **RADIANT FLUX FACTOR** is a very sensitive parameter. It has been found that the lower the RADIANT FLUX FACTOR, the easier and faster the model converges. In some cases, the RADIANT FLUX FACTOR had to be as low as 0.00005 in order to converge.

If the **PERCENT RADIANT** parameter is increased, the model has more difficulty converging. With PERCENT RADIANT above 50%, it was necessary to lower the slope of the control profile and decrease the RADIANT FLUX FACTOR to make the model converge.

Ice Storage (Direct)

For an ice storage device to be simulated by BLAST, it is necessary to specify Ice Storage in the Equipment Selection Data Block. The specification is accomplished as follows:

```
EQUIPMENT SELECTION:
    ICE STORAGE:
        1 OF SIZE 700;
END EQUIPMENT SELECTION;
```

The size specification refers to the storage tank. The units are either kBtu for the English unit system or kW-hr for the Metric unit system. For the example given, there is one ice storage tank of size 700 kBtu (kW-hr). The user should *specify only one storage tank*. If more than one storage tank is in the central plant, specify the sum total of the storage tanks for the tank capacity.

Ice Storage System Control

A BLAST simulation is done in three separate steps: loads, systems, and plants. In other words, BLAST will first simulate the building to determine the heating and cooling loads. Then, using the information developed, the fan system is simulated to determine plant demands. Finally, the central plant is simulated, using the plant demands as determined by the fan system simulation, to determine the primary energy requirements. A benefit of this technique is that the cooling coil loads for the entire simulation period are known before the central plant simulation is started. As a result, the coil loads for the next day are always 'known' and can be used to determine the required amount of ice production. (See discussion of the ICETYPE special parameter below.)

The full storage control strategy is the first system control strategy available in the BLAST ice storage model. The full storage strategy, as discussed previously, meets the entire cooling coil load with ice produced during the off-peak hours. The refrigeration cycle operates only during the off-peak hours of the day. The stored ice is also used to meet the entire off-peak cooling coil load.

The compressor aided option is the second control strategy available in the BLAST ice storage model. The compressor aided control strategy will produce enough ice to meet a portion of the total on-peak cooling coil demand. The user must specify the evaporator load that will be met by the compressor during the on-peak period (PSHAVE). In other words, the refrigeration cycle will operate sufficiently long during the off-peak hours to meet the total cooling coil demand less the cooling provided by the compressor during the on-peak hours. Note that the stored ice will also be used to meet off-peak cooling coil requirements.

The demand limiting (shave) control strategy is the third control strategy available in the BLAST ice storage model. For this option, the ice storage device will meet the total on-peak cooling coil load less a user specified amount of cooling. The user specified amount of cooling will be met by a conventional chiller (PSHAVE). A conventional chiller must be specified with this control strategy. The conventional chiller is also responsible for all of the off-peak cooling coil loads. Note that if the user specified amount of cooling is zero, all of the on-peak cooling will be met by the ice storage device and all of the off-peak cooling will be met by the conventional chiller.

The fourth internal control strategy of the BLAST ice storage system is called parallel evaporator. For simulation purposes only, a conventional chiller must be specified when the parallel evaporator control strategy is used. The parallel evaporator in this type of system is modeled by the conventional chiller. A conventional chiller would not actually be in the central plant, it is specified for simulation purposes only. The conventional chiller or parallel evaporator will supply a constant user specified amount of cooling during the on-peak period (PSHAVE). The ice storage device will meet both the remaining on-peak cooling coil load and the entire off-peak cooling coil load. Note that if the user specified amount of cooling is zero, the parallel evaporator control will operate exactly like the full storage control.

The figure below illustrates the mode of operation for the ice storage device and the conventional chiller for each control strategy. 'Yes' means that this mode of operation is possible, and 'No' means that this mode of operation is not possible. For the compressor aided control option, the ice storage compressor may or may not build ice during the on-peak period. If the user specified on-peak amount of cooling is zero, the ice storage compressor will not operate during the on-peak period. For the shave control strategy, the conventional chiller may or may not operate during the on-peak hours. If the user specified on-peak coil load met by the conventional chiller is zero, the conventional chiller will not operate during on-peak period. In addition, if the shave control strategy is used, and if there is a cooling coil load after the on-peak period with storage available, the ice storage device will be used to meet the coil load.

Control Options	On-Peak			Off-Peak		
	Ice Storage Build Ice	Ice Storage Melt Ice	Convention Chiller	Ice Storage Build Ice	Ice Storage Melt Ice	Convention Chiller
Full Storage	No	Yes	No	Yes	Yes	No
Comp Aided	Yes/No	Yes	No	Yes	Yes	No
Dem Limit	No	Yes	Yes/No	Yes	Yes/No	Yes
Parall Evap	No	Yes	Yes	Yes	Yes	No

Figure 154. Ice Storage Control Options

The specification of the ice storage control strategy is accomplished in the Special Parameters Data Block of the BLAST input file. The syntax is as follows:

ICECTL=1;

PSHAVE=0.0;

where ICECTL is the ice storage control strategy utilized by the ice storage system.

1.) Full storage control strategy

2.) Compressor aided control strategy

3.) Shave control strategy

4.) Parallel Evaporator control strategy

and PSHAVE is the cooling not met by the ice storage device. PSHAVE applies to all of the control strategies except full storage control.

Performance Parameters

CPUMP

The ice storage BLAST model determines the electric power consumption of the chilled water pumps for the Ice Storage unit by :

$$CELEC = CCAP * PELCL * (C1 + C2 * CPLR + C3 * CPLR^2)$$

where *CELEC* is the chilled water pump electric power consumption, *CCAP* is the capacity of the ice storage tank, *PELCL* is the user defined pump power demanded per unit of cooling capacity, *CPLR* is the present cooling load divided by the capacity of the ice storage tank, and *C1,C2,C3* are user defined performance parameters. The specification of the performance parameters is accomplished by the following specification in the Performance Parameters Data Block in the BLAST input file:

CPUMP(C1,C2,C3);

STORE1

The following equation is the function used to determine the evaporator temperature.

$$\left(\frac{Tevap}{Tref}\right) = C1 + C2 * (\%CAP) + C3 * (\%CAP)^2$$

where *%CAP* is the fraction of capacity, or the present tank capacity divided by the total tank capacity, *Tevap* is the evaporating temperature, and *Tref* is the reference temperature. (*Tref*=300ºK=500ºR) The reference temperature is used to non-dimensionalize the performance parameters. For an ice harvester, *C1* is the evaporating temperature divided by the reference temperature, while *C2* and *C3* are zero. The specification of the performance parameters is accomplished by the following specification in the Performance Parameters Data Block in the BLAST input file:

STORE1(C1,C2,C3);

STORE2

The condenser performance is characterized by the heat rejection factor, defined as:

$$HRF = \frac{Qcond}{Qbase}$$

where *Qbase* is the rated condenser capacity and *Qcond* is the heat rejected by the condenser. The rated condenser capacity typically equals the sum of the rated compressor power and the rated evaporator load. The BLAST model used to characterize the condenser is:

$$\left(\frac{Tcond}{Tref}\right) = C1 + C2 * \left(\frac{Tenv}{Tref}\right) + C3 * HRF$$

where *Tcond* is the condenser temperature, *Tref* is the reference temperature. (*Tref*=300ºK=500ºR) *Tenv* is the environmental temperature. The environmental temperature is the outdoor wet bulb temperature for the evaporative condenser and the outdoor dry bulb temperature for the air cooled condenser. The water cooled condenser is operated in conjunction with a cooling tower and the environmental temperature is the entering condenser water temperature as determined from the cooling tower. As before, the performance parameters are non-dimensional. The condenser performance parameters are specified by the Performance Parameters Data Block in the BLAST input file as follows:

STORE2(C1,C2,C3);

STORE3; STORE4; STORE5

The compressor capacity of the BLAST ice storage compressor is determined by:

$$\left(\frac{CAP}{RCAP}\right) = C1 + C2\left(\frac{TC}{Tref}\right) + C3\left(\frac{TE}{Tref}\right) + C4\left(\frac{PC}{PE}\right) + C5\left(\frac{PC}{PE}\right)^2 + C6\left(\frac{TC}{Tref}\right)^2 + C7\left(\frac{TE}{Tref}\right)^2$$

where *TC* is the condensing temperature, *TE* is the evaporating temperature, *Tref* is the reference temperature (*Tref*=300ºK=500ºR), *PC* is the condensing pressure, *PE* is the evaporating pressure, *CAP* is the compressor capacity at the operating condition of interest, and *RCAP* is the compressor rated (nominal) capacity. All temperatures and pressures must be expressed in a consistent absolute scale. Each of the performance parameters is dimensionless. As a result, the model may be used with any system of units by converting *Tref* to the appropriate absolute temperature scale. The specification of the performance parameters is accomplished by the following specification in the Performance Parameters Data Block in the BLAST input file:

STORE3(C1,C2,C3);

STORE4(C4,C5,C6);

STORE5(C7,XX,XX)

Note that XX implies that these parameters are not utilized by the ice storage compressor equation.

STORE5; STORE6; STORE7

The power consumed by the compressor is calculated by :

$$\left(\frac{POW}{RCAP}\right) = C1 + C2\left(\frac{TC}{Tref}\right) + C3\left(\frac{TE}{Tref}\right) + C4 + C5^2 + C6\left(\frac{TC}{Tref}\right)^2 + C7\left(\frac{TE}{Tref}\right)^2$$

where *POW* is the power consumed at full capacity under the operating condition of interest. All of the other parameters are the same as described above. The specification of the performance parameters is accomplished by the following specification in the Performance Parameters Data Block in the BLAST input file:

STORE5(XX,C1,C2);

STORE6(C3,C4,C5);

STORE7(C6,C7,XX);

Note that XX implies that these parameters are not utilized by the equation.

Below a certain part load ratio, the compressor will consume a constant amount of energy regardless of the load. This cut off part load ratio is known minimum part load ratio(MPLR). For the BLAST ice storage model, the minimum part load ratio is the lowest part load ratio at which the compressor can operate. The specification of the minimum part load ratio is accomplished through the Performance Parameters Data Block in the BLAST input file as follows:

STORE7(XX,XX,MPLR);

Note that XX implies that these parameters are not utilized. The BLAST model will determine the number of hours necessary to build the ice. The part load ratio for the last hour is adjusted so that the exact amount of ice is produced. If this requires a part load ratio less than the minimum part load ratio, the minimum part load ratio is used and extra ice is produced.

STORE8; STORE9

Often a compressor will operate at less than full capacity. Operation of the compressor at less than full capacity will affect the compressor performance. When the compressor is operating at less than full capacity the compressor is said to be operating at part load. The part load effect is accounted for in the part load ratio.

$$PLR = C1 + C2\left(\frac{TE}{Tref}\right) + C3\left(\frac{TE}{Tref}\right)^2 + C4(RAT) + C5(RAT)^2 + C6(RAT)\left(\frac{TE}{Tref}\right) + C7$$

where RAT is the fraction of full load which is *Qevap/CAP* or the “desired” evaporator load divided by the predicted compressor capacity and PLR is the part load ratio. The specification of the performance parameters is accomplished by the following specification in the Performance Parameters Data Block in the BLAST input file:

STORE8(C1,C2,C3);

STORE9(C4,C5,C6);

Special Parameters

COMPCP

First, the compressor capacity must be specified. The compressor capacity is specified in the Special Parameters Data Block as follows:

COMPCP = 500.0;

The units for the compressor capacity are kBtu/hr for the English system of units and kW for the Metric system of units.

COMPEF

The electric power consumption of the compressor is calculated by using the compressor efficiency.

ELEC = POW/COMPEF

where ELEC is the electric power consumption of the compressor, POW is the compressor power, and COMPEF is user specified efficiency of the electric compressor motor. The efficiency of the electric motor is specified in the Special Parameters Block of the BLAST input file as follows:

COMPEF = 0.95;

CONDCP

First, the condenser capacity must be specified. The condenser capacity is typically equal to the sum of the compressor design power input and the corresponding evaporator load. The condenser capacity is specified in the Special Parameters Data Block as follows:

CONDCP = 500.0;

The units are kBtu/hr for the English system of units and kW for the Metric system of units.

CONDEL

The electric power consumption of the condenser is determined by

$$ELEC = OPFAC * CONDEL * Qbase$$

where *CONDEL* is a user specified condenser electric power consumption factor, *Qbase* is the rated condenser capacity, and *OPFAC* is the operating factor. The operating factor varies with the heat rejection factor. For heat rejection factors less than 0.33, *OPFAC* is 0.33. For heat rejection factors between 0.33 and 0.66, *OPFAC* is 0.66. And, for heat rejection factors greater than 0.66, *OPFAC* is 1.0. The purpose of the operating factor is to model a variable control condenser. For the evaporative condenser, the condenser electric power includes the consumption of the water pumps and of the air blowers. For the air cooled condenser, it is the electric power consumption of the air blowers. And, for the water cooled condenser, it is the water pumping power. The user specified condenser electric power consumption factor is specified by the user in the Special Parameters Data Block of the BLAST input file as follows:

CONDEL = 0.0012;

CONTYP

There are three types of condenser available in the BLAST ice storage model. They are the evaporative condenser, the air cooled condenser, and the water cooled condenser. Specification of the condenser type is accomplished in the Special Parameters Data block of the BLAST input file as follows:

CONTYP = 1;

For the condenser type Special Parameter, the following code is used to specify the condenser used:

1.) Evaporative Condenser

2.) Air Cooled Condenser

3.) Water Condenser

ICEPAR1; ICEPAR2

In addition, the ice storage tank will consume a small parasitic electric power load. The parasitic load of the ice storage tank includes the electric power consumption from the tank agitation, control, and any extra required pumping power. Similar to the tank loss coefficient, the parasitic load is expressed as a function of the tank capacity.

Parasitic Load = ICEPAR*TCAP

where ICEPAR is the user specified parasitic load coefficient and TCAP is the total tank capacity. There are two parasitic loads that should be determined for a given storage tank. The first is used to account for parasitic electric power consumption that occurs during the melt cycle. The second accounts for any parasitic load occurring during the build cycle. The user specified parasitic load coefficients are specified in the Special Parameters Data Block of the BLAST input file as follows:

ICEPAR1 = 0.012;

ICEPAR2 = 0.012;

where ICEPAR1 accounts for the parasitic load that occurs during the melting of the ice and ICEPAR2 accounts for the parasitic load that occurs during the building of the ice.

IHARLS

There is an additional energy loss associated with the ice harvester unit. Although the ice harvester can maintain a higher evaporating temperature than the ice-on-coil device, the ice harvesting process will result in a loss of energy. The harvesting process allows hot gases from the compressor to flow through the evaporator coils and melt a portion of the ice. The remaining ice then falls into the storage tank positioned below the evaporator plates. There are two losses associated with this. The first loss is a result of no ice building during the harvesting period. The second loss is a result of melting a small portion of the previously formed ice. Both of these losses are accounted for by

$$Q_{SL} = IHARLS * Q_{EVAP}$$

where Q_{SL} is the energy loss due to harvesting, IHARLS is the ice harvesting loss factor, and Q_{EVAP} is the compressor capacity. The harvesting loss factor is specified in the Special Parameters Data Block of the BLAST input file as follows:

IHARLS = 0.033;

The harvesting process occupies a percent of the time that the compressor is running but no ice is being built. Therefore, the harvesting loss is computed as a fraction of the compressor capacity. The build cycle for an ice harvester is typically 20 to 30 minutes while the harvesting cycle is 20 to 40 seconds.

Example: Ice Harvester System with a 25 minute build cycle and a 25 second harvesting cycle.

$$\text{IHARLS} = 2\left(\frac{\text{harvest time}}{\text{build time}}\right) = 2\left(\frac{25\text{ seconds}}{25\text{ minutes}}\right) = 0.033$$

Thus, the harvesting loss factor is approximately 0.033. Note that the fraction of time that the harvesting process consumes should be doubled so that the harvesting loss factor accounts for both previously mentioned losses. This calculation assumes that the ice melt rate during the harvesting process is the same as the compressor's ice building rate.

ITGAIN

The tank heat gain term accounts for the heat gain through the tank walls and the heat gain due to agitation. The tank heat gain term should be determined for each tank. Heat gain through the walls can be determined from a simple UAΔT calculation. The agitation energy imparted in the tank is also application specific. For most ice storage tanks the tank heat gain term is negligible. As a result, the tank heat gain calculation will not be conducted by many users. In an attempt to accommodate the users who wish to calculate the tank heat gain and the users who wish to use an approximate tank heat gain, the heat gain is determined by

Heat Gain = ITGAIN*TCAP

where ITGAIN is the user defined tank heat gain coefficient, and TCAP is the total tank capacity. The user specified heat gain term is specified in the Special Parameters Data Block of the BLAST input file as follows:

ITGAIN = 0.012;

REFTYP

The calculation of the compressor power and capacity are based upon the evaporating temperature and pressure and the condensing temperature and pressure. The condensing temperature and the evaporating temperature are determined from the condenser model and the evaporator model, respectively. However, the condensing pressure and evaporating pressure must be calculated from the saturation temperature. This calculation requires the specification of the refrigerant type. The refrigerant type is specified by the user in the Special Parameters Data Block of the BLAST input file as follows:

REFTYP = 1;

For the refrigerant type Special Parameter, the following code is used to specify the refrigerant used:

1.) R-12

2.) R-22

3.) R-500

4.) R-502

5.) R-717

ICETYPE

In an *indirect* ice storage system, the type of ice storage system is defined by the parameter ICETYPE. It is specified using the following syntax:

ICETYPE = 1;

However, in a direct ice storage, the type of ice storage system is determined by the performance parameters. The ICETYPE parameter for a *direct* ice storage system defines the overall storage control.

With ICETYPE set equal to 1, the ice storage system will implement perfect control. Perfect control assumes that exact amount of ice required for the next day is known and only this amount is built during the off-peak period. This is possible because BLAST simulates the building, the fan systems, and the central plants separately. Thus, all of the coil loads from the fan system simulation are known before the central plant simulation is started, and the amount of ice required to meet the coil load can be determined from this information. Perfect control is most beneficial to the ice-on-coil system which suffers a penalty when ice is left on the coil at the beginning of the charging process.

When ICETYPE is set equal to 2, control schemes which parallel those for the indirect ice storage system will be used. In this case, it is assumed that the coil loads are not known and that the goal of the charging period is to reach the storage capacity of the ice storage unit. This provides a more realistic simulation since in reality the coil loads will not be known in advance.

The following are the default values for ICETYPE:

Ice-on-coil (ICETYPE=1)

Ice harvester (ICETYPE=2)

Output Reports

The ice storage output report is specified in the reports section of the lead input as follows:

REPORTS(ICE STORAGE REPORT),

This syntax will turn on either the design day ice storage report or the annual ice storage report. In the next section, the annual ice storage report and the design day ice storage report will be explained. After this description, the effect of the ice storage device on other BLAST output reports will be discussed. Then, the ice storage dump report will be explained.

Design Day Ice Storage (Direct) Output Report

The design day ice storage output report is described in detail under *Ice Storage Report* in *BLAST Output*. The description includes an example of this report. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the storage tank capacity, the compressor capacity, and the condenser capacity are given.

Annual Ice Storage (Direct) Output Report

The annual ice storage output report is similar to the design day ice storage report shown under *Ice Storage Report* in *BLAST Output*. Some of the output fields for this report are described below. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the storage tank capacity, the compressor capacity, and the condenser capacity are given.

Column	Description
Cooling Energy Stored	The amount of energy that the ice storage device has stored for this month. This should be equal to the amount of stored energy used (reported in the

	Building/Fan/Plant Energy Utilization Summary Report) less the amount of stored energy lost.
Electric Consumption	The electric consumption is broken into on-peak and off-peak consumption and peak. Peak is the peak electric consumption during that period. Consumption is the total electric consumption during that period. In addition, the electric consumption is broken into ice storage consumption and total consumption. Ice storage consumption is the electric consumption of the ice storage device only and total consumption is the electric consumption of the entire plant / fan system / building.
Total Hours Not Met	This column indicates the number of hours for which there was not enough ice to meet the cooling demand. If no chiller is present, this number will be equal to the number of hours that cooling loads not met, reported in the Plant Loads Not Met Summary.
Total Consume Not Met	This column indicates the total cooling load that was not met by the ice storage device. If no chiller is present, this number will be equal to the total cooling load not met, reported in the Plant Loads Not Met Summary.

Figure 155. Terms encountered on the BLAST Ice Storage Report

Ice Storage (Direct) Dump Output Report

For an annual simulation, it is very difficult to determine what the ice storage system is doing on a daily basis. As a result, it was necessary to develop a dump report that would output hourly data for an annual simulation. The dump report is turned on in the lead input of the BLAST input file as follows:

REPORTS(129);

The user should be careful not to turn this dump on for a long simulation period because this dump prints out hourly data for the entire simulation period.

The columns of the dump report are described below. The dump report also gives the plant number and title, the location, and the simulation date and day.

Column	Description
Cooling Energy Stored	The amount of energy that the ice storage device has stored during this hour.
Cooling Energy Used	The amount of energy that the ice storage device has used for cooling purposes during this hour.
Stored Energy Lost	The amount of energy that the ice storage device has lost to the surroundings during

	this hour.
Compressor Electric	The electric consumption of the compressor during this hour.
Condenser Electric	The electric consumption of the condenser during this hour.
Parasitic Electric	The parasitic electric consumption during this hour.
Ice Storage Total Electric	The total electric consumption of the ice storage device during this hour. This should be equal to the sum of the compressor, condenser, and parasitic electric consumptions.
Remaining Cooling Load	The cooling load that was not met by the ice storage system during this hour.
Total Electric Consumption	The total electric consumption of the building, fan system, and central plant for this particular hour.

Figure 156. Terms encountered on the Ice Storage Dump Report

The Effect of Ice Storage (Direct) on Other Reports

An ice storage device is a Central Plant. As a result, it will only affect plant reports. In other words, an ice storage device will not affect any of the fan system or building loads output reports. The effect of ice storage on each of the plant reports is explained below.

Building / Fan / Plant Energy Utilization Summary

1. Any chilled water obtained from the ice storage device will be reported in the Gross Plant Equipment Output **--** Chilled Water column.
2. Any amount of stored ice that is used to meet the cooling demand will be reported in the Non-Purchased Energy **--** Stored Energy Used column.
3. Any electricity consumed by the ice storage device will be reported in the Purchased Energy section. The consumption will show up in either Purchased Electric or in a Purchased Fuel column (if a generator is used in conjunction with the ice storage device).

Plant Equipment Energy Input Breakdown

1. Compressor electric consumption and any ice storage parasitic electric consumption will be reported in the Electric Chiller column.
2. Any condenser electric consumed by the ice storage condenser will be reported in the Condenser Electric column.
3. In addition, all of the electric consumption of the ice storage device will be reported in the Total CW Input column.

Step-by-Step Procedure for Ice Storage Modeling

The procedure for simulating an ice storage system utilizing the BLAST Ice Storage Model is as shown below. In addition, the steps are listed in order of importance, with the first five steps being absolutely necessary for any simulation. It should also be noted that for an accurate simulation all of the steps should be conducted.

1. The user must specify the tank capacity in the equipment selection data block.
2. The user must specify the compressor capacity in the special parameters data block.
3. The user must specify the condenser capacity in the special parameters data block.
4. The user must specify the on-peak hours of the day in the special parameters data block.
5. The user must specify the ice storage control strategy and the PSHAVE parameter in the special parameters data block.
6. The condenser type should be specified in the special parameters data block.
7. The user must specify the evaporator temperature performance parameters in the performance parameters data block.
8. The compressor motor efficiency should be specified in the special parameters data block.
9. The ice storage heat gain coefficient should be specified in the special parameters data block.
10. The ice harvester loss factor should be specified in the special parameters data block.
11. The parasitic loss factors should be specified in the special parameters data block.
12. The condenser electric consumption factor should be specified in the special parameters data block.
13. The compressor capacity and power coefficients should be generated and specified in the performance parameters data block. In addition, the refrigerant type should be specified in the special parameters data block.
14. The compressor part load ratio coefficients should be specified in the performance data block.
15. The condenser performance coefficients should be generated and specified in the performance parameters data block.

Things to Consider When Using Ice Storage

While installing the BLAST ice storage model, a few suggestions were developed that should be considered when using the ice storage model in BLAST. It would be a good idea to investigate each of these potential problem areas.

1. Is the chilled water pump electric consumption too high? The chilled water electric consumption is reported in the Plant Equipment Energy Input Breakdown report. If the consumption is too high investigate the performance parameters CPUMP and the special parameter PELCL. The default parameters could lead to a significant error.
2. Investigate any electric devices such as lights, and electric equipment to make sure that they are being modeled correctly.
3. Make sure than fan electric consumption is being accurately modeled. Is the fan pressures accurately specified? Fan pressure is directly proportional to the electric consumption of the fan. An inaccurate fan pressure will result in an inaccurate simulation.
4. When comparing electric consumption between an ice storage device and a conventional chiller user the Chiller Program to develop accurate performance parameters. An inaccurate chiller model will provide an inaccurate base case to compare the ice storage simulation with.
5. Make sure that the on-peak period is the same between runs that are being compared. The user specified on-peak period directly affects the annual ice storage report even if no ice storage device is being used.

Another topic of ice storage that should be considered is that BLAST will only build enough ice to meet the next days cooling load. No extra ice will be built.[§] In an actual system, estimating tomorrows cooling coil loads is difficult if not impossible. The energy consumption and the accuracy of the simulation is affected by how accurate the coil loads are predicted in the actual system. This effect should be considered when designing and installing ice storage systems.

Note: The BLAST model will calculate the number of hours necessary to build the required amount of ice. Then ice production will begin at an appropriate time to ensure the proper amount of ice production. For each hour, except the last, the part load ratio is one. Or, the compressor is running at full capacity. The part load ratio of the last hour is adjusted to ensure the exact amount of ice is produced. If the required part load ratio is less than the minimum part load ratio of the compressor, the compressor will operate at the minimum part load ratio. As a result, the ice storage device will produce extra ice for this case.

Ice Storage (Indirect)

For an ice storage device to be simulated by BLAST, it is necessary to specify Ice Storage in the Equipment Selection Data Block. The specification is accomplished as follows:

EQUIPMENT SELECTION:

ICE STORAGE:

1 OF SIZE 700;

END EQUIPMENT SELECTION;

The size specification refers to the storage tank. The units are either kBtu for the English unit system or kW-hr for the Metric unit system. For the example given, there is one ice storage tank of size 700 kBtu (kW-hr). The user should *specify only one storage tank*. If more than one storage tank is in the central plant, specify the sum total of the storage tanks for the tank capacity.

Ice Storage System Control

The full storage control strategy is the first system control strategy available in the BLAST indirect ice storage model. The full storage strategy meets the entire cooling coil load with ice produced during the off-peak hours. The refrigeration cycle operates only during the off-peak hours of the day. The brine solution that leaves the ice storage device is used to meet the entire off-peak cooling coil load.

The chiller priority control strategy is the second control strategy available in the BLAST ice storage model. For this option, the ice storage chiller will meet as much of the hourly on-peak cooling coil load as possible up to its capacity. Any additional cooling coil load is met by melting ice which is built during the off-peak period. Again, the brine solution leaving the ice storage device is used to meet all of the off-peak cooling coil load.

The third internal control strategy of the BLAST ice storage system is called ice priority. Ice priority is similar to chiller priority except that the user has the option of limiting the fraction of the load met by the chiller. This is accomplished through the PSHAVE parameter that defines the load met by the ice storage chiller during the on-peak period. If PSHAVE is set equal to zero, this control strategy is identical to the full storage option. If PSHAVE is set equal to the capacity of the ice storage chiller, this control strategy is the same as the chiller priority strategy.

The specification of the ice storage control strategy is accomplished in the Special Parameters Data Block of the BLAST input file. The syntax is as follows:

ICECTL=1;

PSHAVE=0.0;

where ICECTL is the ice storage control strategy utilized by the ice storage system.

1. Full storage control strategy

2. Not Applicable for an Indirect Ice Storage Simulation
3. Chiller Priority control strategy
4. Ice Priority control strategy

and PSHAVE is the cooling met by the ice storage chiller. PSHAVE applies only to the ice priority control strategy.

In addition, the user must specify a charging strategy via the OFFPEAKC parameter. There are three charging strategies that can be implemented in the BLAST indirect ice storage model: Equalized (OFFPEAKC=1), Full on with delay (OFFPEAKC=2), and Near optimal (OFFPEAKC=3). Each of these will be described below.

All of the charging strategies will attempt to attain fully charged conditions by the beginning of the next on-peak period. The equalized strategy will spread the charging load equally over the entire off-peak period. Thus, the chiller is always operating during the off-peak unless no ice was melted during the previous on-peak period. The full on with delay strategy will charge the ice storage system at the maximum capacity of the chiller starting with the first off-peak hour and continuing until the system is fully charged. The user has the option of delaying the charging cycle starting point of this strategy through the use of the BGNCHARG parameter. Finally, the near optimal strategy is a modification of the full on with delay strategy. This control option will determine the optimal number of hours to delay each charging period allowing the system to take advantage of cooler early morning temperatures. It also charges at the maximum capacity of the chiller.

Special Parameters

COMPCP

First, the ice storage chiller capacity must be specified. The chiller capacity is specified in the Special Parameters Data Block as follows:

COMPCP = 500.0;

The units for capacity are kBtu/hr for the English system of units and kW for the Metric system of units.

COMPEF

The electric power consumption of the compressor is calculated by using the compressor efficiency.

ELEC = POW * COMPEF

where ELEC is the electric power consumption of the compressor, POW is the compressor power as predicted by equation (2.7), and COMPEF is user specified efficiency of the electric compressor motor. The efficiency of the electric motor is specified in the Special Parameters Block of the BLAST input file as follows:

COMPEF = 0.95;

CONDCP

First, the condenser capacity must be specified. The condenser capacity is typically equal to the sum of the compressor design power input and the corresponding evaporator load. The condenser capacity is specified in the Special Parameters Data Block as follows:

CONDCP = 500.0;

The units are kBtu/hr for the English system of units and kW for the Metric system of units.

CONDEL

The electric power consumption of the condenser is determined by

$$ELEC = OPFAC * CONDEL * Qbase$$

where *CONDEL* is a user specified condenser electric power consumption factor, *Qbase* is the rated condenser capacity, and *OPFAC* is the operating factor. The operating factor varies with the heat rejection factor. For heat rejection factors less than 0.33, *OPFAC* is 0.33. For heat rejection factors between 0.33 and 0.66, *OPFAC* is 0.66. And, for heat rejection factors greater than 0.66, *OPFAC* is 1.0. The purpose of the operating factor is to model a variable control condenser. For the evaporative condenser, the condenser electric power includes the consumption of the water pumps and of the air blowers. For the air cooled condenser, it is the electric power consumption of the air blowers. And, for the water cooled condenser, it is the water pumping power. The user specified condenser electric power consumption factor is specified by the user in the Special Parameters Data Block of the BLAST input file as follows:

CONDEL = 0.0012;

CONTYP

There are three types of condenser available in the BLAST ice storage model. They are the evaporative condenser, the air cooled condenser, and the water cooled condenser. Specification of the condenser type is accomplished in the Special Parameters Data block of the BLAST input file as follows:

CONTYP = 1;

For the condenser type Special Parameter, the following code is used to specify the condenser used:

1. Evaporative Condenser
2. Air Cooled Condenser
3. Water Condenser

ICEPAR1; ICEPAR2

In addition, the ice storage system will consume a small parasitic electric power load. The parasitic load of the ice storage tank includes the electric power consumption from the tank agitation, control, and any extra required pumping power. Similar to the tank loss coefficient, the parasitic load is expressed as a function of the tank capacity.

Parasitic Load = ICEPAR*TCAP

where ICEPAR is the user specified parasitic load coefficient and TCAP is the total tank capacity. There are two parasitic loads that should be determined for a given storage tank. The first is used to account for parasitic electric power consumption that occurs during the melt cycle. The second accounts for any parasitic load occurring during the build cycle. The user specified parasitic load coefficients are specified in the Special Parameters Data Block of the BLAST input file as follows:

ICEPAR1 = 0.012;

ICEPAR2 = 0.012;

where ICEPAR1 accounts for the parasitic load that occurs during the melting of the ice and ICEPAR2 accounts for the parasitic load that occurs during the building of the ice.

ITGAIN

The tank heat gain term accounts for the heat gain through the tank walls and the heat gain due to agitation. The tank heat gain term should be determined for each tank. Heat gain through the walls can be determined from a simple UAΔT calculation. The agitation energy imparted in the tank is also application specific. For most ice storage tanks the tank heat gain term is negligible. As a result, the tank heat gain calculation will not be conducted by many users. In an attempt to accommodate the users who wish to calculate the tank heat gain and the users who wish to use an approximate tank heat gain, the heat gain is determined by

Heat Gain = ITGAIN*TCAP

where ITGAIN is the user defined tank heat gain coefficient, and TCAP is the total tank capacity. The user specified heat gain term is specified in the Special Parameters Data Block of the BLAST input file as follows:

ITGAIN = 0.012;

ICETYPE

The type of ice storage system is defined by the parameter ICETYPE. It can be specified using the following syntax:

ICETYPE = 3;

where the value of ICETYPE corresponds to:

Ice container (ICETYPE=3)

Ice tank(ICETYPE=4)

TFREEZE

Most standard thermal storage systems use water as the storage medium. The freezing point of water is assumed to be 32°F (0°C). However, there are some systems which use water and eutectic salts or other materials to change the freezing temperature of the storage system. The freezing temperature of the thermal storage system can be taken into account using the following syntax:

TFREEZE = 32.0;

where the units of the parameter are either °F or °C, depending on the unit system used in the input file.

Note that caution should be used when altering the TFREEZE parameter in the input deck. Simply changing this parameter without making any other changes may result in an invalid simulation. A change in storage material may also require new performance parameters (described below) and possibly alter the amount of storage available.

Performance Parameters

CPUMP

The ice storage BLAST model determines the electric power consumption of the chilled water pumps for the Ice Storage unit by :

$$CELEC = CCAP * PELCL * (C1 + C2 * CPLR + C3 * CPLR^2)$$ where

CELEC is the chilled water pump electric power consumption, *CCAP* is the capacity of the ice storage tank, *PELCL* is the user defined pump power demanded per unit of cooling capacity, *CPLR* is the present cooling load divided by the capacity of the ice storage tank, and *C1,C2,C3* are user defined performance parameters. The specification of the performance parameters is accomplished by the following specification in the Performance Parameters Data Block in the BLAST input file:

CPUMP(C1,C2,C3);

STORE1 through STORE9

The actual performance of the ice storage unit selected is specified by the "STORE" performance parameters. The two different types of indirect ice storage models have slightly different performance characteristics. The ice container system assumes that the brine solution flows slowly through the storage unit. Thus, natural convection is dominant regardless of variations in flow rate. On the other hand, the performance of the ice tank system is dictated by the flow through the heat exchanger tubing. As a result, the flow rate through the ice storage unit must be taken into account.

For an **ice container** system, the **discharging** process is characterized by the following equation:

$$q^* = \left[C1 + C2(1-Pc) + C3(1-Pc)^2 + C4(1-Pc)^3 + C5(1-Pc)^4 + C6(1-Pc)^5\right] \\ \left[+C7 + C8(1-Pc) + C9(1-Pc)^2 + C10(1-Pc)^3 + C11(1-Pc)^4 + C12(1-Pc)^5\right]\Delta T_{lm}^*$$

where:

$$q^* \equiv \frac{q\Delta t}{Q_{stor}}$$

$$\Delta T_{lm}^* \equiv \frac{\Delta T_{lm}}{\Delta T_{nominal}}$$

$$\Delta T_{lm} = \frac{T_{brine,in} - T_{brine,out}}{\ln\left(\frac{T_{brine,in} - T_{freeze}}{T_{brine,out} - T_{freeze}}\right)}$$

q is the instantaneous heat transfer rate,

Q_{stor} is the total latent storage capacity,

Δt is a time step (described below),

$\Delta T_{nominal}$ is a nominal temperature difference (18°F = 10°C),

$T_{brine,in}$ is the brine inlet temperature,

$T_{brine,out}$ is the brine outlet temperature,

T_{freeze} is the freezing temperature of water,

P_c is the fraction charged.

The coefficients in the above equation are entered into the BLAST input file using the following syntax:

STORE1(C1,C2,C3);

STORE2(C4,C5,C6);

STORE3(C7,C8,C9);

STORE4(C10,C11,C12);

The **charging** process for an **ice container** system uses an equation of the same form as that shown above. The coefficients for the charging phase are entered into the BLAST input file using:

STORE5(C1,C2,C3);

STORE6(C4,C5,C6);

STORE7(C7,C8,C9);

STORE8(C10,C11,C12);

Finally, the last ice storage performance parameter for an **ice container** system is used to define the *time step* which is part of the definition of q*. The time step is determined solely by the method of fitting q* to ΔT_{lm} and P_c. The time step, Δt, is selected using the following syntax:

STORE9(xx,xx,Δt);

The time step should be expressed in hours (the default value is 1 hour). Note that the first two parameters in STORE9 are not used for the ice container model, but they must be included in the input file.

For an **ice tank** system, the **discharging** process is characterized by the following equation:

$$T_{\circ}^{*} = \left[C1 + C2(1-Pc) + C3(1-Pc)^{2} + C4(1-Pc)^{3} + C5(1-Pc)^{4} + C6(1-Pc)^{5}\right]$$
$$\left[+ C7 + C8(1-Pc) + C9(1-Pc)^{2}\right]q^{*} + \left[C10 + C11(1-Pc) + C12(1-Pc)^{2}\right]\left(q^{*}\right)^{2}$$
$$+ C13T_{i}^{*} + C14(1-Pc)T_{i}^{*}$$

where:

Pc and *q** are defined as before,

$$T_{o}^{*} = \frac{T_{o,abs}}{T_{freeze,abs}},$$

$$T_{i}^{*} = \frac{T_{i,abs}}{T_{freeze,abs}}.$$

The coefficients in the above equation are entered into the BLAST input file using the following syntax:

STORE1(C1,C2,C3);

STORE2(C4,C5,C6);

STORE3(C7,C8,C9);

STORE4(C10,C11,C12);

STORE5(C13,C14,xx);

The **charging** process for the **ice tank** system is characterized by the following equation:

$$\Delta T_{lm}^{*} = \left(C1 + C2Pc + C3Pc^{2} + C4Pc^{3}\right)q^{*} + \left(C5 + C6Pc + C7Pc^{2} + C8Pc^{3}\right)$$

$$+ \left(C9 + C10Pc + C11Pc^{2} + C12Pc^{3}\right)\frac{q^{*}}{m^{*}}$$

where m* is defined as:

$$m^{*} \equiv \frac{m\Delta t}{m_{brine}},$$

m* is the mass flow rate through the ice storage unit,

m_{brine} is the mass of brine in the tank,

Δt is the same time step (default is one hour) used to calculate q*.

The coefficients in the above equation are entered into the BLAST input file using the following syntax:

STORE5(xx,xx,C1);

STORE6(C2,C3,C4);

STORE7(C5,C6,C7);

STORE8(C8,C9,C10);

STORE9(C11,C12,Δt);

Ice Storage Chiller Performance Parameters

The direct ice storage system models the ice storage system and chiller together because ice is produced directly on the evaporator. The indirect ice storage models have a separate chiller model, which was designed to handle chillers operating at ice making temperatures. In some ways, the ice storage chiller model is similar to the standard chiller simulation routine in BLAST. The syntax for specifying an ice storage chiller for an indirect ice storage system is described below.

The parameters ADJTIC and RCAVIC are used to adjust the ice storage chiller capacity to reflect changes in the condenser water temperature and the leaving chilled water (brine) temperature. As with other chillers in BLAST, the relevant equations are:

$$\Delta T = \frac{\left(T_{cond} - A_1\right)}{A_2} - \left(T_{cw} - A_3\right)$$

$$\frac{\text{available capacity}}{\text{nominal capacity}} = B_1 + B_2(\Delta T) + B_3(\Delta T)^2$$

where: T_{cw} is the actual temperature of the leaving chilled water,

T_{cond} is the actual temperature of the leaving condenser water.

The syntax for entering these parameters in the BLAST input file is:

ADJTIC(A1,A2,A3);

RCAVIC(B1,B2,B3);

In addition, the power consumption at full-load of the chiller will vary with both the entering condenser water temperature and the leaving chilled water temperature. This can be taken into account through the use of coefficients of performance.

$$ACOP = DACOP\left[C1 + C2\left(\frac{CCOP}{DCCOP}\right) + C3\left(\frac{CCOP}{DCCOP}\right)^2\right]$$

where:

ACOP is the actual full-load coefficient of performance (ACAP/Actual Power),

DACOP is the design full-load coefficient of performance (DCAP/Design Power), *CCOP* is the Carnot coefficient of performance,

DCCOP is the design Carnot coefficient of performance.

Note that *DACOP* and *DCCOP* should be specified as the special parameters DACTCOP and DCARCOP, respectively, in the SPECIAL PARAMETERS BLOCK.

The Carnot coefficients of performance are defined by the leaving chilled water temperature (LCWT) and the entering condenser water temperature (EWT) and their design values (DCWLT,DEWT) as shown below.

$$CCOP = \frac{LCWT}{EWT - LCWT}$$

$$DCCOP = \frac{DLCWT}{DEWT - DLCWT}$$

where the temperatures are absolute temperatures. The BLAST input file syntax for these parameters is:

COPCIC(C1,C2,C3);

Finally, the part-load performance of the ice storage chiller is determined by the fraction of full-load power (FLP) vs. part-load ratio (PLR) equation shown below:

$$FLP = D_1 + D_2(PLR) + D_3(PLR)^2$$

where: $$D_1 = a_1 + a_2(RDELTA) + a_3(RDELTA)^2$$

$$D_2 = b_1 + b_2(RDELTA) + b_3(RDELTA)^2$$

$$D_3 = c_1 + c_2(RDELTA) + c_3(RDELTA)^2$$

$$RDELTA = \frac{EWT - LCWT}{DEWT - DLCWT}$$

These parameters are implemented in the BLAST input file with the following syntax:

POW1IC(a1,a2,a3);

POW2IC(b1,b2,b3);

POW3IC(c1,c2,c3);

The actual power consumption of the ice storage chiller is then calculated using the following equation:

$$POWER = \left(\frac{ACAP}{ACOP}\right) FLP$$

Output Reports

The ice storage output report is specified in the reports section of the lead input as follows:

REPORTS(ICE STORAGE REPORT),

This syntax will turn on either the design day ice storage report or the annual ice storage report. In the next section, the annual ice storage report and the design day ice storage report will be explained. After this description, the effect of the ice storage device on other BLAST output reports will be discussed. Then, the ice storage dump report will be explained and shown.

Design Day Ice Storage (Indirect) Output Report

The design day ice storage output report is described in detail under *Ice Storage Report* in *BLAST Output*. The description includes an example of this report. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the storage tank capacity, the compressor capacity, and the condenser capacity are given.

Annual Ice Storage (Indirect) Output Report

The annual ice storage output report is similar to the design day ice storage report shown under *Ice Storage Report* in *BLAST*. Some of the output fields for this report are described below. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the storage tank capacity, the compressor capacity, and the condenser capacity are given.

Column	Description
Cooling Energy Stored	The amount of energy that the ice storage device has stored for this month. This should be equal to the amount of stored energy used (reported in the Building/Fan/Plant Energy Utilization Summary Report) less the amount of stored energy lost.
Electric Consumption	The electric consumption is broken into on-peak and off-peak consumption and peak. Peak is the peak electric consumption during that period. Consumption is the total electric consumption during that period. In addition, the electric consumption is broken into ice storage consumption and total consumption. Ice storage consumption is the electric consumption of the ice storage device only and total consumption is the electric consumption of the entire plant / fan system / building.
Total Hours Not Met.	This column indicates the number of hours for which there was not enough ice to meet the cooling demand. If no chiller is present, this number will be equal to the number of hours that cooling loads not met, reported in the Plant Loads Not Met Summary

Total Consume Not Met	This column indicates the total cooling load that was not met by the ice storage device. If no chiller is present, this number will be equal to the total cooling load not met, reported in the Plant Loads Not Met Summary.

Figure 157. Terms in the Ice Storage Report

Ice Storage (Indirect) Dump Output Report

For an annual simulation, it is very difficult to determine what the ice storage system is doing on a daily basis. As a result, it was necessary to develop a dump report that would output hourly data for an annual simulation. The dump report is turned on in the lead input of the BLAST input file as follows:

REPORTS(129);

The user should be careful not to turn this dump on for a long simulation period because this dump prints out hourly data for the entire simulation period.

The columns of the dump report are described below. The dump report also gives the plant number and title, the location, and the simulation date and day.

Column	Description
Cooling Energy Stored	The amount of energy that the ice storage device has stored during this hour.
Cooling Energy Used	The amount of energy that the ice storage device has used for cooling purposes during this hour.
Stored Energy Lost	The amount of energy that the ice storage device has lost to the surroundings during this hour.
Compressor Electric	The electric consumption of the compressor during this hour.
Condenser Electric	The electric consumption of the condenser during this hour.
Parasitic Electric	The parasitic electric consumption during this hour.
Ice Storage Total Electric	The total electric consumption of the ice storage device during this hour. This should be equal to the sum of the compressor, condenser, and parasitic electric consumptions.
Remaining Cooling Load	The cooling load that was not met by the ice storage system during this hour.
Total Electric Consumption	The total electric consumption of the building, fan system, and central plant for this particular hour.

Figure 158. Terms in the Ice Storage Dump Report

The Effect of Ice Storage (Indirect) on Other Reports

An ice storage device is a Central Plant. As a result, it will only affect plant reports. In other words, an ice storage device will not affect any of the fan system or building loads output reports. The effect of ice storage on each of the plant reports is explained below.

Building / Fan / Plant Energy Utilization Summary

1. Any chilled water obtained from the ice storage device will be reported in the Gross Plant Equipment Output **--** Chilled Water column.
2. Any amount of stored ice that is used to meet the cooling demand will be reported in the Non-Purchased Energy **--** Stored Energy Used column.
3. Any electricity consumed by the ice storage device will be reported in the Purchased Energy section. The consumption will show up in either Purchased Electric or in a Purchased Fuel column (if a generator is used in conjunction with the ice storage device).

Plant Equipment Energy Input Breakdown

1. Compressor electric consumption and any ice storage parasitic electric consumption will be reported in the Electric Chiller column.
2. Any condenser electric consumed by the ice storage condenser will be reported in the Condenser Electric column.
3. In addition, all of the electric consumption of the ice storage device will be reported in the Total CW Input column.

Step-by-Step Procedure for Ice Storage Modeling

The procedure for simulating an ice storage system utilizing the BLAST Ice Storage Model is as shown below. In addition, the steps are listed in order of importance, with the first five steps being absolutely necessary for any simulation. It should also be noted that for an accurate simulation all of the steps should be conducted.

1. The user must specify the tank capacity in the equipment selection data block.
2. The user must specify the compressor capacity in the special parameters data block.
3. The user must specify the condenser capacity in the special parameters data block.
4. The user must specify the on-peak hours of the day in the special parameters data block.
5. The user must specify the type of ice storage device is being used. Moreover, the performance parameters which characterize the thermal response of the ice storage unit must also be included.

6. The user must specify the ice storage control strategy and the PSHAVE parameter in the special parameters data block. Also, the charging strategy should be selected through the use of the OFFPEAKC and BGNCHARG parameters.
7. The condenser type should be specified in the special parameters data block.
8. The user must specify the evaporator temperature performance parameters in the performance parameters data block.
9. The compressor motor efficiency should be specified in the special parameters data block.
10. The ice storage heat gain coefficient should be specified in the special parameters data block.
11. The parasitic loss factors should be specified in the special parameters data block.
12. The condenser electric consumption factor should be specified in the special parameters data block.
13. The ice storage chiller capacity and power coefficients should be generated and specified in the performance parameters data block. In addition, the design actual and Carnot coefficients of performance should be specified in the special parameters block as well as the location of the chiller with respect to the ice storage unit.
14. Application-specific parameters such as the brine specific heat, the mass of brine in the tank (ice tank only), and the freezing temperature of the storage medium must be specified.

Things to Consider When Using Ice Storage

While installing the BLAST ice storage model, a few suggestions were developed that should be considered when using the ice storage model in BLAST. It would be a good idea to investigate each of these potential problem areas.

1. Is the chilled water pump electric consumption too high? The chilled water electric consumption is reported in the Plant Equipment Energy Input Breakdown report. If the consumption is too high investigate the performance parameters CPUMP and the special parameter PELCL. The default parameters could lead to a significant error.
2. Investigate any electric devices such as lights, and electric equipment to make sure that they are being modeled correctly.
3. Make sure than fan electric consumption is being accurately modeled. Is the fan pressures accurately specified? Fan pressure is directly proportional to the electric consumption of the fan. An inaccurate fan pressure will result in an inaccurate simulation.
4. When comparing electric consumption between an ice storage device and a conventional chiller user the Chiller Program to develop accurate performance parameters. An inaccurate chiller

model will provide an inaccurate base case to compare the ice storage simulation with.

5. Make sure that the on-peak period is the same between runs that are being compared. The user specified on-peak period directly affects the annual ice storage report even if no ice storage device is being used.

Influence Coefficients: Using BLAST in Design

Using BLAST as a design tool requires considerable judgment and expertise on the part of the user. Unlike some energy analysis programs, BLAST asks the user to supply many input parameters that are difficult to obtain. This characteristic of the BLAST program, while at times frustrating, is indicative of the flexibility and, to a certain extent, the accuracy of the program. Fewer input parameters in an energy analysis program simply means that assumptions have already been made; the user often has no way of knowing how these assumptions impact the energy analysis.

This article describes a method for determining the significance of assumptions made in user supplied parameters to the BLAST program. This method, called the method of influence coefficients, gives the user an indication of the level of accuracy required for a given input parameter.

Parameter Estimation

In general, estimation of BLAST model input parameters is the result of uncertainty in two areas:

1.) uncertainty in the design of the building

2.) uncertainty in the use of the building

Estimation of both design and use parameters is required when BLAST is used in the early stages of design to calculate building heating and cooling loads. Estimation of use parameters is required for both the simulation of existing buildings and the simulation of early design stage buildings.

Design Parameters

At every stage of design, some uncertainty will be reflected in the building simulation model. For example, the designer may not know the transmissivity of the window glass at the time the building is modeled using BLAST. The window glass transmissivity then becomes an estimated input parameter to the BLAST building model. An incomplete list of design parameters that may be significant in an error analysis is shown below.

Building Description

1. window area
2. window type
3. window glass reflectivity and transmissivity
4. wall, roof and floor types
5. external shading

6. building orientation
7. ground temperature

Fan System

1. hot and cold deck temperatures
2. throttling range
3. VAV minimum air flow fraction

Central Plants

1. equipment sizes and number available
2. performance parameters

Use Parameters

Since it is difficult to predict how a building will be used once in operation, use parameters can rarely be estimated with a high degree of accuracy. For example, the amount of infiltration (due to open doors and windows) cannot usually be known with certainty. Infiltration then becomes an estimated input parameter to the BLAST model. An incomplete list of use parameters that may be significant in the analysis of the error involved in the energy calculation is shown below.

Building Description

1. infiltration
2. interior shading by blinds
3. internal loads

Fan System

1. system operation schedule
2. equipment operation schedule

Central Plants

1. equipment part load ratios

Calculating Influence Coefficients

Significance of Assumptions

If an input parameter is "significant," a small change in its value will cause a large change in the desired output or result. On the other hand, even a large change in an "insignificant" input parameter will have very little effect on the desired result.

Significance, as defined in the preceding paragraph, can be measured quantitatively as the slope at any point on a parameter/result curve:

$$\text{Significance} = \frac{\text{change in result}}{\text{change in parameter}} = \text{slopeofcurve}$$

This definition of significance is called an influence coefficient. The influence coefficient quantifies the influence of an *input parameter* on a *simulation result*. Mathematically, the influence coefficient may be written as:

$$\text{InfluenceCoefficient} = \frac{\partial(\text{Result})}{\partial(\text{Parameter})} \approx \frac{\Delta(\text{Result})}{\Delta(\text{Parameter})}$$

An example of a dimensional influence coefficient is shown in the figure below.

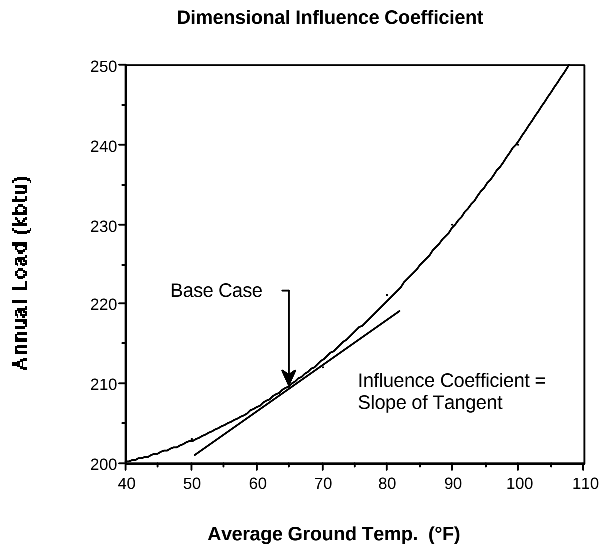

Figure 159. Example of a Dimensional Influence Coefficient

Using BLAST to Determine Influence Coefficients

Using the simplified definition of an influence coefficient allows one to easily calculate influence coefficients using BLAST. The simplified definition is:

$$\text{Influence Coefficient} = \frac{\Delta(\text{Result})}{\Delta(\text{Parameter})}$$

Both Δ(Result), the change in the result, and Δ(Parameter), the change in the parameter can be obtained simply by making two appropriate BLAST runs of the same building model. The procedure for using BLAST to calculate influence coefficients is shown below:

1.) Identify the parameter and the result of interest. In the example shown in the figure above, we were interested in the effect that the parameter "Average Ground Temperature" had on the result "Annual Load."

2.) Simulate the base case building. This simply involves making a BLAST run without making any changes to your BLAST input file.

3.) From the base case building simulation, record the value of both the parameter and the result. For our example, we would record the Average Ground Temperature and the Annual Load.

4.) Modify the input file by changing the parameter of interest (Average Ground Temperature in our example) by an appropriate amount. Then make a BLAST run with the modified input file.

5.) From the modified building simulation, record the values of the modified parameter and the new result. For our example, we would again record the Average Ground Temperature and the Annual Load.

6.) Calculate Δ(Result). For our example we would calculate Δ(Result) by subtracting the base case Annual Load from the modified case Annual Load.

7.) Calculate Δ(Parameter). For our example we would calculate Δ(Parameter) by subtracting the base case Average Ground Temperature from the modified case Average Ground Temperature.

8.) Divide the change in the result by the change in parameter to obtain a dimensional influence coefficient.

9.) Non-dimensionalize the influence coefficient as required by the analysis.

Types of Influence Coefficients

There are at least four different types of influence coefficients. Each type is appropriate for specific applications. For example, the *dimensional type 2* influence coefficient is required by the error analysis method described in the second part of this paper. On the following page, two types of dimensional influence coefficients and two types of non-dimensional influence coefficients are shown.

1. *Dimensional*. This type of influence coefficient retains the dimensions of the parameter and the result. For example:

$$\frac{\partial(\text{Annual Heating Load})}{\partial(\text{Average Ground Temperature})}(BTU/^{o}F)$$

2. *Non-dimensional type 1*. This type of influence coefficient is non-dimensional because the parameter and the result both have the same units. For example:

$$\frac{\P\,(\text{Cooling Load})}{\P\,(\text{Internal Heat Gain})}(BTU/BTU)$$

3. *Non-dimensional type 2*. This influence coefficient is non-dimensionalized by dividing the parameter by its base case value and by dividing the result by its base case value. The calculation is shown below.

$$\frac{\partial(R^*)}{\partial(P^*)} \approx \frac{\Delta R^*}{\Delta P^*}$$

where

$$\Delta R^* = R^*_{bc} - R^*_{\Delta} = \frac{R_{bc}}{R_{bc}} - \frac{R_{\Delta}}{R_{bc}}$$

$$\Delta P^* = P^*_{bc} - P^*_{\Delta} = \frac{P_{bc}}{P_{bc}} - \frac{P_{\Delta}}{P_{bc}}$$

P = Parameter

R = Result

* = Non-dimensionality

bc = Base-case

Δ = Value for perturbed case.

4. *Dimensional type 2*. This type of influence coefficient is similar to the non-dimensional type 2, except that only the numerator is non-dimensionalized.

$$\frac{\partial(R^*)}{\partial(P)} \approx \frac{\Delta R^*}{\Delta P}$$

Sample Calculation of a Dimensional type 2 Influence Coefficient

The following example calculates a dimensional type 2 influence coefficient for average annual ground temperature and total load.

1. From the initial BLAST run obtain:

   average annual ground temperature, $\mathbf{P_{bc}}$=75°F.**

   heating load, **49.4 kBtu.

   cooling load, **230.1 kBtu.

2. Calculate the total load.

   $\mathbf{R_{bc}}$ = 49.42 + 230.1 = 279.52 kBtu.

3. Change the ground temperature in the BLAST input file by 3 °F and run another simulation.

   $\mathbf{P_{\Delta}}$=78°F

4. From your modified BLAST run obtain:

   heating load, **49.05 kBtu.

   cooling load, **231. kBtu.

5. Calculate the total load.

   $\mathbf{R_{\Delta}}$ = 49.42 + 230.1 = 280.05 kBtu.

6. Summarize results.

   total load #1 = **$\mathbf{R_{bc}}$ = 279.52 kBtu**

   total load #2 = **$\mathbf{R_{\Delta}}$ = 280.05 kBtu**

   Avg. ground temp #1 = **$\mathbf{P_{bc}}$=75°F.**

   Avg. ground temp #2 = **$\mathbf{P_{\Delta}}$=78°F**

7. Calculate the type 2 dimensional influence coefficient.

$$\frac{\frac{R_{bc} - R_{\Delta}}{R_{bc}}}{P_{bc} - P_{\Delta}} = \frac{\frac{279.52 - 280.05}{279.52}}{75 - 78} = .000632\ {}^{\circ}F^{-1}$$

Calculating Influence Coefficients: A Case Study

This example is taken from a comparative study of light frame construction family housing units at Ft. Irwin, California. The study compared "factory" and "conventionally" built housing units.

Both building types were four unit, two story apartment buildings. The distinguishing construction features of the two building types are shown in the figure below

Construction Features	
Factory Built Unit	**Conventionally Built Unit**
1. Prefabricated walls	1. Standard Construction
2. Built on a crawlspace	2. Built on a concrete slab
3. Single pane windows	3. Double pane windows
4. Large window area	4. Moderate window area

Figure 160. Construction Features

Five simulation parameters were selected as potentially having a significant impact on the annual load (|heating load| + |cooling load|) of the building. The parameters are shown in the first column of the figures "Influence Coefficients for Conventially Built Units" and "Influence Coefficients for Factory Built Units". Since the exact value of each parameter could not be determined, assumptions were made and the parameters were assigned the values shown in column 2 of the figures. The procedure described in an issue of BLASTnews was then followed to obtain dimensional type 2 influence coefficient (also shown in figures) for each parameter.

Influence Coefficients for Conventional Units		
Simulation Parameter	**Base-case Value**	**Dimensional I.C. Type 2**
Avg. Ground Temp.	75 °F	$0.00374\ {}^{\circ}F^{-1}$
Air infiltration	1204 cfm	$0.000165\ cfm^{-1}$
Internal mass (area)	8876 ft²	$5.2 \times 10^{-7}\ ft^{-2}$
Internal loads	73,951 kBtu	$1.62 \times 10^{-6}\ kBtu^{-1}$
Trans. of blinds	0.5	.0597

Figure 161. Influence Coefficients for Conventionally Built Units

Influence Coefficients for Factory Built Units		
Simulation Parameter	**Base-case Value**	**Dimensional I.C. Type 2**
Avg. Ground Temp.	75 °F	$0.00063\ {}^{\circ}F^{-1}$
Air infiltration	1084 cfm	$0.000176\ cfm^{-1}$
Internal mass (area)	9664 ft²	$1.2 \times 10^{-6}\ ft^{-2}$
Internal loads	73,951 kBtu	$1.16 \times 10^{-6}\ kBtu^{-1}$
Trans. of blinds	0.5	.166

Figure 162. Influence Coefficients for Factory Built Units

Using Influence Coefficients To Estimate Error

The influence coefficients shown in the figures (above) span six orders of magnitude. They can't be directly compared with one another, since the units for each are different. In order to make a direct comparison, the estimated error in the result due to error in each parameter must be calculated. The error in the result is calculated from the dimensional type 2 influence coefficient as follows:

|Error in result| = (Dimensional type 2 influence coefficient) x |Estimated parameter error|

In order to obtain an estimation of the error in the result, the building designer must first estimate the error in the parameter. For example, if the designer is confident that he has guessed the average ground temperature within ± 10°F, the error analysis calculation would be performed as follows:

1. Calculate a dimensional type 2 influence coefficient for the average ground temperature.
2. Estimate the error in the average ground temperature at ± 10°F.
3. Calculate the percent error in the total annual building load due to an average ground temperature that is in error by ± 10°F. Percent error=Type 2 dimensional i.c. x Error in parameter x 100

Percent error=.000632 x 10 x 100=0.632%

Therefore, for this particular building simulation, if the designer's estimate of the average ground temperature is off by 10°F, the annual load obtained from the simulation will be in error by about 0.6%

Error Analysis Using Influence Coefficients: A Case Study

The design differences between the Ft Irwin factory built units and and conventionally built units are evident from an error analyses using influence coefficients. The figures below show the results of such an analysis. The ground temperature had a significant effect on the conventionally built unit since this unit was constructed on a concrete slab. The factory built unit, constructed on a crawlspace, was not particularly sensitive to ground temperature. Shading from blinds was more significant in the factory built unit with its greater window area.

Influence Coefficients and Error Analysis for Conventionally Built Units			
Simulation Parameter	**Dimensional I.C. Type 2**	**Est. Error (Parameter)**	**Est. Error (Result)**
Avg. Ground Temp.	$0.00374\ {}^{\circ}F^{-1}$	10 °F	±3.7 %
Outside air infiltration	$0.000165\ cfm^{-1}$	500 cfm	±8.3 %
Internal mass (area)	$5.2\times10^{-7}\ ft^{-2}$	2000 ft^2	±0.1 %
Internal loads (annual)	$1.62\times10^{-6}\ kBtu^{-1}$	20,000 kBtu	±3.2 %
Trans. of blinds	.5	0.2	±1.2 %

Figure 163. Influence Coefficients and Error Analysis for Conventionally Built Units

Influence Coefficients and Error Analysis for Factory Built Units			
Simulation Parameter	**Dimensional I.C. Type 2**	**Est. Error (Parameter)**	**Est. Error (Result)**
Avg. Ground Temp.	$0.00063\ {}^{\circ}F^{-1}$	10 °F	±0.6 %
Outside air infiltration	$0.000176\ cfm^{-1}$	500 cfm	±8.8 %
Internal mass (area)	$1.2\times10^{-6}\ ft^{-2}$	2000 ft^2	±0.2 %
Internal loads (annual)	$1.16\times10^{-6}\ kBtu^{-1}$	20,000 kBtu	±2.3 %
Trans. of blinds	.5	0.2	±3.3 %

Figure 164. Influence Coefficients and Error Analysis for Factory Built Units

Influence Coefficients Based On Other Simulation Results

The influence coefficients and error analysis presented in the preceding sections are based on the total annual load of the building. This analysis indicates how much the total annual building load will change if the input parameter is changed slightly. Significantly different results may be obtained by using a different simulation result to calculate the influence coefficients. For example influence coefficients may be calculated for the same input parameters based on annual cooling load, annual heating load, or the total annual energy cost.

Cost based influence coefficients are of particular interest. The results of an error analysis using cost based influence coefficients are shown in figures below. The energy costs used for the cost-based calculations are \$0.10/kWh for electricity and \$0.50/therm for gas.

Influence Coefficients and Error Analysis based on Cost		
Factory Built Units		
Simulation Parameter	**Dimensional I.C. Type 2**	**Est. Error (Result)**
Avg. Ground Temp.	5.66×10^{-4} °F^{-1}	±0.6 %
Outside air infiltration	6.41×10^{-3} cfm^{-1}	±3.2 %
Internal mass (area)	8.06×10^{-7} ft^{-2}	±0.2 %
Internal loads (annual)	2.08×10^{-6} kBtu^{-1}	±4.2 %
Trans. of blinds	0.115	±2.3 %

Figure 165. Influence Coefficients and Error Analysis Based on Cost

Influence Coefficients and Error Analysis based on Cost		
Conventionally Built Units		
Simulation Parameter	**Dimensional I.C. Type 2**	**Est. Error (Result)**
Avg. Ground Temp.	2.66×10^{-3} °F^{-1}	±2.7 %
Outside air infiltration	4.12×10^{-3} cfm^{-1}	±2.1 %
Internal mass (area)	-1.71×10^{-7} ft^{-2}	±0.0 %
Internal loads (annual)	2.71×10^{-6} kBtu^{-1}	±5.4 %
Trans. of blinds	0.0378	±0.8 %

Figure 166. Influence Coefficients and Error Analysis Based on Cost

The figure below compares the estimated error in the simulation result for loads based and cost based influence coefficients. Using energy (total loads) based influence coefficients, infiltration was the most significant parameter followed by ground temperature and internal loads. Using cost based influence coefficients, internal loads were the most significant parameter followed by ground temperature and infiltration. The order of significance changes due to the relative costs of heating and cooling.

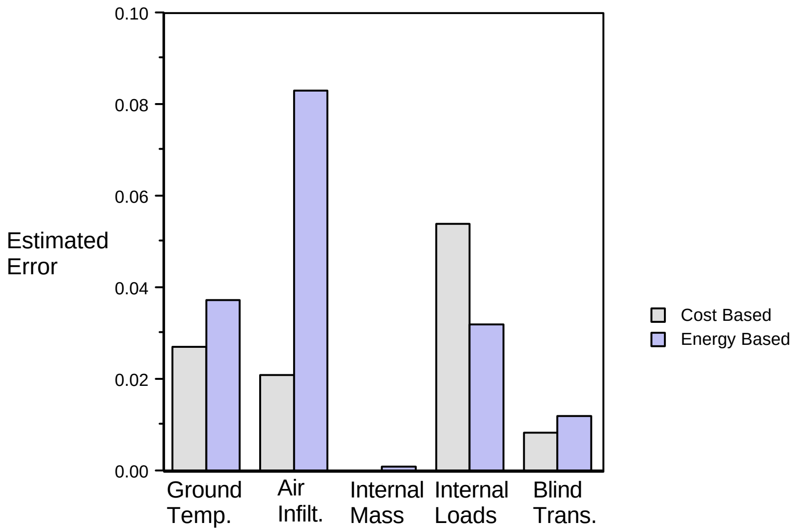

Figure 167. Comparison of Loads Based and Cost Based Influence Coefficients

Summary

Using influence coefficients in an error analysis allows the designer to determine which input parameters have the greatest effect on a particular simulation result. With this information, the designer is able to spend time obtaining good approximations of significant parameters without wasting time refining insignificant parameters

Interaction of Loads and Systems

Interaction of Loads and Systems: A Brief Overview

BLAST was originally developed in 3 major sections; Building Loads, Fan Systems, and Central Plants. To be able to split the loads simulation from the system simulation, the control profile had to be developed to tell loads how the systems will operate before they are actually simulated. When the control profile is specified in loads, the system operation has to be taken into account. Unfortunately, when users fine-tune their system simulation, many of them do not check the assumptions they made while specifying the control profile. To separate the system simulation from the plant simulation is not as difficult, since only the coil deck temperature schedules are needed in the fan system simulation to determine how the plant will perform when it is simulated.

It is important to understand how building loads and fan systems interact in BLAST. The loads simulation is performed first and calculates space temperatures and building loads based on environmental conditions, internal loads, interactions between zones, infiltration, ventilation, and the air handling system. An energy balance is done to find the space temperature at which the zone load balances with the heating or cooling provided by the system. The control profile allows the user to specify the heating and cooling capacities in the loads simulation. No other information is available about the fan system during the loads calculations.

Load Calculations

The loads section of the simulation computes hourly space loads in a building or zone based on user input and weather data. For each hour simulated, BLAST performs a complete radiant, convective, and conductive heat balance for each surface and a heat balance on the room air. In addition, the way space temperatures are controlled must be obtained. This information is required because the heating and cooling load is directly affected by the zone thermostat setting. The magnitude of the heating or cooling load depends on the control strategy that becomes part of the overall heat balance performed on the room. This control strategy is input into the loads simulation through the control profile.

Control Profiles

A control profile is a piecewise linear function that specifies the amount of heating or cooling delivered by the system to a zone. The temperature control profile provides a simplified model of the fan system. It is important to note that the control profile specifies the amount of heating or cooling provided by the system, not the amount of heating or cooling consumed by the system. It is possible that a fan system may provide heating or cooling to the zone without consuming any energy except for the fan or provide no heating or cooling to the zone while consuming large amounts of energy. A system setup using an economy cycle to bring in outside air could provide heating or cooling to the zone consuming only fan energy, if the outside air meets the deck temperature. A system can provide no heating or cooling to a zone, while consuming large amounts of energy conditioning the outside air to the zone temperature. When zone air temperature air is provided to the zone, no heating or cooling is done.

System Calculations

Once zone loads are calculated, they must be translated into hot water, chilled water, steam, gas and electric power demands on a central plant or utility system. This is done by using basic heat and mass balance principles in the system simulation of BLAST. The fan system simulation attempts to match the zone loads and temperatures that have been previously determined by the loads simulation. If the fan system can not match these loads then unmet loads will occur. Unmet loads can occur when the control profile does not accurately describe the fan system that it represents or is mis-matched with the scheduling of the fan equipment

Equipment Schedules

The fan system equipment schedules need to match the assumptions that were made in the control profile. A problem that occurs frequently is specifying a control profile with setback period and then having the fan system operate during setback. During setback, the fan operation should be off so that the fan will operate only when a load exists. Another major source of error is changing equipment schedules without verifying the change with the control profile. This commonly happens with the seasonal scheduling of the heating or cooling coils. Specifying cooling in the winter and heating in the summer is an important aspect of matching control profiles to system performance. Having the heating or cooling coils scheduled on does not necessarily mean that a boiler or chiller is operating; it implies that they are available.

Fan System Equipment

The fan system simulation attempts to match the zone loads and temperatures that have been previously determined by the loads simulation. Normally, the first component that the outside air goes through in the fan system is the mixed air box. The mixed air box responds to the minimum and maximum ventilation schedules and the mixed air control. If an economy cycle is specified as the mixed air control then the zone temperature, determined by loads, becomes a parameter. After the air leaves the mixed air box, the next components are the coils and the supply fan. The conditions under which the cooling coil will operate are that the coil is available or scheduled "ON" and the cooling coil entering air dry bulb temperature (CCEADB) is greater than the cooling coil leaving air dry bulb temperature (CCLADB). So, if the system is running and the coil is left available, the coil will operate anytime the entering temperature is greater than the leaving temperature. This condition will happen anytime the mixed air temperature is greater than CCLADB. So, even on a winter night with the fan system in setback, you can have cooling coil loads with no load on the building. This can happen when the cooling coil and fan system are not scheduled correctly with the control profile.

The conditions under which the heating coil operate are similar to the cooling coil except that the heating coil entering air dry bulb temperature (HCEADB) is less than the heating coil leaving air dry bulb temperature (HCLADB). So, if the system is operating and the heating coil is available, you can have heating loads on a cool summer night with no calculated loads for the building.

Unmet Loads Reports

Many times improper loads and systems interactions will show up in the unmet reports for the fan system simulation. Many BLAST users will adjust fan system parameters to correct the problems and will forget that the problem could have originated in loads with an incorrect control profile.

The first major distinction in the unmet loads reports are the two categories of "With Demand" and "Without Demand". This is directly related to the control profile in the loads section of the simulation. If you specified a heating or cooling profile for the zone, you are specifying that cooling or heating is available to the zone, and the load calculated by BLAST will reflect that assumption. This load is passed to the fan system simulation, which will attempt to meet this demand. If the load is not met then the unmet load with demand report is specified. The other category, "Without Demand", assumes that you do not have a heating or cooling profile for that hour specified in the controls and heating or cooling is not available. The loads simulation calculates a zone temperature that is floating between set-points and does not pass a heating or cooling load to the fan system simulation. When the fan system provides any heating or cooling to the zone, the overheating/overcooling without demand report is specified in the system simulation.

Underheating/Undercooling with demand

Underheating/Undercooling can be caused by having the fan equipment undersized, or it can be related to a scheduling problem with the control profile. The sizing problem can be taken care of by increasing supply air flows or raising or lowering the coil deck temperatures. However in many cases, heating and cooling control profiles are input for the whole year, and then the user seasonally schedules the coils in the fan system. For example, in late spring or early summer, the heating coil has been scheduled "OFF" for the summer, the control profile has a heating profile, and during the night, there is a heating demand. The system has been scheduled off to keep the system from operating overnight, but with a demand, the system will operate for that hour. A heating load is calculated and passed to the fan system simulation. Since the heating coil has been scheduled "OFF", it can't meet the heating load and outside air is brought in and cools the zone further. Since a heating load was calculated, fan system underheating with demand report is specified. The heating demand for the zone will show up from the loads simulation, and the heating provided by the zone will be a negative value since cooling was provided by outside air. If the intent was to schedule the heating coil off during the summer season, this unmet load should <u>not</u> be corrected by changing the heating coil schedule in the fan system. The user should specify the correct heating and cooling profiles for the summer season, which in this case involves removing the heating profile. This same scenario can be imagined for a cooling case in late fall or early spring.

Overheating/Overcooling with demand

The most common case of overheating is caused by excess fan heat when there is a small heating load in the zone. Other cases of overheating occur when warm outside air is brought in with a small heating load in the zone and the heating from the outside air exceeds the heating load. This can happen when there is an unusually warm day when the building is occupied and the minimum outside air is brought in for ventilation requirements.

Overcooling cases are normally caused by ventilation requirements when the minimum air fraction brings in outside air and the heating coil is scheduled off or the cooling load for the zone is exceeded. This can happen in late spring or early fall when there is an unusually cool day, and the heating or reheat coil is seasonally scheduled off. This is usually an equipment scheduling problem.

Heating/Cooling without demand

This section keys on the "Without Demand" which almost always reflects a problem with the control profile and equipment scheduling. This is where the fan system heats or cools the zone even though no heating or cooling demand was calculated by the building simulation. One of the major causes is that the controls specify a setback condition while the fan system is scheduled "ON", the default schedule. The operating fan system brings in outside air, which either heats or cools the zone. If the coils are scheduled off to match the setback condition, but the fan system operates, the outside air will inevitably heat or cool the zone. So, for this case the fan system operation must be scheduled off as well.

Many times with a default fan system, overheating or overcooling is not reported because of the availability of the heating or cooling coils which condition the outside air to the zone temperature and provide no heating or cooling. Even though the fan system provided no heating or cooling to the zone, it consumed energy conditioning outside air when the user has specified, through the control profiles, that the building needs no heating or cooling.

Case Study

The purpose of this part of the section is to:

1.) Show how easily that a loads-system mismatch can occur.

2.) Through an example, show some of the root causes for loads-systems mismatches.

3.) Show how the coils operate and how the loads and temperatures are passed to fan systems from loads.

Default Fan System and Scheduling

When a user specifies a system using HBLC, the default system equipment schedules are determined to give a working system. In many cases, these defaults are fine; however, when the defaults are used with a control profile that contains a setback, a loads-systems mismatch occurs. Default fan system scheduling from HBLC will give the user:

EQUIPMENT SCHEDULES:

SYSTEM OPERATION=**ON**,FROM 01JAN THRU 31DEC;

EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;

HEATING COIL OPERATION=**ON**,FROM 01JAN THRU 31DEC;

COOLING COIL OPERATION=**ON**,FROM 01JAN THRU 31DEC;

TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;

MINIMUM VENTILATION SCHEDULE=**MINOA**,FROM 01JAN THRU 31DEC;

MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;

SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;

END EQUIPMENT SCHEDULES;

END SYSTEM;

END FAN SYSTEM DESCRIPTION;

The more important schedules have been highlighted, since these schedules significantly affect system operation and energy consumption. These equipment schedules result in a working system but not necessarily a system that is scheduled correctly. These default schedules are sufficient for control profiles that do not contain a temperature setback.

If a control profile with a setback has been scheduled with these default equipment schedules, the fan system is operating and trying to condition outside air and return air to meet the desired supply air temperature. During the setback, the zone temperature is coasting until a cooling or heating set point is reached. The temperature to which the zone has coasted is the temperature of the supply air that the fan system will produce so that the fan system will not provide any heating or cooling to the zone. The fan system is using energy when the user specified that there was no load. In this case, the fan system should be scheduled "OFF" during the setback period to keep the fan system from trying to condition zone air temperature during the setback.

EXAMPLE 1: Default DX Unit with "NWS2" Library Control Profile

For this example, a default DX Unit was specified, but the user, knowing that there was a setback for night and weekends, used a library profile "NWS2". The setback profile has only heating specified with no cooling available. A summer design day in July is used for the simulation, and the user noticed some very strange, unexplainable results.

At the end of the day when the occupants had left and the fan system went into setback, the zone started to warm up, since no cooling is specified overnight. In BLAST, the zone report from the loads section showed that the temperature was increasing in the zone, and no heating or cooling loads were calculated. A zone temperature was calculated for each hour; this temperature was passed to the fan systems, shown in the figure below. The zone temperature passed to the fan system is reported as SATEMP (Supply Air Temperature). If the fan system operates during this time, the supply air temperature would have to equal the zone temperature to provide no heating or cooling to the zone. With the default for the fan system operation set to "ON", the fan system will operate during the setback period. We will look at hour 01 on 7/21 to see what happens.

For hour 01, the loads calculation has determined that there are no loads in the zone and that the zone temperature has coasted to 92.5 °F. The fan system is operating due to the default fan system operating schedule "ON" from HBLC. The fan system simulation determines that the supply air temperature must equal the zone temperature, 92.5 °F, to provide no heating or cooling. Outside air is brought in and mixed with the return air, which enters the first coil, the cooling coil. Since the outside air at this time of the night is cooling off, the mixed air temperature is 89.4 °F. If the fan system is operating, the cooling coil does two checks to see if it will operate. The first check is to determine from its operating schedule if the coil is available. The second check compares the cooling coil entering air dry bulb (CCEADB) with the required supply air temperature (SATEMP) to determine if cooling is needed. For this case, the coil is available and CCEADB is less than SATEMP. Thus, the coil does not operate. This can be seen from the table below where the cooling coil leaving air dry bulb (CCLADB) is the same as CCEADB, for hour 01. The heating coil does a similar check except that it looks to see if the heating coil entering air dry bulb temperature (HCEADB) is less than SATEMP. Since, 89.4 °F is less than 92.5 °F, the heating coil operates, and a heating load is calculated. This happens during most hours of the night and is shown in the table below and following figure. The table below and figure show that the heating coil operates when you would not expect any heating loads. This is the logic that the coil routines follow for each hour, and the table shows the problem that the user determined, heating consumption on a warm summer night.

There is a slight increase in temperature from the HCEADB to the heating coil leaving air dry bulb (HCLADB) with or without heating coil operation. This is due to the way that the variables are defined and where the fan heat is added back. For the DX Unit, the supply fan is between the heating and cooling coil, and when the fan heat is added back it shows up in the HCLADB temperature.

Date	Cooling	Heating	CCEADB	CCLADB	HCEADB	HCLADB	SATEMP
Hr01/21/Jul	0	5251	89.4	89.4	89.4	92.5	92.5
Hr02/21/Jul	0	5685	89.1	89.1	89.1	92.3	92.3
Hr03/21/Jul	0	6012.7	88.8	88.8	88.8	92.1	92.1
Hr04/21/Jul	0	6236.5	88.5	88.5	88.5	91.9	91.9
Hr05/21/Jul	0	6260.7	88.4	88.4	88.4	91.8	91.8
Hr06/21/Jul	0	6168.4	88.6	88.6	88.6	92	92
Hr07/21/Jul	34795.5	0	77.3	65.8	65.8	67.1	67.1
Hr08/21/Jul	34928.9	0	77.6	66	66	67.3	67.3
Hr09/21/Jul	35374.3	0	78	66.3	66.3	67.6	67.6
Hr10/21/Jul	36426.9	0	78.5	66.4	66.4	67.8	67.8
Hr11/21/Jul	38126.5	0	79.1	66.4	66.4	67.8	67.8
Hr12/21/Jul	39764.1	0	79.7	66.4	66.4	67.8	67.8
Hr13/21/Jul	41531.5	0	80.1	66.3	66.3	67.6	67.6
Hr14/21/Jul	42720.2	0	80.4	66.2	66.2	67.5	67.5
Hr15/21/Jul	43240.5	0	80.5	66.1	66.1	67.5	67.5
Hr16/21/Jul	42638.8	0	80.4	66.2	66.2	67.5	67.5
Hr17/21/Jul	3049.7	0	91.5	90.5	90.5	91.8	91.8
Hr18/21/Jul	1452.4	0	92	91.5	91.5	92.8	92.8
Hr19/21/Jul	0	0	91.8	91.8	91.8	93.1	93.1
Hr20/21/Jul	0	1397.8	91.4	91.4	91.4	93.2	93.2
Hr21/21/Jul	0	2530.6	91	91	91	93.2	93.2
Hr22/21/Jul	0	3525.5	90.6	90.6	90.6	93.1	93.1
Hr23/21/Jul	0	4295.9	90.2	90.2	90.2	92.9	92.9
Hr24/21/Jul	0	4850.2	89.8	89.8	89.8	92.8	92.8

Table 62 . Night Setback with No Cooling Profile; System Schedule = "ON"

The figure below shows that the heating load was calculated during the uncontrolled periods while in setback. Normally, the fan system is not operating during a setback condition. For the summer design day, this would slow down the overnight heat gain from the environment and the fan.

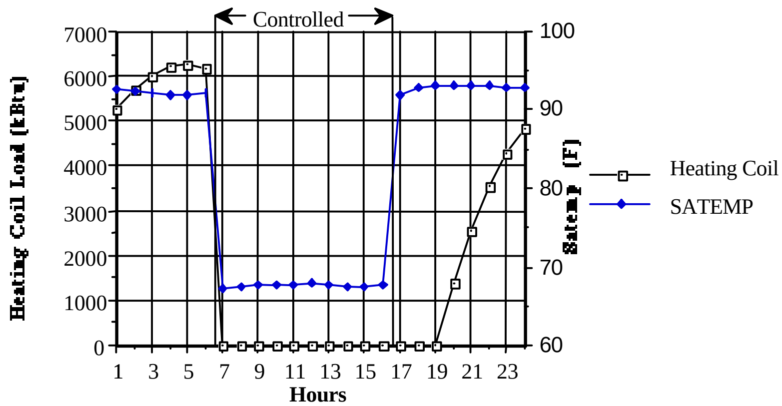

Figure 168. Heating Load with Supply Air Temperature vs Time

The figure below. shows that the cooling coil does operate for hours 17 and 18 during the uncontrolled period as the zone is slowly heating up. This occurs because the outside air is still above the zone air temperature. The cooling coil operates because the coil is available and CCEADB is greater than SATEMP. This results in an over-consumption of cooling energy, which would not happen if the equipment was scheduled correctly.

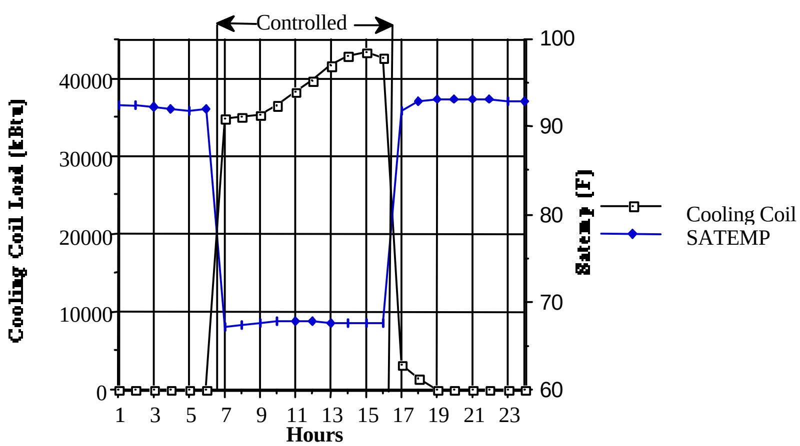

Figure 169. Cooling Load with Supply Air Temperature vs Time

EXAMPLE 2: Default DX Unit with "NWS2" Control Profile and Fan System Operation Scheduled "OFF"

In the second case, a BLAST run was done with the fan system scheduled "OFF" during the setback periods to see how the system operates. The results are shown in the table below and accompanying figure. The first thing that is noticed in the table is that there are not any temperatures for the coils when the fan system does not operate. This is due to the fact that these temperatures are not defined when the system is not operating. In addition, there is not any heating or cooling load calculated during the hours while the system is in setback.

Date	Cooling	Heating	CCEADB	CCLADB	HCEADB	HCLADB	SATEMP
Hr01/21/Jul	0	0					92.5
Hr02/21/Jul	0	0					92.3
Hr03/21/Jul	0	0					92.1
Hr04/21/Jul	0	0					91.9
Hr05/21/Jul	0	0					91.8
Hr06/21/Jul	0	0					92
Hr07/21/Jul	34795.5	0	77.3	65.8	65.8	67.1	67.1
Hr08/21/Jul	34928.9	0	77.6	66	66	67.3	67.3
Hr09/21/Jul	35374.3	0	78	66.3	66.3	67.6	67.6
Hr10/21/Jul	36426.9	0	78.5	66.4	66.4	67.8	67.8
Hr11/21/Jul	38126.5	0	79.1	66.4	66.4	67.8	67.8
Hr12/21/Jul	39764.1	0	79.7	66.4	66.4	67.8	67.8
Hr13/21/Jul	41531.5	0	80.1	66.3	66.3	67.6	67.6
Hr14/21/Jul	42720.2	0	80.4	66.2	66.2	67.5	67.5
Hr15/21/Jul	43240.5	0	80.5	66.1	66.1	67.5	67.5
Hr16/21/Jul	42638.8	0	80.4	66.2	66.2	67.5	67.5
Hr17/21/Jul	0	0					91.8
Hr18/21/Jul	0	0					92.8
Hr19/21/Jul	0	0					93.1
Hr20/21/Jul	0	0					93.2
Hr21/21/Jul	0	0					93.2
Hr22/21/Jul	0	0					93.1
Hr23/21/Jul	0	0					92.9
Hr24/21/Jul	0	0					92.8

Table 63. Night Setback with No Cooling Profile; System Schedule = "OFF"

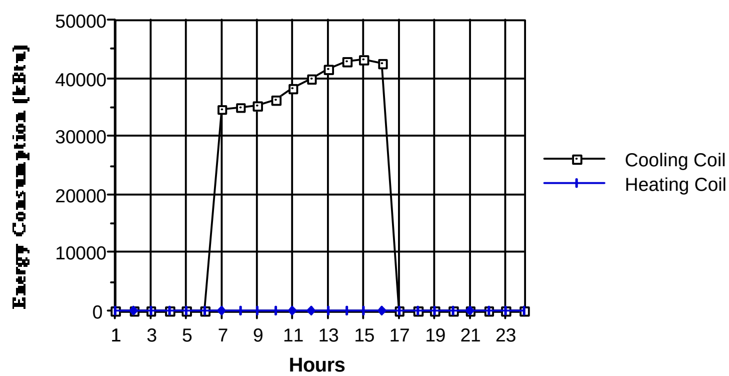

Figure 170. Heating and Cooling Consumptions for System Scheduled "OFF"

The figure above shows that the heating and cooling coils respond as expected. The cooling coil operates during the day when people are present, and the heating coil does not operate at all for the summer design day.

Conclusions

A loads-system mismatch can occur very easily, but it can also be corrected easily when the control profile is put in zones to represent the fan system that will be simulated. Most of the errors that occur between the loads and systems simulation are caused by scheduling of fan equipment. These errors can be easily introduced by adding a setback period to a default fan system. Additional errors are introduced when the control profile initially input in zones is not refined while the user is refining the system simulation. Often changes are made to the fan system schedule block, which invalidate the assumptions made when specifying the control profile.

When a default fan system is used from HBLC, a sizing control profile should be used to initially determine equipment sizes. If a control profile with a setback is used, fan equipment scheduling has to be immediately altered to correctly match the loads simulation with the fan systems. Remember that a heating or cooling load in any zone will turn the entire system "ON". This can cause unmet loads in zones that have no loads. If this causes too much of a problem, the designer should consider splitting up the fan system.

Interior Convection Coefficients

The default interior convection coefficients used by BLAST are numbers for pure natural convection. Therefore, they are not the same as the surface resistances found in the *ASHRAE Handbook of Fundamentals*, which are combined convection-radiation coefficients (1989 Fundamentals, Inch-Pound Edition, p. 22.2, Table 1). In BLAST, the radiant exchange calculation is done separately using a mean radiant temperature method. The only exception is found in the BLAST "ASHRAE Heating Loads Report", which does use the ASHRAE convection-radiation coefficients.

Surface Position	$W/m^2 \bullet C$	$Btu/h \bullet ft^2$
Horizontal, enhanced convection	4.040	0.7092
Horizontal, reduced convection	0.948	0.1660
Vertical	3.076	0.5400
Tilted, enhanced convection	3.870	0.6794
Tilted, reduced convection	2.281	0.4004

Figure 171. BLAST Interior Convection Coefficients

The interior convection coefficients used by BLAST, for pure convection, are shown in the figure above. Note that the coefficient to be used by BLAST is determined only by the surface position, not the surface type. Hence, a vertical window and a vertical wall will both have the same interior convection coefficient. A surface is considered to be horizontal if its tilt is within 22.5° of horizontal, and a surface is considered to be vertical if its tilt is within 22.5° degrees of vertical. All other surfaces are considered to be tilted.

For horizontal and tilted surfaces, the convection coefficient is enhanced or reduced based on the direction of heat flow. When the heat flow is downward, the air will tend to stratify and reduce the natural convection. When the heat flow is upward, the air will tend to circulate and enhance the natural convection. The figure below illustrates a ceiling and floor under typical summer and winter conditions.

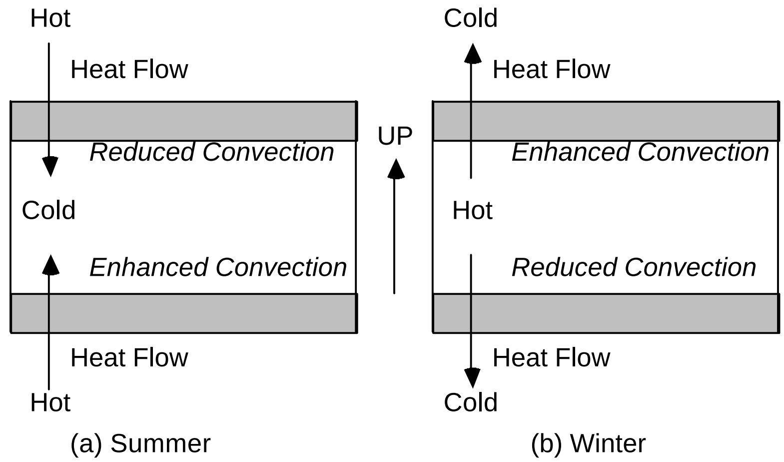

Figure 172. Enhanced and reduced convection for horizontal surfaces.

For information exterior convection coefficients, refer to the appropriate section in the BLAST Technical Reference.

Interpreting Unmet Loads

Unmet loads can be achieved by improper scheduling or sizing of the evaporative coolers. The following explanations discuss how the evaporative cooler affects the results.

Unmet Loads with Demand

Undercooling

Either the system has insufficient supply air volume or the capacity of the evaporative cooler is too small. Evaporative capacity is controlled by the supply air flow for the fan system and by the size of the evaporative pad in the direct evaporative cooler. The capacity of the indirect evaporative cooler is determined by the pad size and secondary flow. In order to eliminate the unmet loads, the size of the fan system can be increased while increasing pad sizes in the evaporative cooler, or a cooling coil can be scheduled "ON".

Underheating

Evaporative cooler will not operate if there is a heating demand and therefore should not affect the heating load. Follow guidelines for underheating in the BLAST Output manual.

Overheating

Overheating can occur when the cooling coil is scheduled off, the evap cooler is scheduled off, the fan system is scheduled on, and a warm day appears in a month that is normally cool. On this warm day when the building is occupied, the fan system is normally scheduled on for ventilation. When the outdoor air temperature is warmer than the desired mixed air temperature, the evaporative control scheme will try to limit the amount of outside air that is brought in, but the minimum amount of outside air will be determined by the minimum ventilation schedule. The warm air brought in exceeds the heating demand for the zone. This can be eliminated by having the evaporative cooler or cooling coil scheduled "ON", or by reducing your minimum ventilation schedule. If you normally schedule your cooling systems off in the fall and this condition appears later in the year, then a small amount of overheating can be tolerated. Normally the evaporative cooler will be scheduled off for part of the year since the water in the sumps is prone to freezing.

Overcooling

If the cooling demand for the zone is between 0% outside air flow and the minimum air flow from the minimum ventilation schedule, then the control scheme will calculate the required supply air flow for cooling. If it is below the minimum ventilation schedule the controls will increase the flow to the minimum. This will provide a small amount of overcooling to the zones and should not occur very often throughout the year. To check that this is the cause for the overcooling, set your minimum ventilation schedule to "OFF" which has a minimum ventilation schedule of 0% outside air and see if the hours of overcooling disappear. If they do not this was not the cause for the overcooling.

Unmet Loads without Demand

Calculation from the loads simulation says that the zone does not require any heating or cooling to maintain the desired temperature in the space. Therefore, if a fan system is scheduled on and is operating, the fan system is only conditioning outside air and increasing the amount of energy used in your heating and cooling coils, or evaporative cooler. So, if in actual operation when you do not have a demand in your zone and your fan system would normally not be operating, make sure your equipment schedules reflect this operation. When this condition might apply is when the building is unoccupied and the fan system is not needed for minimum ventilation requirements, make sure the fan system is scheduled "OFF". When the fan system is scheduled "OFF" this does not mean that it will not run, it means that the fan system will only run if there is a demand on the zone. When the fan system does run it will run for the entire hour. When the fan system is scheduled "ON" the fan system operates continuously whether there is a demand on the zone or not. The default schedule for the fan system is to "ON" for all hours.

Heating Without Demand

This can occur when the fan system is scheduled "ON" and the outside air is warmer than the desired mixed air temperature. The minimum ventilation schedule will bring in air that will overheat the zone. This occurs when you are in the heating season and the cooling coils and evaporative coolers are scheduled "OFF". Otherwise, they would pick up the small cooling load and this would not be reported. To investigate what effect outside air has on this report, increase and decrease the minimum ventilation schedule.

Cooling Without Demand

This can occur when the fan system is scheduled on and the outside air is cooler than the desired mixed air temperature. The minimum ventilation schedule will bring in some air that will overcool the zone. This occurs when you are in the cooling season and the heating coils are scheduled off. Otherwise, they would pick up the small heating load. You need to determine if in the cooling season you want a heating coil scheduled on or not.

Limits on a BLAST Run

When modeling large, complicated buildings with BLAST, users often run into one or more limits on the number of surfaces and zones. Some important limits are listed below. These limits may be overcome by using multiple building descriptions or by simplifying the entire description. Very often, a building does not need to be described in complete detail to accurately model the heat transfer. For example, consider a zone with one exterior wall and three walls to other conditioned zones. This room appears to require six surfaces - 1 EXTERIOR WALL, 3 PARTITIONS, 1 ROOF, and 1 FLOOR. Since the interior walls separate conditioned spaces, their only effect on the zone heat transfer is to give thermal capacitance. So these 3 PARTITIONS could be described as one equivalent PARTITION or INTERNAL MASS without compromising the accuracy of the model. Additional techniques for simplifying building descriptions are discussed in the USA-CERL Technical Report, *Use of Simplified Input for BLAST Energy Analysis* or *Simplifying BLAST Input* in this manual. Both of these are recommended reading for all BLAST users.

BLAST Limits

1000 Heat transfer surfaces per building description (does not include wings and overhangs)

1160 Total surfaces per building description (includes wings and overhangs)

1000 Surfaces per zone description (includes wings and overhangs)

100 Zones per building description

100 Zones per run

20 Zones per fan system

100 Fan systems per run

100 Fan systems per central plant

100 Central plants per run

32 Schedules per zone

32 Schedules per fan system

32 Schedules per central plant

1000 Total schedules (scheduled loads, controls, etc.) per run

24 Control profiles per zone

50 Unique building element constructions

200 Unique material layers

10 Material layers per building element construction

32 Detached shadowing surfaces

72 Special surface coefficients

Maximum Temperature Errors

A number of BLAST users have encountered the fatal error, "EXCEEDED MAXIMUM TEMPERATURE RANGE (HBAIR1)." The error occurs when the mean air temperature of a zone exceeds 99 °C. (The lower zone mean air temperature limit in BLAST is -99 °C). The error message does not indicate a syntax error or a problem with the BLAST algorithm; rather it indicates a modeling problem that is actually resulting in zone air temperatures in excess of 99 °C.

The following guidelines may prove helpful in tracking down the cause of an excessively high zone temperature:

1. *Inadequate Cooling:* High zone air temperatures are most commonly caused by a control profile that does not provide adequate cooling to the zone. Internal loads that are scheduled on during a setback period (no cooling) can cause the zone temperature to rise. If the loads are large enough, the zone temperature may exceed the temperature limit. If cooling is not available, ventilation, infiltration, mixing, and conduction through interzone and exterior surfaces must be sufficient to dissipate the internal loads.
2. *High Internal Loads:* Unrealistically high internal loads may occur if the user fails to schedule the loads properly or fails to enter the loads in the proper units. BLAST requires that internal loads be entered in kBtu's or in kW's.
3. *No heat transfer surfaces:* A zone constructed only of partitions, ceilings, or floors cannot transfer heat to the outside through the zone surfaces. For this type of zone model, cooling, ventilation, and mixing is the only means of removing heat from the zone. Without a mechanism to remove the energy, even a small internal load (such as a light bulb) will eventually raise the zone temperature above the 99°C limit.
4. *Clearness greater than 1:* In specifying a temporary design day, the clearness should be set to a value between zero and one. Specifying clearness greater than one will place a multiplier on the intensity of the sun, quickly overheating the building.
5. In all cases, make sure that you are modeling everything in the zone correctly. If the zone still overheats, then BLAST is telling you that if the zone is built as described it will be too hot and that some mechanism for removing heat must be added to the zone.

Metabolic Rate

The maximum metabolic rate depends upon the level of activity to be performed in the zone. The table below lists the metabolic rate for various activities. These values can be used in absence of accepted values. The default for this parameter is 1.0.

Activity	Metabolic Rate in Met Units†
RESTING	
Sleeping	0.7
Reclining	0.8
Seated, quiet	1.0
Standing, relaxed	1.2
WALKING	
On the level m/s	
0.89	2.0
1.34	2.6
1.79	3.8
MISCELLANEOUS OCCUPATIONS	
Bakery (e.g., cleaning tins, packing boxes)	1.4 to 2.0
Brewery (e.g., filling bottles, loading beer boxes onto belt)	1.2 to 2.4
Carpentry	
Machine sawing, table	1.8 to 2.2
Sawing by hand	4.0 to 4.8
Planning by hand	5.6 to 6.4
Foundry Work	
Using a pneumatic hammer	3.0 to 3.4
Tending furnaces	5.0 to 7.0
Garage Work (e.g., replacing tires, raising cars by jack)	2.2 to 3.0
General Laboratory Work	1.4 to 1.8
Machine Work	
Light (e.g., electrical industry)	2.0 to 2.4
Heavy (e.g., steel work)	3.5 to 4.5
Shop Assistant	2.0
Teacher	1.6
Watch repairer, seated	1.1
Vehicle driving	
Car	1.5

Motorcycle	2.0
Heavy vehicle	3.2
Aircraft flying routine	1.4
Instrument landing	1.8
Combat flying	2.4
DOMESTIC WORK	
House cleaning	2.0 to 3.4
Cooking	1.6 to 2.0
Washing by hand and ironing	2.0 to 3.6
Shopping	1.4 to 1.8
OFFICE WORK	
Typing	1.2 to 1.4
Miscellaneous office work	1.1 to 1.3
Drafting	1.1 to 1.3
LEISURE ACTIVITIES	
Stream fishing	1.2 to 2.0
Calisthenics exercise	3.0 to 4.0
Dancing, social	2.4 to 4.4
Tennis, singles	3.6 to 4.6
Squash, singles	5.0 to 7.2
Basketball, half court, intramural	5.0 to 7.6
Wrestling-competitive or intensive	7.0 to 8.7
Golf, swinging and walking	1.4 to 2.6
Golf, swinging and golf cart	1.4 to 1.8

*† Ranges are for activities which may vary considerably from one place of work or leisure to another or when performed by different people. 1 met = 58.2 W/m**2. Some activities are difficult to evaluate because of differences in exercise intensity and body position.*

Table 64. Metabolic Rate at Different Typical Activities‡

Reprinted by permission from 1985 ASHRAE Handbook of Fundamentals, *p. 8.11.*

Return Air Plenums

Currently, BLAST will not directly model return air plenums. This feature is on the list of future enhancements, but until it is implemented, the following technique may be used.

If you need to model a building with a return air plenum, create two separate zones, ZONE 1 (office) and ZONE 2 (plenum) as shown in the figure below.

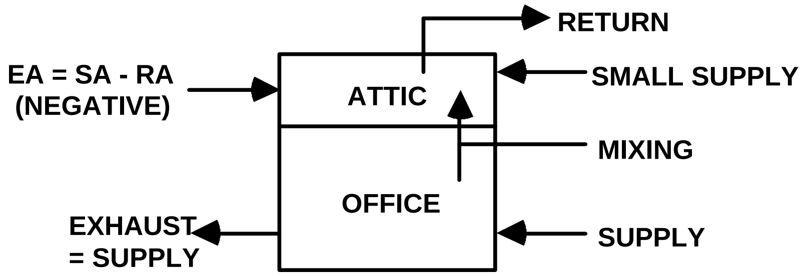

Figure 173. BLAST method for modeling a return air plenum

While ZONE 1 is at a controlled temperature, ZONE 2 (the plenum) is not. Thus the temperature is constantly changing due to surrounding conditions. The return air from ZONE 1 will affect the temperature in the plenum. This air cannot be specified in SYSTEMS since the LOADS section is separate from SYSTEMS. Thus to take credit for the air entering the plenum, the MIXING command in LOADS must be used.

BLAST performs an energy balance as follows:

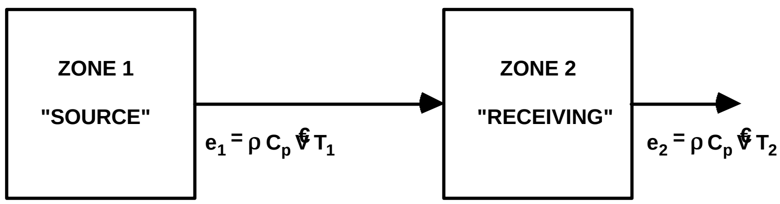

Figure 174. Energy balance in the modeling of a return air plenum

ΔEnergy ZONE 2: $\rho C_p V(T_2 - T_1)$ (BLAST calculates this)

ΔEnergy ZONE 1: None due to MIXING. It does not know that it is losing air at T_1.

In the SYSTEMS portion of BLAST, BLAST will calculate the return air for a zone for a specified supply and exhaust air flow as follows:

RA = SA - EA

Since there is no return air for ZONE 1, the exhaust air must be equal to the supply. For ZONE 2, there is no supply air. All the air from ZONE 1 mixed with ZONE 2 is equal to the return air. Thus the return air needs to be specified by having an exhaust flow as follows:

EA = SA - RA

Note that the exhaust air will be negative, resulting in a positive return air. The supply air to ZONE 2 is technically zero, but since BLAST uses SA in its calculations, a nominal value of 1 CFM must be input. Also, the supply CFM must always be greater than or equal to the exhaust. Also note that the schedule specified in the MIXING command needs to be the same schedule used for the fan system operation.

Example

Office has supply air volume of 500 CFM, and all of this air returns through a plenum.

BUILDING DESCRIPTION:

ZONE 1

nothing special

ZONE 2

MIXING = 500, SYS OP, FROM ZONE 1;

FAN SYSTEM DESCRIPTION:

ZONE 1

SUPPLY AIR VOLUME = 500;

EXHAUST AIR VOLUME = 500;

ZONE 2

SUPPLY AIR VOLUME = 1;

EXHAUST AIR VOLUME = -500;

EQUIPMENT SCHEDULES

SYSTEM OPERATION = SYS OP;

Special Considerations for VAV Systems

For a VAV system, the air supplied to ZONE 1 is constantly changing, thus the air mixed with ZONE 2 is also changing. A conservative approach would be to specify the exhaust air as follows:

EA = SA * MIN. FRACTION

More Information on Mixing

For additional information on the MIXING command, see the BLAST User Reference.

Simplifying BLAST Input

Introduction

BLAST is a sophisticated tool that allows users to describe a building with a wide range of detail. A zone can consist of one surface or numerous surfaces. Likewise, a building can consist of one zone or many zones. BLAST will model whatever the user inputs and will model it as completely as possible. But how much detail is necessary? This series of articles will discuss techniques for simplifying BLAST building descriptions without eliminating important building features.

Describe only what is necessary, and ignore the rest. If a certain feature will have no effect on the results, then there is no sense in taking the time to describe it. The fact that BLAST *allows* great detail does not mean that BLAST *requires* great detail. This is the key to using BLAST efficiently. Other energy analysis programs can limit flexibility by only allowing very simple building descriptions. BLAST allows descriptions which range from very simple to very detailed to give the user as much flexibility as needed.

The most important consideration when preparing a BLAST building description is that BLAST is only a model. A steady-state UAΔT calculation is a very simple model of heat transfer in a building, and BLAST is a very complex model. But BLAST is still just a model, so it is important for users to understand how the BLAST model works. Once a user understands how BLAST models buildings, then the user can decide what building features are important to the model.

The BLAST Building Model

In order to describe a building as efficiently as possible, it is important to know how BLAST is going to model the building. The BLAST building model is composed of four basic components: zones, surfaces, scheduled loads, and controlled heating and cooling. The zones and surfaces describe the heat transfer components of the building. Within a zone, scheduled loads may be described which add heat to the zone or remove heat from the zone. If the zone temperature is to be controlled by some type of heating or cooling system, then a CONTROLS statement is included.

All of these components contribute to the zone heat balance equations that are the heart of the BLAST building model. It is essential that BLAST users understand the basic methods that BLAST uses to model each of these components and how they are all tied together in the zone heat balance.

Zones

A zone in BLAST is a very abstract thing. A zone represents a mass of air on which a heat balance is performed. During the loads simulation, this mass of air has only one property which is of interest **--** temperature. The goal of BLAST during each hour of a simulation is to determine the zone temperature at which all of the heat transfer in the zone is balanced.

A zone is nothing without surfaces and scheduled loads. These are the primary means by which energy enters and leaves the zone. This is a very important concept. Many beginning users assume that the statement BEGIN ZONE implies a volume of air, which is in contact with the outside environment and must be enclosed somehow. This is completely wrong. BEGIN ZONE merely defines a point at which an energy balance is performed. If nothing else is described for that zone, nothing else will happen.

Surfaces, scheduled loads, and controls provide mechanisms for energy flow in to and out of a zone. The amount and direction of energy flow is affected by many factors inside and outside of the zone, including the zone temperature. As all of these components interact, BLAST calculates the zone temperature at which the energy in balances the energy out for the current hour. From the zone temperatures, BLAST will also calculate the sensible heating and cooling loads for all controlled zones.

Surfaces

There are three basic types of heat transfer surfaces in BLAST: surfaces which transfer heat between a zone and the outside environment, surfaces which transfer heat between one zone and another zone, and surfaces which simply store and release heat within a single zone. Surfaces that communicate with the outside environment include EXTERIOR WALLS, BASEMENT WALLS, ROOFS, SLAB ON GRADE FLOORS, EXPOSED FLOORS, and WALLS TO UNCOOLED SPACES. Surfaces that communicate with other zones include INTERZONE PARTITIONS, INTERZONE CEILINGS, and INTERZONE

FLOORS. Surfaces that only act to store and release heat within their own zone include PARTITIONS, CEILINGS, FLOORS, and INTERNAL MASS.

BLAST also allows for subsurfaces and shading surfaces. WINDOWS and DOORS are heat transfer surfaces that will see the same environment as the base surface that contains them. WINGS, OVERHANGS, and DETACHED SHADING are not heat transfer surfaces; they are merely shading devices which alter the amount of solar radiation reaching the exterior surfaces.

Every surface must be associated with a specific zone so that BLAST will know where to direct the energy flow from a particular surface. All heat transfer surfaces conduct heat; and all surfaces will store heat, except those constructions which are described with just an "R" value. The BLAST surface model accounts for the transient effects of heat storage. In addition, WINDOWS that are described on an exterior surface will allow solar radiation to enter a zone and be absorbed by the other heat transfer surfaces in the zone.

Scheduled Loads

Scheduled loads provide a variety of mechanisms for adding energy to a zone or for removing energy from a zone. Examples of scheduled loads include LIGHTS, PEOPLE, INFILTRATION, CROSS MIXING, and GAS EQUIPMENT. Scheduled loads can transfer heat by convection and by radiation. The convective energy goes directly to the zone air, while the radiant energy goes to the surfaces in the zone.

Controls

The CONTROLS statement is added to a zone description if there will be some type of controlled heating and cooling equipment used to control the zone temperature. The control profiles, schedules, and capacities describe how much heating or cooling is provided to the zone as a function of the zone temperature.

For example, a CONTROLS statement may indicate that the maximum heating capacity is 100 kBtu at 67°F and below; at 68°F and above no heat is added to the zone; and there is no cooling available. From this, BLAST now knows exactly how much heat is to be added to the zone for any zone temperature: 100 kBtu at 50°F, 100 kBtu at 67°F, 50 kBtu at 67.5°F, 0 kBtu at 68°F, 0 kBtu

The CONTROLS statement merely describes another piece of the zone energy balance. This piece is optional. If the zone is not a controlled space, such as an attic or shed, then the CONTROLS statement is omitted so that the zone heat balance will only include the effects of the surfaces and scheduled loads.

Heat Balances

BLAST uses an iterative technique to solve the building heat balances. There are three different heat balances that are performed in the BLAST loads calculations: the outside surface heat balance, the inside surface heat balance, and the zone heat balance. Each of these heat balances is performed separately on all of the zones and surfaces within a given building description.

The goal of the outside surface heat balance is to determine the outside surface temperature. ("Outside" means "outside the zone" and does not necessarily mean outdoors.) The outside surface temperature is affected by factors that include the inside surface temperature, heat storage in the surface, and the environment that the surface is exposed to. This environment may be another zone, or it may be the outdoors, which includes sun, wind, and temperature.

The goal of the inside surface heat balance is to determine the inside surface temperature. ("Inside" means the side that is exposed to the zone.) The inside surface temperature is affected by factors which include the outside surface temperature, heat storage in the surface, radiant transfer with other surfaces in the zone, solar radiation entering the zone, radiant energy produced by scheduled loads, and the zone air temperature.

The goal of the zone heat balance is to determine the zone air temperature. The zone air temperature is affected by the zone surface temperatures, convective energy produced by scheduled loads, and heating or cooling energy produced by the CONTROLS statement.

For a given hour of a simulation, BLAST performs the outside surface heat balances, then the inside surface heat balances, then the zone heat balances, and then repeats the process. Each heat balance adjusts the surface temperatures and the zone temperatures so that the next heat balance sees slightly different conditions. The iterations continue until the solution converges and the conditions are no longer changing. At this point the simulation for one hour is complete.

Heating and Cooling Loads

Space temperatures are fine, but what the BLAST user usually wants to know is how much heating and cooling is necessary to keep each zone at the desired conditions. Remember that the CONTROLS statement simply describes the amount of heating and cooling provided to a zone as a function of zone temperature. This amount of heating and cooling has been included in the zone heat balance for each hour in order to determine the zone air temperature. To calculate the heating and cooling loads for each hour, the zone air temperature is plugged back into the CONTROLS function for the current hour and the heating or cooling load is calculated. This load represents the sensible heating or cooling which will be provided by some type of fan system, and that is all that the loads simulation knows and cares about.

Describing as Few Zones as Possible

When describing a building for BLAST, the first step is to zone the building. When placing zone boundaries, it is very important to remember what a zone represents:

A zone represents a mass of air on which a heat balance is performed.

Surfaces, scheduled loads, and controls provide mechanisms for energy flow into and out of a zone.

This means that the entire zone has one mass of air at a single temperature. Any surfaces that are assigned to a given zone exchange energy with the zone air mass and with the other surfaces of the zone. Any scheduled loads and controls that are assigned to a given zone exchange energy with the zone air mass and with the zone surfaces.

Myths About Zones

Before discussing ways to zone a building, there are some common myths about zones that must be dispelled:

A zone must represent an enclosed volume.

This is not necessary unless SOLAR DISTRIBUTION=1 has been specified. If a zone has a hole in it, it will not let in masses of outside air. Surfaces, controls, and scheduled loads are the *only* means by which energy can enter or leave a space. Many zones may be completely described with a single exterior wall and a piece of internal mass.

A zone must represent a continuous volume.

This is not necessary. It is possible to have a single zone consist of several spaces that are far removed from each other. For example, all of the bathrooms in an entire building might be combined into a single zone.

A zone must all be on one floor.

This is not necessary. Very often, it is useful to have a single zone include rooms on several different floors.

Remember that a zone is a very abstract thing **--** it is not limited by the geometry of specific rooms. However, since buildings are divided into rooms, a zone will typically be a collection of rooms.

Start with One Zone

One approach to zoning a building is to start with the entire building as one zone and then subdivide that zone as needed. Any building *may* be modeled as one zone, if desired. This would be a very simple model, but it can be done. If a single-zone model is sufficient for the needs of a project, then there is no need to go any further in zoning the building.

If further zoning is necessary, there are many different criteria that may be used to determine zone boundaries. Four basic criteria are usage, controls type, solar gains, and fan system type. These four characteristics are sufficient to define almost all of the necessary zone boundaries, yet there may often be special conditions that require additional zones to be created.

Zoning by Usage

Rooms that differ greatly in usage typically need to be described in separate zones. All rooms that are included in a zone should have similar internal loads.

Example

A kitchen with high internal loads should not be grouped into the same zone as a storage room with low internal loads. If both of these rooms were modeled in a single zone, the kitchen loads would be distributed evenly throughout both rooms; it would be as though no wall existed between the kitchen and the storage room.

Example

Ten offices with similar lighting levels, occupancy rates, and equipment loads may be described with a single zone. These offices may even be on different floors, and they do not necessarily have to be adjacent to each other. Since all of the rooms will essentially behave the same, nothing is lost by combining them into a single zone.

Zoning by Controls Type

Rooms which have different temperature control strategies typically need to be described in separate zones. A zone can only have one control profile which is active for any given hour, so all rooms that are included in a zone will be controlled the same way.

Example

Fifteen classrooms are heated/cooled from 8am to 5pm and are set back from 5pm to 8am. All of these rooms may be included in a single zone.

Example

A hospital office area is occupied from 7am to 7pm and is set back from 7pm to 7am. The hospital patient rooms are never set back. The offices and the patient rooms must be placed in at least two different zones to model the setback periods properly.

Zoning by Solar Gains

Rooms that have greatly differing solar gains should not be included in the same zone, because the effects of the solar gains will be diluted throughout the entire zone.

Example

A north-facing zone should not be combined with a south-facing zone.

Example

A core of interior offices should not be combined with an atrium.

Zoning by Fan System Type

Rooms that are served by different types of fan systems should not be included in the same zone, since a single zone may be served by only one type of fan system.

Example

A room that is served by a fan coil system should not be combined with a room that is served by a variable air volume (VAV) system.

Special Considerations

There will often be special conditions in a building which require additional zoning in order to model the building conditions accurately. The BLAST user must always analyze the thermal aspects of the building to determine whether the zoning will be sufficient. Here are a few things to consider.

SOLAR DISTRIBUTION = 1

The detailed solar distribution model requires that every zone be described as a completely enclosed volume, which is completely convex. This will often require the description of additional zones.

Shading

When zoning based on solar gains, remember to consider shading effects.

Large Open Spaces

BLAST assumes that all zones are well mixed. If there is reason to believe that different parts of a large space may experience different conditions, then the space may be divided into more the one zone. Remember, though, to provide some means for heat transfer between these zones. This may be accomplished with cross-mixing, mixing, or interzone surfaces.

Unconditioned Spaces

When describing unconditioned spaces, such as attics and crawlspaces, consider the boundaries carefully. For example, if the attic is separated into more than one section, so that the sections will not always be at the same temperature, then it may be necessary to use more than one zone to describe the attic.

Summary

The goal of any BLAST simulation is to take something which is extremely complex (a building) and model it as simply as possible yet as accurately as necessary. One of the most critical steps is the zoning of the building. The more complex the building, the more important this step becomes. Projects with a small number of zones are much easier to manage than projects with an abundance of zones.

Always evaluate the zoning based on the way in which the results will be used. If simple block loads are all that is desired, then one or two zones may be sufficient. If a detailed analysis of different fan system options is desired, then more zones may be necessary. BLAST will model as much or as little as it is given, and it is up to the BLAST user to decide how much detail is worthwhile for each project.

Describing as Few Surfaces as Possible

After a building has been zoned, each zone is described as a collection of surfaces. Once again, the user may take a very detailed or a very simplified approach. Only describe as many surfaces as are necessary. Very often, it may be sufficient to describe a zone as one exterior surface and one piece of internal mass. At other times it may be necessary to use as many as 50-60 surfaces in a single zone. As with zoning, the user must evaluate the way in which the results will be used to determine the level of detail required.

The easiest approach to understand is the detailed approach. Take each surface of the building and describe it -- every window, every door, every wall, every kink, every corner, and so on. More effort is required to reduce the number of surfaces into a manageable set without losing important features of the building. This step may require extra effort initially, but in the end it will save endless frustration and work.

Combine Similar Surfaces and Subsurfaces

The easiest way to reduce the number of surfaces is to combine similar surfaces and subsurfaces into a single surface. Very often, the exact positioning of a surface is not critical. As long as the surface stays in the same plane, it will typically have the same contribution to the zone. So look at each wall of the zone and rearrange the pieces so that all pieces of similar construction are next to each other. Then take all the pieces of one type and describe them as a single surface. The only loss in detail may be some minor changes in shading patterns if shading is important. Otherwise, the heat transfer is equivalent.

Example

If a wall contains five windows of similar construction, then describe one large window with an equivalent area.

Example

If a wall contains several sections of brick wall which are separated by sections of wood, then combine all of the brick areas into one surface and all of the wood areas into a second surface.

Combine Small Surfaces with Larger Surfaces

If a surface is small relative to the other zone surfaces, evaluate its contribution to the overall zone heat transfer. If the surface will not behave significantly different than one of the larger surfaces, then add its area to the larger surface.

Example

The zone pictured in the figure below has a kink along its west wall. The small piece of wall that faces north will essentially behave the same as the large north facing wall. So describe the zone with only four walls instead of six. Also, describe the roof and floor as square surfaces with the appropriate area.

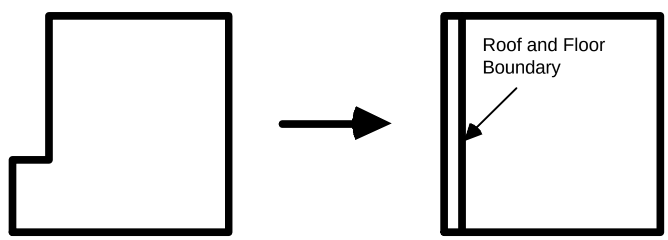

Figure 175. Six walls or four?

Ignore Minor Details

If a feature is so small that its effect on the zone is negligible, the feature should be ignored. This is essentially a special case of the previous section.

Example

A 10,000 sq. ft. concrete block wall has two 100 sq. ft. steel doors on it. The effect of simulating these doors as concrete block instead of steel would be very small, so describe the entire wall as one concrete block surface.

Use INTERNAL MASS

Any surface which is going to be described as a PARTITION, FLOOR, or CEILING can just as easily be described as INTERNAL MASS. These surface types only exchange energy with the zone in which they are described; they do not see any other zones. There are two approaches to using INTERNAL MASS. The first approach is to have several pieces of INTERNAL MASS with each piece having a different construction type. The other approach is to choose an average construction type and combine all of the interior surfaces into a single INTERNAL MASS. Remember to consider including interior floors and ceilings as INTERNAL MASS.

Note: The area that is specified when describing INTERNAL MASS must be the entire surface area that is exposed to the zone. If both sides of a wall are completely within the same zone, then the area of both sides must be included when describing that wall as INTERNAL MASS.

Example

When zoning an office building, five west facing offices have been combined into one zone. All of the offices have interior walls made of the same materials. As shown in the figure below, this zone may be described with 11 PARTITIONS or 1 INTERNAL MASS.

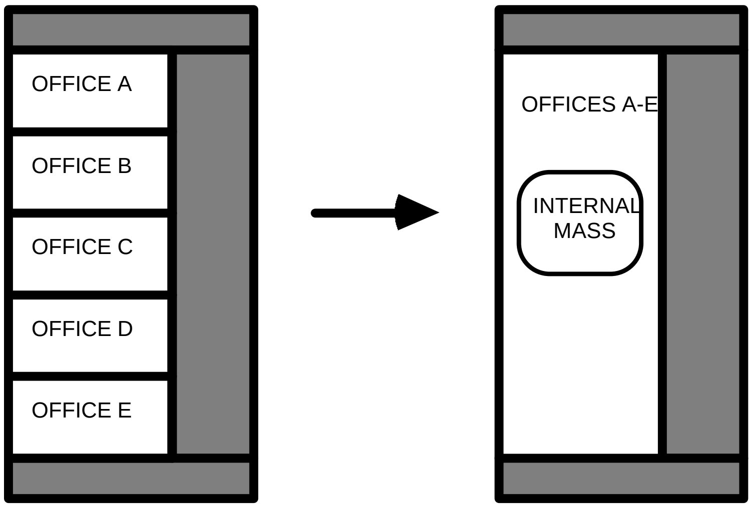

Figure 176. 11 Partitions or 1 Internal Mass

Example

A five story building has the same ceiling/floor construction separating each of the levels. Zones that are on floors 2 through 4 may be described using a single piece of INTERNAL MASS to represent both the floor and ceiling. The construction for this INTERNAL MASS would be identical to the ceiling/floor construction that would be used to describe separate surfaces.

Use INTERZONE Surfaces Only when Necessary

One of the most important features of BLAST 3.0 is the ability to simulate a group of zones simultaneously and to include the heat transfer between zones. This is accomplished by using INTERZONE PARTITIONS, INTERZONE CEILINGS, and INTERZONE FLOORS. The tendency of many users is to use these surfaces throughout the building description, but using INTERZONE surfaces can significantly increase the complexity of the BLAST building description. Use INTERZONE surfaces sparingly.

INTERZONE surfaces should only be used when there will be a significant temperature difference between two zones which share a common surface. Since INTERZONE surfaces are always interior surfaces, their spatial position does not matter (unless SOLAR DISTRIBUTION=1 has been specified), so only one INTERZONE surface will typically be needed between any two zones.

Example

A wood frame office building has several identically controlled offices and an attic. The attic should be described as a separate zone, and INTERZONE surfaces are only needed between each zone and the attic.

Example

A group of offices sticks out into a warehouse area so that three walls and the ceiling of the offices are exposed to the warehouse air. The offices are heated to 68°F and cooled to 78°F; the warehouse is heated to 55°F and is not cooled. Only two INTERZONE surfaces are necessary: one INTERZONE PARTITION to represent the three office walls, and one INTERZONE CEILING to represent the office ceiling. If the ceiling construction is similar to the wall construction, only one INTERZONE surface would be necessary.

Special Considerations for SOLAR DISTRIBUTION=1

When using SOLAR DISTRIBUTION=1, remember that all zones must be completely convex and completely enclosed. This is required because all of the beam solar radiation that is projected into a zone must find a surface to land on. When describing buildings for use with SOLAR DISTRIBUTION=1, it is often not possible to use many of the techniques for reducing the number of surfaces. Keep in mind the purpose of the study and seriously evaluate whether SOLAR DISTRIBUTION=1 is necessary. If it is, simplify each zone as much as possible. If only part of a building requires the detailed solar analysis, it may be useful to separate the building into two building descriptions with only one of the building descriptions using SOLAR DISTRIBUTION=1.

Summary

A BLAST zone can be described with one to one thousand surfaces. To use BLAST efficiently, it is important to minimize the number of surfaces in each zone. By combining similar surfaces, including smaller surfaces as part of larger surfaces, ignoring minor details, using INTERNAL MASS whenever possible, and using INTERZONE surfaces only when necessary, it is possible to greatly reduce the complexity of the BLAST building description. In addition to simplifying the input task and making the results easier to manage, reducing the number of surfaces will also reduce the computation time.

Using HBLC Effectively

Once the user has decided what zones and surfaces will be described, it is time to create the BLAST input file. HBLC provides a fast and easy method for building BLAST input files. Some of the simplifications mentioned in this section apply only to the old methods of creating an input file: by hand with a text editor or with BTEXT. With HBLC it is easy to describe complex zones with close to actual geometry. This is not to say that a user can’t simplify and combine surfaces, rather that with HBLC the effort spent on simplifying the model may be greater than that involved in modeling the building in its complex state.

Conclusions

As stated at the beginning of this series, BLAST is a sophisticated tool that allows users to describe a building with a wide range of detail. BLAST will model whatever the user has described and will model it as completely as possible. Here are a few points to remember when preparing BLAST building descriptions:

1. Take some time to consider how much detail is necessary to obtain the desired results.
2. Plan the zoning and surface descriptions carefully to eliminate wasted effort in describing unimportant details.
3. Remember that the goal is to minimize the number of zones and surfaces while retaining the important characteristics of the building.
4. Utilize the flexibility of HBLC or BTEXT to assist in quickly preparing the BLAST input file.

Special Parameters Definitions

AZMUTH - Compass azimuth angle direction that the solar collectors are facing. Units: degrees

BGNCHARG - The hour which the ice storage system begins to recharge at full capacity of the chiller. This parameter is only valid when the "full on with optional delay" off-peak charging strategy (OFFPEAKC=2) is used. Units: dimensionless

BGNPEAKE- The first hour of the on-peak period for either a direct or indirect ice storage system. Units: dimensionless

BOILEF- Overall efficiency of the boiler being modeled as a simple boiler. Units: dimensionless

BOLELE- Parasitic electrical consumption of the simpler boiler defined as a fraction of the boiler capacity. Units: kBtu per kBtu/hr (kW-hr per kW)

BRINECP- The specific heat of the brine solution circulated through an indirect ice storage system. Units: Btu/lb_m-R (kJ/kg-K)

BTSPEAK- The first hour of the on-peak period for a thermally stratified chilled water storage system. Units: dimensionless

CHFLRATE- The charging volumetric flow rate of water for a thermally stratified chilled water storage tank or the maximum brine flow rate for an indirect ice storage system. Units: ft^3/min (m^3/s)

CHILLOPT- The definition of the chiller placement with respect to the indirect ice storage system. The options are chiller upstream (CHILLOPT=1), chiller downstream (CHILLOPT=2), and chiller in parallel (CHILLOPT=3). Units: dimensionless

CHINTEMP- The inlet water temperature for a thermally stratified chilled water storage tank during the charging process. Units: °F (°C)

CHLREF- Overall efficiency of the chiller equipment being modeled as a simple chiller. Units: dimensionless

COMPCP- The compressor capacity for either a direct or an indirect ice storage system. Units: kBtu/hr (kW)

COMPEF- The efficiency of the compressor electric motor. Units: dimensionless

CONDCP- The condenser capacity for either a direct or an indirect ice storage system. Units: kBtu/hr (kW)

CONDEL- The condenser electric consumption for either a direct or indirect ice storage system. This term is defined as a fraction of condenser capacity (CONDCP). Units: kBtu per kBtu/hr (kW-hr per kW)

CONDTY- The type of condenser for either a direct or an indirect ice storage system. CONDTY is set to 1 for an evaporative condenser, 2 for an air cooled condenser, and 3 for a water cooled condenser. Units: dimensionless

CONTMODE- The overall control method for a thermally stratified chilled water storage system. The options are Full Storage (CONTMODE=1), Load Leveling Chiller (CONTMODE=2), and Load Leveling Storage (CONTMODE=3). Units: dimensionless

CRENTEMP- The maximum allowable coil return temperature. This parameter is only valid for a thermally stratified chilled water storage tank or an indirect ice storage system. Units: °F (°C)

DACTCOP- The design full-load coefficient of performance for the chiller serving the indirect ice storage system. This parameter is used in developing the performance model for the chiller and is the ratio of the actual capacity of the chiller to its power consumption at full-load design conditions. Units: dimensionless

DCARCOP- The design Carnot coefficient of performance for the chiller serving the indirect ice storage system. This parameter is used in developing the performance model for the chiller and is defined as the ratio of the absolute temperature of the leaving chilled water (brine) temperature to the difference in the entering condenser water temperature and the leaving chilled water temperature at design conditions. Units: dimensionless

DHWEFF- Efficiency of the domestic hot water heater. Units: dimensionless

DHWLOS- Heat loss of the domestic hot water heater as a fraction of its capacity. Units: dimensionless

EBEFF- Average efficiency of heat generation by the electric boiler. Efficiency equals heat output/electrical input. Units: dimensionless

ELENUMBR- The number of tank segments used in the thermally stratified chilled water storage tank. Units: dimensionless

ENDPEAKE- The last hour of the on-peak period for either a direct or indirect ice storage system. Units: dimensionless

ETSPEAK- The last hour of the on-peak period for a thermally stratified chilled water storage system. Units: dimensionless

FCCTRL- Free cooling chiller control type. FCCTRL = 1 allows the chiller to work in the free cooling mode between the dates of FCON and FCOFF. FCCTRL = 2 allows the chiller to work in the free cooling mode if the outside air dry-bulb temperature is less than FCTEMP. FCCTRL = 3 allows the chiller to work in the free cooling mode if the outside air wet-bulb temperature is less than FCTEMP. FCCTRL = 4 allows the chiller to work in the free cooling mode if condenser water temperature entering the chiller is less than the desired leaving chilled water temperature. Units: dimensionless

FCOFF- If FCCTRL = 1, the date the free cooling chiller switches from the free cooling mode to the regular mode. The date is computed from 32 * MONTH + DAY. Thus FCOFF for 12 March is 32 * 3 + 12 = 108. Units: dimensionless

FCON- If FCCTRL = 1, the date the free cooling chiller switches from the regular mode to the free cooling chiller mode. The date is computed from 32 * MONTH + DAY. Thus FCON for 18 OCTOBER is 32 * 10 + 18. Units: dimensionless

FCTEMP- The free cooling chiller control temperature. If FCCTRL = 2, FCTEMP will be compared with the outside air dry-bulb temperature. If FCCTRL = 3, FCTEMP will be compared with the outside air wet-bulb temperature. Units: °F (°C)

FLORAREA- The floor area of the thermally stratified chilled water storage tank. Units: ft^2 (m^2)

FLOWRT- Mass flow of water through solar collectors (equivalent mass flow if other fluids are used) per unit collector area. If fluids other than water are used, the actual flow rate should be multiplied by the specific heat ratio of the other fluid to water in order to compute FLOWRT. Units: lb/hour-sq ft (kg/sec-m^2)

HFUELB- Heat content of fuel. Affects boiler efficiency and should be consistent with SRATB. Units: Btu/lb (kJ/kg)

HTXEFF- Effectiveness of heat exchanger between solar collector fluid loop and thermal storage tank fluid loop. If none exists, use 1.0. Units: dimensionless

HXFLMASS- The total mass of the brine solution which is present in the heat exchanger tubing of an ice tank (ice-on-coil internal melt) indirect ice storage system at any one time. Units: lb_m (kg)

ICECTL- The overall control method for the ice storage system. For a direct ice storage system, the options are Full Storage (ICECTL=1), Compressor Aided (ICECTL=2), Demand Limiting (ICECTL=3), and Parallel Evaporator (ICECTL=4). For an indirect ice storage system, the options are Full Storage (ICECTL=1), Chiller Priority (ICECTL=3), and Ice Priority (ICECTL=4). Units: dimensionless

ICEPAR1- The parasitic electric consumption of either a direct or indirect ice storage system during the discharging cycle. This term is defined as a fraction of the ice storage unit capacity. Units: dimensionless

ICEPAR2- The parasitic electric consumption of either a direct or indirect ice storage system during the charging cycle. This term is defined as a fraction of the ice storage unit capacity. Units: dimensionless

ICETYPE- The type of ice storage system. ICETYPE=1 is only valid for a direct ice storage system and will implement "perfect control" as described in the *BLAST Technical Reference*. This option is the default for an ice-on-coil (external melt) system. ICETYPE=2 is only valid for a direct ice storage system and will used control schemes similar in nature to the indirect ice storage systems. This option is the default for an ice harvester system.

OFFPEAKC- The off-peak charging control strategy for indirect ice storage systems and direct ice storage systems not using "perfect control." There are three charging control strategies which can selected: equalized (OFFPEAKC=1), full on with optional delay (OFFPEAKC=2), and near optimal (OFFPEAKC=3). Units: dimensionless

OFFPKI- The off peak indicator for all thermal storage options. When OFFPKI is set to 1, all days will have an on**-** and off-peak period defined by either BGNPEAKE and ENDPEAKE or BTSPEAK and ETSPEAK. When OFFPKI is set to 2, the entire weekend period is considered off-peak. When OFFPKI is equal to 3, the entire weekend and all holidays are assumed to be off-peak periods. Units: dimensionless

PDPBCM- Boiler Conversion Multiplier for Design Plant Run Option

PDPCCM- Cooling Conversion Multiplier for Design Plant Run Option

PDPEGM- Electrical Generation Multiplier for Design Plant Run Option

PELCL- Ratio of electrical energy for circulatory pumps to cooling load. Refer to EQUIPMENT PERFORMANCE PARAMETERS -PUMPS. Units: dimensionless

PELDTWR- The ratio of the direct cooling tower pump electrical energy required to cooling load on the direct cooling tower. Units: dimensionless

PELECND- The ratio of the evaporative condenser pump electrical energy required to condenser load. Units: dimensionless

PELHT- Ratio of electrical energy for circulatory pumps to heating load. Refer to EQUIPMENT PERFORMANCE PARAMETERS - PUMPS. Units: dimensionless

PELTWR- If cooling towers are specified in the input, PELTWR is the ratio of pump electrical energy required to cooling tower load. Refer to EQUIPMENT PERFORMANCE PARAMETERS - COOLING TOWERS. If cooling towers are not specified in the input, PELTWR is the ratio of tower pump electrical energy required to cooling tower load. If no tower is specified, the total electrical demand for towers and pumps is (PELTWR + ELECTRICAL) * (Tower Load) where ELECTRICAL is the power consumption per unit load for towers from PART LOAD RATIOS.

PELWWC- The ratio of well-water condenser pump electrical energy required to condenser load. Units: dimensionless

PSHAVE- The portion of the coil load to be supplied by a chiller. For Compressor Aided direct or Ice Priority indirect ice storage control, the amount of cooling specified by PSHAVE is met by the compressor or chiller which is used during off-peak hours to make ice. In the Demand Limiting direct ice storage control schemes, PSHAVE is met by a conventional chiller. In a Parallel Evaporator controlled direct ice storage system, PSHAVE is met by the second evaporator loop. This parameter is not used for Full Storage or Chiller Priority indirect ice storage control. Units: kBtu/hr (kW)

PSTEAM- Gauge boiler steam pressure, unless steam turbines are selected (equivalent saturation pressure for hot water boilers). If not specified, default is 285 in. water gauge (10.3 psig [71016 Pa]); if two-stage absorber is selected, default is 3990 in. water gauge (144 psig [992845 Pa]). Also, steam turbine exhaust pressure if steam turbines are specified. Units: in. water gauge (Pascals gauge), 1 psi = 27.71 in. water gauge

PSTMTUR- Entering steam pressure to steam turbines. Units: in. water gauge (Pascals gauge), 1 psi = 27.71 in. water gauge

RAVRHDB- Fraction of the available double-bundle chiller condenser heat which is recoverable. The calculated condenser heat available at the part- or full-load condition under which the double-bundle chiller is operating in any hour is multiplied by this number to determine the total heat from the double bundle which can meet heating loads. Units: dimensionless

RAVRHHP- Same as RAVRHDB, but applies to heat pumps.

REFTYP- The type of refrigerant used in the ice storage system. REFTYP is set to 1 for R12, 2 for R22, 3 for R502, and 4 for R717. Units: dimensionless

RFLASH- The boiler flash water or blowdown rate (pounds of steam discharged per pound of steam produced). For water boilers, this parameter should probably be set to zero (no water loss). Units: dimensionless

RHFLASH- Fraction of heat in boiler flash (blowdown) which is recovered in feedwater preheater. Units: dimensionless

RMXKWD- Maximum exhaust flow per unit capacity for diesel engines. The parameter sets an upper limit on exhaust gas flow and exhaust gas heat recovery for diesel engines. Units: lb/hour per kBtu/hour of capacity (kg/sec per kW capacity)

RMXKWDC- Maximum exhaust flow per unit capacity for diesel-driven chillers. The parameter sets an upper limit on exhaust gas flow and therefore exhaust gas heat recovery for diesel engines. Units: lb/hour per kBtu/hour of capacity (kg/sec per kW capacity)

RMXKWG- Same as RMXKWD, but applies to gas turbines.

RMXKWGC- Same and RMXKWDC, but applies to gas turbine-driven chillers.

RPMNOM- Steam turbine angular speed. Units: revolutions per minute (RPM)

RWCDB- Ratio of condenser water flow rate to double-bundle chiller capacity. Units: lb/hour per kBtu/hour of capacity (kg/sec per kW capacity)

RWCDC- Same as RWCDB, but applies to diesel-driven chillers.

RWCFC- Same as RWCDB, but applies to free cooling chillers.

RWCGC- Same as RWCDB, but applies to gas turbine-driven chillers.

RWCHC- Same as RWCDB, but applies to hermetic compression chillers.

RWCHP- Same as RWCDB, but applies to heat pumps.

RWCOC- Same as RWCDB, but applies to open chillers.

RWCRC- Same as RWCDB, but applies to reciprocating chillers.

RWC1A- Same as RWCDB, but applies to one-stage absorption chillers.

RWC2A- Same as RWCDB, but applies to two-stage absorption chillers.

RWC2AE- Same as RWCDB, but applies to one-stage absorption chillers with economizer.

RWSTUR- Ratio of condensate flow to entering steam flow for steam turbines. Accounts for steam and/or condensate leaks in the turbine. Units: dimensionless

SLTMPAPR- The monthly soil temperature for a thermally stratified chilled water tank located below ground (April). Units: °F (°C)

SLTMPAUG- The monthly soil temperature for a thermally stratified chilled water tank located below ground (August). Units: °F (°C)

SLTMPDEC- The monthly soil temperature for a thermally stratified chilled water tank located below ground (December). Units: °F (°C)

SLTMPFEB- The monthly soil temperature for a thermally stratified chilled water tank located below ground (February). Units: °F (°C)

SLTMPJAN- The monthly soil temperature for a thermally stratified chilled water tank located below ground (January). Units: °F (°C)

SLTMPJUL- The monthly soil temperature for a thermally stratified chilled water tank located below ground (July). Units: °F (°C)

SLTMPJUN- The monthly soil temperature for a thermally stratified chilled water tank located below ground (June). Units: °F (°C)

SLTMPMAR- The monthly soil temperature for a thermally stratified chilled water tank located below ground (March). Units: °F (°C)

SLTMPMAY- The monthly soil temperature for a thermally stratified chilled water tank located below ground (May). Units: °F (°C)

SLTMPNOV - The monthly soil temperature for a thermally stratified chilled water tank located below ground (November). Units: °F (°C)

SLTMPOCT- The monthly soil temperature for a thermally stratified chilled water tank located below ground (October). Units: °F (°C)

SLTMPSEP- The monthly soil temperature for a thermally stratified chilled water tank located below ground (September). Units: °F (°C)

SRATB- Air-to-fuel stoichiometric ratio (pounds of air per pound of fuel) for boilers. Affects boiler efficiency and should be consistent with HFUELB. Units: dimensionless

STEAM- Enthalpy of steam from boiler or heat recovery; also enthalpy of steam to absorbers. If not specified, STEAM will be calculated as the saturation enthalpy at PSTEAM and TSATUR. Units: Btu/lb (kJ/kg)

TANKLOCN- The location and surrounding environment indicator for a thermally stratified chilled water storage tank. The options are Above Ground (TANKLOCN=0) and Below Ground (TANKLOCN=1). If the tank is above ground, the temperature of the surroundings is determined by the weather environment. If the tank is below ground, the soil temperature surrounding the tank is determined by the SLTMPmmm parameters where mmm are the first three letters of the appropriate month of the year. Units: dimensionless

TANKUVAL- The overall heat transfer coefficient (U value) between the thermally stratified chilled water storage tank and its surrounding environment. This parameter will be used to determine the heat gain/loss of the tank. Units: Btu/(hr•ft^2•R) (W/m^2/K)

TCOOL- Temperature of chilled water leaving the chiller. For an indirect ice storage system, TCOOL represents the desired temperature of the brine entering the cooling coil. Units: °F (°C)

TCW- Temperature of the water leaving the condenser for double-bundle chillers and heat pumps when they are supplying heat. Units: °F (°C)

TDCTWR- Minimum allowable temperature for water leaving the direct cooling tower. Units: °F (°C)

TEVAPC- Same as TDCTWR but for evaporative condenser.

TFREEZE- The freezing temperature of the storage material in an indirect ice storage system. Changes in the freezing temperature may result in altered performance of the storage unit which would lead to modified performance parameters. The default value for TFREEZE is the freezing point of water. Units: °F (°C)

TILT- Tilt angle from horizontal of solar collectors. Units: degrees

TLEAVE- Temperature of flue gas leaving the boiler stack. Affects boiler efficiency and should be the same as the stack temperature used to compute the RFUELB equipment performance parameter set. Units: °F (°C)

TMINC- Minimum storage tank temperature below which cooling cannot be accomplished with solar energy. Units: °F (°C)

TMINH- Minimum storage tank temperature below which heating cannot be accomplished with solar energy. Units: °F (°C)

TMINHP- Minimum solar storage tank temperature below which false loading of the heat pump cannot be accomplished with solar energy. Units: °F (°C)

TNKCAP- Solar thermal storage capacity per unit collector area. Units: lb/sq ft (kg/m2)

TNKTEM- Initial solar storage tank temperature. Units: °F (°C)

TOWOPR- Tower operation type: 1 or 2

1 = variable water flow rate

2 = fixed water flow rate.

TPELCL- The pump power demanded per unit of cooling capacity for a thermally stratified chilled water storage tank. TPELCL is used in conjunction with the CWTPUMP Performance Parameters to determine the actual consumption of the system water pumps. Units: dimensionless

TSATUR- Steam saturation temperature or boiler hot water temperature; also inlet temperature to absorber at full capacity; also temperature at which heat will be recovered from diesel and gas turbine engine generators. If not specified, TSATUR will be calculated on the basis of PSTEAM. Units: °F (°C)

TSTMTUR- Entering steam temperature to steam turbines. Units: °F (°C)

TSTPAR- The parasitic electric consumption of a thermally stratified chilled water storage tank. This term is defined as a fraction of the tank storage capacity. Units: dimensionless

TTOWR- Minimum allowable temperature for water leaving the cooling tower. Also, initial temperature of water leaving the cooling tower. Units: °F

TWWC- Same as TDCTWR but for well-water condenser.

TWMAKE- Temperature of the plant make up water. Units: °F (°C)

WALLAREA- The total wall area of the thermally stratified chilled water storage tank not including the floor or ceiling of the tank. Units: ft2 (m2)

WRHEIGHT- The water level height in a thermally stratified chilled water storage tank. Units: ft (m)

Thermal Comfort

The incorporation of three popular Thermal Comfort models into BLAST accompanied Phase I of the BLAST Radiant Heat Enhancements (High Temperature Radiant Heaters). A description of the output reports produced by the models can be found in *BLAST Output*.

Thermal Comfort Models in BLAST

The most notable Thermal Comfort models have been developed by P. O. Fanger (the Fanger Comfort Model), the J. B. Pierce Foundation (the Pierce Two-Node Model), and researchers at Kansas State University (the KSU Two-Node Model). All three apply an energy balance to a fictitious person in the space being modeled. (A BLAST "PEOPLE" statement does not have to be included in a BLAST input file in order to use the Thermal Comfort models.) The energy exchanged between the zone and its occupants is used, along with experimentally derived physiological parameters, to predict the thermal sensation and the physiological response of a person due to environmental conditions. The models differ somewhat in the physiological models that represent the human passive system (heat transfer through and from the body) and the human control system (the neural control of shivering, sweating, and skin blood flow) and in the criteria used to predict thermal sensation.

All of the Thermal Comfort models supported by BLAST are related to a Thermal Sensation scale. The final result of any Thermal Comfort model is an index that corresponds to a point on such a scale. The scale is then used to determine the thermal state of a person in the space. Shown below are two commonly used Thermal Sensation scales, the Seven Point Thermal Sensation Scale and the Nine Point Thermal Sensation Scale.

Seven Point Thermal Sensation Scale		**Nine Point Thermal Sensation Scale**	
		4	very hot
3	hot	3	hot
2	warm	2	warm
1	slightly warm	1	slightly warm
0	neutral	0	neutral
-1	slightly cool	-1	slightly cool
-2	cool	-2	cool
-3	cold	-3	cold
		-4	very cold

Figure 177. Thermal sensation scales

The **Fanger** Thermal Comfort model, which was the first of the three to be developed, is probably the most well known Thermal Comfort model and also the easiest to use. It is based on research performed by P. O. Fanger at Kansas State University and the Technical University of Denmark. Numerous experiments involving human subjects were conducted in various environments. Analysis of the resulting data allowed Fanger to relate subjects' responses to variables that influence the level of thermal comfort. The index calculated by the Fanger Comfort model is PMV, which stands for the Predicted Mean Vote. PMV is set on the Seven Point Thermal Sensation scale.

The **Pierce Two-Node** model was developed by the John B. Pierce Foundation at Yale University and has been continually expanding since it was first published in 1970. This model thermally lumps the human body as two isothermal, concentric compartments, one representing the internal section or core (where all the metabolic heat is assumed to be generated) and the other representing the skin. This allows the passive heat conduction from the core compartment to the skin compartment to be taken into consideration. Furthermore, the effects that deviations of the core temperature and the skin temperature from their respective set points have on the blood flow and shivering are also regarded. Shivering is accounted for as an increase in metabolic rate in this model. The Pierce model results in four indices which are briefly described in *BLAST Output* .

The **KSU Two-Node** model, developed at Kansas State University, is quite similar to the Pierce model. The main difference between the two is that the KSU model predicts the Thermal Sensation Vote (TSV) differently for warm and cold environments. The KSU model is based on changes that occur in the thermal conductance between the core and the skin in cold environments and the skin wetness in warm environments.

BLAST Thermal Comfort Execution Time Considerations

The use of Thermal Comfort models in BLAST can have a significant effect on execution time. CPU times for an example run are shown below. Execution times listed are for a simple three zone (six surfaces in each zone) simulation with two design days on an Apollo Domain 3000 computer.

Model Name	Total CPU time (in sec)	Thermal Comfort CPU time (in sec)
None	69.2	
Fanger	73.3	4.1
Pierce	185.4	116.2
KSU	891.9	822.7

Figure 178. CPU time for thermal comfort models

Thermally Stratified Tank

The equations describing the performance of the stratified tank are obtained by dividing the tank into a number, N, of isothermal constant volume elements of height ΔZ, as shown in the figure below, and writing the energy and mass balances for each element.

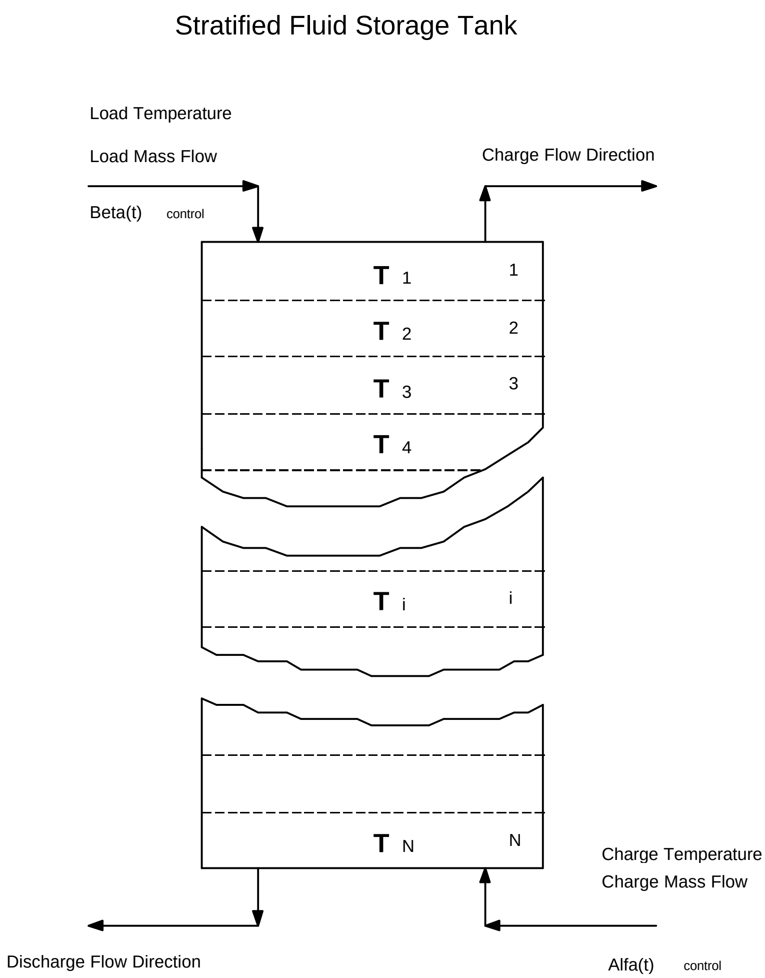

Figure 179. Stratified Fluid Storage Tank

It is assumed that each tank element is perfectly mixed at a uniform temperature and that the incoming fluid to each element will mix instantaneously with the fluid in the element. An energy balance written about the i^{th} tank element is expressed:

$$\rho A_{cond} \Delta Z c_{pf} \frac{dT_i}{dt} = \frac{K_f A_{cond}}{\Delta Z} \left[(T_{i+1} - T_i) + (T_{i-1} - T_i) \right] + UA_{segm}[T_{env} - T_i] \qquad \text{(Eq. 2.6)}$$

Dimensionless time is defined as:

$$t^* = \frac{K_f}{\rho \Delta Z^2 c_{pf}} t \qquad \text{(Eq 2.7)}$$

Therefore:

$$\frac{dt^*}{dt} = \frac{K_f}{\rho \Delta Z^2 c_{pf}} \qquad \text{(Eq.2.8)}$$

Applying the chain rule from calculus to equation 2.6:

$$\rho A_{cond}\Delta Z c_{pf}\left[\frac{dT_i}{dt^*}\right]\left[\frac{dt^*}{dt}\right] = \frac{K_f A_{cond}}{\Delta Z}\left[(T_{i+1} - T_i) + (T_{i-1} - T_i)\right] + UA_{segm}\left[T_{env} - T_i\right] \quad \text{(Eq. 2.9)}$$

Substituting equation 2.8 into equation 2.9 we get:

$$\frac{dT_i}{dt^*} = \left[(T_{i+1} - T_i) + (T_{i-1} - T_i) \right] + \frac{UA_{segm}\Delta Z}{A_{cond}K_f}\left[T_{env} - T_i\right] \quad \text{(Eq. 2.10)}$$

Equation 2.10 was then used to replace equation 2.6 in the stratified tank model. Once equation 2.10 has been solved for each tank element in the simulation, the real time is then found by:

$$t = \frac{\rho \Delta Z^2 c_{pf}}{K_f} t^* \quad \text{(Eq. 2.11)}$$

This time scaled model developed for BLAST is not sensitive to changes in tank geometry. Large tank simulations that became unstable with a dimensional model were stable with the time scaled model. In addition, a decrease in execution time was detected for the simulation cycle with the time scaled model.

Another important reason for using time scaled model in simulations is to avoid confusion between unit systems. The BLAST program gives the user the option of using both English and SI units. By using a time scaled model, unit conversions are only needed at the input and output sections of the program.

The water motion through the tank was approximated by dividing the tank into elements and then moving these elements through the tank at discrete time steps. A discrete time step is defined as the time that it takes to fill an element with water. If the tank is in charging mode one volume element is then introduced at the tank inlet temperature at the bottom of the tank (for chilled water systems) and all water elements are simultaneously displaced toward the top of the tank. The last element is then considered to have been discharged from the tank.

Energy Calculations and Modes of Operations

The stratified tank simulation program developed has three modes of operation: charge mode, discharge mode, and stagnation mode. In the charge and discharge modes, the discrete time step controls the water flow simulation in the appropriate direction and transient conduction and environmental loss calculations are performed for each dimensionless time step. In the stagnation mode there is no flow in or out of the tank and the simulation only calculates the conduction of each stationary tank element to the adjacent elements and thermal losses to the surroundings.

During each dimensionless time step, the simulation keeps track of the energy added or removed from the tank by calculating the enthalpy of the water introduced at the tank inlet or removed at the outlet. These energy quantities are then reported every hour real time as energy stored or energy removed from the tank.

The energy capacity of the tank is calculated by evaluating the changes in internal energy of the tank. It would not be realistic to calculate the energy capacity of the tank by summing the difference of the enthalpy added or removed from the tank since losses due to mixing and environmental losses would not be correctly taken into account. These losses also occur in the stagnation mode so the tank capacity calculation method is valid in all modes. The enthalpy of each tank element is evaluated with the design return temperature into the tank as a reference. The instantaneous tank capacity is then calculated by summing up the enthalpy of all the tank elements. This method works for all three modes of tank operation.

Mixing near the Diffusers

To model the thermocline formation, a mixing coefficient was introduced as an input for the stratified tank simulation. The mixing coefficient is defined as the percent of the total water height in the tank that is mixed around the diffusers. The mixing is then simulated by averaging the temperature of a number of tank elements near the diffuser consistent with the magnitude of the mixing coefficient. The number of elements to average is determined in the following manner:

$$ThicknessofMixingLayer = MixingCoefficient \times WaterHeightinTank$$

$$NumberofElementstoAverage = Integer\left[\frac{ThicknessofMixingLayer}{ElementThickness}\right] + 1$$

In the simulation, the calculated elements are averaged after the first inlet element is filled with water at the inlet charge temperature, before conduction calculations between the elements start.

The value of the mixing coefficient should be selected based on information about diffuser performance and operating conditions. As a rule of thumb, the value of the mixing coefficient should be 3 percent for a diffuser that produces good stratification ranging up to 8 percent for a poor diffuser.

Number of tank elements needed

The recommended size of the tank elements and thus the number of elements will depend on the application. Larger elements would result in a greater error since the approximation of the water flow through the tank is based on moving elements at discrete time steps. Smaller elements are not significantly more accurate and would only increase the execution time of the simulation.

A recommendation for the size of the tank elements can be derived from stability considerations. The resulting relationship between the element height and the characteristic parameters of the storage tank is:

$$\Delta Z = 0.2\frac{A_{cond} K_f}{\dot{m} c_{pf}}$$

The number of elements can then be calculated by dividing the overall tank height by the element height, ΔZ.

Chilled Water Pumps Model

Stratified storage cooling systems usually have higher pumping energy requirements than conventional non-storage systems. However, this penalty is relatively small if storage systems are designed reasonably.

The increase in required pumping energy is due primarily to the three following reasons. First, the addition of the storage tank into the cooling loop requires pumping of storage water to and from the tank. Second, chilled water supplied from storage may be warmer than it was when introduced into the storage tank; hence, a larger volume of water is required through the building to meet the same cooling load as for a conventional system. However, this added pumping cost can be eliminated by designing the storage system to operate at a wider temperature range than conventional systems. Finally, the third reason for increased pumping cost is static lift due to the location of the tank. In other words, the static pressure of the building piping system could be different from the static pressure of the tank due to the location of the unpressurized storage tank. A statistical chilled-water pump model was develop to account for the added pumping requirement in the BLAST stratified thermal storage simulation.

The BLAST program will automatically model a chilled water pump for each hour during the central plant simulation if a cooling load exists for that hour. The energy consumed by the BLAST chilled water pump model is a function of installed chiller capacity, cooling load, and pump power demand per unit cooling capacity. The chilled water pump model in the stratified thermal storage simulation is based on the same principles as the BLAST chilled water pumps.

The additional storage tank pumps determines the electrical power consumption of the pumps by

$$TCELEC = TSTCAP * TPELCL * (C_1 + C_2 * TCPLR + C_3 * TCPLR^2)$$

where:

TCELEC = Storage tank chilled water electric power consumption

TSTCAP = Capacity of the stratified tank

TPELCL = Pump power demanded per unit of cooling capacity

TCPLR = Present cooling load divided by the capacity of the tank

C_1, C_2, C_3 = User defined performance parameters

The above model allows the user to account for the three different primary reasons for increased pumping energy requirement by simply defining a dimensionless ratio of electrical energy for circulatory pumps to cooling load. In addition, the model performance is easily altered by user defined performance parameters.

Large stratified thermal storage systems will consume a small parasitic electrical power load. The parasitic load of the system is primarily the electric consumption of control system. Therefore, a simple parasitic load model is included in the stratified system simulation. The parasitic electrical consumption is defined as:

Parasitic Load = TSTPAR*TSTCAP

where TSTCAP is the storage tank capacity. A parasitic load coefficient is defined as TSTPAR. The user must specify the parasitic load coefficient based on available information about the storage system. If the parasitic power can be neglected in the simulation, the parasitic load coefficient is simply specified as zero.

Control Strategies

Controlling stratified thermal storage systems is a complex task, altogether different from the control of conventional non-storage systems. An ideal control strategy could be implemented if the building's cooling load profile would be known ahead of time in order for the system operator to store enough chilled water to meet the next day cooling coil loads. Predicting the cooling coil loads accurately is difficult since loads are influenced by many factors. Therefore in actual stratified tank systems, the operator usually fully charges the storage tank during the off-peak hours to ensure that there will be enough capacity to meet the required cooling load during on-peak hours. If the on-peak cooling load is smaller than the fully charged storage capacity, less than a complete charging cycle is needed to recharge the storage tank during the next off-peak period.

The design capacity of stratified storage systems depends on the type of control strategy selected for each facility. Systems designed to store enough chilled water during the off-peak period to meet the entire building's on-peak cooling coil load are called full storage systems. Stratified systems designed to meet the on-peak cooling load by shared output of thermal storage and the plant chiller are called partial storage systems. A system operating in partial storage mode will store less chilled water during the off-peak period than required to meet the on-peak cooling load. Partial storage systems require smaller chiller capacity. However, the chiller is in operation for a longer period than full storage cooling plant. The allocation of load between the chiller and storage in partial storage systems depends on different factors and can differ from one facility to another.

The BLAST stratified storage tank model uses three control strategy algorithms, making it unnecessary for the user to create a schedule that would control the operating mode for each hour during the simulation. As mentioned at the beginning of this section, the BLAST simulation is performed in three separate sections illustrated below. First, the building's heating and cooling loads are determined. Then, fan systems are simulated to determine the central plant demands. Finally, the central plant is simulated. The BLAST stratified storage model is assigned a cooling load in the central plant simulation in accordance with the selected control strategy.

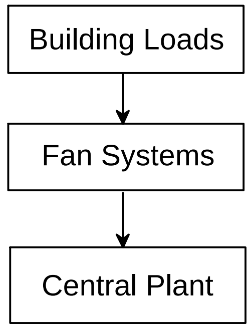

Figure 180. BLAST simulation flowchart

Since the building loads are calculated before the central plant simulation, the coil loads for the next day are ‘known’ when BLAST performs the central plant simulation. However, the stratified storage system control strategies do not use that information to determine the amount of chilled water to store during off-peak. Instead, the user inputs the average volumetric flow needed to fully charge the storage tank during the off-peak period. There are two primary reasons why this approach was taken: (1) Stratified tank operators out in the field usually fully charge the tank during off-peak hours; (2) The next generation of BLAST (EnergyPlus) now under development simulates all the sections in the simulation simultaneously, and the BLAST stratified tank model code was structured to be compatible with EnergyPlus.

The next four figures illustrate a simple cooling load profile for an office building. The building requires a 120-ton chiller operating at full capacity for the ten hour on-peak period. The first figure below shows a cooling load profile for a non-storage convention system and the following 3 figures show the load profile for the same building if the three BLAST stratified system control strategies are used.

The full storage (FS) control strategy is the first operational control strategy that users can select in the BLAST stratified storage system. The full storage, as outlined previously, transfers all chiller operation for the entire on-peak cooling load to off-peak. The figure below shows how a full storage control shifts a 1200 ton-hours office building cooling demand to fourteen available off-peak hours.

The second control strategy available is a partial storage control referred to as load leveling the chiller (LLC). This control strategy relies on operating the chiller continuously during the on-peak period. The user specifies the maximum amount of cooling provided by the chiller and the remaining cooling, if needed, is provided by the storage tank. This maximum limit, during on-peak, is referred to as load level or the demand limit. The figure "Partial Load – Load Leveling Chiller" illustrates how a chiller operates with a set demand limit for the simplified cooling load of the 1200 ton-hours office building.

The third control strategy available in the BLAST stratified storage system model is another partial storage strategy referred to as load leveling the storage tank (LLS). This system control strategy sets a demand limit on the energy discharged from the stratified storage tank. This limit is specified by the user. If the on-peak cooling load goes beyond the demand limit the chiller comes on line to meet that load. The figure "Partial Load – Load Leveling Storage" illustrates how the load leveling storage control is applied to the office building example.

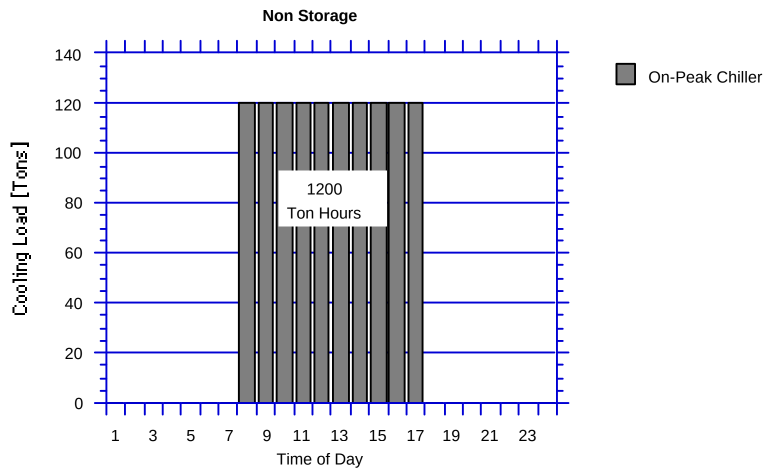

Figure 181. Non storage load profile

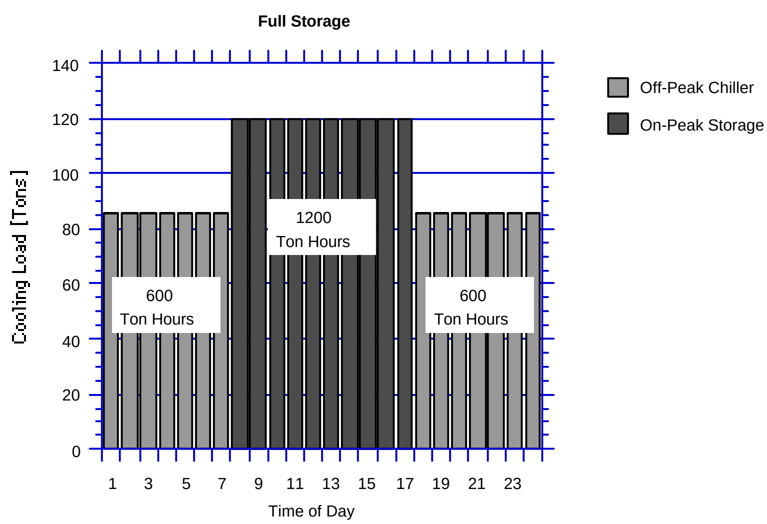

Figure 182. Full storage load profile

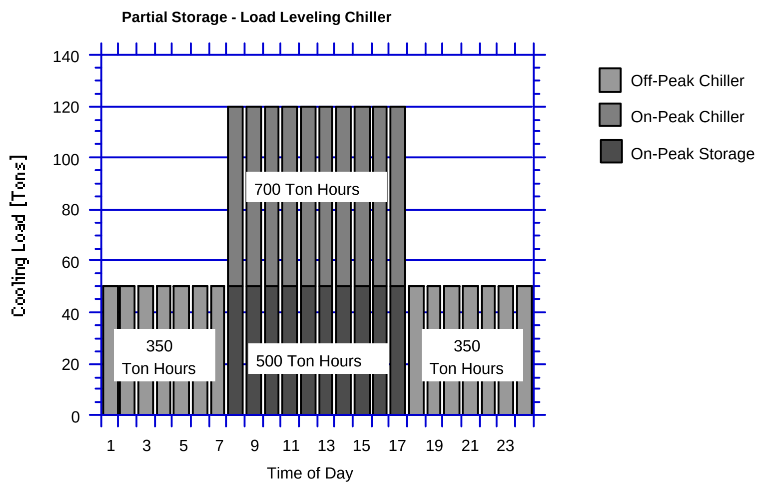

Figure 183. Partial storage - load leveling chiller

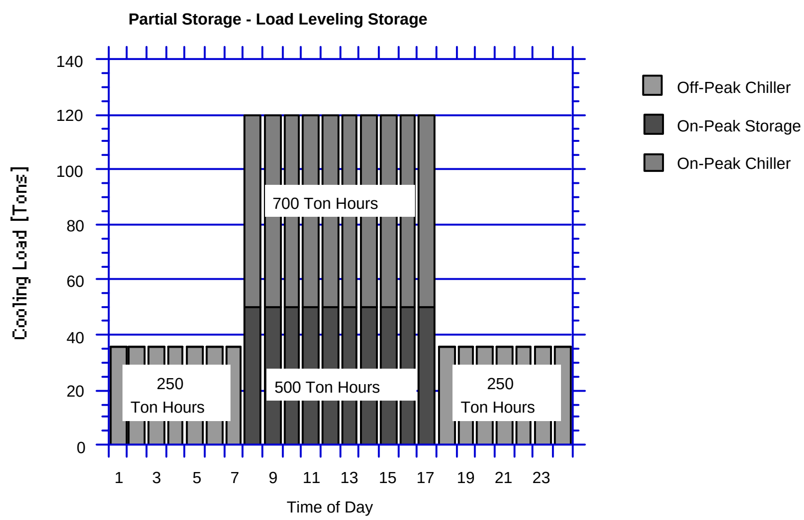

Figure 184. Partial storage - load leveling storage

Partial storage system controls may operate as a full storage or a non storage conventional systems when the cooling demand is well below the system design peak. The BLAST stratified storage system model accounts for this and will operate the stratified system in full storage mode if the entire on-peak load is less than the user defined load level limit for LLS controls. In addition, if the stratified system is operating in LLC mode and the entire on-peak load is less than the defined load level limit, the system will operate as a conventional system.

The stratified storage system control options are summarized in the figure below. 'Yes' means that it is possible to operate in this control mode, and 'No' means that it is not possible to operate in this control mode.

Control options	On-Peak	Off-Peak

	TSTank charge	TSTank discharge	Chiller	TSTank charge	TSTank discharge	Chiller
Full storage	No	Yes	No	Yes	No	Yes
Load-leveling chiller	No	Yes/No	Yes	Yes	No	Yes
Load-leveling storage	No	Yes	Yes/No	Yes	No	Yes

Figure 185. Stratified thermal storage control options

Using the BLAST Model

The main objective of most building energy studies is to determine the total energy needed to heat and cool a specified facility. Therefore, simulating a central part is an important part of a building energy analysis. Plant simulations are a valuable tool in plant designs and simulations of existing plants can be helpful. Plant designers can use BLAST to size and select the appropriate plant equipment based on energy consumption. BLAST simulations of existing plants can aid in retrofit studies and in the development of new control strategies to optimize plant energy savings.

The BLAST stratified thermal storage tank model is valuable in design and feasibility studies of new systems and retrofit and control optimization analysis of existing systems. Users must have a fundamental understanding of stratified thermal storage systems to use the BLAST model as a design tool. The BLAST model is capable of providing detailed simulation results (e.g., hourly temperature distributions), which are valuable to designers but not reported in the default BLAST energy output reports.

It is important that input information (e.g., tank geometry, flow rate, etc.) describing the stratified system is as accurate as possible to be able to perform a legitimate simulation. The same applies to the BLAST chiller models used to supply chilled water to the stratified storage tank. It is essential that accurate chiller performance parameters are used in the simulation since energy savings is obtained in thermal storage systems by running chillers at design conditions, eliminating part load operations. Conventional non-storage systems operate at part load when the cooling load does not require maximum capacity. This part load ratio operation can cause higher energy consumption since chiller efficiency is not constant over the range of operation. The BLAST chiller program converts available manufacturers' data, including part load information, into BLAST chiller model performance parameters.

There are many different types of chiller models available in BLAST: Double bundle chiller, hermetic compression chiller, open centrifugal chiller, reciprocating chiller, free cooling chiller air cooled chiller, diesel-driven chiller, gas turbine-driven chiller, heat pump, and absorption chiller. All these chiller models can be used to serve the stratified storage tank model in BLAST. However, for realistic thermal storage systems electric powered chillers are the only option.

Sizing of Chilled Water Storage Systems

Determining the optimal size of a stratified tank can be a difficult task. Optimum sizing of stratified tanks is primarily a function of the daily building cooling coil demand and the utility rate structure. The BLAST stratified tank model can be used to optimally size a stratified storage system by simulating various stratified system configurations and determining the electric power consumption for each case. The electric power consumption information can then be used along with capital and maintenance cost information to perform economic analysis on the feasibility of each system configuration being analyzed.

All equipment types in the plant sections of BLAST are sized by specifying the number of units and the capacity (size) of the units in the BLAST input language. On the other hand, stratified thermal storage capacity is a function of tank geometry specified in the BLAST input language. However, sizing the stratified tank to meet the required energy demand is a relatively simple task. To obtain the required load on the stratified tank, one should take the daily total cooling coil demand from a BLAST load and fan system simulation for a summer design day. To allow for 15% over capacity, multiply the total daily load by 1.15 to get the total load on the tank. The required tank volume can be determined as follows:

For SI units:

$$\text{Volume }(m^3) = \frac{\text{Load }(kWh) \times 3600\ (kJ/kWh)}{r\ (kg/m^3) \times c_p\ (kJ/kg\ {}^\circ C) \times \Delta T\ ({}^\circ C) \times \%\ \text{Usable vol.}}$$

(Eq. 5.1a)

For English units:

$$\text{Volume }(gal) = \frac{\text{Load }(Btu)}{r\ (lb/gal) \times c_p\ (Btu/lb\ {}^\circ F) \times \Delta T\ ({}^\circ F) \times \%\ \text{Usable vol.}}$$

(Eq. 5.1b)

where:

r is the water density

c_p is the specific heat of water

ΔT is the average temperature differential

The average temperature differential is the temperature difference of the return water temperature and the discharge supply temperature. During discharge, the supply temperature is rising as shown in the figure below so the temperature differential is not constant. It is sufficient to use the difference between design supply and return temperature for the average temperature differential in equation 5.1.

The percent usable tank volume concept is illustrated in the figure below. During discharge, a small portion of the stored chiller water forms a thermocline with the returning water in the tank. Therefore, some of the stored water becomes unusable since the temperature at a some point in the thermocline is higher than the acceptable discharge temperature. The table below presents an example where the supply temperature limit is 7.2 °C resulting in a 90 percent usable tank volume. Studies for different sized tanks showed that it is reasonable to assume 90 percent usable tank volume when sizing stratified tanks for a BLAST simulation. To obtain an exact value for the percent usable volume in the tank, one should turn on the hourly temperature distribution report for a BLAST design day simulation and look at the change in discharge temperature. However, such detailed analysis is not necessary for energy analysis with the stratified thermal storage model in BLAST.

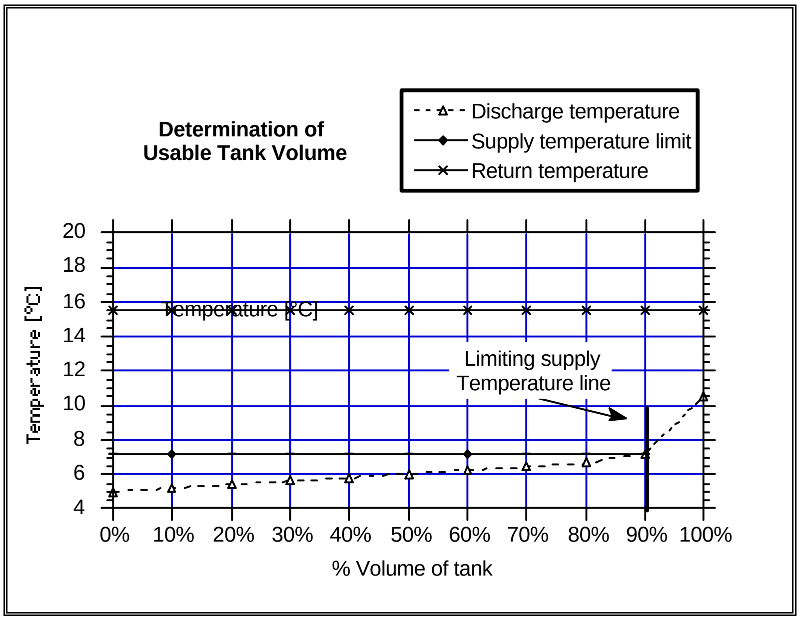

Figure 186. Determination of usable tank volume for tank sizing example

Equation 5.1c shows a stratified tank sizing example for a 1500 kWh load and a design supply and return temperature difference of 9.5 °C.

$$\text{Volume}\ (m^3) = \frac{1500\ (kWh) \times 3600\ (kJ/kWh)}{999\ (kg/m^3) \times 4.19\ (kJ/kg\ ^\circ C) \times 9.5\ (^\circ C) \times 0.90} = 15\ldots$$

(Eq 5.1c)

The BLAST stratified tank model requires a charge flow rate to be specified. Equation 5.2 presents how to calculate the charge flow rate after the tank volume has been fixed.

$$\text{Charge flow rate}\ \left[m^3/s\right] = \frac{\text{Tank volume}\ \left[m^3\right]}{\#\ \text{of off - peak charging hours}\ [hr] \times 3600\ \left[s/hr\right]}$$

(Eq 5.2)

Example: Using the BLAST Chiller Models

A BLAST user from the Fort Worth District of the U.S. Army Corps of Engineers, was puzzled by the electrical energy input for cooling in one of his annual BLAST runs. The simulation showed very high chiller electric consumption in the winter, so he sent his input file to the BLAST Support Office for further investigation.

An initial annual run was done to reproduce the user's results and to provide a baseline to compare to other annual simulations. Then some basic influences of the chiller models were isolated to determine their contribution to annual energy consumption. The influences considered were:

1.) Outside temperature,

2.) Part load effects,

3.) Equipment performance parameters.

Using the default performance parameters, the chillers responded predictably to part load situations. However, there was a problem with how the default performance parameters responded to outdoor temperature influences. At low outdoor temperatures the chiller power consumption increased, and in the case of the air cooled chiller, the power consumption increased dramatically.

The simulation was improved by using the Chiller Program (available as part of the BLAST Family of Programs) to provide customized chiller performance parameters to obtain a better response of the chiller models to outdoor temperature. This article contains important information about the characteristics of the BLAST chiller models and guidelines for using them effectively.

BLAST Chiller Models

All of the reciprocating and centrifugal chillers, heat pumps and double-bundle chillers in BLAST are modeled in the same way. The inputs to the BLAST chiller model are the cooling load on the chiller, the entering condenser water temperature, and the desired chilled water temperature. The outputs from the model are the chiller energy consumption and the load on the cooling tower or condenser. The inputs and outputs are related by a series of algebraic equations with coefficients (EQUIPMENT PERFORMANCE PARAMETERS) which are calculated from manufacturer's data.

In the PART LOAD RATIOS statement in BLAST, ELECTRICAL = 1/COP at nominal conditions. The nominal COP is normally obtained from chiller manufacturer's data. The ELECTRICAL parameter should always be changed to reflect the nominal power of the compressor. This parameter will have a large effect on the accuracy of the BLAST central plant simulation.

Base Line Annual Simulation

The baseline simulation was a small office building with:

1.) Eight zones

2.) Zone multipliers for similar zones to increase load

3.) Three Deck Multizone fan system

4.) BLAST default air cooled chiller.

For this run, the chiller was sized approximately 10% over the peak chilled water demand. A single air cooled chiller of 1560 kBtu/hr was specified. Looking at the results from the annual run, the overall COP was smaller in the winter and increasingly larger as the temperatures increased in the summer. This seemed opposed to intuition, and further investigation was needed to explain this behavior.

Part Load Influences using Default Parameters

Part Load effects were thought to be one of the problems, and to isolate part load effects, the following simulation was performed:

1.) Single Internal Zone, no heat transfer surfaces

2.) Varying monthly scheduled electric equipment loads

3.) Weather tape with constant weather

Outdoor dry bulb = 94°F

Outdoor wet bulb= 72°F

4.) BLAST default air cooled chiller

Size = 178 kBtu/hr

Electrical = 0.398

The default air cooled chiller model showed a predictable response due to part load effects. At small part loads the energy consumption was almost constant, as expected. Therefore, on the base line annual run, part of the cause of a small COP during the winter months was due to operating at small part loads with a large chiller.

Multiple Chillers vs. Single Chiller using Default Parameters

To improve the part load effects, three simulations were performed using multiple chillers to serve the baseline building:

1.) One air cooled chiller at 1560 kBtu/hr

2.) Two air cooled chillers at 780 kBtu/hr

3.) Three air cooled chillers at 520 kBtu/hr

4.) Weather tape for Augusta, Georgia

The results of these runs are shown in the figures below.

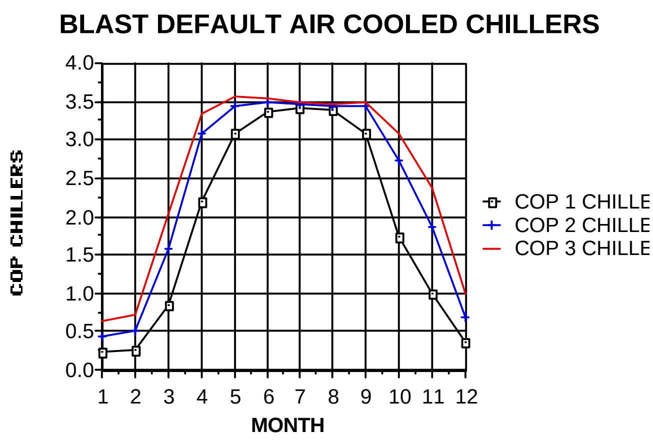

Figure 187. Monthly average chiller COP with default parameters.

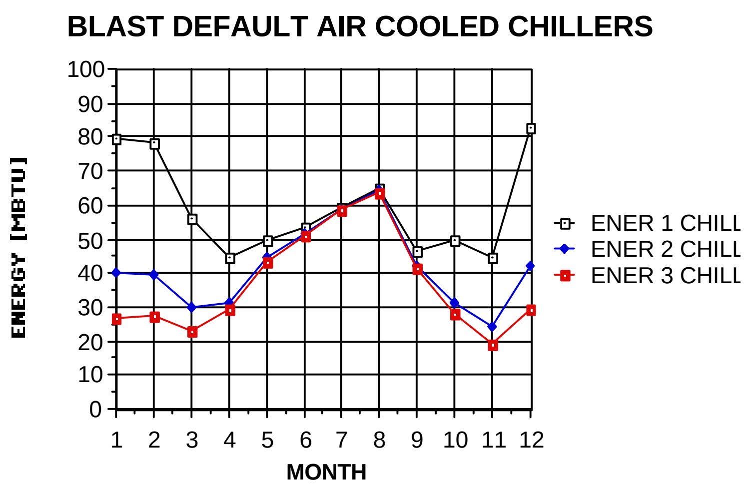

Figure 188. Monthly chiller energy use with default parameters

The preceeding figures show that as the cooling load is split up between multiple chillers the COP improves in the winter months. This occurs because the smaller chiller size is more in line with the winter loads, so the chiller will operate at a more efficient part load. The COP's all converge in the summer as the chillers are operating at higher part loads. The problem with the graphs is that chiller consumption still increases significantly during the cooler months.

Outdoor Temperature Influences using Default Parameters

To isolate outdoor temperature influences, the following simulation was performed:

1.) Single internal zone, no heat transfer surfaces

2.) Constant scheduled electric equipment loads throughout the year

3.) Different weather tapes from mild southern to harsh northern weather

4.) BLAST default air cooled chiller

Size = 178 kBtu/hr

Electrical = 0.398

Normally, reducing the condenser temperature reduces the power input required to the compressor. However, below certain limits, lowering the condenser temperature further increases the power consumption to the compressor. This is due to an overall loss in compressor efficiency. Below the optimum entering condenser temperature, the compressor efficiency decreases faster than the gain in efficiency realized by reducing the head pressure. The actual condenser temperature where this optimum appears depends on many factors and can range from 50 to 65°F for water cooled chillers, and can be as low as 35°F for air cooled chillers.

It was found that all of the BLAST default chillers start consuming more energy at condenser temperatures of 60 to 70°F. In the cold months the increase in chiller energy consumption is dramatic. This effect is tempered for the water cooled chillers, because the entering condenser temperature never falls below the value of TTOWR or TEVAPC. TTOWR, the minimum leaving tower water temperature, and TEVAPC, the minimum leaving evaporative condenser water temperature, both default to 60°F. However, the air cooled chiller sees the full range of outdoor dry bulb temperature. With the default performance parameters this has a very detrimental effect on the energy consumption. Actual air cooled chillers do not experience this increase in power until much lower temperatures. The effect due to outdoor temperature can be a very significant part of the energy consumption when using the default chiller performance parameters.

Multiple Chillers vs. Single Chiller using Customized Parameters

To improve the simulation, better chiller performance parameters are needed to correct the effect for outdoor temperature. To obtain better performance parameters, manufacturer's data for air cooled chillers was used in the BSO's Chiller Program. Using the customized chiller parameters, the chiller model now responds more predictably to outdoor temperature.

Three annual simulations were performed using multiple chillers with customized parameters to serve the baseline building:

1.) One air cooled chiller of 1560 kBtu/hr

2.) Two air cooled chillers of 780 kBtu/hr

3.) Three air cooled chillers of 520 kBtu/hr

4.) Weather tape for Augusta, Georgia

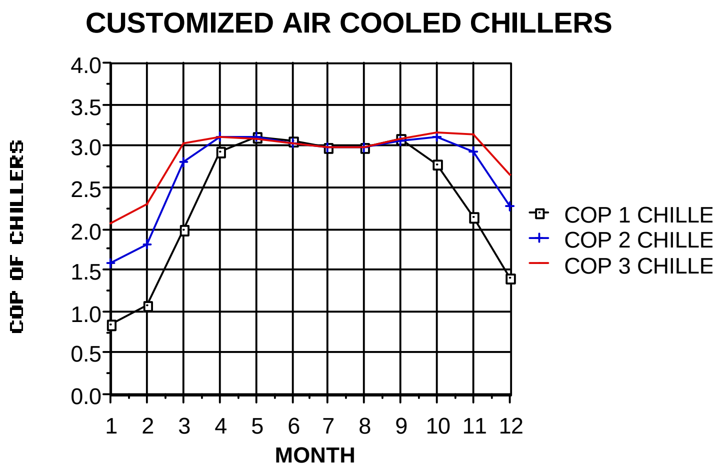

Figure 189. Monthly average chiller COP with customized parameters.

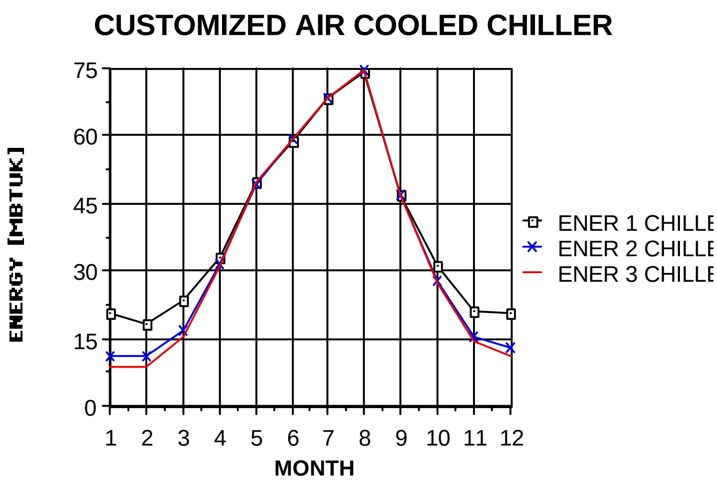

Figure 190. Monthly chiller energy use with customized parameters

The results in the preceeding figures show the desired trends. In the summer, all of the COP's converge as the chillers reach their more efficient part loads. In the winter months, with small cooling loads, the 1 large chiller has poorer COP's since it operates at a smaller fraction of full load.

With the chillers responding appropriately to outdoor temperature there is no longer a large increase in energy consumption as the temperature decreases. The COP is low during the cooler months due to part load effects, high during the spring and fall, and lower again during the hot summer months.

Conclusions

There are a few changes that can easily be made to BLAST chiller simulations which will have a significant effect on the total energy budget. The following guidelines should be applied:

1.) Size the chillers as they would be sized for an actual installation. If multiple chillers will be used, then specify multiple chillers.

Since BLAST takes into account part load effects, this will give a more accurate simulation of the central plant and will significantly change the annual energy budget.

2.) Use the Chiller Program to produce the chiller performance parameters, ***especially*** if an air cooled chiller model is used. ***If an air cooled chiller is simulated with the default parameters, and if it runs during cool months, it can give erroneous energy usage.***

3.) If a water cooled condenser is used, leave TTOWR and TEVAPC at 60°F to limit the influences of entering condenser water temperature. If a lower value is specified for TTOWR or TEVAPC, then use the Chiller Program to produce better chiller performance parameters.

View to Sky and Ground

Effects of Changing VIEW TO SKY/GROUND

A series of runs was performed to determine the effect of view to sky and ground on the cooling loads in a simple one wall zone. The results of these runs can be found in the figure below. Note that clearness is a design day parameter. If the clearness is set to zero, then no solar radiation will hit the wall. Also, snow on the ground increases the amount of solar radiation reflected from the ground and thus will increase the amount of radiation that is incident on the wall.

The results of this series of runs show that there is no effect on the zone loads if the clearness is set to zero. This verifies that the view to sky/ground does not affect anything but incident solar radiation. As expected, increasing the view to sky and the view to ground (when there is sunshine) increases the load on the zone. Also, the snow parameter increases the zone load. In an actual BLAST run, the view to sky plus the view to ground should equal one. In this example, to emphasize the effects of these functions, the sum of the view to sky and view to ground may have been greater or less than one.

The effect of the change of the tilt on the load can be seen in the figure "Effect of Tilt Angle on Loads" below. Notice that with higher angles the zone load goes down. This is because the load from beam radiation has gone down. This effect is lessened when there is snow because the higher ground diffuse intensity offsets the lower beam flux.

Results of VIEW TO SKY/GROUND Runs

VIEW TO SKY	VIEW TO GROUND	CLEAR-NESS	SNOW	PEAK LOAD	TOTAL COOLING LOAD
*	*	0.0	Y/N	0.76	5.2
0.0	0.0	1.0	Y	2.14	23.1
0.0	0.0	1.0	N	2.14	23.1
0.5	0.0	1.0	Y	2.70	31.4

0.5	0.0	1.0	N	2.70	31.4
0.5	0.5	1.0	Y	4.95	68.7
0.5	0.5	1.0	N	3.34	41.7
0.5	1.0	1.0	Y	7.26	106.5
0.5	1.0	1.0	N	3.99	52.5
0.0	0.5	1.0	Y	4.44	59.7
0.0	0.5	1.0	N	2.82	33.2
1.0	0.5	1.0	Y	5.48	77.7
1.0	0.5	1.0	N	3.87	50.7
1.0	1.0	1.0	Y	7.79	115.5
1.0	1.0	1.0	N	4.51	61.5
0.35	0.65	1.0	Y	5.49	77.4
0.35	0.65	1.0	N	3.39	42.3
0.65	0.35	1.0	Y	4.44	60.1
0.65	0.35	1.0	N	3.31	41.2

Figure 191. Effect of Changing VIEW TO SKY/GROUND

TILT	CLEAR-NESS	SNOW	PEAK LOAD	TOTAL LOADS
*	0.0	Y/N	0.76	5.2
80.0	1.0	Y	5.51	77.3
80.0	1.0	N	4.16	55.0
90.0	1.0	Y	4.95	68.7
90.0	1.0	N	3.35	41.7
100.0	1.0	Y	4.46	60.8
100.0	1.0	N	2.57	20.5

Figure 192. Effect of Tilt Angle on Loads Using Default View Factors

* When Clearness is set to zero, the other view parameters have no effect, and thus the load remains constant.

Water Loop Heat Pump System (WLHPS)

WLHPS Loop Model

LOOP MASS RATIO

LOOP MASS

The BLAST model of a WLHPS consists of six basic component models. These models include the individual water source heat pump units, the circulation loop, circulation pump, central plant control, ventilation system and the thermal storage model.

The water loop for the WLHP system is modeled by dividing the loop into two sections or nodes. The first node includes the mass of water between the central plant and first heat pump inlet. The second node consists of all the water mass from the first heat pump inlet to the central plant inlet. The figure below illustrates the loop division.

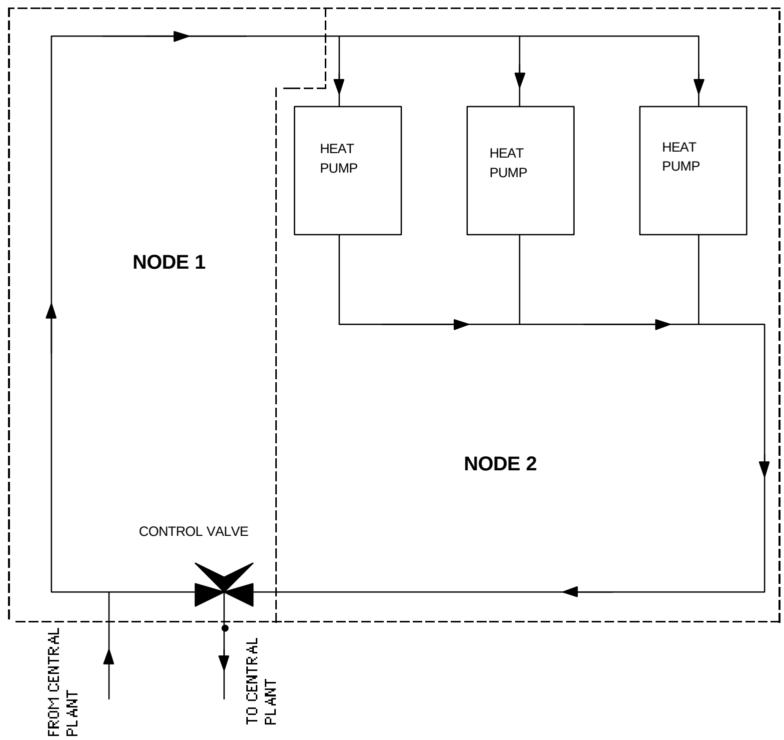

Figure 193. Heat pump system nodes

The performance of the two node model can be described by the following coupled differential equations.

Node 1:

$$M1 \cdot c_p \frac{dT1}{dt} = m \cdot c_p (T2 - T1) + Qplant \qquad (1)$$

Node 2:

$$M2 \cdot c_p \frac{dT2}{dt} = m \cdot c_p (T1 - T2) + Qpumps \qquad (2)$$

Where:

T1 = Water temperature of node 1 (°C)

T2 = Water temperature of node 2 (°C)

M1 = Water mass in node 1 (kg)

M2 = Water mass in node 2 (kg)

cþ = Specific heat of water (kJ/kg °C)

m = Mass flow rate of water in the loop (kg/s)

Q*plant* = Net heat added by the central plant (kW)

Q*pumps* = Net heat added by the all heat pump units (kW)

The solution to these coupled first order differential equations can easily be found by employing the Laplace transform method. The Laplace Transformation converts the first order differential equations into two algebraic equations in the Laplace domain. The equations can then solved like two ordinary algebraic equations. Once a solution it the Laplace domain is reached, the inverse Laplace transform is performed to bring the solution back into the time domain.

In order to solve the coupled node equations, the constants must first be regrouped in an orderly fashion.

Node 1:

$$\frac{dT1}{dt} = C1(T2 - T1) + G1 \qquad (3)$$

Node 2:

$$\frac{dT2}{dt} = C2(T1 - T2) + G2 \qquad (4)$$

Where:

$$Ci = \frac{m}{Mi}$$

and

$$Gi = \frac{m}{Mi \cdot c_p}$$

Once the equations have been regrouped, the Laplace transform is taken of each equation of each equation to yield the following algebraic equations in the "s" domain.

Node 1:

$$sT_1 - T_{o1} = C_1(T_2 - T_1) + \frac{G_1}{s} \qquad (5)$$

Node 2:

$$sT_2 - T_{o2} = C_2(T_1 - T_2) + \frac{G_2}{s} \qquad (6)$$

Where:

T_{o1} = Initial temperature of node 1

T_{o2} = Initial temperature of node 2

Equation (5) is solved for T1 in terms of T2 and substituted in to equation (6) to yield one equation with one unknown.

$$T_2 = \frac{1}{C_2 + s + \frac{C_2C_1}{[C_1+s]}}\left[T_{o2} + \frac{G_2}{s} + \frac{C_2T_{o1}}{[C_1+s]} + \frac{C_2G_1}{s[C_1+s]}\right] \qquad (7)$$

The inverse Laplace of T2 yields the time dependent equation for T2:

$$T_2 = T_{o2}e^{-Bt} + \frac{[T_{o1}C_2 + T_{o1}C_1 + G_2]}{B}\left[1 - e^{-Bt}\right] + \frac{[G_1C_2 + G_2C_1]}{B^2}\left[Bt - 1 + e^{-Bt}\right] \qquad (8)$$

Where:

$B = (C1 + C2)$

Similarly for T1:

$$T_1 = T_{o1}e^{-Bt} + \frac{[T_{o1}C_2 + T_{o2}C_1 + G_1]}{B}\left[1 - e^{-Bt}\right] + \frac{[G_1C_2 + G_2C_1]}{B^2}\left[Bt - 1 + e^{-Bt}\right] \qquad (9)$$

The preceding equations for the loop temperatures were solved on the assumptions that both Q*plant* and Q*pumps* are constant power inputs to the loop. In reality these values are a function of the loop temperature. Any variation in these values will affect the analytical solution. In order to account for the discreet nature of the actual power inputs, the boundary conditions To1 and To2 must be updated to the most recent value of their respective node temperatures every time the values of Q*plant* and Q*pumps* are changed. The values of Q*plant* and Q*pumps* are updated every time step of the simulation and the process is assumed to be quasi-steady during a time step. The BLAST model time step is 60 seconds.

WLHPS Heat Pump Unit Model

HEAT PUMP FLOW RATE

HEAT PUMP CAPACITY

HEAT PUMP EER

HEAT PUMP COP

NOMINAL FLOW RATE

NOMINAL PRESSURE DROP

HCCP,HHCP,HEER,HCOP,PRSURE

Water source heat pumps are rated by the American Refrigeration Institute (ARI) certification program. The rating systems rates water source heat pump performance at specified entering water temperatures. Because water loop heat pump systems seldom operate at a specific water temperature, correlations for heat pump performance as a function of the loop temperature, ambient air temperature and flow rate can be derived from manufacture’s data. A typical set of manufacture’s data for a heat pump in cooling mode can be seen in the table below.

Cooling													
		4.0 GPM				3.25 GPM				2.5 GPM			
EWB	EWT												
		TC	SC	KW	HR	TC	SC	KW	HR	TC	SC	KW	HR
71	55	14	8.1	.88	17	14	8	.91	17	13	8.0	.93	17
70	65	14	8.0	.96	17	14	7.9	.98	17	13	7.8	1.0	17
69	75	13	7.8	1.0	17	13	7.7	1.1	17	13	7.6	1.1	17
68	85	13	7.7	1.1	16	12	7.2	1.2	16	12	7.1	1.2	17

Legend
EWB = Entering wet bulb temperature (°F)
EWT = Entering water temperature (°F)
TC = Total Cooling Capacity (kBtu/hr)
SC = Sensible Cooling Capacity (kBtu/hr)
KW = Kilowatts input
HR = Heat rejected to water (kBtu/hr)

Table 65. Heat Pump Cooling Data

The heat pump performance trends based on the air temperature, entering water temperature, and the mass flow rate of the water can be developed in the following forms.

Cooling mode

$$\frac{\text{Cooling Capacity}}{\text{Basecap(i)}} = HCCP(1) + HCCP(2)\left[\frac{T_{Loop}}{T_{Ref}}\right] + HCCP(3)\left[\frac{T_{Ref}}{\text{Basecap(i)}*\dot{m}_{Bas}}\right.$$

$$\frac{\text{EER}}{\text{BaseEER(i)}} = HEER(1) + HEER(2)\left[\frac{T_{Loop}}{T_{Ref}}\right] + HEER(3)\left[\frac{T_{Ref}}{\text{Basecap(i)}*\dot{m}_{Base}}\right]\left[\frac{MD}{T}\right.$$

Heating mode

$$\frac{\text{Heating Capacity}}{\text{Basecap(i)}} = HHCP(1) + HHCP(2)\left[\frac{T_{Loop}}{T_{Ref}}\right] + HHCP(3)\left[\frac{T_{Ref}}{\text{Basecap(i)}*\dot{m}_{Bas}}\right.$$

$$\frac{\text{Heating COP}}{\text{Basecap(i)}} = \text{HCOP(1)} + \text{HCOP(2)} \left[\frac{T_{Loop}}{T_{Ref}}\right] + \text{HCOP(3)} \left[\frac{T_{Ref}}{\text{Basecap(i)}^* \dot{m}_{Base}}\right] \left[\frac{M}{}\right.$$

where:

T_{ref} = 283 K or 511 °R

T_{Loop} = Loop Temperature (node 1) (°R or K)

mbase =*NOMINAL FLOW RATE* for a packaged heat pump. This is the design flow rate divided by the design capacity . This value is essentially constant for all sizes of packaged heat pumps.

MDOT(i) = *HEAT PUMP FLOW RATE* of water through the pump i. (kg/s or lb/hr)

T_{db}, T_{wb} = The dry bulb and wet bulb air temperatures. (°R or K)

BaseCap(i) = The base *HEAT PUMP CAPACITY* of the heat pump unit i. (kW or kBtu/hr)

HCCP = Performance parameters for heat pump cooling capacity.

HHCP = Performance parameters for heat pump heating capacity.

HEER = Performance parameters for heat pump EER.

HCOP = Performance parameters for heat pump COP.

All base values are determined from ARI standards or manufacture’s recommendations. Commercial packaged heat pump units are rated by ARI standards at specified operating conditions. The base values referred to in the preceding equations are the rated values of the unit at the specified operating conditions.

Trends for heat pump performance from several manufacturers are shown in the following figures "performance trends in heating and cooling modes". The slope of the performance area is determined by the loop temperature, and the location within the performance graph area is effected by the ratio of mass flow rate to air temperature. The performance areas presented for each parameter cover the entire range of possible performance variations. Through evaluation of these graphs, values for the coefficients in for the performance equations can be determined.

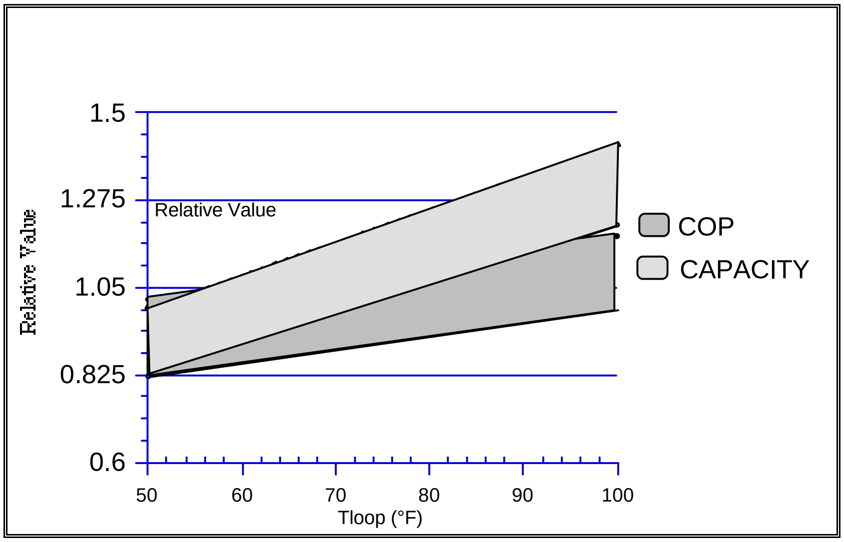

Figure 194. Water source heat pump performance trends in heating mode

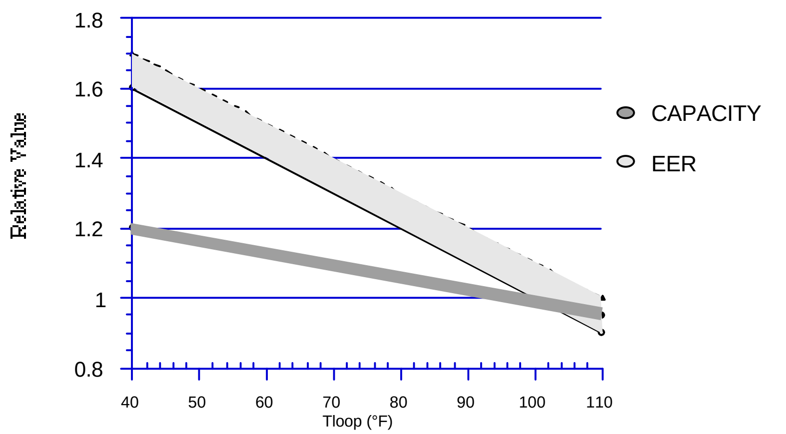

Figure 195. Water source heat pump performance trends in cooling mode

In the BLAST model of a WLHPS, the system is limited to a single heat pump unit in each zone. Because in reality a zone will probably contain multiple heat pump units in each zone, the total capacity of each unit is summed together to create a single combined heat pump unit shown in the figure below.

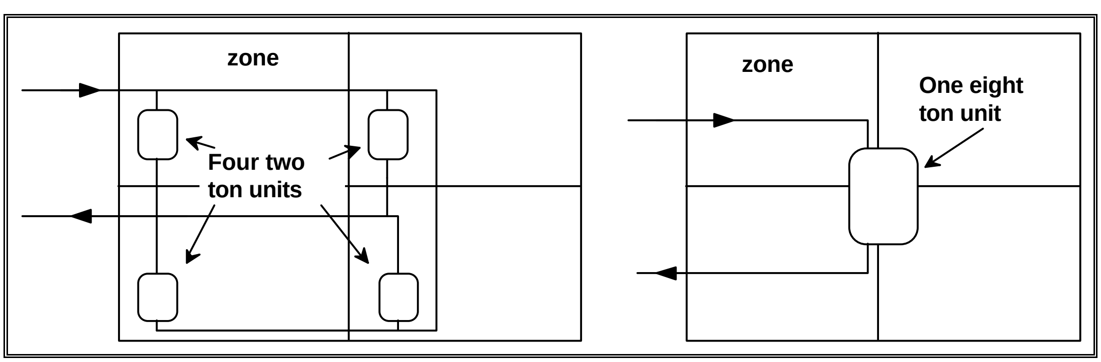

Figure 196. BLAST Heat Pump Model Lumping

The lumping of heat pump units in the BLAST model is valid for two reasons. The first is that BLAST handles all areas in a zone identically. This means that each heat pump unit in that zone will see the same load and all the units in a zone will work together to meet this load. Second, the statistical heat pump models are based on the relative or non-dimensional performance of packaged heat pumps and not the absolute values. It was found that all packaged heat pump units can be modeled using the same non-dimensional model. This means that all packaged heat pump units will tend to vary their performance from design values due to inlet parameter changes by the same amount per step change in inlet conditions. The performance of the model is based on the product of the non-dimensional performance model and the design capacities, EER's and COP's. Because of the non-dimensional nature of the model, base capacities can be summed together and the resulting single unit will provide the same capacity and use the same amount of energy as the individual units. The combination of different EER's and COP's must also be taken in to account when summing heat pump units into a single packaged unit. The following equations can be used to determine the lumped COP and EER.

$$COP_{lump} = \frac{\sum_{1}^{n} BaseCap_i}{\sum_{1}^{n} \frac{BaseCap_i}{COP_i}}$$

$$EER_{lump} = \frac{\sum_{1}^{n} BaseCap_i}{\sum_{1}^{n} \frac{BaseCap_i}{EER_i}}$$

Where:

n = Number of Heat Pump Units Lumped.

i = Individual Heat Pump Unit

Within each zone description block of BLAST, the user must specify the following parameters:

HEAT PUMP COP = COP_{lump}

HEAT EER = EER_{lump}

HEAT PUMP FLOW RATE = Lumped flow rate through the heat pump unit (MDOT(i))

HEAT PUMP CAPACITY = Lumped base capacities (BASECAP(i))

For heat pumps in general, the following performance parameters must be determined from manufacture’s data:

HCCP

HHCP

HEER

HCOP

PRSURE

The user must also specify the *NOMINAL FLOW RATE* in the special parameters section. This value is the nominal flow rate per unit of capacity. The nominal flow rate can be determined by dividing the design flow rate of a heat pump unit by the nominal capacity. This value is relatively constant for most package heat pump units.

WLHPS Central Plant Models

FIXED LOOP TEMPERATURE

MAXIMUM LOOP TEMPERATURE

MINIMUM LOOP TEMPERATURE

SUPPLEMENTAL HEAT TYPE

SUPPLEMENTAL COOL TYPE

LOOP CONTROL

TOWER ELECTRIC COEFFICIENT

TOWER PUMP COEFFICIENT

WLPT

WLHPS LOOP CONTROL SCHEDULE

In order to control the loop temperature within a specified operating range a heat rejection device and a heat supplement device must be supplied. These devices are not connected directly to the closed circuit water loop, but when they are needed a control valve diverts flow through a low approach high efficiency heat exchanger coupled with the proper central plant unit.

WLHPS LOOP CONTROL

FIXED TEMPERATURE

The fixed temperature option allows the central plant outlet temperature to be set at a fix temperature. This fixed temperature is specified with the FIXED LOOP TEMPERATURE parameter. This option allows precise control of the loop temperature and central plant and can be used to run the system at an optimal loop temperature.

DEAD BAND

The dead band control strategy is a band control option that allows the loop temperature to float freely between the upper and lower loop temperature limit. When the limits are reached, the central plant is employed and will set the plant outlet temperature to the MAXIMUM LOOP TEMPERATURE or MINIMUM LOOP TEMPERATURE. If the maximum temperature limit is exceeded, the plant is set to the MAXIMUM LOOP TEMPERATURE. If the minimum temperature limit is violated the plant output is set to the MINIMUM LOOP TEMPERATURE.

HOURLY SCHEDULE

The hourly schedule strategy is a hourly control schedule option that allows the loop temperature to be set for each hour. This is accomplished using the WLHPS LOOP CONTROL SCHEDULE. The schedule is used to define the hourly central plant outlet temperature.

WLHPS CENTRAL PLANT EQUIPMENT

The central plant control model can use many different types of supplemental heating sources. These sources are selected using the *SUPPLEMENTAL HEAT TYPE* parameter. The options are hot water, gas, steam, and electric. The type of supplemental cooling unit is selected using the *SUPPLEMENTAL COOL TYPE* parameter. A cooling tower *(TOWER*) or central chiller *(COMPERESSION*) unit can be specified. If a chiller is used, the loop is controlled by one of the three loop control types and the cooling loads are passed to the central plant simulation. The chiller control option assumes that the central plant has adequate capacity to meet any loop loads. If a cooling tower is chosen, an integrated fan system cooling tower is used. The cooling tower will be simulated in fan systems, and only its electric consumption will be based to plants. The cooling tower performance is limited by the specified capacity and outside air temperature. The cooling tower capacity and performance characteristics are chosen using the following special and performance parameters:

COOLING TOWER CAPACITY

TOWER ELECTRIC COEFFICIENT

TOWER PUMP COEFICIENT

WLPT

The electric consumption of the cooling tower is determined from the above parameters in the following way:

Electric Power = TLOAD*ELECTRICAL + TOWER PUMP POWER

Where:

TLOAD = Current hours load on the cooling tower.

ELECTRICAL= TOWER ELECTRIC COEFFICIENT

TOWER PUMP POWER = TCAP*PTWR*(A1+A2*PLR + A3*PLR^{2}s)

TCAP	= COOLING TOWER CAPACITY
PTWR	= TOWER PUMP COEFFICIENT
PLR	= TLOAD/TCAP
A1, A2, A3	= Coefficients of the WLPT set

If the tower is to be sized in a simulation, the capacity of the tower should be set extremely large, and the loop loads will be met without any capacity restrictions and the peak cooling load can be found. (Note: The outside wet bulb temperature may still limit the ability of the cooling tower to meet the load)

WLHPS Loop Pump Model

SYSTEM PRESSURE HEAD

LOOP PUMP EFFICIENCY

PUMP TYPE

NOMINAL PRESSURE DROP

PRSURE

The purpose of a loop pump is to circulate the loop water through the system at a constant or variable flow rate. Because the specific volume changes of the water as it passes through the pump are negligible, the pump power in an actual pumping process can be approximated by:

$$P_{actual} = \frac{Q\Delta p}{\eta}$$

In the preceding formula the actual power is equal to the volumetric flow rate Q multiplied by the pressure loss in the piping. The efficiency of the pump is represented by (η) and is specified using the *LOOP PUMP EFFICIENCY* parameter. The efficiency of pumps used in WLHP systems range from 70% to 85%.

Because most water loop heat pump systems are closed loop systems, the pressure loss the system is a function of friction losses in the piping and fittings and pressure drops across the heat pumps. The relative height does not add pressure head because the system is a closed circuit.

Pressure drop caused by fluid friction can be described by the Darcy-Weisbach equation:

$$\Delta p = f\,\frac{L}{D}\,\frac{\rho V^2}{2}$$

where

Δp = Pressure drop (Pa)

f = Moody chart friction factor

L = length of pipe (m)

D = Internal diameter of pipe (m)

ρ = Fluid density (kg/m³)

V = Velocity of fluid (m/s)

A standard WLHPS will have anywhere from 200 kPa to 400 kPa of pressure loss due to the pipe runs and fittings. The friction lose can be specified with the *SYSTEM PRESSURE HEAD PARAMETER.*

In order to evaluate the loss in the pump network across the heat pumps, the heat pump network can be treated as a parallel resistance network.

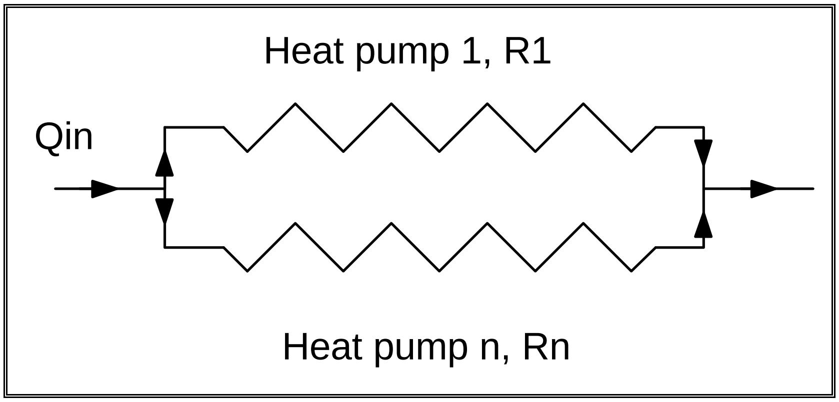

Figure 197. Parallel Resistance in Heat Pump Networks

The resistance across each heat pump is a function of the pressure drop across each pump and the flow rate through each pump. This resistance can be represented by equation:

$$R_i = \frac{\Delta p_i}{\dot{m}_i^2}$$

where

R_i = The resistance across pump i.

Δp_i = The pressure drop across pump i.

$\dot{m}_i$ = The flow rate through pump i.

The equivalent pressure drop across the total pump network can be represented by the equation:

$$\Delta p_{network} = \left[\frac{\dot{m}_{loop}}{\frac{1}{\sqrt{R_1}} + \cdots\cdots \frac{1}{\sqrt{R_n}}} \right]^2$$

The sum of the piping and fitting pressure loss with the equivalent heat pump network pressure loss is the amount of system head that the loop pumps must overcome.

The pressure drop across a single heat pump unit can be represented by the following equation:

$$\frac{P}{Basecap(i)*P_{rated}} = PRSURE(1) + PRSURE(2)* \left[\frac{MDOT(i)}{Basecap(i)*\dot{m}_{base}} \right]$$

Where:

P=Pressure drop across the unit

P_{rated}=Pressure drop at the rated conditions per unit of capacity. *(NOMINAL PRESSURE DROP)*

MDOT(i) =Mass flow rate through pump(i). *(HEAT PUMP FLOW RATE)*

Mbase = Nominal flow rate per unit of capacity. *(NOMINAL FLOW RATE)*

PRSURE = The coefficients of the *PRSURE* data set. *PRSURE(3)* is not used.

Actual variations of pressure as a function of flow rates derived from manufacturers data are shown in the figure below.

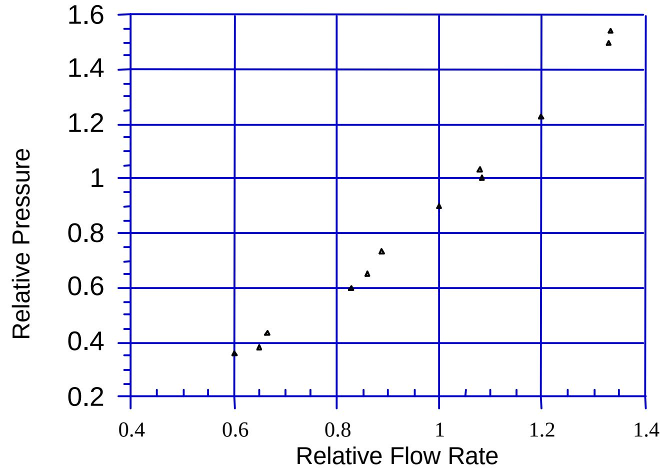

Figure 198. Relative pressure drop vs. Relative flow rate.

The type of loop pump can be either variable speed or constant speed. If a variable speed pump is used, the loop pump will adjust the flow rate when a heat pump unit cycles down so that no flow is passed through a non-operating pump. This is accomplished via on-off valves at the heat pump inlet branch. A variable speed pump is selected by choosing the *VARIABLE FLOW* option for *PUMP TYPE*. If a constant speed pump is desired, the option *CONSTANT FLOW* should be selected. A constant speed pump circulated the same flow volume regardless of the heat pump unit's on-off mode.

WLHPS Storage Tank Model

STORAGE VOLUME

TANK TEMPERATURE

WLHPS STORAGE TANK OPERATING SCHEDULE

The BLAST loop storage model allows the user to increase the capacitance of the water loop. The water loop is coupled to a thermal storage tank via a low approach heat exchanger, which allows the loop to remain closed. The user must specify two parameters for the added storage simulation.

TANK TEMPERATURE = The initial storage tank temperature.

STORAGE VOLUME = The volume of the storage tank.

The storage tank can be scheduled hourly using the schedule defined in equipment schedules. If the WLHPS is to be coupled to a lake or the earth, an extremely large storage volume can be used to approximate a constant temperature source or sink.

WLHPS Air Handler/Ventilation System Model

WLHPS VENTILATION SYSTEM OPERATION SCHEDULE

Ventilation for the Water Loop Heat Pump System is supplied by a single duct system. Please see the diagram in the EQUIPMENT DESCRIPTION of the Water Loop Heat Pump System. This single duct can be used to ventilate each zone with a fixed volume of air. The volume of air for each zone is set with the SUPPLY AIR VOLUME statement in the ZONE DATA BLOCK. This air can be conditioned through the use of an air to air heat recovery box outside the mixing box or through the use of the heating and cooling coils in the duct. The use of the heat recovery box, heating coil, and cooling coil can be controlled by either a predefined or a user input schedule in the EQUIPMENT SCHEDULES DATA BLOCK. If they are not present in the system, they can be removed through the use of a schedule in the EQUIPMENT SCHEDULES DATA BLOCK that shuts them off. The temperature controls for the heating and cooling coil is through the use of the COLD DECK and HOT DECK statements in the OTHER SYSTEM PARAMETERS. The air to air heat recovery options are controlled through the use of the HEAT RECOVERY PARAMETERS. Since the Water Loop Heat Pump System is the main system used to provide energy to the zone, it is controlled through the use of the SYSTEM OPERATION statement in the EQUIPMENT SCHEDULES DATA BLOCK. The ventilation system is controlled through the use of the WLHPS VENTILATION SYSTEM OPERATION statement in the EQUIPMENT SCHEDULES DATA BLOCK. These two are independent systems and each can be controlled independent of the other. Air pre-conditioning can be achieved using the heating and cooling coils or the air to air heat recovery box. If the ventilation system does not have any coils, the heating and cooling coils should be shut off in the equipment schedules data block. If only outside air is desired, the mixed air control type should be set to fixed percent and the minimum ventilation schedule should be set to 100%. If the system being modeled has only induced air flow through the individual heat pump units and not a separate fan system, the ventilation system should be modeled the same as a separate fan system, but the supply fan pressure should be set to zero. This will cause the loads due to outside air and ventilation to be taken into account without any fan electric usage. For example, if ventilation is on and outside air is 100% of the air supplied to the zone by the fan system, during the winter the air could be heated through the use of the heating coil up to a higher temperature (for example, 50 °F). The specified outside air quantity is multiplied by the MINIMUM VENTILATION SCHEDULE amount for that hour. Please read the Mixed Air Control section in the User Reference section for a complete description of ventilation control in BLAST.

WLHPS TUTORIAL

The following is a short, one-zone example of how to describe a WLHPS in BLAST. The model zone is shown below. This zone includes four packaged heat pump units, six rooms and a hall way.

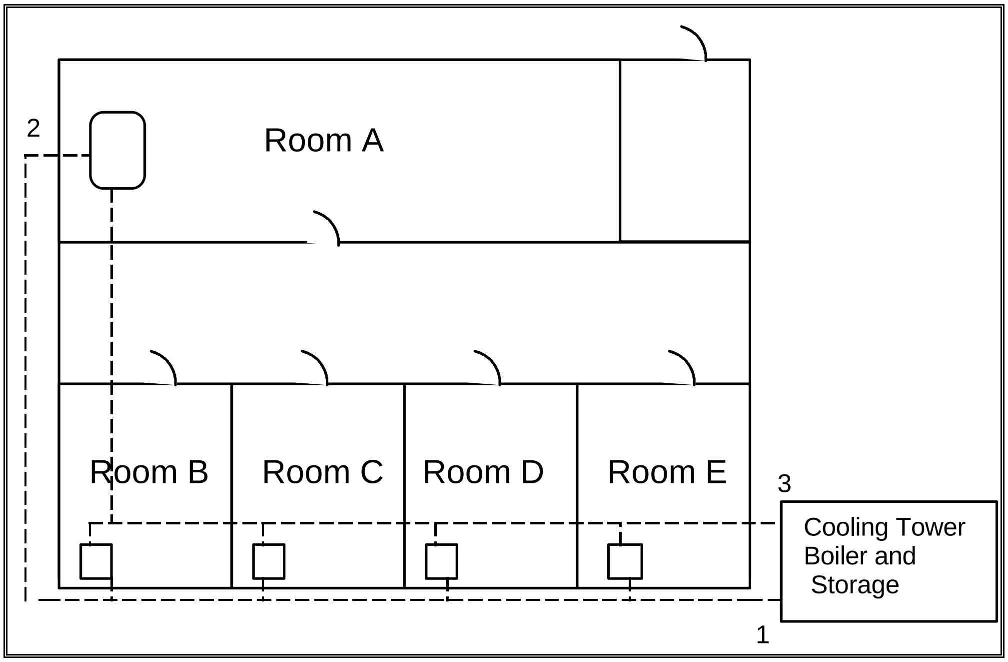

Figure 199. Test WLHPS

The design specifications for each of the five heat pumps are listed in the table below.

Heat Pump A	Heat Pump B	Heat Pump C	Heat Pump E	Heat Pump D
27.8 kW	7.03 kW	10.3 kW	7.03 kW	10.3 kW
COP = 4.2	COP = 3.8	COP = 3.6	COP = 3.8	COP = 3.6
EER = 11.7	EER = 11	EER = 10.5	EER = 11	EER = 10.5
1.55 kg/s	0.39 kg/s	0.58 kg/s	0.39 kg/s	0.58 kg/s

Table 66. Heat pump design specifications

If the preceding layout is to be modeled as a single zone in BLAST, the first step is to reduce the five heat pump units to a single lumped unit. The equivalent capacity and mass flow rate for the lumped unit is simply the sum of the individual values. For this model the lumped capacity and mass flow rate is 62.46 kW and 3.49 kg/s respectively. The lumped COP and EER are determined from the equations given in the heat pump model section as 3.9 and 11.12. Now that the lumped heat pump model has been designed the ZONE input block can be set up.

ZONE DATA BLOCK:

```
FOR ZONE 1:
           HEAT PUMP FLOW RATE =  3.49;
           HEAT PUMP CAPACITY=62.46;
           HEAT PUMP EER = 11.12;
           HEAT PUMP COP = 3.9;
           ZONE MULTIPLIER=1;
END ZONE;
```

The performance parameters for the heat pump units can be determined from a data reduction of the manufacture’s data. For this model, we will use the default values given for the performance equations. The defaults are accurate for most heat pump units, but should be tested against the specific units being installed. (Remember that the performance parameters are non-dimensional and are used to model all units in a single WLHPS).

The next step in modeling a WLHPS in BLAST is to specify the special parameters used in the system. Each of these parameters will be discussed below:

LOOP MASS RATIO**-** This is the amount of water mass that is between central plant outlet and the parallel heat pump network inlet divided by the total loop mass. In the table above, this is the amount of water mass between point 1 and point 2 divided by the total loop water mass. For this example, this ratio is roughly 0.5.

SYSTEM PRESSURE HEAD**-** This parameter is used to define the pressure drop in the piping. There are many ways to estimate this loss and it will be left up to the user to determine the value. For this system, the pressure head was found to be 100 kPa. Remember, if the system is a closed circuit, the relative height of the system has no affect on this value.

LOOP PUMP EFFICIENCY**-** This parameter is used to define the efficiency of the loop pump. For this system, the pump efficiency is 85%.

FIXED LOOP TEMPERATURE, MAXIMUM LOOP TEMPERATURE, MINIMUM LOOP TEMPERATURE**-** These parameters are used to define the loop control temperature. For this system, an hourly loop temperature profile will be used, so these parameters will not be utilized. If these parameters were used, remember they are the central plant outlet temperature and not necessarily the loop temperature.

SUPPLEMENTAL HEAT TYPE**-** This parameter is used to define the loop heating control type. For this system, the heat type be steam from a fuel fired boiler.

SUPPLEMENTAL COOL TYPE**-** This parameter is used to define the loop heat rejection device. For this system, the cooling component will be a direct cooling tower coupled to the loop with a low approach heat exchanger.

NOMINAL FLOW RATE**-** This parameter is used to define the heat pump units design flow rate per unit of design capacity. For the wide range of heat pumps used these values are:

Heat Pump	Flow Rate	Capacity	Nominal Flow Rate
A	1.55	27.8	0.0557
B	0.39	7.03	0.0554

C	0.58	10.3	0.0563
D	0.39	7.03	0.0554
E	0.58	10.3	0.0563

Table 67. Heat pump nominal flow rate comparison

The model assumption is that this value is relatively constant for all heat pump units. For this simulation, the value is set to 0.056 kg/(s kW).

LOOP MASS- This is the amount of water mass that is in the total water loop. A good rule of thumb is 14 kg per kW of installed capacity. For this simulation, the mass is 900 kg.

LOOP CONTROL- HEAT PUMP- The loop control type is determined using this parameter. As mentioned before, this system will use and hourly control profile specified in equipment schedules. For this system, the control type is HOURLY SCHEDULE.

PUMP TYPE- This system will utilize a constant speed pump.

TOWER CAPACITY- Used to specify the cooling tower capacity. If you are sizing a tower, specify an extremely large capacity to determine the loop cooling load that is not limited by tower capacity and only outside wet bulb temperature. Then size the tower on the peak loop cooling load.

TOWER PUMP COEFFICIENT, TOWER ELECTRIC COEFFICIENT- These parameters can be determined from evaluation of the type of cooling tower installed. The performance equation is given in the technical reference section.

STORAGE VOLUME AND TANK TEMPERATURE- These parameters affect the loop storage tank. The volume is the amount of water in the tank and the tank temperature is the initial tank temperature. The initial tank temperature is important when specifying an extremely large storage unit.

For this simulation, the capacity of the tank will be ten cubic meters.

This system will also utilize an outside air ventilation system with an air to air heat exchanger mixing return air and outside air. The inlet air will be 100% outside air and the system will run only during the day. The following parameters affect the ventilation system.

The Zone Data Block must be modified to include the amount of supply air. This simulation will have .5 m³/s.

ZONE DATA BLOCK:

```
FOR ZONE 1:
    SUPPLY AIR VOLUME = 0.5;
    HEAT PUMP FLOW RATE =  3.49;
    HEAT PUMP CAPACITY=62.46;
    HEAT PUMP EER = 11.12;
    HEAT PUMP COP = 3.9;
    ZONE MULTIPLIER=1;
END ZONE;
```

The other system parameters must be set up to allow for 100% outside air.

MIXED AIR CONTROL TYPE- Used to set the type of mixed air control. FIXED PERCENT will allow us to specify 100% outside air by setting the minimum ventilation schedule to 100%. This means that 100% of the supply air volume will be outside air.

HEAT RECOVERY CAPACITY- Used to set the capacity of the air to air heat exchanger.

The other system parameters data block is now complete and should look like the following input deck section.

OTHER SYSTEM PARAMETERS DATA BLOCK:

```
OTHER SYSTEM PARAMETERS:
    LOOP MASS RATIO = 0.5;
    SYSTEM PRESSURE HEAD = 100000;
    LOOP PUMP EFFICIENCY =.85;
    STORAGE VOLUME = 10;
    SUPPLEMENTAL HEAT TYPE = STEAM;
    SUPPLEMENTAL COOL TYPE = TOWER;
    NOMINAL FLOW RATE = 0.056;
    MIXED AIR CONTROL TYPE = FIXED PERCENT;
    HEAT RECOVERY CAPACITY = 100;
    LOOP MASS =45;
    LOOP CONTROL = HOURLY SCHEDULE;
    TOWER CAPACITY= 1000;
    TOWER ELECTRIC COEFFICIENT = .25
    TOWER PUMP COEFFICIENT = 0.013
    PUMP TYPE=CONSTANT FLOW
       END OTHER SYSTEM PARAMETERS;
```

The next step is to define the equipment operation schedules. The following schedules apply to this system.

SYSTEM OPERATION- Used to schedule the water loop heat pump system operation. ON will allow the entire system to run.

HEATING COIL OPERATION- Used to schedule the water loop heat pump system heating coil operation. Since we do not have a heating coil, this schedule should be set to OFF.

COOLING COIL OPERATION- Used to schedule the water loop heat pump system cooling coil operation. Since we do not have a cooling coil, this schedule should be set to OFF.

HEAT RECOVERY OPERATION- Used to schedule the air to air heat exchanger. Since we are only using the ventilation system during the day, the operation schedule is set to the same schedule as the ventilation system. DAYVENT is a night set back temporary schedule previously defined.

MINIMUM VENTILATION SCHEDULE- Used to schedule the percentage of supply air that is outside air. Setting to DAYVENT will allow 100% outside air.

WLHPS STORAGE TANK OPERATION SCHEDULE- Used to schedule the operation of a closed loop storage tank for the water loop heat pump system by means of a previously defined operation schedule and dates for which this schedule will apply. The storage tank will be on continuously and will use the schedule ON.

WLHPS VENTILATION SYSTEM OPERATION SCHEDULE- Used to schedule the operation of a ventilation system for a water loop heat pump system by means of a previously defined operation schedule and dates for which this schedule will apply. This system will run on the DAYVENT schedule.

WLHPS LOOP CONTROL SCHEDULE- Used to schedule the hourly loop control temperatures for a water loop heat pump system by means of a previously defined operation schedule and dates for which this schedule will apply. This schedule's values are actual fixed temperature values and can be either metric or English depending on the input deck type. The schedule TEMP1 is defined below and is set up for daytime cooling and nighttime heating.

Example. Temporary Schedule (TEMP1):

Monday Thru Friday
(33,33,33,33,33,31,29,27,25,23,21,19,17,15,15,15,15,17,20,23,26,29,31,33);

```
EQUIPMENT SCHEDULES:
     SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
     HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
     COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
     HEAT RECOVERY OPERATION=DAYVENT,FROM 01JAN THRU 31DEC;
     MINIMUM VENTILATION SCHEDULE=DAYVENT,FROM 01JAN THRU
31DEC;
     WLHPS STORAGE TANK OPERATION=ON,FROM 01JAN THRU 31DEC;
     WLHPS VENTILATION SYSTEM OPERATION=DAYVENT,FROM 01JAN
THRU 31DEC;
     WLHPS LOOP CONTROL SCHEDULE=TEMP1,FROM 01JAN THRU
31DEC;
END EQUIPMENT SCHEDULES;
```

The entire simulation input deck is given on the next page. The final step is to run the simulation and size the cooling tower and the fuel boiler on design day peak loop heating and cooling loads.

```
BEGIN FAN SYSTEM DESCRIPTION;
WATER LOOP HEAT PUMP SYSTEM 1
"WLHPS " SERVING ZONES 1;
FOR ZONE 1:
    SUPPLY AIR VOLUME = 0.5;
    HEAT PUMP FLOW RATE =  3.49;
    HEAT PUMP CAPACITY=62.46;
    HEAT PUMP EER = 11.12;
    HEAT PUMP COP = 3.9;
    ZONE MULTIPLIER=1;
END ZONE;
OTHER SYSTEM PARAMETERS:
    LOOP MASS RATIO = 0.5;
    SYSTEM PRESSURE HEAD = 100;
    LOOP PUMP EFFICIENCY =.85;
    STORAGE VOLUME = 10;
    SUPPLEMENTAL HEAT TYPE = STEAM;
    SUPPLEMENTAL COOL TYPE = TOWER;
    NOMINAL FLOW RATE = 0.056;
    MIXED AIR CONTROL TYPE = FIXED PERCENT;
    HEAT RECOVERY CAPACITY = 100;
    LOOP MASS =45;
    LOOP CONTROL = HOURLY SCHEDULE;
    TOWER CAPACITY = 1000;
    TOWER ELECTRIC COEFFICIENT = .25
    TOWER PUMP COEFFICIENT = 0.013
    PUMP TYPE=CONSTANT FLOW
END OTHER SYSTEM PARAMETERS;
WATER SOURCE HEAT PUMP PARAMETERS:
    HHCP(-3.6975,4.337,0.0745);
    HCCP(3.1175,-2.07,0.07459);
    HCOP(-1.1101,1.93,1.107);
    HEER(7.5,-6.3,0.216);
    PRSURE(1,0,0);
    WLPT(0,1,0);
END WATER SOURCE HEAT PUMP PARAMETERS;
EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
    HEATING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    COOLING COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=DAYVENT,FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=DAYVENT,FROM 01JAN THRU 31DEC;
    WLHPS STORAGE TANK OPERATION=ON,FROM 01JAN THRU 31DEC;
    WLHPS VENTILATION SYSTEM OPERATION=DAYVENT,FROM 01JAN THRU
31DEC;
    WLHPS LOOP CONTROL SCHEDULE=TEMP1,FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
END SYSTEM;
END FAN SYSTEM DESCRIPTION;
```

Window4 Additions to BLAST

WINDOW 4.1 is a publicly available IBM PC compatible computer program for calculating total window thermal performance indices (i.e. U-values, solar heat gain coefficients, shading coefficients, and visible transmittances). WINDOW 4.1 provides a versatile heat transfer analysis method consistent with the rating procedure developed by the National Fenestration Rating Council (NFRC). The program can be used to design and develop new products, to assist educators in teaching heat transfer through windows, and to help public officials in developing building energy codes.

BLAST can accept windows that have been specified using the WINDOW 4.1 program and use them during the simulations. You will need to obtain the WINDOW 4.1 computer program separately; it is available from the Lawrence

Berkeley National Laboratory. Please refer to the WINDOW 4.1 helps and manual for assistance in using the WINDOW 4.1 program.

The WINDOW 4.1 DOE-2 data file may be used to define glazing systems for BLAST. This allows a significant increase in the types of windows which may be incorporated into the BLAST simulation. Once the data file has been generated, the BLAST input file must be modified to use it.

The WINDOW 4.1 data file is included as a temporary material. Example syntax follows:

```
TEMPORARY MATERIALS:
DBLE.W4 = (VERY SMOOTH, DOE WINDOW4);
DBLEHM77.W4 = (R=0.024,TRANS=0.40,
IR=1.52,VERY SMOOTH,DOE WINDOW4);
END;
```

The name of the data file is used as the name of the material (i.e. DBLE.W4). The keywords DOE WINDOW4 tells BLAST that it is a WINDOW 4 defined material. The VERY SMOOTH parameter describes the surface roughness for convection calculations. All other parameters will be ignored (i.e. R, TRANS, IR, from the second material).

** Note: If a temporary material is defined with a WINDOW 4.1 data file, then that file must exist in the local directory where BLAST is run (Working Directory for HBLC users). BLAST will quit with a severe error if it cannot find the file. It does not matter if the material is used later in the input or not.

A temporary window must also be defined using the WINDOW 4.1 defined temporary material.

Example syntax follows:

```
TEMPORARY WINDOWS:
MY TEST WINDOW= (DBLE.W4);
END;
```

The window construction in the example has the name MY TEST WINDOW, and has the construction given by DBLE.W4. When defining a WINDOW 4.1 temporary window, the WINDOW 4.1 data file name must be the only layer. It cannot be combined with other BLAST materials.

To get more detail on the window information used by BLAST, specify the WALLS report. An example of the output is below:

```
CONSTRUCTION NUMBER = 2 MY TEST WINDOW
DESCRIPTION OF CONSTRUCTION
LAYER THICKNESS CONDUCTIVITY DENSITY SPECIFIC HEAT RESISTANCE
METERS W/(M*K) KG/M**3 KJ/(KG*K) M**2*K/W
DBLE. W4 0.0000 0.000 0.000 0.000 0.176
1 CONDUCTION TRANSFER FUNCTIONS OF ORDER 0
TIME INTERNAL CROSS EXTERNAL FLUX
1 5.67047739 5.67047739 5.67047739
THERMAL CONDUCTANCE = 5.670 W/(M**2*K)
OUTER THERMAL ABSORPTANCE =0.84
INNER THERMAL ABSORPTANCE =0.83
OUTER SOLAR ABSORPTANCE =0.75
INNER SOLAR ABSORPTANCE =0.75
OUTER SURFACE ROUGHNESS: VRY SMOOTH
************************
OPTICAL PROPERTIES OF TEST WINDOW
WINDOW4.1 DATA FILE NORMAL NORMAL INDEX OF TRANSMITTANCE
TRANSMITTANCE REFLECTANCE REFRACTION WITH FILM
DBLE. W4 0.720 0.135
ANGULAR DEPENDENCE OF PROPERTIES:
COS(THETA): 1.0000 0.9848 0.9397 0.8660 0.7660 0.6428 0.5000 0.3420 0.1736 0.0000 DIFFUSE
TRANSMITTANCE: 0.7200 0.7190 0.7160 0.7100 0.6960 0.6650 0.5970 0.4560 0.2210 0.0010 0.6190
REFLECTANCE: 0.1350 0.1350 0.1360 0.1380 0.1470 0.1720 0.2360 0.3750 0.6220 0.9870 0.2140
ABSORPTANCE: 0.0850 0.0850 0.0870 0.0890 0.0920 0.0970 0.1030 0.1100 0.1140 0.0100 0.0950
ABSORPTANCE: 0.0600 0.0600 0.0610 0.0630 0.0640 0.0650 0.0650 0.0590 0.0440 0.0020 0.0610
ABSORPTANCE: 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
ABSORPTANCE: 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
```

```
FITTED PROPERTIES FOR LOADS CALCULATIONS:
TRANSMITTANCE: 0.7200 0.7190 0.7160 0.7098 0.6963 0.6648 0.6036 0.4471 0.2265 0.0000 0.6190
OUTER ABSORPTANCE:0.0849 0.0853 0.0867 0.0890 0.0923 0.0968 0.0971 0.1180 0.1091 0.0000 0.0950
INNER ABSORPTANCE:0.0598 0.0602 0.0612 0.0627 0.0641 0.0650 0.0641 0.0603 0.0432 0.0000 0.0610
```

In the first section, the window is shown as R-value represented in the heat balance. The value reported does not include surface heat transfer coefficients. The inner and outer solar absorptance reported here are for opaque materials, and do not apply to any window construction.

In the optical section of the report, the name of the data file is given, along with the properties read from the file. The optical properties are reported as a function of the cosine of the polar angle of incidence, THETA. The curve fit properties used in the hourly calculations are reported last.

Output

Output Introduction

For ease of reference, BLAST program information is presented under four separate tabs:

1. The *Quick Reference* defines BLAST syntax.
2. The *User Reference* is an encyclopedic listing of user information.
3. The *Output* section explains all BLAST output reports.
4. The *Technical Reference* contains engineering, modeling, and advanced user information.

Output describes all output reports generated by BLAST to help the user obtain a type of report and understand the information contained in each report. An example of each output report created by BLAST is shown in this section.

Output begins with the input syntax for a sample BLAST run specifying all the possible reports to be output. The reports follow the input syntax and are placed in the manual in the same order as they appear in the output of a BLAST run. Each report displays the title of the report, the command which creates the report, a block displaying an example of the report, a detailed description of the output block, and definitions of key words used in the output.

INPUT SYNTAX

```
####                   ####                                             ####
####                   ####                                             ####
####                   ####                                             ####
####   <#####>         ####        <#####>   ####       <#######>       ####
#### <#########>       ####      <#########> ####     <###     ###>   ########
####<# ! ! ! ! #>      ####     <# ! ! ! ! #>####    <###      #####  ########
#####! ! ! ! ! ##>     ####    <## ! ! ! ! !#####    ####               ####
#### ! ! ! ! ! ###>    ####   <### ! ! ! ! ! ####    <###>              ####
####-----------------------------------------####     <#########>       ####
####           #<! ! ! ! ! ! ! !>#           ####      <#########>      ####
####           ##< ! ! ! ! ! ! >##           ####             >###>     ####
#####          ##><! ! ! ! ! !><##          #####              ####     ####
####<#         #>   <!_!_!_!>   <#         #>####    ####      ###>     ####
#### <#########>       ####      <#########> ####    <###     ###>      <#####
####   <#####>         ####        <#####>   ####      <#######>         <####
                                                                               TRADEMARK
                                                                                 APPLIED FOR


                    *****************************************************
                    *                                                   *
                    *   A U.S. ARMY CORPS OF ENGINEERS PROGRAM          *
                    *                                                   *
                    *                      BY                           *
                    *                                                   *
                    *   CONSTRUCTION ENGINEERING RESEARCH LABORATORY    *
                    *        P.O. BOX 4005                              *
                    *        CHAMPAIGN, ILLINOIS  61824-4005            *
                    *                                                   *
                    *****************************************************


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****************************************************************************************************
**                                                                                                **
**                              INPUT ECHO AND USER SPECIFIED REPORTS                             **
**                                                                                                **
****************************************************************************************************
   BEGIN INPUT;
     RUN CONTROL:
       NEW ZONES,
       NEW AIR SYSTEMS,
       PLANT,
       REPORTS(ZONE LOADS,SYSTEM LOADS,PLANT LOADS,COIL LOADS,WALLS,ZONE,SHADE,
               SYSTEM,DESIGN DAYS,EQUIPMENT PARAMETERS,
               ASHRAE HEATING LOAD CALCULATION,KSU,FANGER,PIERCE,
               EVAPORATIVE REPORT,HUMIDITY REPORT,ICE STORAGE REPORT,
               ANNUAL COMFORT REPORT,LCC FILE,LCC CONDENSED FILE,WLHPS REPORT,
               STRATIFIED TANK REPORT,ZONE SUMMARY,HOURLY PROFILES,
               SURFACE VERTICES,ZONE VIEW,ZONE GROUP,ZONE LOAD SPLITS,
               DETAILED UNMET LOADS,PLANT,ENERGY UTILIZATION,EQUIPMENT STATS,96,
               AHS USAGE SUMMARY),
       UNITS(IN = ENGLISH, OUT = ENGLISH);
       PROJECT="REPORT EXAMPLES


                                    (HBLC) 2000 1196 ";
       LOCATION=CHANUTE                                 ;
       DESIGN DAYS=CHANUTE SUMMER                          ,
                   CHANUTE WINTER                          ;
       WEATHER TAPE FROM 01JAN THRU 14JAN;
       GROUND TEMPERATURES=(54.00,55.00,58.00,62.00,67.00,74.00,72.00,
           68.00,64.00,62.00,58.00,55.00);
     BEGIN BUILDING DESCRIPTION;
       BUILDING="REPORT                                   ";
         NORTH AXIS=0.00;
         SOLAR DISTRIBUTION=-1;
```

```
ASHRAE HEATING OUTDOOR TEMPERATURE=30.00;
ASHRAE HEATING INDOOR TEMPERATURE=78.00;
ASHRAE HEATING INFILTRATION=1000.00;
ASHRAE HEATING GROUND TEMPERATURE=55.00;
ZONE 1 "ZONE 1                                  ":
  ORIGIN:(40.29,12.23,0.00);
  NORTH AXIS =0.00;
  ASHRAE HEATING INDOOR TEMPERATURE=78.00;
  ASHRAE HEATING INFILTRATION=900.00;
  EXTERIOR WALLS:
    STARTING AT(0.00,0.00,0.00)
    FACING(180.00)
    TILTED(90.00)
    EXTERIOR(60.00 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(7.90 BY 5.10)
        REVEAL(0.00)
        AT (0.60,4.80)
      WITH DOORS OF TYPE
      HOLLOW WOOD DOOR(6.50 BY 9.80)
        REVEAL(0.00)
        AT (11.70,0.00),
    STARTING AT(60.00,0.00,0.00)
    FACING(90.00)
    TILTED(90.00)
    EXTERIOR(20.20 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(4.00 BY 5.00)
        REVEAL(0.00)
        AT (0.60,4.70),
    STARTING AT(60.00,20.20,0.00)
    FACING(0.00)
    TILTED(90.00)
    EXTERIOR(34.00 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(4.20 BY 4.80)
        REVEAL(0.00)
        AT (0.60,5.10),
    STARTING AT(0.00,20.20,0.00)
    FACING(270.00)
    TILTED(90.00)
    EXTERIOR(20.20 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(4.00 BY 5.00)
        REVEAL(0.00)
        AT (0.60,4.70);
  INTERZONE PARTITIONS:
    STARTING AT(26.00,20.20,0.00)
    FACING(0.00)
    TILTED(90.00)
    INTERIOR(26.00 BY 10.00)
    ADJACENT TO ZONE (2);
  SLAB ON GRADE FLOORS:
    STARTING AT(0.00,0.00,0.00)
    FACING(90.00)
    TILTED(180.00)
    SLAB FLOOR(34.80 BY 34.80);
  ROOFS:
    STARTING AT(0.00,0.00,10.00)
    FACING(180.00)
    TILTED(0.00)
    ROOF31(34.80 BY 34.80);
  PEOPLE=0,DORMITORY OCCUPANCY,
    AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=300.00,DORMITORY LIGHTING,
    0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
  INFILTRATION=900.000000,CONSTANT,
    WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
    FROM 01JAN THRU 31DEC;
  CONTROLS=DB,
    3412000.0 HEATING, 3412000.0 COOLING,
    0.00 PERCENT MRT,
    FROM 01JAN THRU 31DEC;
  RELATIVE VELOCITY= 25 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  RELATIVE HUMIDITY= 0.5 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  METABOLIC RATE= 1 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  WORK EFFICIENCY= 0 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
```

```
  CLOTHING INSULATION= 1 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 2 "ZONE 2                                  ":
  ORIGIN:(5.82,36.60,0.00);
  NORTH AXIS =0.00;
  ASHRAE HEATING INDOOR TEMPERATURE=77.00;
  ASHRAE HEATING INFILTRATION=1050.00;
  EXTERIOR WALLS:
    STARTING AT(0.00,0.00,0.00)
    FACING(180.00)
    TILTED(90.00)
    EXTERIOR(34.00 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(4.20 BY 4.80)
        REVEAL(0.00)
        AT (0.60,5.10),
    STARTING AT(60.00,0.00,0.00)
    FACING(90.00)
    TILTED(90.00)
    EXTERIOR(20.00 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(4.00 BY 5.00)
        REVEAL(0.00)
        AT (0.60,4.70),
    STARTING AT(60.00,20.00,0.00)
    FACING(0.00)
    TILTED(90.00)
    EXTERIOR(60.00 BY 10.00)
      WITH WINDOWS OF TYPE
      DOUBLE PANE WINDOW(10.80 BY 4.90)
        REVEAL(0.00)
        AT (0.60,5.00)
      WITH DOORS OF TYPE
      HOLLOW WOOD DOOR(7.80 BY 9.80)
        REVEAL(0.00)
        AT (12.40,0.00),
    STARTING AT(0.00,20.00,0.00)
    FACING(270.00)
    TILTED(90.00)
    EXTERIOR(20.00 BY 10.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW(5.10 BY 4.00)
        REVEAL(0.00)
        AT (0.60,5.70);
  INTERZONE PARTITIONS:
    STARTING AT(34.00,0.00,0.00)
    FACING(180.00)
    TILTED(90.00)
    INTERIOR(26.00 BY 10.00)
    ADJACENT TO ZONE (1);
  SLAB ON GRADE FLOORS:
    STARTING AT(0.00,0.00,0.00)
    FACING(90.00)
    TILTED(180.00)
    SLAB FLOOR(34.60 BY 34.70);
  ROOFS:
    STARTING AT(0.00,0.00,10.00)
    FACING(180.00)
    TILTED(0.00)
    ROOF31(34.70 BY 34.60);
  PEOPLE=0,OFFICE OCCUPANCY,
    AT ACTIVITY LEVEL 0.45,60.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=400.00,OFFICE LIGHTING,
    0.00 PERCENT RETURN AIR, 40.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
  INFILTRATION=1050.000000,CONSTANT,
    WITH COEFFICIENTS (0.606000,0.020200,0.000598,0.000000),
    FROM 01JAN THRU 31DEC;
  CONTROLS=DB,
    3412000.0 HEATING, 3412000.0 COOLING,
    0.00 PERCENT MRT,
    FROM 01JAN THRU 31DEC;
  RELATIVE VELOCITY= 25 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  RELATIVE HUMIDITY= 0.5 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  METABOLIC RATE= 1 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  WORK EFFICIENCY= 0 ,CONSTANT,
    FROM 01JAN THRU 31DEC;
  CLOTHING INSULATION= 1 ,CONSTANT,
```

```
        FROM 01JAN THRU 31DEC;
    END ZONE;
END BUILDING DESCRIPTION;
BEGIN FAN SYSTEM DESCRIPTION;
  DUAL DUCT VARIABLE VOLUME SYSTEM  1
  "DDVAV" SERVING ZONES
      1;
    FOR ZONE  1:
      SUPPLY AIR VOLUME=2000.0;
      EXHAUST AIR VOLUME=0;
      BASEBOARD HEAT CAPACITY=0;
      BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
      ZONE MULTIPLIER=1;
      MINIMUM AIR FRACTION=0.1;
    END ZONE;
    OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      SUPPLY FAN EFFICIENCY=0.7;
      EXHAUST FAN PRESSURE=1.00396;
      EXHAUST FAN EFFICIENCY=0.7;
      GAS BURNER EFFICIENCY=0.8;
      SYSTEM ELECTRICAL DEMAND=0.0;
      RETURN FAN PRESSURE=0.0;
      RETURN FAN EFFICIENCY=0.7;
      HEATING COIL ENERGY SUPPLY=HOT WATER;
      HEATING COIL CAPACITY=3412000.0;
      MIXED AIR CONTROL=FIXED PERCENT;
      DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
      OUTSIDE AIR VOLUME=0.0;
      PREHEAT COIL LOCATION=NONE;
      PREHEAT TEMPERATURE=46.4;
      PREHEAT ENERGY SUPPLY=HOT WATER;
      PREHEAT COIL CAPACITY=3412000.0;
      HUMIDIFIER TYPE=NONE;
      HUMIDISTAT SET POINT=50.0;
      COLD DECK CONTROL=FIXED SET POINT;
      COLD DECK TEMPERATURE=55.04;
      COLD DECK THROTTLING RANGE=7.2;
      COLD DECK CONTROL SCHEDULE=(55 AT 90, 65 AT 70);
      HOT DECK CONTROL=FIXED SET POINT;
      HOT DECK TEMPERATURE=140.0;
      HOT DECK THROTTLING RANGE=7.2;
      HOT DECK CONTROL SCHEDULE=(140 AT 0, 70 AT 70);
      VAV VOLUME CONTROL TYPE=INLET VANES;
    END OTHER SYSTEM PARAMETERS;
    EQUIPMENT SCHEDULES:
      SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
      TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
      SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
      PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
      HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      COOLING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
      HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
      MINIMUM VENTILATION SCHEDULE=MINIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
      MAXIMUM VENTILATION SCHEDULE=MAXIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    END EQUIPMENT SCHEDULES;
    COOLING COIL DESIGN PARAMETERS:
      COIL TYPE=CHILLED WATER;
      AIR VOLUME FLOW RATE=600.0668;
      BAROMETRIC PRESSURE=405.489;
      AIR FACE VELOCITY=492.126;
      ENTERING AIR DRY BULB TEMPERATURE=84.92;
      ENTERING AIR WET BULB TEMPERATURE=64.04;
      LEAVING AIR DRY BULB TEMPERATURE=55.04;
      LEAVING AIR WET BULB TEMPERATURE=52.7;
      ENTERING WATER TEMPERATURE=44.96;
      LEAVING WATER TEMPERATURE=55.04;
      WATER VOLUME FLOW RATE=0.5063364;
      WATER VELOCITY=275.59;
    END COOLING COIL DESIGN PARAMETERS;
    HEAT RECOVERY PARAMETERS:
      HTREC1( 0.85 , 0 , 0 );
      HTREC2( 0 , 0 , 0 );
      HTREC3( 0 , 0 , 0 );
      HTREC4( 0 , 0 , 0 );
      HTREC5( 0 , 0 , 0 );
      HTREC6( 0 , 0 , 0 );
      HTPWR( 0 , 0 , 0 );
      HEAT RECOVERY CAPACITY=3412000.0;
    END HEAT RECOVERY PARAMETERS;
  END SYSTEM;
  SINGLE ZONE DRAW THRU SYSTEM  2
```

```
  "SZD" SERVING ZONES
      2;
    FOR ZONE  2:
      SUPPLY AIR VOLUME=2000.0;
      EXHAUST AIR VOLUME=0;
      BASEBOARD HEAT CAPACITY=0;
      BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
      ZONE MULTIPLIER=1;
    END ZONE;
    OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=2.49783;
      SUPPLY FAN EFFICIENCY=0.7;
      EXHAUST FAN PRESSURE=1.00396;
      EXHAUST FAN EFFICIENCY=0.7;
      GAS BURNER EFFICIENCY=0.8;
      SYSTEM ELECTRICAL DEMAND=0.0;
      RETURN FAN PRESSURE=0.0;
      RETURN FAN EFFICIENCY=0.7;
      HEATING COIL ENERGY SUPPLY=HOT WATER;
      HEATING COIL CAPACITY=3412000.0;
      MIXED AIR CONTROL=FIXED PERCENT;
      DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
      OUTSIDE AIR VOLUME=0.0;
      PREHEAT COIL LOCATION=NONE;
      PREHEAT TEMPERATURE=46.4;
      PREHEAT ENERGY SUPPLY=HOT WATER;
      PREHEAT COIL CAPACITY=3412000.0;
      HUMIDIFIER TYPE=NONE;
      HUMIDISTAT SET POINT=50.0;
    END OTHER SYSTEM PARAMETERS;
    EQUIPMENT SCHEDULES:
      SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
      EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
      TSTAT BASEBOARD HEAT OPERATION=OFF,FROM 01JAN THRU 31DEC;
      SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
      PREHEAT COIL OPERATION=OFF,FROM 01JAN THRU 31DEC;
      HEATING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      COOLING COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
      HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
      HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
      MINIMUM VENTILATION SCHEDULE=MINIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
      MAXIMUM VENTILATION SCHEDULE=MAXIMUM OUTSIDE AIR,FROM 01JAN THRU 31DEC;
    END EQUIPMENT SCHEDULES;
    COOLING COIL DESIGN PARAMETERS:
      COIL TYPE=CHILLED WATER;
      AIR VOLUME FLOW RATE=600.0668;
      BAROMETRIC PRESSURE=405.489;
      AIR FACE VELOCITY=492.126;
      ENTERING AIR DRY BULB TEMPERATURE=84.92;
      ENTERING AIR WET BULB TEMPERATURE=64.04;
      LEAVING AIR DRY BULB TEMPERATURE=55.04;
      LEAVING AIR WET BULB TEMPERATURE=52.7;
      ENTERING WATER TEMPERATURE=44.96;
      LEAVING WATER TEMPERATURE=55.04;
      WATER VOLUME FLOW RATE=0.5063364;
      WATER VELOCITY=275.59;
    END COOLING COIL DESIGN PARAMETERS;
    HEAT RECOVERY PARAMETERS:
      HTREC1( 0.85 , 0 , 0 );
      HTREC2( 0 , 0 , 0 );
      HTREC3( 0 , 0 , 0 );
      HTREC4( 0 , 0 , 0 );
      HTREC5( 0 , 0 , 0 );
      HTREC6( 0 , 0 , 0 );
      HTPWR( 0 , 0 , 0 );
      HEAT RECOVERY CAPACITY=3412000.0;
    END HEAT RECOVERY PARAMETERS;
  END SYSTEM;
END FAN SYSTEM DESCRIPTION;
BEGIN CENTRAL PLANT DESCRIPTION;
PLANT 1 "PLANT 1" SERVING SYSTEM
  1, 2;
 EQUIPMENT SELECTION:
   BOILER:
       1  OF SIZE  400 ;
   CHILLER WITH EVAPORATIVE CONDENSER:
       1  OF SIZE  400 ;
   DIESEL:
       1  OF SIZE  230 ;
   EVAPORATIVE CONDENSER:
       1  OF SIZE  200 ;
   FUEL DOMESTIC HOT WATER HEATER:
       1  OF SIZE  120 ;
   STRATIFIED TANK:
```

```
          1  OF SIZE  1 ;
    END EQUIPMENT SELECTION;
    PART LOAD RATIOS:
      BOILER (MIN=.01, MAX=1, BEST=.87, ELECTRICAL=0);
      CHILLER (MIN=.1, MAX=1.05, BEST=.65, ELECTRICAL=.2275);
      DIESEL (MIN=.02, MAX=1.05, BEST=.6, ELECTRICAL=0);
      EVAPORATIVE CONDENSER (MIN=0, MAX=1, ELECTRICAL=.012);
    END PART LOAD RATIOS;
    SCHEDULE:
      PLANT ELECTRICAL DEMAND=20, CONSTANT,FROM 01JAN THRU 31DEC;
      PROCESS WASTE HEAT=30, CONSTANT,FROM 01JAN THRU 31DEC, AT LEVEL 5;
      HOT WATER= 0 , CONSTANT,FROM 01JAN THRU 31DEC,
                AT  125  SUPPLIED BY BOILER;
      HOT WATER= 0 , CONSTANT,FROM 01JAN THRU 31DEC,
                AT  125  SUPPLIED BY FUEL DOMESTIC HOT WATER HEATER;
    END SCHEDULE;
    SPECIAL PARAMETERS:
      TCOOL=44.006;
      STEAM=1168.678;
      PSTEAM=284.4099;
      TSATUR=241.5302;
      DHWLOS=0.0;
      DHWEFF=0.75;
      HFUELB=20013.0;
      RFLASH=0.071;
      RHFLASH=0.5;
      SRATB=17.0;
      TLEAVE=550.04;
      MLLSU=170.0;
      MLLCU=170.0;
      WRHEIGHT=11.74;
      WALLAREA=789.26;
      FLORAREA=190.312;
      CHFLRATE=3.907;
      CHINTEMP=42.0;
      CRENTEMP=61.3;
      ELENUMBR=28.0;
      TANKUVAL=0.439;
      MIXCOEFF=0.05;
      BTSPEAK=7.0;
      ETSPEAK=16.0;
      TSTPAR=0.0002;
      TPELCL=0.018;
      CONTMODE=1.0;
      TANKLOCN=0.0;
      OFFPKI=1.0;
      SLTMPJAN=54.0;
      SLTMPFEB=55.0;
      SLTMPMAR=58.0;
      SLTMPAPR=62.0;
      SLTMPMAY=67.0;
      SLTMPJUN=74.0;
      SLTMPJUL=72.0;
      SLTMPAUG=68.0;
      SLTMPSEP=64.0;
      SLTMPOCT=62.0;
      SLTMPNOV=58.0;
      SLTMPDEC=55.0;
      RMXKWD=1.4644;
      PELECND=0.012;
      TEVAPC=60.008;
    END SPECIAL PARAMETERS;
    EQUIPMENT PERFORMANCE PARAMETERS:
      CPUMP ( 1.0, 0.0, 0.0);
      HPUMP ( 1.0, 0.0, 0.0);
      RFUELB ( 0.6, 0.8888889, -0.4938272);
      ADJE1C ( 2.3201, -1.46175, 0.181487);
      ADJT1C ( 95.0, 2.5, 44.0);
      RCAV1C ( 1.01846, -0.03075, -0.0001442);
      RPWR1C ( 0.18717, 0.122387, 0.67436);
      CWTPUMP ( 0.0, 0.9, 0.0);
      RELD ( 0.09755, 0.6318, -0.4165);
      REXD ( 0.3144, -0.1353, 0.09726);
      RJACD ( 0.3922, -0.4367, 0.27796);
      RLUBD ( 0.0883, -0.1371, 0.0803);
      TEXD ( 1179.396, 59.9994, 0.0);
      UACD ( 0.00952329, 0.9, 0.0);
      ECPUMP ( 1.0, 0.0, 0.0);
    END EQUIPMENT PERFORMANCE PARAMETERS;
    FOR SYSTEM 1 :
      SYSTEM MULTIPLIER= 1 ;
    END SYSTEM;
    FOR SYSTEM 2 :
      SYSTEM MULTIPLIER= 1 ;
```

```
     END SYSTEM;
  END PLANT;
 END CENTRAL PLANT DESCRIPTION;
END INPUT;
```

REVIEW SUMMARY REPORT - Automatic

See Also:

User Reference:Default Reports

Produced by default.

In general, the **REVIEW SUMMARY REPORT** consists of three main of sections: echo of important input data, design day simulation summary, and annual simulation summary. Each of these sections is further subdivided to present information in a logical and concise manner.

INPUT SUMMARY

The input summary provides a concise review of the zones, fan systems, and central plants data processed from the input file. This section reports the information in a logical order from a general overview of the building and simulation to more specific details of the parameters used to describe the building.

SIMULATION OVERVIEW

```
SIMULATION SUMMARY:

 1 BUILDING  WITH   2 ZONES
 1 SYSTEM
 1 PLANT
OUTPUT UNITS IN ENGLISH
PROJECT = REPORT EXAMPLES


                    **************************************
                    ***  BUILDING/ZONE INPUT SUMMARY  ***
                    **************************************


     FOR ZONE    1, "ZONE 1":
                     FLOOR AREA      1211.04 FT**2
                     CEILING HEIGHT       10.0 FT
                     APPROXIMATE VOLUME       12110. FT**3

     FOR ZONE    2, "ZONE 2":
                     FLOOR AREA      1200.62 FT**2
                     CEILING HEIGHT       10.0 FT
                     APPROXIMATE VOLUME       12006. FT**3
```

1. Provides most general level of information about the building and the simulation:
   - Number of buildings and zones on each building
   - Number of systems
   - Number of central plants
   - Output units (English or Metric)
   - Project title
   - For each zone:

     \- Zone name

     \- Floor area (ft² or m²)

- Ceiling height (ft or m)
- Approximate zone volume (ft³ or m³)

PLAN VIEW OF BUILDING SURFACES

```
                                          ****************************************
                                          ***  PLAN VIEW OF BUILDING SURFACES  ***
                                          ****************************************

                                                                                                   Y+            N
MIN X =      5.82  FT                                                                              1             1
MAX X =    100.29  FT             * = BUILDING SURFACE, + = SHADOWING SURFACE                 -X--+--+X      W--+--E
MIN Y =     12.23  FT                                                                              1             1
MAX Y =     71.20  FT                                                                             -Y             S
SOLAR DISTRIBUTION = -1

BUILDING TITLE - REPORT
```

```
**********************
                     *
                     *
                     *
                     *
**************************************
*                    *               *
*                    *               *
*                    *               *
*                    ***********************
*                    *               *     *
*                    *               *     *
**************************************     *
                                           *
                     ***************************************
                     *                     *               *
                     *                     *               *
                     *                     *               *
                     *                     *               *
                     *                     *               *
                     *                     *               *
                     ***************************************
```

1. Provides a graphical display of the relative size and orientation of each building surface and displays shadowing surfaces.
2. Shows maximum displacement of building surfaces from building origin (ft or m).
3. Shows solar distribution level (-1, 0, +1).

Note: The surfaces are displayed as entered in the input file so that they will not generally show the true building plan view. This does not affect the simulation except when the solar distribution level is set to +1.

BUILDING ENVELOPE DATA

```
                                ********************************
                                ***  BUILDING ENVELOPE DATA  ***
                                ********************************

      NOTE ** SURFACES IN ZONES DESIGNATED AS ATTIC OR CRAWLSPACE ARE NOT INCLUDED

                   BUILDING TITLE: REPORT

*NORTH= 0.
```

```
                                   AREA          U       AZIMUTH*      TILT      PER CENT       EAST= 90.0
                                  (FT**2)    (B/H*F**2*R) (DEGREES)    (DEGREES)   GLAZING

ROOF                              2411.66        0.125     *****         0.0         0.0
 ROOF31                           2411.66        0.125     *****         0.0

EXTERIOR WALL                      940.00        0.196     180.0        90.0         6.4
 EXTERIOR                          815.85        0.104     180.0        90.0
 SINGLE PANE HW WINDOW              60.45        1.115     180.0        90.0
 HOLLOW WOOD DOOR                   63.70        0.504     180.0        90.0

EXTERIOR WALL                      402.00        0.204      90.0        90.0        10.0
 EXTERIOR                          362.00        0.104      90.0        90.0
 SINGLE PANE HW WINDOW              40.00        1.115      90.0        90.0

EXTERIOR WALL                      940.00        0.183       0.0        90.0         7.8
 EXTERIOR                          790.48        0.104       0.0        90.0
 SINGLE PANE HW WINDOW              20.16        1.115       0.0        90.0
 DOUBLE PANE WINDOW                 52.92        0.553       0.0        90.0
 HOLLOW WOOD DOOR                   76.44        0.504       0.0        90.0

EXTERIOR WALL                      402.00        0.205     270.0        90.0        10.0
 EXTERIOR                          361.60        0.104     270.0        90.0
 SINGLE PANE HW WINDOW              40.40        1.115     270.0        90.0

SLAB ON GRADE FLOOR               2411.66        0.091     *****       180.0         0.0
 SLAB FLOOR                       2411.66        0.091     *****       180.0

                                   ======        =====                            =====
                                  7507.32        0.194 (OVERALL WALL AVERAGE)        8.0 % OF TOTAL WALL AREA
                                                 0.139 (BUILDING OVERALL AVERAGE)    8.9 % OF TOTAL FLOOR AREA


FLOOR AREA OF BUILDING              =      2411.66  FT**2
APPROX EXTERIOR SURFACE AREA        =      7507.32  FT**2
APPROXIMATE VOLUME                  =     24115.42  FT**3
APPROX VOLUME / FLOOR AREA          =         10.0  FT (APPROXIMATE BUILDING WALL HEIGHT)
```

1. Summarizes building exterior surface information based on the type of surface (roof, slab on grade floor, or exterior wall) and the facing angle or azimuth of that surface.
   - AREA (ft² or m²) - Total area of all surfaces with the specified azimuth and tilt
   - U-value (Btu/h-ft²-°R or W/m²-K) - For each type of construction element, this represents the actual value of the conductance. The overall values for all the walls facing in a specified direction, and the overall wall average, are based on an area weighted average of the U values for each surface and subsurface type.
   - AZIMUTH - The wall facing angle with respect to true North.
   - TILT - The angle between the horizontal and the plane of the surface.
   - PERCENT GLAZING - The fraction of the total wall area which is glass which means that it will transmit radiation directly into the zone.
2. Provides approximate measure of building size.
   - FLOOR AREA OF BUILDING (ft² or m²) - Total building floor area.
   - APPROX EXTERIOR SURFACE AREA (ft² or m²) - Estimated exposed area of walls, roofs, and floors.
   - APPROXIMATE VOLUME (ft³ or m³) - Estimated building volume.

- APPROX VOLUME / FLOOR AREA (ft or m) - Result is approximate or average wall height for the building.

SURFACE CONSTRUCTIONS

```
*******************************
***  SURFACE CONSTRUCTIONS  ***
*******************************

          BUILDING TITLE: REPORT


                                                        U
                                               WITHOUT FILM COEFF
                                                (B/H*F**2*R)


EXTERIOR                                         0.114
   A2 - 4 IN DENSE FACE BRICK                             2.162
   B3 - 2 IN INSULATION                                   0.150
   C2 - 4 IN LW CONCRETE BLOCK                            0.661
   E1 - 3 / 4 IN PLASTER OR GYP BOARD                     6.720

SINGLE PANE HW WINDOW                           21.186
   GLASS - CLEAR PLATE 1 / 4 IN                          21.186

HOLLOW WOOD DOOR                                 0.880
   WOOD - HARDWOOD 1 / 8 IN                               8.846
   B1 - AIRSPACE RESISTANCE                               1.099
   WOOD - HARDWOOD 1 / 8 IN                               8.846

INTERIOR                                         0.495
   C7 - 8 IN LW CONCRETE BLOCK                            0.495

SLAB FLOOR                                       0.097
   DIRT 12 IN                                             0.100
   CONCRETE - SAND AND GRAVEL 4 IN                        3.003

ROOF31                                           0.139
   E2 - 1 / 2 IN SLAG OR STONE                           19.904
   E3 - 3 / 8 IN FELT AND MEMBRANE                        3.514
   B6 - 2 IN DENSE INSULATION                             0.150
   C12 - 2 IN HW CONCRETE                                 5.988

DOUBLE PANE WINDOW                               1.045
   GLASS - CLEAR SHEET 1 / 8 IN                          42.373
   B1 - AIRSPACE RESISTANCE                               1.099
   GLASS - CLEAR SHEET 1 / 8 IN                          42.373
```

1. Summarizes each type of construction used in the building and lists its components layer-by-layer.
   - U-value (Btu/h-ft²-°R or W/m²-K) - In addition to the overall conductance of the construction, conductance values are listed for each individual layer.

SCHEDULED LOADS

```
                                                   *************************
                                                   ***  SCHEDULED LOADS  ***
                                                   *************************

   ZONE                                                                          DESIGN PEAK LOAD    # HOURS
AVERAGE LOAD
  NUMBER  FROM  THRU          SCHEDULE                             DESIGN PEAK LOAD      PER FT**2      PER WEEK
WHEN LOAD SCHEDULED

 PEOPLE:
      1   1JAN 31DEC  DORMITORY OCCUPANCY                            50.0     PEOPLE     4.129E-02         168.
3.545E+01  PEOPLE
      2   1JAN 31DEC  OFFICE OCCUPANCY                               20.0     PEOPLE     1.666E-02         60.0
1.450E+01  PEOPLE

 LIGHTS:
```

```
      1   1JAN 31DEC  DORMITORY LIGHTING                       300.     1000BTU    2.477E-01         168.
1.271E+02  1000BTU
      2   1JAN 31DEC  OFFICE LIGHTING                          400.     1000BTU    3.332E-01         168.
1.402E+02  1000BTU

                                                 NO ELECT EQUIP:

                                                 NO GAS EQUIP:

                                                 NO OTHER EQUIP LOADS:
```

1. Summarizes all the scheduled loads on the building by listing loads of the same type (i.e. PEOPLE, LIGHTS, ELECTRIC EQUIPMENT, GAS EQUIPMENT, OTHER EQUIPMENT) zone-by-zone.
   - FROM **-** The starting date when the load goes into effect.
   - THRU **-** The ending date after which the load is no longer in effect.
   - SCHEDULE **-** The name of the schedule which controls the hourly variation of the load.
   - DESIGN PEAK LOAD **-** The maximum value of the load and the appropriate units. Units are Btu or kWh except for people which records the maximum number of occupants in the zone.
   - DESIGN PEAK LOAD PER (ft^2 OR m^2) **-** The design peak load divided by the zone floor area.
   - # HOURS PER WEEK **-** The number of hours per week in which there is a non-zero scheduled load.
   - AVERAGE LOAD WHEN LOAD SCHEDULED **-** The total energy gain by the zone from the scheduled load divided by the number of hours the schedule is in effect. The appropriate units are also listed.
2. Report indicates when no scheduled loads of a specific type exist.

FAN SYSTEM PARAMETERS

```
                                                    *******************************
                                                    ***  FAN SYSTEM PARAMETERS  ***
                                                    *******************************


  SYSTEM    1 DUAL DUCTVAV             DDVAV
  SERVING ZONES:    1,   2


         MIXED AIR CONTROL = FIXED PERCENT                        DESIRED MIXED AIR TEMP = COLD DECK TEMP
         COLD DECK CONTROL = FIXED SET POINT                      COLD DECK FIXED TEMP   =  55 DEG. F
         HOT  DECK CONTROL = FIXED SET POINT                      HOT  DECK FIXED TEMP   = 140 DEG. F

         SYSTEM OPERATION = ON, 1JAN THRU 31DEC                   EXHAUST FAN OPERATION = ON, 1JAN THRU 31DEC
         PREHEAT COIL OPERATION = OFF, 1JAN THRU 31DEC            HEATING COIL OPERATION = ON, 1JAN THRU 31DEC
         COOLING COIL OPERATION = ON, 1JAN THRU 31DEC             HUMIDIFIER OPERATION = ON, 1JAN THRU 31DEC
         TSTAT BASEBOARD HEAT OPERATION = OFF, 1JAN THRU 31DEC    HEAT RECOVERY OPERATION = OFF, 1JAN THRU 31DEC
         MINIMUM VENTILATION SCHEDULE = MINIMUM OUTSIDE AIR, 1JAN THRU 31DEC
         MAXIMUM VENTILATION SCHEDULE = ON, 1JAN THRU 31DEC
         SYSTEM ELECTRICAL DEMAND SCHEDULE = ON, 1JAN THRU 31DEC
         WLHPS VENTILATION SYSTEM OPERATION =ON,01JAN THRU 31DEC
         WLHPS LOOP CONTROL SCHEDULE =ON,01JAN THRU 31DEC
         VAV MINIMUM AIR FRACTION SCHEDULE =ON,01JAN THRU 31DEC

      ZONE      SUPPLY      MINIMUM         EXHAUST     REHEAT       BASEBOARD     RECOOL         ZONE
                 AIR          AIR             AIR      CAPACITY        HEAT       CAPACITY     MULTIPLIER
                VOLUME      FRACTION        VOLUME                   CAPACITY
```

```
       FT**3/MIN                  FT**3/MIN     1000BTU       1000BTU       1000BTU

 1     9.762E+03     0.10         0.000E+00    0.000E+00     0.000E+00     0.000E+00         1
 2     1.459E+04     0.10         0.000E+00    0.000E+00     0.000E+00     0.000E+00         1
```

1. Summarizes zone-by-zone the fan system input parameters relating to system capacities and flow rates for each system.
   - SUPPLY AIR VOLUME (ft^3/min or m^3/s) **-** The maximum air flow rate to be supplied to the zone by the air handling system.
   - MINIMUM AIR FRACTION **-** Only applicable to systems with variable air volume flow rates; this is the minimum air flow rate that will be provided to the zone as a fraction of the specified supply air volume.
   - EXHAUST AIR VOLUME (ft^3/min or m^3/s) **-** The maximum zone exhaust air flow rate. This is air which is vented directly to the outside and does not enter the return air system.
   - REHEAT CAPACITY (kBtu/h or kW) **-** The maximum capacity of the zone reheater boxes. This is not applicable to all systems.
   - BASEBOARD HEAT CAPACITY(kBtu/h or kW) **-** The maximum capacity of the zone thermostatic baseboard units. This is not applicable to all systems.
   - RECOOL CAPACITY(kBtu/h or kW) **-** The maximum cooling capacity of the zone recooling units.
   - ZONE MULTIPLIER **-** Used when the system serves two or more identical zones to prevent duplication of computation.

PLANT EQUIPMENT PARAMETERS

```
                                         *************************************
                                         ***  PLANT/EQUIPMENT PARAMETERS   ***
                                         *************************************

PLANT    1    PLANT 1
 SERVING SYSTEMS:    1
 EQUIPMENT TYPE                  SIZE (1000BTU   )
   1 BOILER                               376
   1 CHILLER                              450
```

1. Summarizes plant equipment types, capacities, and systems served by the plant.
   - SERVING SYSTEMS **-** The system numbers served by this plant.
   - EQUIPMENT TYPE **-** Lists specific equipment types found in this plant, i.e., DIESEL CHILLER, ELECTRIC BOILER, etc.
   - SIZE (kBtu/h or kW) **-** Reports capacity of the indicated equipment type.

OUTPUT SUMMARY

The output summary reviews key information generated by the zone, fan system, and central plant simulations. All of the data from each simulation environment is grouped together to make it easier to cross reference zone, fan system, and central plant outputs. The format of the annual simulation output is slightly different than the design day information since data is usually recorded month-by-month rather than hour-by-hour.

DESIGN DAY ZONE LOAD SUMMARY

```
*****************************************************************************************************
***  ENVIRONMENT NUMBER  1: CHANUTE AFB ILLINOIS WINTER                                           ***
***   DESIGN DAY 21 JAN WITH GROUND TEMPERATURE  54.000  MAKE UP WATER TEMPERATURE  55.004         ***
*****************************************************************************************************
           ****************************
           ***  ZONE GROUP SUMMARY  ***
           ****************************


 ZONE GROUP LOADS FOR CHANUTE AFB ILLINOIS WINTER

 DATE 21 JAN   (MONDAY   )

    NUMBER         NAME                             MULTIPLIER

  1      1  ZONE 1                                       1
  2      2  ZONE 2                                       1


          TOTAL       TOTAL       TOTAL        PEAK        PEAK        PEAK        MAX        MIN
       CONVECTIVE    RADIANT    SENSIBLE   CONVECTIVE    RADIANT    SENSIBLE      TEMP       TEMP
         HEATER      HEATER     COOLING      HEATER      HEATER     COOLING
  ZONE    LOAD        LOAD        LOAD        LOAD        LOAD        LOAD

         1000BTU     1000BTU     1000BTU   1000BTU/HR  1000BTU/HR  1000BTU/HR    DEG. F     DEG. F

     1   2.121E+03   0.000E+00   0.000E+00   1.513E+02   0.000E+00   0.000E+00    70.32      68.02
     2   2.114E+03   0.000E+00   0.000E+00   1.852E+02   0.000E+00   0.000E+00    77.29      68.02

 GROUP:  4.234E+03   0.000E+00   0.000E+00   3.194E+02   0.000E+00   0.000E+00    77.29      68.02

 PEAK DATES (MO/DY/HR):                       1/21/ 6     1/21/ 1     1/21/ 1    1/21/17    1/21/24

 TOTAL ITERATIONS =   210
 DID NOT CONVERGE =     0
```

1. Reports details of the design day environment including: location, type (summer or winter), date of design day simulation, ground temperature, and make-up water temperature.
2. Summarizes building zones in the simulation and reports the zone multiplier for each zone.
3. Reports total and peak heating and cooling loads experienced by each zone during the design day. The heating load is split into radiant and convective components, while the cooling load is sensible cooling only.
   - TOTAL CONVECTIVE HEATER LOAD (kBtu or kWh) **-** The total heating load passed to the convective (air) heating system.
   - TOTAL RADIANT HEATER LOAD (kBtu or kWh) **-** The total heating load met by the radiant heater system.
   - TOTAL SENSIBLE COOLING LOAD (kBtu or kWh) **-** The total amount of sensible cooling passed to the air handling system.
   - PEAK CONVECTIVE HEATER LOAD (kBtu/h or kW) **-** The peak heating load passed to the convective (air) heating system.

- PEAK RADIANT HEATER LOAD (kBtu/h or kW) - The peak heating load met by the radiant heater system.
- PEAK SENSIBLE COOLING LOAD (kBtu/h or kW) - The peak amount of sensible cooling passed to the air handling system.
- MAX TEMP (°F or °C) - The maximum temperature experienced in the zone during the simulation period.
- MIN TEMP (°F or °C) - The minimum temperature experienced in the zone during the simulation period.

DESIGN DAY SYSTEM LOAD SUMMARY

```
****************************************************************************
**                    S Y S T E M   L O A D   S U M M A R Y               **
****************************************************************************


SYSTEM LOADS FOR CHANUTE AFB ILLINOIS WINTER

DATE 21 JAN   (MONDAY   )

SYSTEM             LATENT COOLING BY SYSTEM COIL          SENSIBLE COOLING BY SYSTEM COIL
NUMBER            TOTAL          PEAK        PEAK TIME       TOTAL          PEAK        PEAK TIME
                 1000BTU      1000BTU/HR     MO/DY/HR       1000BTU      1000BTU/HR     MO/DY/HR
     1          1.1419E+00    9.5179E-02      1/21/17      1.5865E+02    1.2376E+01      1/21/17


SYSTEM             TOTAL COOLING BY SYSTEM COIL            TOTAL HEATING BY SYSTEM COIL
NUMBER            TOTAL          PEAK        PEAK TIME       TOTAL          PEAK        PEAK TIME
                 1000BTU      1000BTU/HR     MO/DY/HR       1000BTU      1000BTU/HR     MO/DY/HR
     1          1.5979E+02    1.2472E+01      1/21/17      5.1510E+03    3.5847E+02      1/21/ 6


SYSTEM         TOTAL ELECTRIC       TOTAL ENERGY        TOTAL FLOOR           ENERGY
NUMBER        (SYSTEM & ZONES)                             AREA               BUDGET
                  1000BTU             1000BTU              FT**2            1000BTU/SF/DAY
     1           7.9730E+03          1.3284E+04         2.4117E+03          5.5081E+00


SYSTEM                              FRACTION OF OUTSIDE AIR                           HRS SYSTEM
NUMBER          MAX [%]        TIME         AVG [%]        MIN [%]         TIME       OPERATED
                             MO/DY/HR                                    MO/DY/HR
     1           15.00        1/21/ 1        15.00          15.00         1/21/ 1          24
```

1. Reports sensible and latent cooling coil loads for each system. The total of each type of load is given for the simulation period along with peak values and the hour at which the peak value occurred. Units for totals are in kBtu or kWh and units for peak loads are in kBtu/h or kW.
2. Reports total cooling coil and total heating coil loads for each system. The total of each type of load is given for the simulation period along with peak values and the hour at which the peak value occurred. Units for totals are in kBtu or kWh and units for peak loads are in kBtu/h or kW.
3. Reports total electric use, total energy use, and the total floor area served by each system. The energy budget is reported as energy use per unit floor area per day.
   - TOTAL ELECTRIC (kBtu or kWh) - The total amount of electrical energy used by the system and the zones it serves.
   - TOTAL ENERGY (kBtu or kWh) - The total amount of energy, including electric and coil, used by the system and the zones it serves.

- TOTAL FLOOR AREA (ft² or m²) **-** The total floor area of all the zones served by the system.
- ENERGY BUDGET (kBtu/ft² or kWh/m²) **-** The total energy consumption per unit floor area for the design day.

4. Indicates how much outside air was brought in by the system during the simulation period. The average flow rate of outside air as a fraction of the system maximum air flow rate is reported as are the extreme values of the outside air flow rate. The number of hours that the system operated during the design day is also provided.

DESIGN DAY PLANT LOAD SUMMARY

```
*****************************************************************************
**                      P L A N T   L O A D   S U M M A R Y               **
*****************************************************************************


 PLANT LOADS FOR CHANUTE AFB ILLINOIS WINTER

 DATE 21 JAN   (MONDAY   )

                                                                              PURCHASED ENERGY

                                     BOILER FUEL                                      GAS TURBINE FUEL                                   DIESEL FUEL
 PLANT    TOTAL          PEAK       PEAK TIME         TOTAL          PEAK      PEAK TIME        TOTAL          PEAK
PEAK TIME
          1000BTU     1000BTU/HR    MO/DY/HR         1000BTU    1000BTU/HR    MO/DY/HR         1000BTU    1000BTU/HR
MO/DY/HR

    1     6.67E+03     4.55E+02    1/21/ 6          0.00E+00     0.00E+00    1/21/24          0.00E+00     0.00E+00
1/21/24


                                     NATURAL GAS                                     PURCHASED ELECTRIC                         PURCHASED
HEATING
 PLANT    TOTAL          PEAK       PEAK TIME         TOTAL          PEAK      PEAK TIME        TOTAL          PEAK
PEAK TIME
          1000BTU     1000BTU/HR    MO/DY/HR         1000BTU    1000BTU/HR    MO/DY/HR         1000BTU    1000BTU/HR
MO/DY/HR

    1     0.00E+00     0.00E+00    1/21/24          8.99E+03     6.13E+02    1/21/17          0.00E+00     0.00E+00
1/21/24

                                                                         *********************************************
                                  PURCHASED COOLING                      **        TOTAL ENERGY PURCHASED          **
 PLANT    TOTAL          PEAK       PEAK TIME                            **    TOTAL          PEAK      PEAK TIME  **
          1000BTU     1000BTU/HR    MO/DY/HR                             **    1000BTU    1000BTU/HR    MO/DY/HR   **
                                                                         **                                        **
    1     0.00E+00     0.00E+00    1/21/24                               **    1.57E+04     7.91E+02    1/21/17    **
                                                                         *********************************************
```

1. Provides a breakdown by type of plant energy usage. For each type of energy, the report indicates the total amount consumed, the peak rate of consumption, and the time at which the peak consumption occurred. Units are in Btu or kWh for totals and Btu/h or kW for peak values. The categories of fuel usage are:
   - BOILER FUEL
   - GAS TURBINE FUEL
   - DIESEL FUEL
   - NATURAL GAS
   - PURCHASED ELECTRIC
   - PURCHASED HEATING
   - PURCHASED COOLING

- TOTAL ENERGY PURCHASED

ANNUAL SIMULATION ZONE LOAD SUMMARY

```
*****************************************************************************************************************
        **
**
        **                             A N N U A L   S I M U L A T I O N   O U T P U T
**
        **
**

*****************************************************************************************************************
          ****************************
          ***  ZONE GROUP SUMMARY  ***
          ****************************

 ZONE GROUP LOADS FOR CHANUTE AFB, ILLINOIS 1440 1957

 SIMULATION PERIOD  1 JAN 1957 THRU 31 DEC 1957

    NUMBER         NAME                           MULTIPLIER

  1      1  ZONE 1                                     1
  2      2  ZONE 2                                     1


            TOTAL       TOTAL       TOTAL        PEAK        PEAK        PEAK        MAX         MIN
         CONVECTIVE    RADIANT    SENSIBLE    CONVECTIVE    RADIANT    SENSIBLE      TEMP        TEMP
           HEATER      HEATER      COOLING      HEATER      HEATER      COOLING
  ZONE      LOAD        LOAD        LOAD         LOAD        LOAD        LOAD

           1000BTU     1000BTU     1000BTU    1000BTU/HR  1000BTU/HR  1000BTU/HR    DEG. F      DEG. F

     1   2.672E+04   0.000E+00   6.055E+05   1.611E+02   0.000E+00   2.316E+02     78.00       68.02
     2   1.001E+05   0.000E+00   6.661E+05   2.456E+02   0.000E+00   3.224E+02     78.00       68.02

 GROUP:  1.268E+05   0.000E+00   1.272E+06   4.067E+02   0.000E+00   4.607E+02     78.00       68.02

 PEAK DATES (MO/DY/HR):                       1/14/ 6     1/ 1/ 1     8/15/17    12/31/24    12/31/24

 TOTAL ITERATIONS = 20940
 DID NOT CONVERGE =     0
```

1. Duplicates the form and function of the design day zone loads summary. Totals and peak values are now based on the entire simulation period not just a single design day.

ANNUAL SIMULATION ZONE TEMPERATURE SUMMARY

```
                                                     **************************************
                                                     **   SPACE TEMPERATURES  DEG. F     **
                                                     **************************************

  ZONE
 NUMBER            CONTROLS                                       HEATING                     COOLING                   NO
HEATING OR COOLING
                                                           OCCUPIED      UNOCCUPIED     OCCUPIED      UNOCCUPIED
OCCUPIED     UNOCCUPIED
                                                          MAX     MIN     MAX     MIN     MAX     MIN     MAX     MIN     MAX
MIN    MAX    MIN

     1   DEAD BAND                                       68.02  68.02 ****** ******  78.00  78.00 ****** ******  78.00
68.02 ****** ******

     2   DEAD BAND                                       68.02  68.02  68.02  68.02  78.00  78.00  78.00  78.00  77.98
68.02  78.00  68.02
```

1. Provides an analysis of the temperature extremes for each zone.

- CONTROLS **-** The name of the control profile which is regulating the zone temperature.
- HEATING **-** Reports the maximum and minimum temperatures obtained in each zone when there is a heating load on the zone. Further subdivides the reporting into cases when the zone is occupied (i.e. when people are scheduled to be in the zone), and unoccupied.
- COOLING **-** Reports the maximum and minimum temperatures obtained in each zone when there is a cooling load on the zone. Otherwise the same as HEATING.
- NO HEATING OR COOLING **-** Reports the maximum and minimum temperatures obtained in each zone when there is neither a heating nor a cooling load on the zone. Otherwise the same as HEATING.

ANNUAL SIMULATION ZONE INFILTRATION AND VENTILATION LOAD SUMMARY

```
                                ******************************************************
                                **    INFILTRATION AND SCHEDULED VENTILATION LOAD   **
                                ******************************************************

   ZONE                                                                                     OCCUPIED         UNOCCUPIED
  NUMBER   FROM  THRU                                                                     MAX      MIN      MAX      MIN
SPECIFIED PEAK FLOW

 INFILTRATION:

      1    1JAN 31DEC  CONSTANT                                  AIR CH/HR      13.9      2.7  *******  *******
4.5
                                                                 FT**3/MIN   2.8E+03  5.5E+02 ******** ********
9.0E+02
                                                                 MO/DA/HR   12/10/24  6/ 3/18 ******** ********

      2    1JAN 31DEC  CONSTANT                                  AIR CH/HR      17.2      3.2     15.7      3.2
5.2
                                                                 FT**3/MIN   3.4E+03  6.4E+02  3.1E+03  6.4E+02
1.0E+03
                                                                 MO/DA/HR    2/26/14  6/ 3/18 12/11/ 6  8/ 8/22

 INFILTRATION HEAT LOSS =  250782.88 1000BTU, 197.8 PERCENT OF THE HEATING LOAD

 INFILTRATION HEAT GAIN =    8331.96 1000BTU,   0.7 PERCENT OF THE COOLING LOAD

                                         NO NATURAL VENTILATION:
```

1. Reports the extremes of infiltration and natural ventilation air flow rates in each zone. Maximum and minimum flow rates are indicated in quantities of air changes per hour (AIR CH/HR) and ft^3/min or m^3/s. Flow rates are provided for cases where the zone is occupied and unoccupied as determined by the PEOPLE schedule. The peak flow rate specified in the input as well as the building total heat loss or gain due to infiltration is also reported.

ANNUAL SIMULATION MECHANICAL SYSTEM VENTILATION SUMMARY

```
                                   ************************************************
                                   **     MECHANICAL FAN SYSTEM VENTILATION      **
                                   ************************************************

  SYSTEM                                                                                    OCCUPIED         UNOCCUPIED
  NUMBER   FROM  THRU                                                                     MAX      MIN      MAX      MIN
PEAK FLOW

 OUTSIDE AIR:
```

```
     1    1JAN 31DEC, ON                                           FT**3/MIN   2.8E+03  1.2E+02 ******** ********
2.8E+03
                                                                   MO/DA/HR    8/15/17  1/ 1/ 2 ******** ********
```

1. Reports the extremes of forced ventilation air flow rates by each system for each zone. Maximum and minimum flow rates are indicated in quantities of ft³/min or m³/s. Flow rates are provided for cases where the zone is occupied and unoccupied as determined by the PEOPLE schedule. The peak flow rate specified in the input is also reported.

ANNUAL SIMULATION SYSTEM LOAD SUMMARY

```
                             ***************************************************************************
                             **                  S Y S T E M   L O A D   S U M M A R Y                **
                             ***************************************************************************


SYSTEM LOADS FOR CHANUTE AFB, ILLINOIS 1440 1957

SIMULATION PERIOD  1 JAN 1957 THRU 31 DEC 1957

SYSTEM                 LATENT COOLING BY SYSTEM COIL              SENSIBLE COOLING BY SYSTEM COIL
NUMBER             TOTAL          PEAK        PEAK TIME       TOTAL          PEAK        PEAK TIME
                  1000BTU      1000BTU/HR     MO/DY/HR       1000BTU      1000BTU/HR     MO/DY/HR
     1           4.0929E+05    2.9166E+02      8/ 2/12      1.2650E+06    5.2059E+02      8/15/17


SYSTEM                 TOTAL COOLING BY SYSTEM COIL                TOTAL HEATING BY SYSTEM COIL
NUMBER             TOTAL          PEAK        PEAK TIME       TOTAL          PEAK        PEAK TIME
                  1000BTU      1000BTU/HR     MO/DY/HR       1000BTU      1000BTU/HR     MO/DY/HR
     1           1.6743E+06    8.0031E+02      8/15/17      2.3109E+05    4.6249E+02      1/14/ 6


SYSTEM          TOTAL ELECTRIC       TOTAL ENERGY        TOTAL FLOOR            ENERGY
NUMBER         (SYSTEM & ZONES)                             AREA                BUDGET
                  1000BTU              1000BTU              FT**2             1000BTU/SF
     1           2.4357E+06           4.3410E+06          2.4117E+03          1.8000E+03


SYSTEM                                FRACTION OF OUTSIDE AIR                               HRS SYSTEM
NUMBER            MAX [%]        TIME         AVG [%]        MIN [%]         TIME         OPERATED
                               MO/DY/HR                                    MO/DY/HR
     1             15.00        1/ 2/ 1        11.90           5.00         1/ 1/ 1          8760
```

1. Duplicates the form and function of the design day system load summary. Totals and peak values are now based on the entire simulation period not just a single design day.

ANNUAL SIMULATION PLANT/EQUIPMENT USE SUMMARY

```
                                                  ******************************
                                                  **   PLANT/EQUIPMENT DATA   **
                                                  ******************************


PLANT    1    PLANT 1
SERVING SYSTEMS:    1

 EQUIPMENT TYPE       SIZE      OPER         MAX         AVERAGE       PEAK        PERCENT      CHILLER COP
                                HOURS        LOAD         OPER         OPER         HOURS           OR
                                                          RATIO        RATIO       AT PEAK      BOILER EFF
                     1000BTU                1000BTU                                              (AVERAGE)

 BOILER                376      2218          376         0.032        1.00           0            0.56
 CHILLER               450      8721          472         0.410        1.00          13            6.00
```

1. Summarizes separately, central plant equipment input and reports average and peak usage statistics during the simulation period.

- SIZE (kBtu/h or kW) **-** The capacity of the indicated equipment as specified in the input.
- OPER HOURS **-** The number of hours the equipment operated during the simulation period.
- MAX LOAD (kBtu/h or kW) **-** The maximum load passed to the indicated plant equipment.
- AVERAGE OPER RATIO **-** The equipment part load ratio averaged over the number of hours the equipment operated during the simulation. Note that the number of hours of operation is not usually the same as the number of hours of the simulation.
- PEAK OPER RATIO **-** The maximum part load ratio at which the equipment operated during the simulation.
- PERCENT HOURS AT PEAK **-** The number of hours the equipment was operating at the maximum part load ratio as a percentage of the total number of hours the equipment operated.
- CHILLER COP OR BOILER EFF. (AVERAGE) **-** The chiller coefficient of performance (COP) or boiler efficiency averaged over the total time the equipment operated. In the case of a chiller, this would be the ratio of the total cooling provided by the chiller to the total energy input. The average boiler efficiency is the total heating supplied divided by the total energy input to the boiler.

ANNUAL PLANT LOADS SUMMARY REPORT

```
                             ***************************************************************************
                             **                     P L A N T   L O A D   S U M M A R Y              **
                             ***************************************************************************


PLANT LOADS FOR CHANUTE AFB, ILLINOIS 1440 1957

SIMULATION PERIOD  1 JAN 1957 THRU 31 DEC 1957

                                                              PURCHASED ENERGY

                  BOILER FUEL                                  GAS TURBINE FUEL                              DIESEL FUEL
PLANT    TOTAL        PEAK     PEAK TIME    TOTAL        PEAK     PEAK TIME    TOTAL        PEAK     PEAK TIME
         1000BTU    1000BTU/HR   MO/DY/HR    1000BTU    1000BTU/HR   MO/DY/HR    1000BTU    1000BTU/HR   MO/DY/HR

   1     1.91E+05     5.24E+02   1/14/ 5    0.00E+00     0.00E+00  12/31/24     0.00E+00    0.00E+00  12/31/24


                  NATURAL GAS                                 PURCHASED ELECTRIC                            PURCHASED HEATING
PLANT    TOTAL        PEAK     PEAK TIME    TOTAL        PEAK     PEAK TIME    TOTAL        PEAK     PEAK TIME
         1000BTU    1000BTU/HR   MO/DY/HR    1000BTU    1000BTU/HR   MO/DY/HR    1000BTU    1000BTU/HR   MO/DY/HR

   1     0.00E+00    0.00E+00  12/31/24     3.01E+06    6.99E+02   8/14/17     0.00E+00    0.00E+00  12/31/24

                                                                    *********************************************
               PURCHASED COOLING                                    **          TOTAL ENERGY PURCHASED          **
PLANT    TOTAL        PEAK     PEAK TIME                            **    TOTAL        PEAK      PEAK TIME    **
         1000BTU    1000BTU/HR   MO/DY/HR                           **    1000BTU    1000BTU/HR   MO/DY/HR    **
                                                                    **                                        **
   1     0.00E+00     0.00E+00   12/31/24                           **    3.20E+06     8.31E+02   1/14/ 8     **
                                                                    *********************************************
```

1. Provides a breakdown by type of plant energy usage. For each type of energy, the report indicates the total amount consumed,

the peak rate of consumption, and the time at which the peak consumption occurred. Units are in Btu or kWh for totals and Btu/h or kW for peak values. The categories of fuel usage are:

- BOILER FUEL
- GAS TURBINE FUEL
- DIESEL FUEL
- NATURAL GAS
- PURCHASED ELECTRIC
- PURCHASED HEATING
- PURCHASED COOLING
- TOTAL ENERGY PURCHASED

ANNUAL SIMULATION ENERGY BUDGET REPORT SUMMARY

```
****************************************************************************
**                                                                        **
**            E N E R G Y   B U D G E T   R E P O R T                     **
**                                                                        **
****************************************************************************

                              SIMULATION PERIOD =  1 JAN 1957 - 31 DEC 1957
                              LOCATION = CHANUTE AFB, ILLINOIS 1440 1957
                              HEATING DEGREE DAYS = 5902.5
                              COOLING DEGREE DAYS =  994.5
                              GROUND TEMPS = 54,55,58,62,67,74,72,68,64,62,58,55
```

1. The energy budget report header summarizes: dates of simulation, building location, number of heating and cooling degree days, and monthly ground temperatures at the specified location.

ANNUAL SIMULATION ZONE ENERGY BUDGET

```
                                       *******************************
                                       ***    ZONES ENERGY BUDGET  ***
                                       *******************************

 FACILITY TYPE        =                                             SIMULATION PERIOD =  1 JAN 1957 - 31 DEC 1957
 FACILITY DESCRIPTION = UNKNOWN BUILDING CATEGORY                   BUDGET REGION =
 LOCATION      = CHANUTE AFB, ILLINOIS 1440 1957                    HEATING DEGREE DAYS   = 5902.5
 PROJECT TITLE = REPORT EXAMPLES                                    COOLING DEGREE DAYS   =  994.5
                                                                    REQUIRED ENERGY BUDGET=  ???  1000BTU/SF

                                           (HBLC) 2000 1196

                                                      ZONE LOAD

NUMBER TOTAL HEAT TOTAL COOL TOTAL ELECT TOTAL GAS TOTAL LIGHT INFIL LOSS INFIL GAIN TOTAL AREA ENERGY BUDGET
        1000BTU    1000BTU    1000BTU     1000BTU   1000BTU     1000BTU    1000BTU      FT**2      1000BTU/SF

  1    2.672E+04  6.055E+05  1.112E+06   0.000E+00  1.112E+06  8.064E+04  3.846E+03   1.211E+03    1.440E+03
  2    1.001E+05  6.661E+05  1.193E+06   0.000E+00  1.193E+06  1.701E+05  4.486E+03   1.201E+03    1.632E+03
       =========  =========  =========   =========  =========  =========  =========   =========
TOTAL  1.268E+05  1.272E+06  2.305E+06   0.000E+00  2.305E+06  2.508E+05  8.332E+03   2.412E+03

 ENERGY BUDGET FOR ALL ZONES = 1.536E+03  1000BTU/SF

 *** ZONE ENERGY BUDGETS DO NOT INCLUDE FAN SYSTEMS OR EQUIPMENT INEFFICIENCIES
```

1. Reports totals for the simulation period of all heat gains to or losses from each zone. The total amount of energy required to heat and cool each zone is provided as an energy usage per unit

floor area. Energy units are kBtu or kWh and area units are ft² or

TOTAL HEAT. **-** The total heating load on the zone or the total amount of heat which the system must provide.

- TOTAL COOL. **-** The total cooling load on the zone or the total amount of cooling which the system must provide.
- TOTAL ELECT **-** The total electric load on the zone. This is due to lights and electric equipment being specified as scheduled zone loads.
- TOTAL GAS **-** The total load due to gas equipment on the zone. This is due to gas equipment being specified as a scheduled zone load.
- INFIL LOSS **-** The total amount of heat lost by the zone due to outside air infiltration.
- INFIL GAIN **-** The total amount of heat gained by the zone due to outside air infiltration.
- TOTAL AREA **-** The total floor area of the zone.
- ENERGY BUDGET **-** The combined total zone heating and cooling loads per unit floor area.

ANNUAL SIMULATION SYSTEM ENERGY BUDGET

```
                                                   *******************************
                                                   ***  SYSTEMS ENERGY BUDGET  ***
                                                   *******************************

FACILITY TYPE        =                                                     SIMULATION PERIOD =  1 JAN 1957 - 31 DEC 1957
FACILITY DESCRIPTION = UNKNOWN BUILDING CATEGORY                           BUDGET REGION =
LOCATION      = CHANUTE AFB, ILLINOIS 1440 1957                            HEATING DEGREE DAYS   = 5902.5
PROJECT TITLE = REPORT EXAMPLES                                            COOLING DEGREE DAYS   =  994.5
                                                                           REQUIRED ENERGY BUDGET=  ???  1000BTU/SF

                                        (HBLC) 2000 1196


                                                     SYSTEM LOADS

NUMBER  UNDER HEAT        UNDER COOL        OVER HEAT         OVER COOL         HEAT W/O DMD      COOL W/O DMD
        1000BTU  HOURS    1000BTU  HOURS    1000BTU  HOURS    1000BTU  HOURS    1000BTU  HOURS    1000BTU  HOURS

  1    0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)
       =========          =========          =========          =========          =========          =========
TOTAL  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)  0.000E+00 (    0)




NUMBER  TOTAL HEAT     TOTAL COOL     TOTAL ELECT    TOTAL GAS      TOTAL AREA                    ENERGY BUDGET
          1000BTU        1000BTU        1000BTU        1000BTU         FT**2                        1000BTU/SF

   1    2.311E+05      1.674E+06      2.436E+06      0.000E+00      2.412E+03                      1.800E+03
        =========      =========      =========      =========      =========
 TOTAL  2.311E+05      1.674E+06      2.436E+06      0.000E+00      2.412E+03

ENERGY BUDGET FOR ALL SYSTEMS = 1.800E+03  1000BTU/SF

*** ENERGY BUDGET DOES NOT INCLUDE UNDER/OVER/W.O. DEMAND HEATING/COOLING ITEMS
```

1. Reports totals of all system unmet loads and the number of hours that an unmet load was incurred. Energy units are kBtu or kWh and area units are ft² or m².

   - UNDER HEAT - The difference between the total zone heating load and the heating output of the system when the system did not have sufficient capacity to meet zone heating loads.
   - UNDER COOL - The difference between the total zone cooling load and the cooling output of the system when the system did not have sufficient capacity to meet zone cooling loads.
   - OVER HEAT - The difference between the total zone heating load and the heating output of the system when the system supplied more heating to the zone than was required.
   - OVER COOL - The difference between the total zone cooling load and the cooling output of the system when the system supplied more cooling to the zone than was required.
   - HEAT W/O DEMAND - The total amount of heating supplied by the system to the zones when there was no heating load.
   - COOL W/O DEMAND - The total amount of cooling supplied by the system to the zones when there was no cooling load.

2. Summarizes totals of all heating and cooling coil loads, combined building and system electric and gas energy usage, and a total of the system energy consumption reported per unit floor area. Energy units are kBtu or kWh and area units are ft² or m².

   TOTAL HEAT - The total heating, reheat, and preheat coil load for each system.

   - TOTAL COOL - The total cooling coil load for each system.
   - TOTAL ELECT - The total of all electric consumption by the system and the zones which it serves.
   - TOTAL GAS - The total of all gas consumption by the system and the zones which it serves.
   - TOTAL FLOOR AREA - The total floor area of all the zones served by the system.
   - ENERGY BUDGET - The total system energy consumption including heating coil and cooling coil energy, electric consumption, and gas consumption per unit floor area.

ANNUAL SIMULATION PLANT ENERGY BUDGET

```
                                    *******************************
                                    ***    PLANT ENERGY BUDGET  ***
                                    *******************************

 FACILITY TYPE        =                                                             SIMULATION PERIOD =  1 JAN
1957 - 31 DEC 1957
 FACILITY DESCRIPTION = UNKNOWN BUILDING CATEGORY                                   BUDGET REGION =
 LOCATION      = CHANUTE AFB, ILLINOIS 1440 1957                                    HEATING DEGREE DAYS   = 5902.5
 PROJECT TITLE = REPORT EXAMPLES                                                    COOLING DEGREE DAYS   =  994.5
```

```
                                                                                    REQUIRED ENERGY BUDGET=  ???
1000BTU/SF
                                         (HBLC) 2000 1196

                                                      PURCHASED ENERGY

 PLANT         PURCHASED       BOILER     GAS TUR-       DIESEL       NATURAL      PURCHASED    PURCHASED
 NUMBER        ELECTRIC         FUEL      BINE FUEL       FUEL          GAS        HOT WATER   CHILL WATER
                1000BTU       1000BTU      1000BTU      1000BTU       1000BTU       1000BTU      1000BTU

    1          3.010E+06     1.906E+05    0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00
               =========     =========    =========    =========    =========    =========    =========
  TOTAL        3.010E+06     1.906E+05    0.000E+00    0.000E+00    0.000E+00    0.000E+00    0.000E+00

                                         PLANT UNMET LOADS / BUDGETS


 NUMBER              UNMET HEATING       UNMET COOLING       UNMET ELECTRIC      FLOOR AREA          ENERGY BUDGET
                          LOAD                LOAD                LOAD             SERVED
                        1000BTU             1000BTU             1000BTU            FT**2              1000BTU/SF

    1                  1.539E+02           5.914E+04           0.000E+00          2.412E+03           1.327E+03
                       =========           =========           =========           =========
  TOTAL                1.539E+02           5.914E+04           0.000E+00          2.412E+03

 BUILDING ENERGY BUDGET = 1.327E+03  1000BTU/SF

 *** ENERGY BUDGET DOES NOT INCLUDE UNMET HEATING/COOLING/ELECTRIC LOADS

 REQUIRED ENERGY BUDGET =  ???  1000BTU/SF      FOR UNKNOWN BUILDING CATEGORY
```

1. Summarizes separately, central plant equipment input and reports average and peak usage statistics during the simulation period.

SIMULATION REPORT

See Also:

BLDFL and AHLDFL Files

Produced by default.

```
    REPORTING WILL BE DONE IN ENGLISH UNITS

    SIMULATIONS WILL BE ALLOWED FOR TYPES: ZONES      SYSTEMS    PLANTS

           1 BUILDING SIMULATIONS WILL BE ATTEMPTED

         SIMULATIONS WILL BE ATTEMPTED FOR   2 ZONES

         SIMULATIONS WILL BE ATTEMPTED FOR   2 SYSTEMS

         SIMULATIONS WILL BE ATTEMPTED FOR   1 PLANTS

  NEW BLDFL AND AHLDFL FILES WILL BE CREATED
       FROM USER INPUT, AS NECESSARY

      LOCATION TAKEN FROM ATTACHED WTHRFL
      TITLE= CHANUTE AFB, ILLINOIS 1440 1957           LAT=   40.130 LONG=   88.270 TIME ZONE= 6.0

   * * * * *
   BLDFL FOR
    REPORT EXAMPLES


                           (HBLC) 2000 1196
   LOCATION CHANUTE AFB, ILLINOIS 1440 1957          LAT=    40.130 LONG=    88.270 TIME ZONE= 6.0
   DATE OF FILE CREATE/UPDATE 20 AUG 98 NUMBER OF ENVIRONMENTS  3
   NUMBER OF ZONES  2 WITH ZONE NUMBERS
    1    2

   * * * * *
   AHLDFL FOR
    REPORT EXAMPLES
```

```
                         (HBLC) 2000 1196
   LOCATION CHANUTE AFB, ILLINOIS 1440 1957          LAT=    40.130 LONG=    88.270 TIME ZONE= 6.0
   DATE OF FILE CREATE/UPDATE 20 AUG 98 NUMBER OF ENVIRONMENTS  3
   NUMBER OF SYSTEMS  2 WITH SYSTEM NUMBERS
    1    2
```

1. BLAST reports the number and type of simulations it will be attempting. An error in the input could result in a different number of simulations than anticipated. BLAST reports whether BLDFL and AHLDFL files are to be created or attached from existing files. If a weather tape is used, a description of it is reported.
2. The BLDFL being used is described including location, file creation date, number of environments, number of zones, and zone numbers.
3. The AHLDFL being used is described including location, file creation date, number of environments, number of zones, and zone numbers.

DESIGN DAY REPORT

Produced by specifying DESIGN DAYS in the REPORTS section of RUN CONTROL.

ENVIRONMENT CHANUTE AFB ILLINOIS WINTER

DATE 21 JAN (MONDAY) DECLINATION SINE= -.3432 COSINE= 0.9393 EQTIME= -0.1858

HOUR	RAIN	SNOW	DRY BULB DEG.F	WET BULB DEG.F	BARO PRESSURE IN-H2O	HUMID RATIO	WIND SPEED FT/MIN	WIND DIREC	SKY TEMP DEG.F	BEAM BTUH/F^2	DIFFUSE BTUH/F^2	GROUND REFLECT BTUH/F^2	TOTAL HORIZ BTUH/F^2
1			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
2			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
3			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
4			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
5			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
6			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
7			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
8			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
9			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
10			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
11			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
12			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
13			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
14			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
15			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
16			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
17			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
18			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
19			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
20			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
21			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
22			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
23			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
24			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
***			0.00	0.00	400.60	0.0008	1114.10	326.0	-10.80	0.00	0.00	0.00	0.00
			AVERAGE	AVERAGE		AVERAGE			AVERAGE	TOTAL	TOTAL	TOTAL	TOTAL

1. The date and design day type are indicated.

Based on the data, the declination (Earth's tilt) is calculated. Values of SINE, COSINE, AND EQTIME (equation of time) are reported. These values are needed for calculating sun angles.

The following values are reported for each hour of the design day: The AVERAGE or TOTAL values are also reported as appropriate.

RAIN: Indicates rain during that hour.

SNOW: Indicates snow on the ground during that hour.

DRY BULB: The outside dry bulb temperature calculated from input values for HIGH and LOW.

WET BULB: The outside wet bulb temperature calculated from input value of WB.

BARO PRESSURE: The barometric pressure as input.

HUMID RATIO: The calculated humidity ratio.

WIND SPEED: The input value of WS.

WIND DIREC: Wind direction as specified by DIR. North=0.

SKY TEMP: Used for radiation balance on exterior surfaces. Calculated from DRY BULB.

Note: (SKY TEMP)=(DRY BULB)-10.8ºF.

BEAM: Beam radiation calculated from CLEARNESS, LOCATION, and DATE.

DIFFUSE: Diffuse radiation calculated from CLEARNESS, LOCATION, and DATE.

GROUND REFLECT: Solar radiation reflected from ground. Calculated from CLEARNESS, LOCATION, and DATE.

TOTAL HORIZ: The total horizontal radiation.

ENVIRONMENT REPORT

Produced by default for each environment type.

```
ENVIRONMENT NUMBER  1 FOR BLDFL  TITLE IS CHANUTE AFB ILLINOIS WINTER
      DESIGN DAY 21 JAN WITH GROUND TEMPERATURE  54.000  MAKE UP WATER TEMPERATURE  55.004
     ENVIRONMENT NUMBER  1 FOR AHLDFL TITLE IS CHANUTE AFB ILLINOIS WINTER
      DESIGN DAY 21 JAN WITH GROUND TEMPERATURE  54.000  MAKE UP WATER TEMPERATURE  55.004
ENVIRONMENT NUMBER  2 FOR BLDFL  TITLE IS CHANUTE AFB ILLINOIS SUMMER
      DESIGN DAY 21 JUL WITH GROUND TEMPERATURE  72.000  MAKE UP WATER TEMPERATURE  55.004
     ENVIRONMENT NUMBER  2 FOR AHLDFL TITLE IS CHANUTE AFB ILLINOIS SUMMER
      DESIGN DAY 21 JUL WITH GROUND TEMPERATURE  72.000  MAKE UP WATER TEMPERATURE  55.004
     ENVIRONMENT NUMBER  3 FOR BLDFL  TITLE IS CHANUTE AFB, ILLINOIS 1440 1957
      WEATHER STATION  14806 START DATE OF  1 JAN 1957 NO. OF DAYS  14
      WITH GROUND TEMPERATURES  JAN =54.00 FEB =55.00 MAR =58.00 APR =62.00 MAY =67.00 JUN =74.00
                                JUL =72.00 AUG =68.00 SEP =64.00 OCT =62.00 NOV =58.00 DEC =55.00
      WITH MAKE UP WATER TEMPERATURES  JAN =55.00 FEB =55.00 MAR =55.00 APR =55.00 MAY =55.00 JUN =55.00
                                JUL =55.00 AUG =55.00 SEP =55.00 OCT =55.00 NOV =55.00 DEC =55.00
ENVIRONMENT NUMBER  3 FOR AHLDFL TITLE IS CHANUTE AFB, ILLINOIS 1440 1957
      WEATHER STATION  14806 START DATE OF  1 JAN 1957 NO. OF DAYS  14
      WITH GROUND TEMPERATURES  JAN =54.00 FEB =55.00 MAR =58.00 APR =62.00 MAY =67.00 JUN =74.00
                                JUL =72.00 AUG =68.00 SEP =64.00 OCT =62.00 NOV =58.00 DEC =55.00
      WITH MAKE UP WATER TEMPERATURES  JAN =55.00 FEB =55.00 MAR =55.00 APR =55.00 MAY =55.00 JUN =55.00
                                JUL =55.00 AUG =55.00 SEP =55.00 OCT =55.00 NOV =55.00 DEC =55.00
```

1. The environment type and values of ground and water temperatures are reported for each environment used with BLDFL* and AHLDFL*.

TEMPERATURE CONTROL PROFILES

Produced by HOURLY PROFILES in the REPORTS section of RUN CONTROL.

```
TEMPERATURE CONTROL PROFILES --

    1 --                40        50        60        70        80        90       100
                        +         +         +         +         +         +         +

  ( 68.00/ 1.00)   +1.0  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +1.0
  ( 68.02/ 0.00)         XXXXXXXXXXXXXXXXXXXXXXXXXXXX
  ( 78.00/ 0.00)   +0.8  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +0.8
  ( 78.02/-1.00)         XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                   +0.6  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +0.6
                   HEAT  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  HEAT
                   +0.4  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +0.4
                         XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                   +0.2  XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                  +0.2
                         XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                    0.0  ------------------------------------------------------------   0.0
                                                               XXXXXXXXXXXXXXXXXXXXXX
                   -0.2                                        XXXXXXXXXXXXXXXXXXXXXX  -0.2
                                                               XXXXXXXXXXXXXXXXXXXXXX
                   -0.4                                        XXXXXXXXXXXXXXXXXXXXXX  -0.4
                   COOL                                        XXXXXXXXXXXXXXXXXXXXXX  COOL
                   -0.6                                        XXXXXXXXXXXXXXXXXXXXXX  -0.6
                                                               XXXXXXXXXXXXXXXXXXXXXX
                   -0.8                                        XXXXXXXXXXXXXXXXXXXXXX  -0.8
                                                               XXXXXXXXXXXXXXXXXXXXXX
                   -1.0                                        XXXXXXXXXXXXXXXXXXXXXX  -1.0
                        +         +         +         +         +         +         +
```

1. These profiles graphically demonstrate each temperature control profile used in the simulation. The profiles may be input in the Temporary Controls section or taken from the Control Schedule Library, as in this example:

   CONTROLS=DEAD BAND

   The profile numbers (1,2,...) are referred to in the description of Zone Reports.

GENERAL SCHEDULE PROFILES

Produced by HOURLY PROFILES in the REPORTS section of RUN CONTROL.

```
  GENERAL SCHEDULE PROFILES --

1 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 + XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                            XXXXXXXX + 100
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                            XXXXXXXX +
 80 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX            XXXX                XXXXXXXX            XXXXXXXXXXXX +  80
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX            XXXX                XXXXXXXX            XXXXXXXXXXXX +
 60 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX            XXXX                XXXXXXXX            XXXXXXXXXXXX +  60
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX        XXXX                XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 40 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX        XXXX                XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  40
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX        XXXX            XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 20 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  20
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

      100 100 100 100 100 100 100  80  50  20  20  80  20  20  20  30  80  80  50  50  50  80 100 100


2 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                        XXXX + 100
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                                                        XXXX +
 80 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                XXXXXXXX                XXXXXXXX +  80
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                XXXXXXXX                XXXXXXXX +
 60 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                XXXXXXXX                XXXXXXXX +  60
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 40 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  40
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 20 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  20
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

      100 100 100 100 100 100 100 100 100  80  80  80  50  50  50  50  80  80  50  50  50  50  80 100

 3 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 +                                                                             XXXXXXXXXXXXXXXXXXXX + 100
    +                                                                             XXXXXXXXXXXXXXXXXXXX +
 80 +                         XXXX                                        XXXXXXXXXXXXXXXXXXXXXXXXXXXX +  80
    +                         XXXX                                        XXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 60 +                         XXXX                                        XXXXXXXXXXXXXXXXXXXXXXXXXXXX +  60
    +                         XXXXXXXX            XXXX                XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 40 +                         XXXXXXXX            XXXX                XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  40
    +                         XXXXXXXX            XXXX                XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 20 + XXXX                    XXXXXXXXXXXX        XXXX                XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  20
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

       20  10  10  10  10  10  80  50  20  10  10  50  10  10  10  10  50  80  80 100 100 100 100 100
```

1. These profiles graphically demonstrate each hourly schedule used in the simulation. The schedules may be input in the Temporary Schedule section, taken from the General Schedule Library, or defined in conjunction with a Temporary Control Profile. In this simulation library schedules are used:

   PEOPLE=0,DORMITORY OCCUPANCY

   LIGHTS=100,DORMITORY LIGHTING

   There are two profiles used for each of the Dormitory schedules, one for weekdays and one for weekends. Only the first 3 are illustrated here.

   The profile number (1,2,...) are referred to in the Description of Zone Reports.

CONDUCTIVE PROPERTIES OF HEAT TRANSFER SURFACES

Produced by specifying WALLS in the REPORTS section of RUN CONTROL.

```
CONDUCTIVE PROPERTIES OF HEAT TRANSFER SURFACES:

 ************************

 CONSTRUCTION NUMBER =  1     EXTERIOR

 DESCRIPTION OF CONSTRUCTION

  LAYER                                   THICKNESS  CONDUCTIVITY  DENSITY  SPECIFIC HEAT  RESISTANCE
                                            FEET    BTU/(HR*FT*F)  LB/FT**3   BTU/(LB*F) HR*FT**2*F/BTU

 A2 - 4 IN DENSE FACE BRICK                0.3330         0.720    130.000        0.220       0.000
 B3 - 2 IN INSULATION                      0.1670         0.025      2.000        0.200       0.000
 C2 - 4 IN LW CONCRETE BLOCK               0.3330         0.220     38.000        0.200       0.000
 E1 - 3 / 4 IN PLASTER OR GYP BOARD        0.0625         0.420    100.000        0.200       0.000

   6 CONDUCTION TRANSFER FUNCTIONS OF ORDER 2

    TIME     INTERNAL        CROSS         EXTERNAL     FLUX

       1     2.34531736     0.00009099     5.10992241     1.09425354
       2    -4.30905867     0.00601265    -8.79301739    -0.29829448
       3     2.37943959     0.01343513     4.23547220
       4    -0.39112836     0.00349584    -0.52760720
       5    -0.00138219     0.00013665    -0.00158651
       6    -0.00001420     0.00000218    -0.00001040

 THERMAL CONDUCTANCE =   0.114 BTU/(HR*FT**2*F)
 OUTER THERMAL ABSORPTANCE =0.90
 INNER THERMAL ABSORPTANCE =0.90
 OUTER SOLAR ABSORPTANCE =0.93
 INNER SOLAR ABSORPTANCE =0.92
 OUTER SURFACE ROUGHNESS:  ROUGH

 ************************

 CONSTRUCTION NUMBER =  2     SINGLE PANE HW WINDOW

 DESCRIPTION OF CONSTRUCTION

  LAYER                                   THICKNESS  CONDUCTIVITY  DENSITY  SPECIFIC HEAT  RESISTANCE
                                            FEET    BTU/(HR*FT*F)  LB/FT**3   BTU/(LB*F) HR*FT**2*F/BTU

 GLASS - CLEAR PLATE 1 / 4 IN              0.0000         0.000      0.000        0.000       0.047

   1 CONDUCTION TRANSFER FUNCTIONS OF ORDER 0

    TIME     INTERNAL        CROSS         EXTERNAL     FLUX

       1    21.18643951    21.18643951    21.18643951

 THERMAL CONDUCTANCE =  21.186 BTU/(HR*FT**2*F)
 OUTER THERMAL ABSORPTANCE =0.90
 INNER THERMAL ABSORPTANCE =0.90
 OUTER SOLAR ABSORPTANCE =0.75
 INNER SOLAR ABSORPTANCE =0.75
 OUTER SURFACE ROUGHNESS:  VRY SMOOTH

 ************************

 CONSTRUCTION NUMBER =  3     HOLLOW WOOD DOOR

 DESCRIPTION OF CONSTRUCTION

  LAYER                                   THICKNESS  CONDUCTIVITY  DENSITY  SPECIFIC HEAT  RESISTANCE
                                            FEET    BTU/(HR*FT*F)  LB/FT**3   BTU/(LB*F) HR*FT**2*F/BTU

 WOOD - HARDWOOD 1 / 8 IN                  0.0104         0.092     45.000        0.300       0.000
 B1 - AIRSPACE RESISTANCE                  0.0000         0.000      0.000        0.000       0.910
 WOOD - HARDWOOD 1 / 8 IN                  0.0104         0.092     45.000        0.300       0.000

   1 CONDUCTION TRANSFER FUNCTIONS OF ORDER 0

    TIME     INTERNAL        CROSS         EXTERNAL     FLUX
```

```
      1     0.88021427     0.88021427     0.88021427

 THERMAL CONDUCTANCE =   0.880 BTU/(HR*FT**2*F)
 OUTER THERMAL ABSORPTANCE =0.90
 INNER THERMAL ABSORPTANCE =0.90
 OUTER SOLAR ABSORPTANCE =0.78
 INNER SOLAR ABSORPTANCE =0.78
 OUTER SURFACE ROUGHNESS:  MED SMOOTH

 ************************

 CONSTRUCTION NUMBER =  4     INTERIOR

 DESCRIPTION OF CONSTRUCTION

  LAYER                                  THICKNESS  CONDUCTIVITY  DENSITY  SPECIFIC HEAT  RESISTANCE
                                           FEET    BTU/(HR*FT*F)  LB/FT**3   BTU/(LB*F) HR*FT**2*F/BTU

 C7 - 8 IN LW CONCRETE BLOCK              0.6670         0.330     38.000       0.200       0.000

   4 CONDUCTION TRANSFER FUNCTIONS OF ORDER 2

    TIME     INTERNAL        CROSS         EXTERNAL     FLUX

      1     1.78698206     0.03649400     1.78698206     0.40285680
      2    -1.76435661     0.20645089    -1.76435661    -0.00809625
      3     0.28009480     0.05590425     0.28009480
      4    -0.00327635     0.00059449    -0.00327635

 THERMAL CONDUCTANCE =   0.495 BTU/(HR*FT**2*F)
 OUTER THERMAL ABSORPTANCE =0.90
 INNER THERMAL ABSORPTANCE =0.90
 OUTER SOLAR ABSORPTANCE =0.65
 INNER SOLAR ABSORPTANCE =0.65
 OUTER SURFACE ROUGHNESS:  ROUGH



 **********************

 OPTICAL PROPERTIES OF SINGLE PANE HW WINDOW

  LAYER                                     NORMAL       NORMAL      INDEX OF  TRANSMITTANCE
                                        TRANSMITTANCE REFLECTANCE   REFRACTION   WITH FILM

 GLASS - CLEAR PLATE 1 / 4 IN               0.800                    1.520


 ANGULAR DEPENDENCE OF PROPERTIES:

 COS(THETA):0.06250.12500.18750.25000.31250.37500.43750.50000.56250.62500.68750.75000.81250.87500.9375 1.00
DIFFUSE

 TRANSMITTANCE:
0.11710.26170.38820.49090.57070.63140.67690.71070.73570.75440.76820.77860.78630.79220.79660.80000.7217
 REFLECTANCE:
0.76690.59870.46280.35610.27480.21420.16990.13790.11510.09910.08820.08090.07630.07370.07250.07230.1363
 ABSORPTANCE:
0.11600.13960.14890.15300.15450.15440.15330.15150.14920.14650.14360.14060.13740.13420.13100.12770.1420

 FITTED PROPERTIES FOR LOADS CALCULATIONS:

 TRANSMITTANCE:
0.11800.26020.38880.49170.57040.63070.67700.71140.73580.75450.76830.77850.78620.79220.79670.80000.7217
 OUTER ABSORPTANCE:
0.05710.07130.07390.07570.07760.07790.07650.07500.07460.07330.07180.07030.06870.06710.06550.06390.0710
 INNER ABSORPTANCE:
0.05710.07130.07390.07570.07760.07790.07650.07500.07460.07330.07180.07030.06870.06710.06550.06390.0710
```

1. CONSTRUCTION NUMBER=n (construction name)

   n = an internal counter for each construction type.

2. The material names and properties (L,K,D,CP,R) of each layer of the construction are reported.

   L = Thickness (ft or m)

   K = Conductivity (Btu/hr-ft-ºF or W/m-K)

D = Density (lbm/ft^3 or kg/m^3)

CP = Specific Heat (Btu/lbm-ºF or kJ/kg-K)

R = Overall Resistance ($hr\text{-}ft^2\text{-}{}^\circ F$ or $m^2\text{-}K/W$)

The user should specify an 'R' value or the combination of L,CP,D and K. A material specification should not contain all of the elements, L,CP,D,K and R. For materials specified with R, the variables L,CP,D, and K will be reported as zero. For materials specified with L,CP,D, and K, the variable R will be reported as zero.

3. Conduction Transfer Functions:

M Conduction Transfer Functions of Order N.

M = number of hours of temperature history.

N = number of hours of flux history.

The conduction transfer functions are temperature and flux coefficients which characterize the thermal properties of the wall.

The heat flux through the wall at any time is calculated from a series of terms consisting of products of the temperature coefficients multiplied by past hourly temperatures and products of the flux coefficients multiplied by past hourly heat flux values.

It is necessary to use the conduction transfer functions labeled "Internal" and "Cross" to calculate the heat flux at the inside surface and the conduction transfer functions labeled "External" and "Cross" to calculate the heat flux at the outside surface. Internal and External coefficients will be identical for symmetric walls.

4. THERMAL CONDUCTANCE=1/(R + 1/K)

*Note that thermal conductance does not include convection coefficients.

OUTER THERMAL ABSORPTANCE = TABS for outer material layer

INNER THERMAL ABSORPTANCE = TABS for inner material layer

(Default for TABS=0.9)

OUTER SOLAR ABSORPTANCE = ABS for outer material layer

INNER SOLAR ABSORPTANCE = ABS for inner material layer

(Default for ABS=0.75)

OUTER SURFACE ROUGHNESS = one of: VERY ROUGH, ROUGH, MEDIUM ROUGH,MEDIUM, MEDIUM SMOOTH, SMOOTH,VERY SMOOTH

5. Optical Properties

Produced in the walls report whenever a window is one of the subsurfaces.

NORMAL TRANSMITTANCE: The transmittance at normal (right angle) incidence.

NORMAL REFLECTANCE: The reflectance at normal (right angle) incidence.

INDEX OF REFRACTION: (If not specified, the default is 1.5 for glass and 1.0 for air).

TRANSMITTANCE, WITH FILM: The transmittance for coated glass at normal (right angle) incidence.

6. ANGULAR DEPENDENCE OF PROPERTIES: The values of transmittance, reflectance and absorbence are shown as functions of the angle of incidence. These values are based on fundamental optical equations. Note that at normal incidence the transmittance is equal to the specified value of TRANSMITTANCE. Also note that for each angle, the sum of transmittance, reflectance and absorbence equals 1.0. These values are used to calculate the direct solar gain for each hour. The diffuse values are used for diffuse short wave radiation from the sky.

7. FITTED PROPERTIES FOR LOADS CALCULATION: To save computation, BLAST calculates the optical properties from the fundamental equations for several angles of incidence. Then BLAST fits polynomials to these series of properties. During the simulation, the polynomials are used to evaluate the optical properties, thus eliminating the need to grind through the optical equations for every hour.

   The table of FITTED PROPERTIES is a listing of the properties as calculated by the polynomial curve fits. For non-symmetric glass (e.g. coated on one side) the INNER and OUTER ABSORPTANCE will be different.

DESCRIPTION OF ZONE REPORT

Produced by ZONE SUMMARY in the REPORTS section of RUN CONTROL.

```
DESCRIPTION OF ZONE     1:  ZONE 1                                    REPORT

 SURF    HTS     TYPE OF SURFACE        AREA     U    AZM   TILT   CONSTRUCTION
 NUMBER  NUMBER    TYPE OF SUBSURFACE

   1       1  EXTERIOR WALL            496.0  0.104 180.0  90.0   EXTERIOR
   2       2       WINDOW               40.3  1.115               SINGLE PANE HW WINDOW
   3       3       DOOR                 63.7  0.504               HOLLOW WOOD DOOR
   4       4  EXTERIOR WALL            182.0  0.104  90.0  90.0   EXTERIOR
   5       5       WINDOW               20.0  1.115               SINGLE PANE HW WINDOW
   6       6  EXTERIOR WALL            319.8  0.104   0.0  90.0   EXTERIOR
   7       7       WINDOW               20.2  1.115               SINGLE PANE HW WINDOW
   8       8  EXTERIOR WALL            182.0  0.104 270.0  90.0   EXTERIOR
   9       9       WINDOW               20.0  1.115               SINGLE PANE HW WINDOW
  10      10  INTERZONE PARTITION      260.0  0.296   0.0  90.0   INTERIOR
  11      11  SLAB ON GRADE FLOOR     1211.0  0.091  90.0 180.0   SLAB FLOOR
  12      12  ROOF                    1211.0  0.125 180.0   0.0   ROOF31

 EXTERIOR SURFACE AREA =    2555.04      AVERAGE U-VALUE = 0.163

 ZONE FLOOR AREA=    1211.04 FT**2

 APPROXIMATE ZONE VOLUME =       12110. FT**3      AIR HEAT CAPACITY =    268.741 BTU/DEG F
  GENERAL SCHEDULES DATA:                                          SUN MON TUE WED THU FRI SAT HOL SP1 SP2 SP3 SP4

 PEOPLE:                0.000E+00      FROM  1JAN THRU 31DEC         2   1   1   1   1   1   2   2   2   2   2   2
         4.500E+02 BTUH ACTIVITY LEVEL,  60.0% RADIANT

 LIGHTS:                3.000E+05 BTUH FROM  1JAN THRU 31DEC         4   3   3   3   3   3   4   4   4   4   4   4
           0.0% RETURN AIR,  40.0% RADIANT,  20.0% VISIBLE,   0.0% REPLACEABLE

 INFILTRATION:          9.000E+02 CFM  FROM  1JAN THRU 31DEC         5   5   5   5   5   5   5   5   5   5   5   5
         MODIFIER =  0.60600 +  0.02020*DT +  0.00060*V +  0.00000*V**2

 RELATIVE VELOCITY:     2.500E+01 FT/MIN  FROM  1JAN THRU 31DEC      5   5   5   5   5   5   5   5   5   5   5   5

 RELATIVE HUMIDITY:     5.000E-01         FROM  1JAN THRU 31DEC      5   5   5   5   5   5   5   5   5   5   5   5

 METABOLIC RATE:        1.000E+00 MET     FROM  1JAN THRU 31DEC      5   5   5   5   5   5   5   5   5   5   5   5

 WORK EFFICIENCY:       0.000E+00         FROM  1JAN THRU 31DEC      5   5   5   5   5   5   5   5   5   5   5   5

 CLOTHING INSULATION:   1.000E+00 CLO     FROM  1JAN THRU 31DEC      5   5   5   5   5   5   5   5   5   5   5   5

 CONTROL SCHEDULES DATA:

 HEATING CAPACITY = 3.412E+09 BTUH   COOLING CAPACITY = 3.412E+09 BTUH      0.0% MRT,      0.0% RADIANT HEAT,
                  0.000E+00 1/FT**2  RADIANT FLUX FACTOR,  0.0% LOST,       0.0% LATENT,
                  FROM  1JAN THRU 31DEC

 BECAUSE THIS IS NOT A RADIANT HEATER, RADIANT FLUX FACTOR, % LOST AND  % LATENT
 HAVE NO MEANING.  THESE VARIABLES ALSO HAVE NO MEANING WHEN COOLING.

         HOUR:     1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24
          SUN      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          MON      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          TUE      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          WED      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          THU      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          FRI      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          SAT      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          HOL      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          SP1      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          SP2      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          SP3      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
          SP4      1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1   1
```

1. A description is given for each surface/subsurface in the zone.

   NUMBER: Assigned according to the order in which the surfaces were specified.

   TYPE: One of the allowable surface/subsurface types.

AREA: The area (ft^2 or m^2) is calculated based on specified geometry.

U: This is the value of the overall heat transfer coefficient ($Btu/hr\text{-}ft^2\ ^oF$ or $W/m^2\text{-}K$) used in the basic steady-state equation for U.

where: ho= Outside film coefficient

hi = Inside film coefficient

L = Thickness

C = Thermal conductance (see WALLS report).

The film coefficients used to calculate this U-value are chosen to represent an average condition. BLAST adjusts the inside and outside film coefficients as conditions change during the simulation. The U-value listed here is only to give the user a quick overview of the building surface properties. Since BLAST uses conduction transfer functions to calculate heat fluxes, the concept of a U-value really has no meaning to BLAST.

AZM: Direction angle of the outward normal (facing angle: 0^o=North, 90^o=East, 180^o=South, 270^o=West).

TILT: Specifies angle between the z-axis and the outward normal of the surface. Defaults: Roof and ceilings=0^o; walls=90^o;

Note: AZM and TILT are not listed for subsurfaces, they are equal to AZM and TILT for their base surface.

CONSTRUCTION: Construction type from the BLAST Standard Library (i.e. WALLS LIBRARY, ROOFS LIBRARY, etc.) or a specified Temporary type (i.e. TEMPORARY WALLS, TEMPORARY ROOFS, etc.).

2. EXTERIOR SURFACE AREA = (exterior walls, windows, roofs, slab on grade floors, exposed floors).

AVERAGE U VALUE = (exterior area)/Total exterior area.

ZONE FLOOR AREA = (area of any surface with a tilt equal to 180^o).

APPROXIMATE ZONE VOLUME: Requires that all surfaces enclosing the zone be described. If a zone is only partially described, the reported volume will be meaningless, but will not affect the simulation.

APPROXIMATE ZONE VOLUME is reported. This volume is calculated with a formula which requires that all surfaces enclosing the zone be described. If a zone is only partially described, the reported volume will be meaningless. *This does not affect the simulation.* The formula for APPROXIMATE ZONE VOLUME is:

APXVOL = [(sum of the surface areas) **-** 2*(floor area)]*SQRT(FLOOR AREA)/4

This volume is only calculated for the DESCRIPTION OF ZONE report; it is not used in any load calculation.

AIR HEAT CAPACITY =

This value indicates the amount of heat needed to raise the temperature one degree. Note that this value is not used in any load calculation.

3. GENERAL SCHEDULES DATA: Possible schedules include people, lights, electrical equipment, gas equipment, other loads, infiltration, ventilation, mixing, baseboard heating, controls, daylight and internal mass. For each of these optional schedules, the schedule number (corresponding to the applicable profile number in the GENERAL SCHEDULE PROFILES report) is given for each day of the week including holidays and special days. Also specified are the overall schedules which determine when during the year the schedule will be followed and when the schedule will be ignored. Default values for all schedules are zero. The other information given varies for each schedule, and is described in the scheduled loads section of the BLAST user's manual.
4. CONTROL SCHEDULES DATA: This chart shows which temperature control profile is being used each hour of each day. The numbers refer to the corresponding temperature control profile which is printed in the TEMPERATURE CONTROL PROFILES report.

SURFACE VERTICES REPORT

Produced by specifying SURFACE VERTICES in the REPORTS section of RUN CONTROL.

```
SURFACE VERTICES OF ZONE     1:  ZONE 1

  NS ORG  DIRECTION COSINES  COORDINATES

   1 ABS  0.000-1.000 0.000 ( 40.3, 12.2, 10.0) ( 40.3, 12.2,  0.0) (100.3, 12.2,  0.0) (100.3, 12.2, 10.0)
   2 REL  0.000-1.000 0.000 (  0.6,  9.9,  0.0) (  0.6,  4.8,  0.0) (  8.5,  4.8,  0.0) (  8.5,  9.9,  0.0)
   3 REL  0.000-1.000 0.000 ( 11.7,  9.8,  0.0) ( 11.7,  0.0,  0.0) ( 18.2,  0.0,  0.0) ( 18.2,  9.8,  0.0)
   4 ABS  1.000 0.000 0.000 (100.3, 12.2, 10.0) (100.3, 12.2,  0.0) (100.3, 32.4,  0.0) (100.3, 32.4, 10.0)
   5 REL  1.000 0.000 0.000 (  0.6,  9.7,  0.0) (  0.6,  4.7,  0.0) (  4.6,  4.7,  0.0) (  4.6,  9.7,  0.0)
   6 ABS  0.000 1.000 0.000 (100.3, 32.4, 10.0) (100.3, 32.4,  0.0) ( 66.3, 32.4,  0.0) ( 66.3, 32.4, 10.0)
   7 REL  0.000 1.000 0.000 (  0.6,  9.9,  0.0) (  0.6,  5.1,  0.0) (  4.8,  5.1,  0.0) (  4.8,  9.9,  0.0)
   8 ABS -1.000 0.000 0.000 ( 40.3, 32.4, 10.0) ( 40.3, 32.4,  0.0) ( 40.3, 12.2,  0.0) ( 40.3, 12.2, 10.0)
   9 REL -1.000 0.000 0.000 (  0.6,  9.7,  0.0) (  0.6,  4.7,  0.0) (  4.6,  4.7,  0.0) (  4.6,  9.7,  0.0)
  10 ABS  0.000 1.000 0.000 ( 66.3, 32.4, 10.0) ( 66.3, 32.4,  0.0) ( 40.3, 32.4,  0.0) ( 40.3, 32.4, 10.0)
  11 ABS  0.000 0.000-1.000 ( 75.1, 12.2,  0.0) ( 40.3, 12.2,  0.0) ( 40.3, 47.0,  0.0) ( 75.1, 47.0,  0.0)
  12 ABS  0.000 0.000 1.000 ( 40.3, 47.0, 10.0) ( 40.3, 12.2, 10.0) ( 75.1, 12.2, 10.0) ( 75.1, 47.0, 10.0)
```

1. SURFACE VERTICES OF ZONE: The coordinates of each surface and subsurface are listed for each zone. Subsurface coordinates are relative to the base surface origin, base surface coordinates are relative to the building origin.

ZONE VIEW REPORT

Produced by specifying ZONE VIEW in the REPORTS section of RUN CONTROL.

```
PLAN VIEW OF ZONE HEAT TRANSFER SURFACES.
                                                        +Y            N
 MIN X =     40.29                                       1            1
 MAX X =    100.29                                   -X--+--+X     W--+--E
 MIN Y =     12.23                                       1            1
 MAX Y =     47.03                                      -Y            S

 * = ZONE SURFACE
              ZONE 1






      ***********************************
      *                                 *
      *                                 *
      *                                 *
      *                                 *
      *                                 *
      *                                 *
      *                                 *
      *                                 *
      *************************************************************
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *                                 *                         *
      *************************************************************
```

1. PLAN VIEW OF ZONE HEAT TRANSFER SURFACES: A plan view of all zone heat transfer surfaces is printed for each zone. Note that subsurfaces are not included.

```
PLAN VIEW OF BUILDING SURFACES.
                                                        +Y            N
 MIN X =      5.82                                       1            1
 MAX X =    100.29                                   -X--+--+X     W--+--E
 MIN Y =     12.23                                       1            1
 MAX Y =     71.20                                      -Y            S

 * = BUILDING SURFACE, + = SHADOWING SURFACE

              REPORT






      **********************
      *                    *
      *                    *
      *                    *
      *                    *
      **************************************
      *                    *               *
      *                    *               *
      *                    *               *
      *                    ***********************
      *                    *               *     *
      *                    *               *     *
      **************************************     *
```

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*                     *
***************************************
*                     *               *
*                     *               *
*                     *               *
*                     *               *
*                     *               *
*                     *               *
***************************************
```

1. PLAN VIEW OF BUILDING SURFACES: A plan view of all building surfaces is printed for each building. Shadowing surfaces are also indicated.

ZONE REPORT

Produced by specifying ZONE in the REPORTS section of RUN CONTROL.

Specifying the ZONE report activates the following four zone related reports:

HOURLY PROFILES (See Temperature Control Profiles and General Schedule Profiles)

ZONE SUMMARY

SURFACE VERTICES

ZONE VIEW

SHADE REPORT

Produced by specifying SHADE in the REPORTS section of RUN CONTROL.

```
SHADOWING COMBINATIONS

 GRSNR =   1     NGSS =  0     NBKS =  0     NSBS =  2
     SBSNR =     2    3

 GRSNR =   4     NGSS =  0     NBKS =  0     NSBS =  1
     SBSNR =     5

 GRSNR =   6     NGSS =  0     NBKS =  0     NSBS =  1
     SBSNR =     7

 GRSNR =   8     NGSS =  0     NBKS =  0     NSBS =  1
     SBSNR =     9

 GRSNR =  12     NGSS =  0     NBKS =  0     NSBS =  0

 GRSNR =  13     NGSS =  0     NBKS =  0     NSBS =  1
     SBSNR =    14

 GRSNR =  15     NGSS =  0     NBKS =  0     NSBS =  1
     SBSNR =    16

 GRSNR =  17     NGSS =  0     NBKS =  0     NSBS =  2
     SBSNR =    18   19

 GRSNR =  20     NGSS =  0     NBKS =  0     NSBS =  1
     SBSNR =    21

 GRSNR =  24     NGSS =  0     NBKS =  0     NSBS =  0

 RESULTS OF SHADOWING CALCULATIONS

     DATE = 21JUL     SIN(DECL) =0.3521     COS(DECL) =0.9360     EQN OF TIME =-.1038

 FORM OF DATA:  / COSINE OF INCIDENCE, SUNLIT FRACTION /

 STANDARD TIME =  5:30
 / -.346,0.000/ -.346,0.000/ -.346,0.000/ 0.928,1.000/    / 0.928,1.000/ 0.346,1.000/ 0.346,1.000/ -.928,0.000/
 / -.928,0.000/ 0.346,0.000/ -.136,0.000/ 0.136,1.000/    / -.346,0.000/ -.346,0.000/ 0.928,1.000/ 0.928,1.000/
 / 0.346,1.000/ 0.346,1.000/ 0.346,1.000/ -.928,0.000/    / -.928,0.000/ -.346,0.000/ -.136,0.000/ 0.136,1.000/

 STANDARD TIME =  6:30
 / -.189,0.000/ -.189,0.000/ -.189,0.000/ 0.928,1.000/    / 0.928,1.000/ 0.189,1.000/ 0.189,1.000/ -.928,0.000/
 / -.928,0.000/ 0.189,0.000/ -.322,0.000/ 0.322,1.000/    / -.189,0.000/ -.189,0.000/ 0.928,1.000/ 0.928,1.000/
 / 0.189,1.000/ 0.189,1.000/ 0.189,1.000/ -.928,0.000/    / -.928,0.000/ -.189,0.000/ -.322,0.000/ 0.322,1.000/

 STANDARD TIME =  7:30
 / -.037,0.000/ -.037,0.000/ -.037,0.000/ 0.864,1.000/    / 0.864,1.000/ 0.037,1.000/ 0.037,1.000/ -.864,0.000/
 / -.864,0.000/ 0.037,0.000/ -.503,0.000/ 0.503,1.000/    / -.037,0.000/ -.037,0.000/ 0.864,1.000/ 0.864,1.000/
 / 0.037,1.000/ 0.037,1.000/ 0.037,1.000/ -.864,0.000/    / -.864,0.000/ -.037,0.000/ -.503,0.000/ 0.503,1.000/

 STANDARD TIME =  8:30
 / 0.099,1.000/ 0.099,1.000/ 0.099,1.000/ 0.741,1.000/    / 0.741,1.000/ -.099,0.000/ -.099,0.000/ -.741,0.000/
 / -.741,0.000/ -.099,0.000/ -.664,0.000/ 0.664,1.000/    / 0.099,1.000/ 0.099,1.000/ 0.741,1.000/ 0.741,1.000/
 / -.099,0.000/ -.099,0.000/ -.099,0.000/ -.741,0.000/    / -.741,0.000/ 0.099,0.000/ -.664,0.000/ 0.664,1.000/

 STANDARD TIME =  9:30
```

```
/ 0.210,1.000/ 0.210,1.000/ 0.210,1.000/ 0.568,1.000/    / 0.568,1.000/ -.210,0.000/ -.210,0.000/ -.568,0.000/
/ -.568,0.000/ -.210,0.000/ -.796,0.000/ 0.796,1.000/    / 0.210,1.000/ 0.210,1.000/ 0.568,1.000/ 0.568,1.000/
/ -.210,0.000/ -.210,0.000/ -.210,0.000/ -.568,0.000/    / -.568,0.000/ 0.210,0.000/ -.796,0.000/ 0.796,1.000/

STANDARD TIME = 10:30
/ 0.289,1.000/ 0.289,1.000/ 0.289,1.000/ 0.356,1.000/    / 0.356,1.000/ -.289,0.000/ -.289,0.000/ -.356,0.000/
/ -.356,0.000/ -.289,0.000/ -.889,0.000/ 0.889,1.000/    / 0.289,1.000/ 0.289,1.000/ 0.356,1.000/ 0.356,1.000/
/ -.289,0.000/ -.289,0.000/ -.289,0.000/ -.356,0.000/    / -.356,0.000/ 0.289,0.000/ -.889,0.000/ 0.889,1.000/

STANDARD TIME = 11:30
/ 0.329,1.000/ 0.329,1.000/ 0.329,1.000/ 0.119,1.000/    / 0.119,1.000/ -.329,0.000/ -.329,0.000/ -.119,0.000/
/ -.119,0.000/ -.329,0.000/ -.937,0.000/ 0.937,1.000/    / 0.329,1.000/ 0.329,1.000/ 0.119,1.000/ 0.119,1.000/
/ -.329,0.000/ -.329,0.000/ -.329,0.000/ -.119,0.000/    / -.119,0.000/ 0.329,0.000/ -.937,0.000/ 0.937,1.000/

STANDARD TIME = 12:30
/ 0.329,1.000/ 0.329,1.000/ 0.329,1.000/ -.125,0.000/    / -.125,0.000/ -.329,0.000/ -.329,0.000/ 0.125,1.000/
/ 0.125,1.000/ -.329,0.000/ -.936,0.000/ 0.936,1.000/    / 0.329,1.000/ 0.329,1.000/ -.125,0.000/ -.125,0.000/
/ -.329,0.000/ -.329,0.000/ -.329,0.000/ 0.125,1.000/    / 0.125,1.000/ 0.329,0.000/ -.936,0.000/ 0.936,1.000/

STANDARD TIME = 13:30
/ 0.287,1.000/ 0.287,1.000/ 0.287,1.000/ -.361,0.000/    / -.361,0.000/ -.287,0.000/ -.287,0.000/ 0.361,1.000/
/ 0.361,1.000/ -.287,0.000/ -.887,0.000/ 0.887,1.000/    / 0.287,1.000/ 0.287,1.000/ -.361,0.000/ -.361,0.000/
/ -.287,0.000/ -.287,0.000/ -.287,0.000/ 0.361,1.000/    / 0.361,1.000/ 0.287,0.000/ -.887,0.000/ 0.887,1.000/

STANDARD TIME = 14:30
/ 0.208,1.000/ 0.208,1.000/ 0.208,1.000/ -.572,0.000/    / -.572,0.000/ -.208,0.000/ -.208,0.000/ 0.572,1.000/
/ 0.572,1.000/ -.208,0.000/ -.793,0.000/ 0.793,1.000/    / 0.208,1.000/ 0.208,1.000/ -.572,0.000/ -.572,0.000/
/ -.208,0.000/ -.208,0.000/ -.208,0.000/ 0.572,1.000/    / 0.572,1.000/ 0.208,0.000/ -.793,0.000/ 0.793,1.000/

STANDARD TIME = 15:30
/ 0.097,1.000/ 0.097,1.000/ 0.097,1.000/ -.744,0.000/    / -.744,0.000/ -.097,0.000/ -.097,0.000/ 0.744,1.000/
/ 0.744,1.000/ -.097,0.000/ -.661,0.000/ 0.661,1.000/    / 0.097,1.000/ 0.097,1.000/ -.744,0.000/ -.744,0.000/
/ -.097,0.000/ -.097,0.000/ -.097,0.000/ 0.744,1.000/    / 0.744,1.000/ 0.097,0.000/ -.661,0.000/ 0.661,1.000/

STANDARD TIME = 16:30
/ -.040,0.000/ -.040,0.000/ -.040,0.000/ -.866,0.000/    / -.866,0.000/ 0.040,1.000/ 0.040,1.000/ 0.866,1.000/
/ 0.866,1.000/ 0.040,0.000/ -.499,0.000/ 0.499,1.000/    / -.040,0.000/ -.040,0.000/ -.866,0.000/ -.866,0.000/
/ 0.040,1.000/ 0.040,1.000/ 0.040,1.000/ 0.866,1.000/    / 0.866,1.000/ -.040,0.000/ -.499,0.000/ 0.499,1.000/

STANDARD TIME = 17:30
/ -.192,0.000/ -.192,0.000/ -.192,0.000/ -.928,0.000/    / -.928,0.000/ 0.192,1.000/ 0.192,1.000/ 0.928,1.000/
/ 0.928,1.000/ 0.192,0.000/ -.318,0.000/ 0.318,1.000/    / -.192,0.000/ -.192,0.000/ -.928,0.000/ -.928,0.000/
/ 0.192,1.000/ 0.192,1.000/ 0.192,1.000/ 0.928,1.000/    / 0.928,1.000/ -.192,0.000/ -.318,0.000/ 0.318,1.000/

STANDARD TIME = 18:30
/ -.350,0.000/ -.350,0.000/ -.350,0.000/ -.928,0.000/    / -.928,0.000/ 0.350,1.000/ 0.350,1.000/ 0.928,1.000/
/ 0.928,1.000/ 0.350,0.000/ -.131,0.000/ 0.131,1.000/    / -.350,0.000/ -.350,0.000/ -.928,0.000/ -.928,0.000/
/ 0.350,1.000/ 0.350,1.000/ 0.350,1.000/ 0.928,1.000/    / 0.928,1.000/ -.350,0.000/ -.131,0.000/ 0.131,1.000/
```

1. SHADOWING COMBINATIONS: The following information is given for applicable surfaces.

   GRSNR: General receiving surface number (includes EXTERIOR WALLS, ROOFS, EXPOSED FLOORS)

   GSSNR: General shadowing surface number (includes WINGS, OVERHANGS, DETACHED SHADING)

   SBSNR: Subsurface number (includes WINDOWS and DOORS)

   NGSS: Number of general shadowing surfaces

   NBKS: Unknown

   NSBS: Number of subsurfaces on surface

   The surface numbers referred to are those found in the ZONE REPORT. Note that surface 8 is not included in this report since it is a floor.

2. RESULTS OF SHADOWING CALCULATIONS: This report shows the cosine of the angle of incidence and the fraction of surface area which is sunlit for each zone heat transfer surface. These values are printed for each hour of daylight. In this example there are three of these reports: One for a weekday

design day, one for a weekend design day, and fifteen for the annual simulation. For an annual simulation this report is produced for 15 typical days throughout the year.

ZONE LOAD SPLITS REPORT

Produced by specifying LOAD SPLITS in the REPORTS section of RUN CONTROL.

```
ZONE LOADS SPLITS FOR CHANUTE AFB ILLINOIS WINTER

 DATE 21 JAN   (MONDAY   )


  APPROXIMATE Loads Splits By Zone
                        Fraction of Total Sensible Load By:
  Zone   1  Fenestration   Internal Loads   Infiltration   Conduction   Zone Mixing
               0.00%        -48.02%         177.45%        -29.43%        0.00%

  Fraction of the Conduction Load Only (Conduction Only for Windows)
                North           East             South          West
  Walls         28.95%           6.16%           16.83%          6.14%
  Windows       -4.54%          -4.51%           -9.12%         -4.51%
  Doors          0.00%           0.00%           -4.91%          0.00%

  Roof          20.54%
  Floor         48.97%
```

1. The **approximate** fraction, as a percentage, of the total sensible load on each zone due to fenestration, internal loads, infiltration, conduction, and interzone mixing. These percentages are calculated based on the total sensible zone load and the total load due to each load component summed over the design day. Load splits CANNOT be reported for an annual simulation Positive values indicate a load component which adds to the total load. Negative values indicate a load component which subtracts from the total load. If the total load were a heating load then a negative value implies a load component which is adding heat to the zone. In the case of the total load being a cooling load, a negative value implies that the load component is removing heat from the zone. For winter design days, the negative load components would most likely be internal loads and fenestration if solar radiation (direct beam, diffuse, and reflected) is present. Infiltration, conduction, and zone mixing are the components most likely to have negative values for summer design days.

The following values are reported for each design day:

FENESTRATION: The percentage of the total sensible zone load due to solar radiation through the windows.

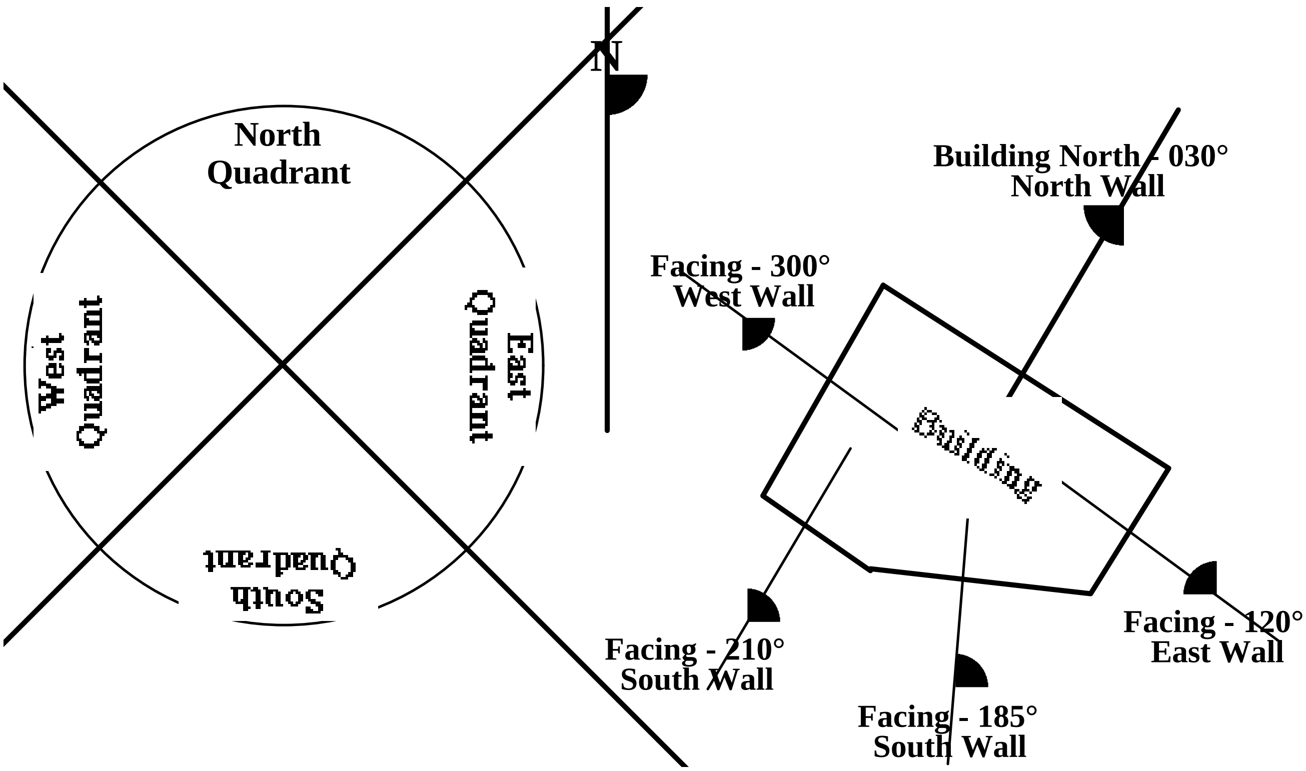
INTERNAL LOADS: The percentage of the total sensible zone load due to lights, people, electrical equipment, etc.

INFILTRATION: The percentage of the total sensible zone load due to infiltration of outside air into the zone.

CONDUCTION: The percentage of the total sensible load due to conduction through the zone surfaces (walls, roofs, floors, etc) and subsurfaces (windows, doors, etc).

ZONE MIXING: The percentage of the total sensible load due to the exchange of air between zones.

2. The conduction load on the zone is broken down by surface or subsurface type and directional orientation on the building, i.e. North, South, East, and West. Because building walls are not always aligned with these directions, each direction should be taken to represent a quadrant ±45° on each side of the nominal direction. This is illustrated below.



The following values are reported for each design day:

WALLS: The percentage of the total sensible load due to conduction through all the walls facing in the specified direction.

WINDOWS: The percentage of the total sensible load due to conduction only through all the windows facing in the specified direction.

DOORS: The percentage of the total sensible load due to conduction through all the doors facing in the specified direction.

ROOF: The percentage of the total sensible load due to conduction through all the roofs on the zone.

FLOOR: The percentage of the total sensible load due to conduction through all the floors in the zone.

PIERCE THERMAL COMFORT REPORT

Produced by specifying PIERCE in the REPORTS section of RUN CONTROL.

```
THERMAL COMFORT REPORT: J.B. PIERCE FOUNDATION TWO NODE MODEL

          SAMPLE OUTPUT



0LOCATION:  CHANUTE AFB, ILLINOIS 1440 1957
0ZONE:      1    ZONE 1                                     SAMPLE
0ENVIRONMENT   ANY DAY                                        1 DAYS

 DATE 21 JUL   (MONDAY )

                                         RATE   PARTIAL    MEAN  CALC MEAN           BODY       PRED
               METAB   CLOTHING   AIR     OF   PRESSURE OF  AIR   RADIANT   SKIN     CORE       MEAN  DI
   TIME        RATE      INSUL  VELOCITY  WORK WATER VAPOR  TEMP    TEMP    TEMP     TEMP       VOTE

    HR      BTU/HR*FT2   CLO     FT/MIN BTU/HR*FT2 IN-H2O  DEG. F   DEG. F  DEG. F   DEG. F      ET

     1         18.46     1.00    26.97     0.00     4.66    78.00   123.64   97.14    98.63     2.93
     2         18.46     1.00    26.97     0.00     4.66    78.00   123.65   97.14    98.63     2.93
     3         18.46     1.00    26.97     0.00     4.66    78.00   123.59   97.14    98.63     2.93
     4         18.46     1.00    26.97     0.00     4.66    78.00   123.50   97.14    98.63     2.93
     5         18.46     1.00    26.97     0.00     4.66    78.00   123.38   97.13    98.63     2.92
     6         18.46     1.00    26.97     0.00     4.66    78.00   123.34   97.13    98.63     2.92
     7         18.46     1.00    26.97     0.00     4.66    78.00   122.73   97.10    98.62     2.88
     8         18.46     1.00    26.97     0.00     4.66    78.00   121.50   97.03    98.60     2.80
     9         18.46     1.00    26.97     0.00     4.66    78.00   120.01   96.95    98.59     2.75
    10         18.46     1.00    26.97     0.00     4.66    78.00   119.20   96.90    98.58     2.71
    11         18.46     1.00    26.97     0.00     4.66    78.00   120.90   97.00    98.60     2.80
    12         18.46     1.00    26.97     0.00     4.66    78.00   119.85   96.94    98.58     2.72
    13         18.46     1.00    26.97     0.00     4.66    78.00   119.45   96.92    98.58     2.71
    14         18.46     1.00    26.97     0.00     4.66    78.00   119.29   96.91    98.58     2.71
    15         18.46     1.00    26.97     0.00     4.66    78.00   119.63   96.93    98.58     2.72
    16         18.46     1.00    26.97     0.00     4.66    78.00   121.50   97.03    98.60     2.80
    17         18.46     1.00    26.97     0.00     4.66    78.00   122.50   97.08    98.62     2.88
    18         18.46     1.00    26.97     0.00     4.66    78.00   122.05   97.06    98.61     2.84
    19         18.46     1.00    26.97     0.00     4.66    78.00   121.78   97.05    98.61     2.84
    20         18.46     1.00    26.97     0.00     4.66    78.00   121.40   97.02    98.60     2.80
    21         18.46     1.00    26.97     0.00     4.66    78.00   122.10   97.06    98.61     2.84
    22         18.46     1.00    26.97     0.00     4.66    78.00   123.03   97.11    98.62     2.89
    23         18.46     1.00    26.97     0.00     4.66    78.00   123.39   97.13    98.63     2.93
    24         18.46     1.00    26.97     0.00     4.66    78.00   123.63   97.14    98.63     2.93
0MAX:          18.46     1.00    26.97     0.00     4.66    78.00   123.65   97.14    98.63     2.93
0MIN:          18.46     1.00    26.97     0.00     4.66    78.00   119.20   96.90    98.58     2.71
0AVG:          18.46     1.00    26.97     0.00     4.66    78.00   121.88   97.05    98.61     2.84
```

1. This report list the hour by hour thermal comfort indices for all design day environments

   TIME: The time of day.

   METAB: The metabolic rate.

   ICL: The clothing insulation in "clo".

   VEL: The air velocity.

   WORK: The rate of doing work.

   PA: Partial pressure of the water vapor in the zone.

   MAT: The Mean Air Temperature.

   CMRT: Calculate Mean Radiant Temperature

   TSK: The skin temperature.

TCR: The body core temperature.

PMV(ET): The PMV calculated with ET.

DISC: The discomfort index.

PMV(SET): The PMV calculated with SET.

TSEMS: The thermal sensation index

KSU THERMAL COMFORT REPORT

Produced by specifying KSU in the REPORTS section of RUN CONTROL.

```
0THERMAL COMFORT REPORT: KANSAS STATE UNIVERSITY TWO NODE MODEL
          SAMPLE OUTPUT



0LOCATION:  CHANUTE AFB, ILLINOIS 1440 1957
0ZONE:      1    ZONE 1                                       SAMPLE
0ENVIRONMENT   ANY DAY                                          1 DAYS

 DATE 21 JUL   (MONDAY )

                                     RATE   PARTIAL    MEAN  CALC MEAN          BODY
              METAB   CLOTHING   AIR      OF  PRESSURE OF  AIR    RADIANT   SKIN    CORE     SKIN   WE
   TIME        RATE      INSUL  VELOCITY   WORK WATER VAPOR  TEMP    TEMP     TEMP    TEMP    WETNESS   F

    HR      BTU/HR*FT2   CLO     FT/MIN BTU/HR*FT2 IN-H2O  DEG. F   DEG. F   DEG. F   DEG. F     ---

     1         18.46     1.00    26.97     0.00      4.66    78.00   123.64   95.69    98.56     0.45
     2         18.46     1.00    26.97     0.00      4.66    78.00   123.65   95.70    98.56     0.45
     3         18.46     1.00    26.97     0.00      4.66    78.00   123.59   95.69    98.56     0.45
     4         18.46     1.00    26.97     0.00      4.66    78.00   123.50   95.69    98.56     0.45
     5         18.46     1.00    26.97     0.00      4.66    78.00   123.38   95.68    98.56     0.45
     6         18.46     1.00    26.97     0.00      4.66    78.00   123.34   95.68    98.56     0.45
     7         18.46     1.00    26.97     0.00      4.66    78.00   122.73   95.64    98.56     0.45
     8         18.46     1.00    26.97     0.00      4.66    78.00   121.50   95.57    98.55     0.44
     9         18.46     1.00    26.97     0.00      4.66    78.00   120.01   95.48    98.54     0.43
    10         18.46     1.00    26.97     0.00      4.66    78.00   119.20   95.42    98.54     0.43
    11         18.46     1.00    26.97     0.00      4.66    78.00   120.90   95.54    98.55     0.44
    12         18.46     1.00    26.97     0.00      4.66    78.00   119.85   95.47    98.54     0.43
    13         18.46     1.00    26.97     0.00      4.66    78.00   119.45   95.44    98.54     0.43
    14         18.46     1.00    26.97     0.00      4.66    78.00   119.29   95.43    98.54     0.43
    15         18.46     1.00    26.97     0.00      4.66    78.00   119.63   95.45    98.54     0.43
    16         18.46     1.00    26.97     0.00      4.66    78.00   121.50   95.57    98.55     0.44
    17         18.46     1.00    26.97     0.00      4.66    78.00   122.50   95.63    98.56     0.45
    18         18.46     1.00    26.97     0.00      4.66    78.00   122.05   95.60    98.55     0.44
    19         18.46     1.00    26.97     0.00      4.66    78.00   121.78   95.59    98.55     0.44
    20         18.46     1.00    26.97     0.00      4.66    78.00   121.40   95.57    98.55     0.44
    21         18.46     1.00    26.97     0.00      4.66    78.00   122.10   95.61    98.55     0.45
    22         18.46     1.00    26.97     0.00      4.66    78.00   123.03   95.66    98.56     0.45
    23         18.46     1.00    26.97     0.00      4.66    78.00   123.39   95.68    98.56     0.45
    24         18.46     1.00    26.97     0.00      4.66    78.00   123.63   95.69    98.56     0.45
0MAX:          18.46     1.00    26.97     0.00      4.66    78.00   123.65   95.70    98.56     0.45
0MIN:          18.46     1.00    26.97     0.00      4.66    78.00   119.20   95.42    98.54     0.43
0AVG:          18.46     1.00    26.97     0.00      4.66    78.00   121.88   95.59    98.55     0.44
```

1. This report list the hour by hour thermal comfort indices for all design day environments

TIME: The time of day.

METAB: The metabolic rate.

ICL: The clothing insulation in "clo".

VEL: The air velocity.

WORK: The rate of doing work.

PA: Partial pressure of the water vapor in the zone.

MAT: The Mean Air Temperature.

CMRT: Calculated Mean Radiant Temperature

TSK: The skin temperature.

TCR: The body core temperature.

ESW: The skin wetness factor.

WET: The skin wettedness.

EVC: The vasoconstriction factor.

TSV: The thermal sensation vote.

FANGER THERMAL COMFORT REPORT

Produced by specifying FANGER in the REPORTS section of RUN CONTROL.

```
0THERMAL COMFORT REPORT: FANGER MODEL - PREDICTION OF MEAN VOTE
          SAMPLE OUTPUT



0LOCATION:  CHANUTE AFB, ILLINOIS 1440 1957
0ZONE:      1    ZONE 1                                        SAMPLE
0ENVIRONMENT   ANY DAY                                           1 DAYS

 DATE 21 JUL   (MONDAY )
```

TIME	METAB RATE	RATE OF WORK	PARTIAL PRESSURE OF WATER VAPOR	MEAN AIR TEMP	CALC MEAN RADIANT TEMP	CLOTHING INSULATION
HR	BTU/HR*FT2	BTU/HR*FT2	IN-H2O	DEG. F	DEG. F	CLO
1	18.46	0.00	4.66	78.0	123.6	1.00
2	18.46	0.00	4.66	78.0	123.6	1.00
3	18.46	0.00	4.66	78.0	123.6	1.00
4	18.46	0.00	4.66	78.0	123.5	1.00
5	18.46	0.00	4.66	78.0	123.4	1.00
6	18.46	0.00	4.66	78.0	123.3	1.00
7	18.46	0.00	4.66	78.0	122.7	1.00
8	18.46	0.00	4.66	78.0	121.5	1.00
9	18.46	0.00	4.66	78.0	120.0	1.00
10	18.46	0.00	4.66	78.0	119.2	1.00
11	18.46	0.00	4.66	78.0	120.9	1.00
12	18.46	0.00	4.66	78.0	119.8	1.00
13	18.46	0.00	4.66	78.0	119.5	1.00
14	18.46	0.00	4.66	78.0	119.3	1.00
15	18.46	0.00	4.66	78.0	119.6	1.00
16	18.46	0.00	4.66	78.0	121.5	1.00
17	18.46	0.00	4.66	78.0	122.5	1.00
18	18.46	0.00	4.66	78.0	122.1	1.00
19	18.46	0.00	4.66	78.0	121.8	1.00
20	18.46	0.00	4.66	78.0	121.4	1.00
21	18.46	0.00	4.66	78.0	122.1	1.00
22	18.46	0.00	4.66	78.0	123.0	1.00
23	18.46	0.00	4.66	78.0	123.4	1.00
24	18.46	0.00	4.66	78.0	123.6	1.00
0 MAX:	18.46	0.00	4.66	78.0	123.6	1.00
0 MIN:	18.46	0.00	4.66	78.0	119.2	1.00
0 AVG:	18.46	0.00	4.66	78.0	121.9	1.00

1. This report list the hour by hour thermal comfort indices for all design day environments

   TIME: The time of day.

   METAB: The metabolic rate.

   ICL: The clothing insulation in "clo".

   VEL: The air velocity.

   WORK: The rate of doing work.

   PA: Partial pressure of the water vapor in the zone.

   MAT: The Mean Air Temperature.

   CMRT: The Calculated Mean Radiant Temperature.

FCL: The ratio of the surface area of the clothed body to that of the nude body.

PMV: The predicted mean vote.

ZONE GROUP LOADS

Included in the default review summary report and can be produced separately by specifying ZONE GROUP in the REPORTS section of RUN CONTROL.

```
ZONE GROUP LOADS FOR CHANUTE AFB ILLINOIS WINTER

 DATE 21 JAN   (MONDAY   )

    NUMBER         NAME                            MULTIPLIER

  1      1  ZONE 1                                      1
  2      2  ZONE 2                                      1


          TOTAL       TOTAL       TOTAL       PEAK        PEAK        PEAK        MAX         MIN
       CONVECTIVE    RADIANT    SENSIBLE   CONVECTIVE    RADIANT    SENSIBLE      TEMP        TEMP
         HEATER      HEATER     COOLING      HEATER      HEATER     COOLING
  ZONE    LOAD        LOAD        LOAD        LOAD        LOAD        LOAD

         1000BTU     1000BTU     1000BTU   1000BTU/HR  1000BTU/HR  1000BTU/HR    DEG. F      DEG. F

     1   2.306E+03   0.000E+00   0.000E+00   1.563E+02   0.000E+00   0.000E+00     68.65       68.02
     2   2.133E+03   0.000E+00   0.000E+00   1.858E+02   0.000E+00   0.000E+00     76.96       68.02

 GROUP:  4.439E+03   0.000E+00   0.000E+00   3.318E+02   0.000E+00   0.000E+00     76.96       68.02

 PEAK DATES (MO/DY/HR):                       1/21/ 6     1/21/ 1     1/21/ 1     1/21/17     1/21/24

 TOTAL ITERATIONS =   216
 DID NOT CONVERGE =     0
```

1. The simulated environment and simulation period day type (weekday, weekend, etc.) are indicated here.
2. NUMBER: The first number is the sequential zone number, the second number is the user supplied zone number.

   NAME: Zone name specified in input.

   MULTIPLIER: Zone multiplier used to model identical zones. Default is 1.
3. For each zone the following is given:

   TOTAL HEATING: Zone sensible heating load.

   TOTAL COOLING: Zone sensible cooling load.

   PEAK HEATING: Maximum heating energy per hour.

   PEAK COOLING: Maximum cooling energy per hour.

   MAX TEMP: Maximum zone temperature during simulation.

   MIN TEMP: Minimum zone temperature during simulation.

   GROUP: This row gives total values for the entire building.

   PEAK DATES: The dates of PEAK HEATING, PEAK COOLING, MAX TEMP, and MIN TEMP are identified.

TOTAL ITERATIONS: BLAST iterates several times each hour. This number is the total number of iterations for this simulation period. Initialization iterations are included.

DID NOT CONVERGE: BLAST has a limit to the number of iterations in a given hour. This number is the number of hours in which the limit was exceeded. The value should be zero.

ZONE LOADS REPORT

Produced by specifying ZONE LOADS in the REPORTS section of RUN CONTROL.

```
LOCATION:  CHANUTE AFB, ILLINOIS 1440 1957
0ZONE:      1    ZONE 1                                       SAMPLE
0ENVIRONMENT   ANY DAY                                          1 DAYS

 DATE 21 JUL   (MONDAY   )
0 HR     HEATING    COOLING    LATENT    RETURN AIR  BASEBOARD  ELECTRIC     GAS      INFILT     INFIL
          LOAD       LOAD       LOAD     HEAT GAIN     LOAD       LOAD      LOAD    HEAT LOSS  HEAT G
         1000BTU    1000BTU    1000BTU    1000BTU    1000BTU    1000BTU    1000BTU    1000BTU    1000B

   1    0.000E+00  3.688E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   2    0.000E+00  3.693E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   3    0.000E+00  3.682E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   4    0.000E+00  3.661E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   5    0.000E+00  3.636E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   6    0.000E+00  3.628E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   7    0.000E+00  2.947E+00  7.693E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   8    0.000E+00  1.846E+00  4.808E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
   9    0.000E+00  6.835E-01  1.923E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  10    0.000E+00  4.885E-01  1.923E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  11    0.000E+00  2.508E+00  7.693E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  12    0.000E+00  6.329E-01  1.923E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  13    0.000E+00  5.237E-01  1.923E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  14    0.000E+00  4.773E-01  1.923E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  15    0.000E+00  8.227E-01  2.885E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  16    0.000E+00  2.609E+00  7.693E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  17    0.000E+00  2.843E+00  7.693E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  18    0.000E+00  1.923E+00  4.808E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  19    0.000E+00  1.860E+00  4.808E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  20    0.000E+00  1.777E+00  4.808E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  21    0.000E+00  2.764E+00  7.693E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  22    0.000E+00  3.535E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  23    0.000E+00  3.625E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
  24    0.000E+00  3.687E+00  9.617E+00  0.000E+00  0.000E+00  1.000E+02  0.000E+00  0.000E+00  0.000E
0TOT    0.000E+00  5.754E+01  1.568E+02  0.000E+00  0.000E+00  2.400E+03  0.000E+00  0.000E+00  0.000E
0HEATING LOAD = 0.000E+00 1000BTU   /FT**2    COOLING LOAD = 5.754E-01 1000BTU   /FT**2    ZONE FLOOR
LOADS AND TEMPERATURES:
     MAX HEATING LOAD =  0.000E+00 1000BTU/HR AT HOUR 24 WITH ZONE AIR TEMP OF  78.00 DEG. F
     MAX COOLING LOAD =  3.693E+00 1000BTU/HR AT HOUR  2 WITH ZONE AIR TEMP OF  78.00 DEG. F
     MAX ZONE AIR TEMP =   78.00 DEG. F     AT HOUR 24
     MIN ZONE AIR TEMP =   78.00 DEG. F     AT HOUR 24

0ZONE LOADS REPORT

          SAMPLE OUTPUT
```

1. The location, the zone name, the building name, the environment and the simulation period is identified for each report. A report will be printed for each zone for each environment simulation type. Using the examples, you can see or produce three ZONE LOADS REPORTS (a weekday design day, weekend design day, and a one year weather tape simulation).

2. For each hour of a design day the following is reported:

   HEATING LOAD: Zone sensible heating load for that hour.

   COOLING LOAD: Zone sensible cooling load for that hour.

LATENT LOAD: Energy required to vaporize moisture released from PEOPLE and EQUIPMENT. This moisture is added to the zone air during the fan system simulation.

RETURN AIR HEAT GAIN: Lighting energy released into return air rather than zone. Specified by PERCENT RETURN AIR in LIGHTS command.

BASEBOARD LOAD: Energy used by outside temperature-controlled baseboard heating.

ELECTRIC LOAD: Energy used for lighting, electrical equipment and ventilation fan.

GAS LOAD: Energy used for gas equipment.

INFILT HEAT LOSS: Heat loss due to infiltration (applicable only when there is a heating load).

INFILT HEAT GAIN: Heat gain due to infiltration (applicable only when there is a cooling load.)

MAT: Zone mean air temperature.

ODB: Outside dry bulb temperature.

OWB: Outside wet bulb temperature.

Daily totals are given for the loads. These total values should equal the value reported in the ZONE GROUP LOADS.

3. The total heating and cooling loads are reported per zone floor area. The zone floor area is also indicated.

   MAX HEATING LOAD: The maximum hourly heating load (Btu/hr or kW) of the design day is reported along with the zone air temperature at that hour.

   MAX COOLING LOAD: The maximum hourly cooling load (Btu/hr or kW) of the design day is reported along with the zone air temperature at that hour.

   MAX ZONE AIR TEMP: The maximum zone air temperature along with the hour at which it occurred is reported.

   MIN ZONE AIR TEMP: The minimum zone air temperature along with the hour at which it occurred is reported.

   The above loads and temperatures should be the same as those reported in the ZONE GROUP LOADS.

4. For an annual simulation the ZONE LOADS REPORT is slightly different than for a design day. The energy loads are reported for each month of the year. The totals are for an entire year.

   SYSTEM STATUS:

   H-EX: Number of hours that heating exceeds 99% of heating capacity.

   H-ON: Number of hours heating is on and capacity not exceeded.

   Note -- The sum of H-EX AND H-ON Gives the total hours heating is on.

VENT: Number of hours that ventilation is on. Note that ventilation cannot be on when heating or cooling is on.

C-ON: Number of hours cooling is on and capacity not exceeded.

C-EX: Number of hours cooling exceeds 99% of cooling capacity.

Note - The sum of C-ON and C-EX gives the total hours cooling is on.

ASHRAE HEATING LOADS CALCULATION REPORT

Produced by specifying ASHRAE HEATING LOAD CALCULATION in the REPORTS section of RUN CONTROL.

```
 ASHRAE HEATING LOADS CALCULATION REPORT

 ZONE NUMBER     1  ZONE NAME ZONE 1                                   BUILDING TITLE REPORT

 SURFACE TYPE                  SURFACE AREA   U-VALUE    ZONE TEMP  OPPOSITE TEMP HEAT TRANSFER
                                   FT**2     B/H*F**2*R    DEG. F      DEG. F       1000BTU/HR

   EXTERIOR WALL                    496.0       0.104      78.00        30.00       2.467E+00
   WINDOW                            40.3       1.218      78.00        30.00       2.355E+00
   DOOR                              63.7       0.524      78.00        30.00       1.601E+00
   EXTERIOR WALL                    182.0       0.104      78.00        30.00       9.050E-01
   WINDOW                            20.0       1.218      78.00        30.00       1.169E+00
   EXTERIOR WALL                    319.8       0.104      78.00        30.00       1.590E+00
   WINDOW                            20.2       1.218      78.00        30.00       1.178E+00
   EXTERIOR WALL                    182.0       0.104      78.00        30.00       9.050E-01
   WINDOW                            20.0       1.218      78.00        30.00       1.169E+00
   INTERZONE PARTITION              260.0       0.296      78.00        77.00       7.685E-02
   SLAB ON GRADE FLOOR             1211.0       0.089      78.00        55.00       2.475E+00
   ROOF                            1211.0       0.126      78.00        30.00       7.307E+00

 INFILTRATION RATE=    900.0 FT**3/MIN     DELTA TEMP= 48.00 DEG. F        LOAD DUE TO INFILTRATION =  4.641E+01
1000BTU/HR

 TOTAL ZONE LOAD =  6.961E+01 1000BTU/HR    CONDUCTION LOAD =  2.320E+01 1000BTU/HR

 ASHRAE HEATING LOADS CALCULATION REPORT

COMPARISON OF ASHRAE METHOD TO BLAST

 LOCATION:  CHANUTE AFB, ILLINOIS 1440 1957
 ENVIRONMENT   CHANUTE AFB ILLINOIS WINTER

 DATE 21 JAN   (MON)

           ASHRAE GROUND                BLAST GROUND
            TEMPERATURE                  TEMPERATURE
            55.00 DEG. F                54.00 DEG. F

           ASHRAE OUTDOOR               BLAST OUTDOOR        DEGREE
         DESIGN TEMPERATURE            LOW TEMPERATURE       RANGE
             30.00 DEG. F                 0.00 DEG. F      0.00 DEG. F

  ZONE   ASHRAE PEAK     ASHRAE    BLAST PEAK     BLAST       HOUR OF
 NUMBER    HEATING    TEMPERATURE   HEATING   TEMPERATURE     BLAST
         1000BTU/HR     DEG. F     1000BTU/HR    DEG. F        PEAK

    1    6.961E+01       78.00     1.563E+02      68.02         16
```

ASHRAE Heating Load Report

General Syntax and Parameters

This report is specified in the RUN CONTROL block (See Chapter 3):

REPORTS (ASHRAE HEATING LOAD CALCULATION),

Global parameters, which apply to the entire building, are specified in the BUILDING DESCRIPTION block; they appear below with their default values:

BEGIN BUILDING DESCRIPTION:

ASHRAE HEATING OUTDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INFILTRATION = 0.0; (ft^3/min, m^3/s)

ASHRAE HEATING GROUND TEMPERATURE = 55; (°F, °C)

ZONE 1 ...

The ASHRAE HEATING OUTDOOR TEMPERATURE and INDOOR TEMPERATURE *must* be specified; there are no default values. The ASHRAE HEATING GROUND TEMPERATURE should be specified if the building has any SLAB ON GRADE FLOORS or any BASEMENT WALLS.

Zone parameters may be used to override the global parameters for a given zone.

ZONE 1 ...

ASHRAE HEATING INDOOR TEMPERATURE = (none); (°F, °C)

ASHRAE HEATING INFILTRATION = 0.0; (ft^3/min, m^3/s)

END ZONE;

If a zone parameter is not specified, the value of the global parameter will be used for that zone. ASHRAE HEATING OUTDOOR TEMPERATURE and ASHRAE HEATING GROUND TEMPERATURE cannot be overridden.

Description of Calculations

To arrive at a conduction load for a given zone, BLAST calculates UAΔT for each surface, and adds these loads together. For each surface:

conduction load = UAΔT

where: U = U-value of the surface

A = area of the surface

ΔT = the difference in temperature across the surface.

The area is calculated from the input geometry. The U-value is also calculated from input but it may differ slightly from the value in the DESCRIPTION OF ZONE report because a radiation film coefficient is used as specified in the ASHRAE method. For outside walls and roofs, ΔT is the difference between the ASHRAE HEATING INDOOR TEMPERATURE and the ASHRAE HEATING OUTDOOR TEMPERATURE. For SLAB ON GRADE FLOORS and BASEMENT WALLS, ΔT is the difference between the ASHRAE HEATING INDOOR TEMPERATURE and the ASHRAE HEATING GROUND TEMPERATURE. For interzone surfaces, ΔT is the difference between the ASHRAE HEATING INDOOR TEMPERATURES for the two adjacent zones. For non-interzone interior surfaces (partitions, ceilings, floors), the ΔT is zero.

The infiltration load for each zone is calculated as follows:

$$\text{Infiltration} = Q \rho C_p \Delta T$$

where: Q = input infiltration flow rate,

ρ = density of the outside air,

C_p = specific heat of the outside air,

ΔT = the difference between the outdoor and indoor temperature.

The conduction loads for each surface are then added to the infiltration loads for each zone to arrive at a total zone load. The total ASHRAE zone load is then compared with the peak BLAST load for each design day.

DESIGN SYSTEM REPORT SUMMARY

See Also:

User Reference:Optional System Reports

User Reference:Design Systems

Produced by default when the DESIGN SYSTEMS option is selected in RUN CONTROL.

```
***************************************************************************
**                                                                       **
**      S Y S T E M   D E S I G N   R E P O R T   S U M M A R Y          **
**                                                                       **
***************************************************************************


   PROJECT  REPORT EXAMPLES


                                    (HBLC) 2000 1196


   SYSTEM NUMBER        1  SYSTEM TITLE DDVAV

   SYSTEM TYPE DUAL DUCTVAV

   USER INPUT PARAMETERS

       DESIGN DELTA           DESIGN
      TEMPERATURE DEG.      AIR VOLUME
    HEATING     COOLING     COEFFICIENT
    -------------------     -----------
      70.00       20.00        1.00


                    DESIGN AIR    DESIGN ZONE      DESIGN ZONE     LOAD TYPE
  ZONE     ZONE      QUANTITY    SENSIBLE LOAD    SENSIBLE LOAD    FOR DESIGN
   NO   MULTIPLIER                  COOLING          HEATING      AIR QUANTITY
                    FT**3/MIN     1000BTU/HR       1000BTU/HR
  ----  ----------  ----------   --------------   --------------  ------------

    1     1.0       1.0122E+04       2.1748E+02       1.5592E+02     COOLING
    2     1.0       1.4694E+04       3.1572E+02       2.2049E+02     COOLING


   NOTE ***
   USE OF THE DESIGN SYSTEM AND DESIGN PLANT FEATURES CAUSE A SIMULATION BASED
   ON THE USER SUPPLIED PARAMETERS (I.E., SUPPLY AIR TEMPERATURE DIFFERENCES,
   COIL CONTROL TYPE, CONTROLLER THROTTLING RANGES, ETC.).  WHEN MAKING
   ALTERNATIVE STUDIES WITH THIS OPTION COMPARISON OF LIFE CYCLE COSTS MAY BE
   ERRONEOUS DUE TO DIFFERENT CAPITAL COSTS ASSOCIATED WITH SIZING OF CENTRAL
   PLANT COMPONENTS.  WHEN SIMULATING THE PERFORMANCE OF EXISTING BUILDINGS
   ACTUAL CONDITIONS SHOULD BE ENTERED, AND ALTERNATIVE STUDIES SHOULD BE BASED
   ON INTENDED ALTERATIONS.
```

1. Input file parameters are reported for easy reference and include the project title; the system number, type, and title; the design temperature differentials for the heating and cooling coils; and the design air volume coefficient (safety factor for sizing the maximum supply air flow rate).
2. Results for the DESIGN SYSTEMS run are presented for all of the zones of this fan system.
   - ZONE MULTIPLIER **-** User supplied zone multiplier used to account for identical zones.
   - DESIGN AIR QUANTITY **-** The calculated supply air flow rate for the zone in units of ft³/min or m³/s.

     DESIGN ZONE SENSIBLE LOAD (COOLING) **-** The peak sensible cooling load for the zone in units of kBtu/h or kW.
   - DESIGN ZONE SENSIBLE LOAD (HEATING) **-** The peak sensible heating load for the zone in units of kBtu/h or kW.
   - LOAD TYPE FOR DESIGN AIR QUANTITY **-** The design air quantity is the maximum of the value defined by the peak heating load or the peak cooling load. This reports which load type produced the greater design air flow rate. In the case shown above, the COOLING load produces a higher design air flow rate. A note is also made in this case that the thermostatic baseboard will meet the heating demands of the zone.

AIR HANDLING SYSTEM DESCRIPTION

Produced by specifying SYSTEM in the REPORTS section of RUN CONTROL.

```
***************************************************************************
**                                                                      **
**    A I R   H A N D L I N G   S Y S T E M   D E S C R I P T I O N    **
**                                                                      **
***************************************************************************


  SYSTEM NUMBER=         1, DDVAV

  TYPE SYS = DUAL DUCTVAV              NO. DISTINCT ZONES ON SYS. =    1



  TOTAL SUPPLY  FAN PRESSURE =    2.49783     IN-H2O
  TOTAL RETURN  FAN PRESSURE =    0.00000     IN-H2O
  TOTAL EXHAUST FAN PRESSURE =    1.00396     IN-H2O


  SUPPLY  FAN EFFICIENCY =   0.70
  RETURN  FAN EFFICIENCY =   0.70
  EXHAUST FAN EFFICIENCY =   0.70

  MIXED AIR CONTROL = FIXED PERCENT
  DESIRED MIXED AIR TEMPERATURE = COLD DECK TEMP

  HOT DECK  CONTROL = FIXED SET POINT
  HOT DECK  THROTTLING RANGE =    7.20000     DEG. F
  HOT DECK  FIXED TEMPERATURE =  140.00000     DEG. F

  HEATING COIL CAPACITY =  0.341E+07     1000BTU/HR
  HEATING COIL ENERGY SUPPLY =  HOT WATER
```

```
 COLD DECK CONTROL = FIXED SET POINT
 COLD DECK THROTTLING RANGE =    7.20000     DEG. F
 COLD DECK FIXED TEMPERATURE =   55.04000     DEG. F

                            ZONE DATA SUMMARY

 ZONE      ZONE        ZONE        ZONE        ZONE        ZONE        ZONE        ZONE
NUMBER    SUPPLY     EXHAUST      REHEAT      REHEAT     TSTAT BB    TSTAT BB      MULT
          AIR VOL    AIR VOL      CAPCTY      ENERGY      CAPCTY      ENERGY
     1   2.000E+03   0.000E+00   0.000E+00   HOT WATER   0.000E+00   HOT WATER       1.0

 TOTAL DESIGN SUPPLY AIR VOLUME =  2.000E+03
```

1. Reported here are all input values for the fan system descriptions including values specified by the user as well as those supplied as defaults by the program. User specifications are input as OTHER SYSTEM PARAMETERS. These values are all defaults.

   Note that this report is not very sophisticated. It lists the same set of parameters for all system types. This means that many of the listed parameters may not apply to the type of system being simulated.

2. ZONE DATA SUMMARY: The following values are specified for each zone supplied by the system.

ZONE SUPPLY AIR VOLUME: Zone air flow rate (ft^3/min or m^3/s) under peak conditions may be specified by user or calculated by DESIGN SYSTEM.

ZONE EXHAUST AIR VOLUME: The amount of air (ft^3/min or m^3/s) which will be removed directly from the zone (without heat recovery) whenever the fan system is in operation. BLAST will always verify that the supply air volume, whether fixed or variable, is equal to or greater than the exhaust air volume.

ZONE REHEAT CAPACITY: Input by user in kBtu/hr (or kW) or defaults to 0. Applies only to terminal reheat, variable volume with reheat, subzone reheat, unit ventilator, unit heater, or two/four pipe induction systems.

ZONE REHEAT ENERGY: Source of energy for REHEAT. Is one of HOT WATER, STEAM, ELECTRIC, or GAS. The default is HOT WATER.

ZONE TSTAT BB CAPACITY: Baseboard heat capacity, specified in kBtu/hr (or kW), for thermostatically controlled baseboard heat. This can only be used with Single Duct VAV Systems. This differs from reheat in that it does not require air flow through fan system to operate at full capacity. Both BASEBOARD HEAT CAPACITY and REHEAT CAPACITY cannot be specified for the same zone.

ZONE TSTAT BB ENERGY: Source of energy for BASEBOARD HEAT. Is one of HOT WATER, STEAM, ELECTRIC, or GAS. The default is HOT WATER.

ZONE MULTIPLIER: This is used to simulate identical or nearly identical zones, without redundant load calculations. Specified by user or defaults to 1.0.

TOTAL DESIGN SUPPLY AIR VOLUME: The sum of all ZONE SUPPLY AIR VOL's (ft^3/min or m^3/s).

AIR HANDLING SYSTEM ENERGY USE SUMMARY

Produced by specifying AHS Usage Summary in the REPORTS section of RUN CONTROL.

SYSTEM NUMBER= 1, MULTIZONE
DESIGN DAY ANY DAY SIMULATION DATE 21JUL1990 (MONDAY

E L E C T R I C I T Y

HOUR	BUILDING ELECTRIC CONSUMPTION (BTU)	BUILDING ELECTRIC PEAK DEMAND (BTU/HR)	SYSTEM EQUIPMENT CONSUMPTION (BTU)	SYSTEM EQUIPMENT PEAK DEMAND (BTU/HR)	ELECTRIC HEATING CONSUMPTION (BTU)	ELECTRIC HEATING PEAK DEMAND (BTU/HR)	TOTA CONSUMPTION (BTU)
1	2.000E+05	2.000E+05	5.865E+02	5.865E+02	0.000E+00	0.000E+00	2.006E+05
2	2.000E+05	2.000E+05	5.865E+02	5.865E+02	0.000E+00	0.000E+00	2.006E+05
3	2.000E+05	2.000E+05	5.862E+02	5.862E+02	0.000E+00	0.000E+00	2.006E+05
4	2.000E+05	2.000E+05	5.857E+02	5.857E+02	0.000E+00	0.000E+00	2.006E+05
5	2.000E+05	2.000E+05	5.850E+02	5.850E+02	0.000E+00	0.000E+00	2.006E+05
6	2.000E+05	2.000E+05	5.851E+02	5.851E+02	0.000E+00	0.000E+00	2.006E+05
7	2.000E+05	2.000E+05	5.714E+02	5.714E+02	0.000E+00	0.000E+00	2.006E+05
8	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
9	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
10	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
11	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
12	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
13	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
14	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
15	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
16	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
17	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
18	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
19	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
20	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
21	2.000E+05	2.000E+05	5.677E+02	5.677E+02	0.000E+00	0.000E+00	2.006E+05
22	2.000E+05	2.000E+05	5.804E+02	5.804E+02	0.000E+00	0.000E+00	2.006E+05
23	2.000E+05	2.000E+05	5.848E+02	5.848E+02	0.000E+00	0.000E+00	2.006E+05
24	2.000E+05	2.000E+05	5.863E+02	5.863E+02	0.000E+00	0.000E+00	2.006E+05
TOT	4.800E+06	2.000E+05	1.379E+04	5.865E+02	0.000E+00	0.000E+00	4.814E+06

HOUR	GAS TOTAL USE CONSUMPTION (BTU)	GAS TOTAL USE PEAK DEMAND (BTU/HR)	STEAM TOTAL USE CONSUMPTION (BTU)	STEAM TOTAL USE PEAK DEMAND (BTU/HR)	HOT WATER TOTAL USE CONSUMPTION (BTU)	HOT WATER TOTAL USE PEAK DEMAND (BTU/HR)	COOLING COI TOTA CONSUMPTION (BTU)
1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.910E+04
2	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.903E+04
3	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.889E+04
4	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.872E+04
5	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.857E+04
6	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.865E+04
7	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.529E+04
8	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.641E+03
9	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	7.841E+03
10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.969E+03
11	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.001E+04
12	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.166E+03
13	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.286E+03
14	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.389E+03
15	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.354E+03
16	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.350E+04
17	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.569E+04
18	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.061E+04
19	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.013E+04
20	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.512E+03
21	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.461E+04
22	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.859E+04
23	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.898E+04
24	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.919E+04
TOT	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.197E+05

```
|SYSTEM NUMBER=         1, MULTIZONE
|          SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957          SIMULATION PERIOD  1JAN1957 - 31DE(
|0                                                E L E C T R I C I T Y
|0     MONTH           BUILDING ELECTRIC                   FANS                     HEATING                   TO
|               CONSUMPTION   PEAK DEMAND   CONSUMPTION   PEAK DEMAND   CONSUMPTION   PEAK DEMAND   CONSUMPTION
|                  (BTU)        (BTU/HR)        (BTU)        (BTU/HR)        (BTU)        (BTU/HR)        (BTU)
|0      JAN       1.488E+08     2.000E+05     4.223E+05     5.677E+02     0.000E+00     0.000E+00     1.492E+08
|0      FEB       1.344E+08     2.000E+05     3.815E+05     5.677E+02     0.000E+00     0.000E+00     1.348E+08
|0      MAR       1.488E+08     2.000E+05     4.224E+05     5.682E+02     0.000E+00     0.000E+00     1.492E+08
|0      APR       1.440E+08     2.000E+05     4.101E+05     5.919E+02     0.000E+00     0.000E+00     1.444E+08
|0      MAY       1.488E+08     2.000E+05     4.254E+05     5.969E+02     0.000E+00     0.000E+00     1.492E+08
|0      JUN       1.440E+08     2.000E+05     4.159E+05     6.128E+02     0.000E+00     0.000E+00     1.444E+08
|0      JUL       1.488E+08     2.000E+05     4.335E+05     6.275E+02     0.000E+00     0.000E+00     1.492E+08
|0      AUG       1.488E+08     2.000E+05     4.323E+05     6.179E+02     0.000E+00     0.000E+00     1.492E+08
|0      SEP       1.440E+08     2.000E+05     4.135E+05     6.183E+02     0.000E+00     0.000E+00     1.444E+08
|0      OCT       1.488E+08     2.000E+05     4.230E+05     5.863E+02     0.000E+00     0.000E+00     1.492E+08
|0      NOV       1.440E+08     2.000E+05     4.087E+05     5.720E+02     0.000E+00     0.000E+00     1.444E+08
|0      DEC       1.488E+08     2.000E+05     4.223E+05     5.677E+02     0.000E+00     0.000E+00     1.492E+08
|0               ----------    ----------    ----------    ----------    ----------    ----------    ----------
|0      TOT       1.752E+09     2.000E+05     5.011E+06     6.275E+02     0.000E+00     0.000E+00     1.757E+09
```

```
|0                        G A S                       S T E A M                 H O T  W A T E R         C H I L L E
|0     MONTH             TOTAL USE                    TOTAL USE                    TOTAL USE                    TOTA
|               CONSUMPTION   PEAK DEMAND   CONSUMPTION   PEAK DEMAND   CONSUMPTION   PEAK DEMAND   CONSUMPTION
|                  (BTU)        (BTU/HR)        (BTU)        (BTU/HR)        (BTU)        (BTU/HR)        (BTU)
|0      JAN       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     4.698E+06
|0      FEB       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     5.201E+06
|0      MAR       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     6.271E+06
|0      APR       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     7.946E+06
|0      MAY       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     1.019E+07
|0      JUN       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     1.219E+07
|0      JUL       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     1.389E+07
|0      AUG       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     1.337E+07
|0      SEP       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     1.089E+07
|0      OCT       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     8.257E+06
|0      NOV       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     6.343E+06
|0      DEC       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     5.751E+06
|0               ----------    ----------    ----------    ----------    ----------    ----------    ----------
|0      TOT       0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     0.000E+00     1.050E+08
```

1. This report lists the total and peak demand for ELECTRICITY, GAS, STEAM, HOT WATER, and CHILLED WATER. Values for electricity are broken down onto BUILDING ELECTRIC, FANS, and HEATING. For design day simulations this information is reported hourly and daily; for weather simulations, it is reported monthly and annually.

ELECTRICITY - TOTAL USE:

This column includes all of the following electric loads:

1. Building Lights
2. Building Electric Equipment
3. Fans
4. Electric Heating Coils (in Fan System)
5. System Electric Demand (in Other System Parameters)
6. DX Condensing Units (These are simulated during the fan system simulation.)

EVAPORATIVE COOLER REPORT

See Also:

User Reference

Technical Reference

Produced by specifying EVAPORATIVE REPORT in the REPORTS section of RUN CONTROL.

```
*********************************************************************************************
**                                                                                         **
**          E V A P O R A T I V E   C O O L E R   S Y S T E M   U S A G E   S U M M A R Y  **
**                                                                                         **
*********************************************************************************************
```

SYSTEM NUMBER= 1, DDVAV
SYSTEM LOCATION = 14806 CHANUTE AFB, ILLINOIS 1440 1957 SIMULATION PERIOD 1JAN1957 - 31DEC1957

MONTH	H2O CONSMP GALLONS	PEAK H2O CONSMP GALLONS/HR	EVAP ELECT 1000BTU	PEAK EVAP ELECT 1000BTU/HR	COOLING EVAP 1000BTU	PEAK COOLING EVAP 1000BTU/HR	CHILLED WATER DEMAND 1000BTU
JAN	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.010E+04
FEB	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.683E+04
MAR	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.943E+04
APR	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.412E+04
MAY	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.275E+05
JUN	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.533E+05
JUL	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.741E+05
AUG	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.658E+05
SEP	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.263E+05
OCT	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	9.318E+04
NOV	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	6.033E+04
DEC	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	5.013E+04
	----------	----------	----------	----------	----------	----------	----------
TOT	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.181E+06

WET COIL INDIRECT STAGE CONFIGURATION

SECONDARY VOLUMETRIC FLOW FT**3/MIN	FAN PRESS IN-H2O	FAN EFFIC %	WET COIL MAX EFF %	WET COIL FLOW RATIO
8.000E+03	1.000E-01	70.000	80.000	0.160

DIRECT STAGE CONFIGURATION

PAD FACE VEL. FT/MIN	PAD AREA FT**2	PAD DEPTH FT
0.000E+00	2.000E+01	1.000E+00

1 H2O Consumption Water consumed from the evaporation process only, bleed water can be found by taking the percentage bleed and multiplying by H_2O consumption.

2 Evap Electrical Electric energy used for the secondary fan and pump in the indirect stage, and the pump in the direct stage.

This electrical consumption will also show up in the "Air Handling System Energy Use Summary" under Electricity in the Total Use column. This column shows the total electrical use for the fan systems and the evaporative cooler.

3 Cooling Evap Cooling provided by the evaporative cooler.

4 Chilled Water Consumption Chilled water consumption from the cooling coil.

At the bottom of this report, are the values used in the evaporative cooler model, these are defaults or user inputs. Also there is an intermediate calculation displayed, pad face velocity, which is used to determine the saturation efficiency.

Indirect Stage Configuration

Sec Volumetric Flow   Volumetric air flow rate through the secondary stream in the evaporative cooler (from input).

Pad Area   Pad area of the indirect evaporative media (from input).

Pad Depth   Depth of the evaporative media (from input).

Pad Face Velocity   Volumetric flow through the pad divided by the pad area. This is used to find the saturation efficiency of the pad in the evaporative cooler (calculated from input).

Evap Cooler Press Drop   Pressure drop across the evaporative cooler for the secondary air flow (from input).

Heat Exchanger Effect The effectiveness of the air-to-air heat exchanger (from input).

Fan Efficiency   Efficiency of the indirect fan for the secondary air flow (from input).

Direct Stage Configuration

Pad Area   Pad area of the direct evaporative media (from input).

Pad Depth   Depth of the evaporative media (from input).

Pad Face Velocity   Volumetric flow through the pad divided by the pad area. This is used to find the saturation efficiency of the pad in the evaporative cooler (calculated from input).

HUMIDITY REPORT

Produced by specifying HUMIDITY REPORT in the REPORTS section of RUN CONTROL.

```
**************************************************************************************************************
**                                                                                                          **
**                               S Y S T E M   H U M I D I T Y   R E P O R T                                **
**                                                                                                          **
**************************************************************************************************************


           SYSTEM NUMBER=         1, DDVAV
           DESIGN DAY CHANUTE AFB ILLINOIS WINTER                              SIMULATION DATE 21JAN1998 (MONDAY
)


                     RELATIVE HUMIDITY                                                  HUMIDITY RATIO
 ZONE         MAXIMUM       AVERAGE       MINIMUM                         MAXIMUM       AVERAGE       MINIMUM
                                                                         LB  WATER/    LB  WATER/    LB  WATER/
                 %             %             %                           LB DRY AIR    LB DRY AIR    LB DRY AIR

   1            5.601         5.596         5.480                        8.173E-04     8.173E-04     8.173E-04
 MX/MN DATES   1/21/ 1                     1/21/24                        1/21/ 1                      1/21/ 1
(MO/DY/HR)


 HUMIDITY VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!
```

System Humidity Report

The fields are calculated only on the system operating hours. When the fan system is not operating the humidities in the zone are undefined. The maximum and minimum humidities, the month, day and hour are reported.

The humidity report can be run for any fan system and can also be used without an evaporative cooler specified.

WLHPS SYSTEM ENERGY USAGE REPORT

See Also:

<u>Water Loop Heat Pump System</u>

Produced by specifying WLHPS REPORT in the REPORTS section of RUN CONTROL.

```
 *****************************************************************************************************************
 **                                                                                                             **
 **                      W L H P S   S Y S T E M   E N E R G Y   U S A G E   R E P O R T                       **
 **                                                                                                             **
 *****************************************************************************************************************


  SYSTEM NUMBER=         1, CLASSROOMS
  DESIGN DAY CHANUTE AFB ILLINOIS SUMMER                              SIMULATION DATE 21JUL1993 (MONDAY   )
                                  W L H P S   E N E R G Y   D E M A N D S

OUR       HEAT PUMPS          LOOP PUMP           HEAT LOAD          COOL LOAD           LOOP TEMP       TANK TEMP
     CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/PEAK        MAX     MIN     MAX     MIN
     1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H        DEG. F          DEG. F
1    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
2    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
3    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
4    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
5    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
6    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
7    3.45E+01  3.45E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  2.11E+02  2.11E+02      80.0    80.0    80.8    80.8
8    4.91E+01  4.91E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  3.54E+02  3.54E+02      80.0    80.0    80.8    80.8
9    7.73E+01  7.73E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.19E+02  5.19E+02      80.0    80.0    80.8    80.8
0    9.37E+01  9.37E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  6.76E+02  6.76E+02      80.0    80.0    80.8    80.8
1    1.17E+02  1.17E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  9.02E+02  9.02E+02      80.0    80.0    80.8    80.8
2    1.25E+02  1.25E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  9.82E+02  9.82E+02      80.0    80.0    80.8    80.8
3    1.33E+02  1.33E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.06E+03  1.06E+03      80.0    80.0    80.8    80.8
4    1.55E+02  1.55E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.14E+03  1.14E+03      80.0    80.0    80.8    80.8
5    1.63E+02  1.63E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.22E+03  1.22E+03      80.0    80.0    80.8    80.8
6    1.63E+02  1.63E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.22E+03  1.22E+03      80.0    80.0    80.8    80.8
7    1.55E+02  1.55E+02  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.14E+03  1.14E+03      80.0    80.0    80.8    80.8
8    7.28E+01  7.28E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  6.31E+02  6.31E+02      80.0    80.0    80.8    80.8
9    1.28E+01  1.28E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.27E+02  1.27E+02      80.0    80.0    80.8    80.8
0    1.28E+01  1.28E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.22E+02  1.22E+02      80.0    80.0    80.8    80.8
1    1.28E+01  1.28E+01  4.88E+02  4.88E+02  0.00E+00  0.00E+00  1.22E+02  1.22E+02      80.0    80.0    80.8    80.8
2    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.77E+01  5.77E+01      80.0    80.0    80.8    80.8
3    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.73E+01  5.73E+01      80.0    80.0    80.8    80.8
4    6.38E+00  6.38E+00  4.88E+02  4.88E+02  0.00E+00  0.00E+00  5.72E+01  5.72E+01      80.0    80.0    80.8    80.8
     --------  --------  --------  --------  --------  --------  --------  --------
T    1.43E+03  1.63E+02  1.17E+04  4.88E+02  0.00E+00  0.00E+00  1.09E+04  1.22E+03
```

1. HEAT PUMPS- The total heat pump network consumption and peak values.
2. LOOP PUMP- The loop pump consumption and peak values.
3. HEAT LOAD- The supplemental heating load required by the loop.
4. COOL LOAD- The supplemental cooling load required by the loop.

5 LOOP TEMPERARTURE- The maximum and minimum hourly heat pump inlet temperature.

6 TANK TEMPERATURE- The maximum and minimum hourly storage tank temperature.

HEAT PUMP NETWORK SUMMARY

See Also:

Water Loop Heat Pump System

Produced by specifying WLHPS REPORT in the REPORTS section of RUN CONTROL.

```
 ***************************************************************************************************
**
**                             H E A T   P U M P   N E T W O R K   S U M M A R Y
**
***************************************************************************************************


 SYSTEM NUMBER=        1, CLASSROOMS
 DESIGN DAY CHANUTE AFB ILLINOIS SUMMER                              SIMULATION DATE 21JUL1993 (MON



               ZONE 1             ZONE 2             ZONE 3
HOUR            PUMP1              PUMP2              PUMP3              PUMP4              PUMP5
            CONSUMPTION/PEAK   CONSUMPTION/PEAK   CONSUMPTION/PEAK   CONSUMPTION/PEAK   CONSUMPTION/P
          1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000B
  1       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  2       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  3       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  4       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  5       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  6       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  7       7.12E+00  7.12E+00  1.91E+01  1.91E+01  8.25E+00  8.25E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
  8       7.12E+00  7.12E+00  2.55E+01  2.55E+01  1.65E+01  1.65E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
  9       1.42E+01  1.42E+01  3.83E+01  3.83E+01  2.47E+01  2.47E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 10       1.42E+01  1.42E+01  3.83E+01  3.83E+01  4.12E+01  4.12E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 11       1.42E+01  1.42E+01  4.46E+01  4.46E+01  5.77E+01  5.77E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 12       1.42E+01  1.42E+01  4.46E+01  4.46E+01  6.60E+01  6.60E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 13       1.42E+01  1.42E+01  4.46E+01  4.46E+01  7.42E+01  7.42E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 14       2.14E+01  2.14E+01  5.10E+01  5.10E+01  8.24E+01  8.24E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 15       2.14E+01  2.14E+01  5.10E+01  5.10E+01  9.06E+01  9.06E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 16       2.14E+01  2.14E+01  5.10E+01  5.10E+01  9.06E+01  9.06E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 17       2.14E+01  2.14E+01  5.10E+01  5.10E+01  8.24E+01  8.24E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
 18       7.13E+00  7.13E+00  5.74E+01  5.74E+01  8.27E+00  8.27E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
 19       0.00E+00  0.00E+00  1.28E+01  1.28E+01  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
 20       0.00E+00  0.00E+00  1.28E+01  1.28E+01  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
 21       0.00E+00  0.00E+00  1.28E+01  1.28E+01  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
 22       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
 23       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
 24       0.00E+00  0.00E+00  6.38E+00  6.38E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E
          --------  --------  --------  --------  --------  --------  --------  --------  --------  -----
TOT       1.78E+02  2.14E+01  6.12E+02  5.74E+01  6.43E+02  9.06E+01  0.00E+00  0.00E+00  0.00E+00  0.00E
```

Provides the individual heat pump unit energy demand summaries and the heat pump network outlet temperature.

WLHPS COOLING TOWER ENERGY USAGE REPORT

See Also:

Water Loop Heat Pump System

Produced by specifying WLHPS REPORT in the REPORTS section of RUN CONTROL.

```
          ****************************************************************************************************
          **
          **              W L H P S   C O O L I N G   T O W E R   E N E R G Y   U S A G E   R E P O R T
          **
          ****************************************************************************************************



           SYSTEM NUMBER=         1, CLASSROOMS
           DESIGN DAY CHANUTE AFB ILLINOIS SUMMER                              SIMULATION DATE 21JUL1993 (MOND



        HOUR             TOWER PUMPS                       FAN ELECTRIC                      TOTAL ELECTRIC
                    CONSUMPTION    PEAK DEMAND       CONSUMPTION    PEAK DEMAND       CONSUMPTION    PEAK DEM
                     1000BTU        1000BTU/H         1000BTU        1000BTU/H         1000BTU        1000BTU
          1          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
          2          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
          3          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
          4          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
          5          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
          6          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
          7          2.75E+00       2.75E+00          5.10E+01       5.10E+01          5.37E+01       5.37E+0
          8          4.60E+00       4.60E+00          8.53E+01       8.53E+01          8.99E+01       8.99E+0
          9          6.74E+00       6.74E+00          1.25E+02       1.25E+02          1.32E+02       1.32E+0
         10          8.79E+00       8.79E+00          1.63E+02       1.63E+02          1.72E+02       1.72E+0
         11          1.17E+01       1.17E+01          2.17E+02       2.17E+02          2.29E+02       2.29E+0
         12          1.28E+01       1.28E+01          2.37E+02       2.37E+02          2.50E+02       2.50E+0
         13          1.38E+01       1.38E+01          2.56E+02       2.56E+02          2.70E+02       2.70E+0
         14          1.48E+01       1.48E+01          2.75E+02       2.75E+02          2.89E+02       2.89E+0
         15          1.58E+01       1.58E+01          2.94E+02       2.94E+02          3.10E+02       3.10E+0
         16          1.59E+01       1.59E+01          2.94E+02       2.94E+02          3.10E+02       3.10E+0
         17          1.48E+01       1.48E+01          2.75E+02       2.75E+02          2.90E+02       2.90E+0
         18          8.20E+00       8.20E+00          1.52E+02       1.52E+02          1.60E+02       1.60E+0
         19          1.65E+00       1.65E+00          3.05E+01       3.05E+01          3.22E+01       3.22E+0
         20          1.59E+00       1.59E+00          2.94E+01       2.94E+01          3.10E+01       3.10E+0
         21          1.59E+00       1.59E+00          2.94E+01       2.94E+01          3.10E+01       3.10E+0
         22          7.51E-01       7.51E-01          1.39E+01       1.39E+01          1.47E+01       1.47E+0
         23          7.45E-01       7.45E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
         24          7.44E-01       7.44E-01          1.38E+01       1.38E+01          1.45E+01       1.45E+0
                     --------       --------          --------       --------          --------       -------
        TOT          1.42E+02       1.59E+01          2.64E+03       2.94E+02          2.78E+03       3.10E+0
```

Provides the cooling tower energy usage broken down by fan consumption, pump consumption, and total usage.

WLHPS SYSTEM LOADS REPORT

See Also:

Water Loop Heat Pump System

Produced by specifying WLHPS REPORT in the REPORTS section of RUN CONTROL.

```
           SYSTEM NUMBER=        1, WATER LOOP SYSTEM TEST FILE
           DESIGN DAY CHANUTE AFB ILLINOIS SUMMER                        SIMULATION DATE 21JUL1993 (M


                              ZONE 1                                        ZONE 2
       HOUR         HEATING             COOLING             HEATING             COOLING             HEATING
               CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/P
              1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   100
          1   0.00E+00  0.00E+00  4.97E+01  4.97E+01  0.00E+00  0.00E+00  7.70E+01  7.70E+01  0.00E+00  0.0
          2   0.00E+00  0.00E+00  4.49E+01  4.49E+01  0.00E+00  0.00E+00  6.86E+01  6.86E+01  0.00E+00  0.0
          3   0.00E+00  0.00E+00  4.03E+01  4.03E+01  0.00E+00  0.00E+00  6.08E+01  6.08E+01  0.00E+00  0.0
          4   0.00E+00  0.00E+00  3.59E+01  3.59E+01  0.00E+00  0.00E+00  5.36E+01  5.36E+01  0.00E+00  0.0
          5   0.00E+00  0.00E+00  3.19E+01  3.19E+01  0.00E+00  0.00E+00  4.73E+01  4.73E+01  0.00E+00  0.0
          6   0.00E+00  0.00E+00  2.93E+01  2.93E+01  0.00E+00  0.00E+00  4.51E+01  4.51E+01  0.00E+00  0.0
          7   0.00E+00  0.00E+00  2.90E+01  2.90E+01  0.00E+00  0.00E+00  4.66E+01  4.66E+01  0.00E+00  0.0
          8   0.00E+00  0.00E+00  3.01E+01  3.01E+01  0.00E+00  0.00E+00  4.95E+01  4.95E+01  0.00E+00  0.0
          9   0.00E+00  0.00E+00  3.42E+01  3.42E+01  0.00E+00  0.00E+00  5.68E+01  5.68E+01  0.00E+00  0.0
         10   0.00E+00  0.00E+00  4.21E+01  4.21E+01  0.00E+00  0.00E+00  6.88E+01  6.88E+01  0.00E+00  0.0
         11   0.00E+00  0.00E+00  5.26E+01  5.26E+01  0.00E+00  0.00E+00  8.40E+01  8.40E+01  0.00E+00  0.0
         12   0.00E+00  0.00E+00  6.38E+01  6.38E+01  0.00E+00  0.00E+00  9.96E+01  9.96E+01  0.00E+00  0.0
         13   0.00E+00  0.00E+00  7.37E+01  7.37E+01  0.00E+00  0.00E+00  1.14E+02  1.14E+02  0.00E+00  0.0
         14   0.00E+00  0.00E+00  8.10E+01  8.10E+01  0.00E+00  0.00E+00  1.29E+02  1.29E+02  0.00E+00  0.0
         15   0.00E+00  0.00E+00  8.48E+01  8.48E+01  0.00E+00  0.00E+00  1.41E+02  1.41E+02  0.00E+00  0.0
         16   0.00E+00  0.00E+00  8.48E+01  8.48E+01  0.00E+00  0.00E+00  1.47E+02  1.47E+02  0.00E+00  0.0
         17   0.00E+00  0.00E+00  8.44E+01  8.44E+01  0.00E+00  0.00E+00  1.52E+02  1.52E+02  0.00E+00  0.0
         18   0.00E+00  0.00E+00  8.30E+01  8.30E+01  0.00E+00  0.00E+00  1.52E+02  1.52E+02  0.00E+00  0.0
         19   0.00E+00  0.00E+00  7.89E+01  7.89E+01  0.00E+00  0.00E+00  1.40E+02  1.40E+02  0.00E+00  0.0
         20   0.00E+00  0.00E+00  7.41E+01  7.41E+01  0.00E+00  0.00E+00  1.26E+02  1.26E+02  0.00E+00  0.0
         21   0.00E+00  0.00E+00  6.94E+01  6.94E+01  0.00E+00  0.00E+00  1.15E+02  1.15E+02  0.00E+00  0.0
         22   0.00E+00  0.00E+00  6.45E+01  6.45E+01  0.00E+00  0.00E+00  1.05E+02  1.05E+02  0.00E+00  0.0
         23   0.00E+00  0.00E+00  5.95E+01  5.95E+01  0.00E+00  0.00E+00  9.48E+01  9.48E+01  0.00E+00  0.0
         24   0.00E+00  0.00E+00  5.46E+01  5.46E+01  0.00E+00  0.00E+00  8.57E+01  8.57E+01  0.00E+00  0.0
              --------  --------  --------  --------  --------  --------  --------  --------  --------  ---
       TOT    0.00E+00  0.00E+00  1.38E+03  8.48E+01  0.00E+00  0.00E+00  2.26E+03  1.52E+02  0.00E+00  0.0


           SYSTEM NUMBER=        1, WATER LOOP SYSTEM TEST FILE
           SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957          SIMULATION PERIOD  1JAN1957


                              ZONE 1                                        ZONE 2
      MONTH         HEATING             COOLING             HEATING             COOLING             HEATING
               CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/PEAK    CONSUMPTION/P
              1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   1000BTU/H 1000BTU   100
       JAN    9.38E+04  1.93E+02  0.00E+00  0.00E+00  1.25E+05  2.60E+02  0.00E+00  0.00E+00  9.38E+04  1.9
       FEB    5.52E+04  1.26E+02  0.00E+00  0.00E+00  7.12E+04  1.68E+02  1.02E+01  4.56E+00  5.52E+04  1.2
       MAR    4.71E+04  1.27E+02  5.26E+02  3.76E+01  6.06E+04  1.74E+02  1.26E+03  7.63E+01  4.71E+04  1.2
       APR    2.65E+04  1.08E+02  4.80E+03  7.45E+01  3.29E+04  1.48E+02  9.44E+03  1.31E+02  2.65E+04  1.0
       MAY    6.19E+03  7.56E+01  9.66E+03  7.28E+01  6.63E+03  1.02E+02  1.98E+04  1.21E+02  6.19E+03  7.5
       JUN    7.82E+02  3.59E+01  2.48E+04  9.20E+01  8.67E+02  5.15E+01  4.16E+04  1.46E+02  7.82E+02  3.5
       JUL    0.00E+00  0.00E+00  3.78E+04  9.84E+01  0.00E+00  0.00E+00  5.97E+04  1.63E+02  0.00E+00  0.0
       AUG    4.46E+01  1.02E+01  3.68E+04  1.09E+02  3.08E+01  9.39E+00  5.66E+04  1.69E+02  4.46E+01  1.0
       SEP    2.34E+03  5.28E+01  1.83E+04  8.92E+01  2.83E+03  7.33E+01  2.91E+04  1.50E+02  2.34E+03  5.2
       OCT    2.11E+04  1.01E+02  4.35E+03  7.55E+01  2.69E+04  1.38E+02  7.45E+03  1.25E+02  2.11E+04  1.0
       NOV    4.80E+04  1.28E+02  1.03E+02  2.60E+01  6.36E+04  1.82E+02  2.33E+02  4.26E+01  4.80E+04  1.2
       DEC    6.45E+04  1.70E+02  0.00E+00  0.00E+00  8.61E+04  2.31E+02  0.00E+00  0.00E+00  6.45E+04  1.7
              --------  --------  --------  --------  --------  --------  --------  --------  --------  ---
       TOT    3.66E+05  1.93E+02  1.37E+05  1.09E+02  4.77E+05  2.60E+02  2.25E+05  1.69E+02  3.66E+05  1.9
```

The Water Loop System Loads Report provides the user with the heating and cooling supplied by the water loop heat pumps to each zone, along with the hourly heating and cooling peak for each zone.

AIR HANDLING SYSTEM COMPONENT LOAD SUMMARY

Produced by specifying COIL LOADS in the REPORTS section of RUN CONTROL.

```
                     SYSTEM NUMBER=        1, MULTIZONE
           DESIGN DAY ANY DAY                                                  S
0                    MONTH       CONSUMPTION        PEAK DEMAND        HRS CNSM
                                    (BTU)            (BTU/HR)           (HOURS
0 HEATING COIL LOADS
                      JUL          0.000E+00         0.000E+00         0.000E+0
                                  ----------        ----------        ---------
                      ANN          0.000E+00         0.000E+00         0.000E+0
0 COOLING COIL LOADS
                      JUL          3.197E+05         1.919E+04         2.400E+0
                                  ----------        ----------        ---------
                      ANN          3.197E+05         1.919E+04         2.400E+0

           SYSTEM NUMBER=        1, MULTIZONE
           SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957            S
0                    MONTH       CONSUMPTION        PEAK DEMAND        HRS CNSM
                                    (BTU)            (BTU/HR)           (HOURS
```

```
0 HEATING COIL LOADS
                     JAN        0.000E+00        0.000E+00        0.000E+0
                     FEB        0.000E+00        0.000E+00        0.000E+0
                     MAR        0.000E+00        0.000E+00        0.000E+0
                     APR        0.000E+00        0.000E+00        0.000E+0
                     MAY        0.000E+00        0.000E+00        0.000E+0
                     JUN        0.000E+00        0.000E+00        0.000E+0
                     JUL        0.000E+00        0.000E+00        0.000E+0
                     AUG        0.000E+00        0.000E+00        0.000E+0
                     SEP        0.000E+00        0.000E+00        0.000E+0
                     OCT        0.000E+00        0.000E+00        0.000E+0
                     NOV        0.000E+00        0.000E+00        0.000E+0
                     DEC        0.000E+00        0.000E+00        0.000E+0
                               ----------       ----------       ---------
                     ANN        0.000E+00        0.000E+00        0.000E+0
0 COOLING COIL LOADS
                     JAN        4.698E+06        1.413E+04        7.440E+0
                     FEB        5.201E+06        1.582E+04        6.720E+0
                     MAR        6.271E+06        1.753E+04        7.440E+0
                     APR        7.946E+06        2.457E+04        7.200E+0
                     MAY        1.019E+07        2.526E+04        7.440E+0
                     JUN        1.219E+07        2.937E+04        7.200E+0
                     JUL        1.389E+07        3.064E+04        7.440E+0
                     AUG        1.337E+07        3.007E+04        7.440E+0
                     SEP        1.089E+07        2.958E+04        7.200E+0
                     OCT        8.257E+06        2.002E+04        7.440E+0
                     NOV        6.343E+06        1.889E+04        7.200E+0
                     DEC        5.751E+06        1.505E+04        7.440E+0
                               ----------       ----------       ---------
                     ANN        1.050E+08        3.064E+04        8.760E+0
```

1. This report lists the month by month (as well as annual) consumption and use statistics for all components listed below:

PREHEAT COIL LOADS

HEATING COIL LOADS

HUMIDIFIER LOADS

COOLING COIL LOADS

REHEAT COIL LOADS

RECOOL COIL LOADS

TSTAT BASEBOARD LOADS

FANCOIL HEATING LOADS

FANCOIL COOLING LOADS

OA BASEBOARD LOADS

DX CONDENSING UNIT ELEC CONSUMPTION

HEAT RECOVERY - HEAT ADDED TO INCOMING OUTSIDE AIR

HEAT RECOVERY - HEAT REMOVED FROM INCOMING AIR

HEAT RECOVERY - ELECTRICITY CONSUMED

HEAT PUMP - COMPRESSOR ENERGY CONSUMPTION

HEAT PUMP - BACKUP ENERGY CONSUMPTION

CONSUMPTION: Total energy used by component during month.

PEAK DEMAND: Maximum demand during any hour of the month.

HRS CNSMPTN: Number of hours that component is consuming energy.

PK CAP EXCD: The maximum amount by which demand exceeded capacity.

HRS CAP EXCD: Number of hours that capacity was exceeded.

FAN SYSTEM UNDERHEATING/UNDERCOOLING SUMMARY

See Also:

User Reference

Produced by default when unmet loads occur.

```
        SYSTEM NUMBER=         1, MULTIZONE
        DESIGN DAY ANY DAY                                         SIMULATION DATE 21JUL


                               F A N   S Y S T E M   U N D E R H E A T I N G
                   **********************************************************************



   FOR ZONE     1
    NO UNDERHEATING FOR THIS ZONE


   FOR ZONE     2
    NO UNDERHEATING FOR THIS ZONE


                               F A N   S Y S T E M   U N D E R C O O L I N G
                   **********************************************************************



   FOR ZONE     1
    NO UNDERCOOLING FOR THIS ZONE


   FOR ZONE     2
    NO UNDERCOOLING FOR THIS ZONE




        SYSTEM NUMBER=         1, MULTIZONE
        SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957           SIMULATION PERIOD  1J
```

F A N   S Y S T E M   U N D E R H E A T I N G

MONTH	HEATING DEMAND FOR ZONE 1000BTU	HEATING PROVIDED BY FAN SYSTEM 1000BTU	HEATING NOT PROVIDED BY FAN SYSTEM 1000BTU	PEAK NOT PROV BY FAN SYSTEM 1000BTU/HR
FOR ZONE 1				
JAN	7.317E+00	-2.816E+01	3.547E+01	1.769E+00
DEC	5.920E+00	-1.251E+01	1.843E+01	2.080E+00
TOTALS	1.324E+01	-4.067E+01	5.390E+01	2.080E+00

MONTH	HEATING DEMAND FOR ZONE 1000BTU	HEATING PROVIDED BY FAN SYSTEM 1000BTU	HEATING NOT PROVIDED BY FAN SYSTEM 1000BTU	PEAK NOT PROV BY FAN SYSTEM 1000BTU/HR
FOR ZONE 2				
JAN	3.740E+01	-6.867E+01	1.061E+02	2.487E+00
DEC	9.072E+00	-1.769E+01	2.676E+01	2.251E+00
TOTALS	4.647E+01	-8.636E+01	1.328E+02	2.487E+00

F A N   S Y S T E M   U N D E R C O O L I N G

MONTH	COOLING DEMAND FOR ZONE 1000BTU	COOLING PROVIDED BY FAN SYSTEM 1000BTU	COOLING NOT PROVIDED BY FAN SYSTEM 1000BTU	PEAK NOT PROV BY FAN SYSTEM 1000BTU/HR
FOR ZONE 1				
APR	1.365E+01	1.365E+01	1.830E-06	4.890E-07
MAY	2.977E+00	2.977E+00	4.099E-07	4.099E-07
JUN	1.044E+01	1.044E+01	1.420E-06	5.292E-07
JUL	3.640E+00	3.640E+00	4.919E-07	4.919E-07
AUG	1.769E+01	1.769E+01	2.333E-06	5.660E-07
SEP	1.409E+01	1.409E+01	1.880E-06	5.014E-07
TOTALS	6.248E+01	6.248E+01	8.364E-06	5.660E-07

MONTH	COOLING DEMAND FOR ZONE 1000BTU	COOLING PROVIDED BY FAN SYSTEM 1000BTU	COOLING NOT PROVIDED BY FAN SYSTEM 1000BTU	PEAK NOT PROV BY FAN SYSTEM 1000BTU/HR
FOR ZONE 2				
APR	6.403E+00	6.403E+00	8.458E-07	4.277E-07
MAY	1.011E+01	1.011E+01	1.347E-06	4.719E-07
JUN	2.090E+01	2.090E+01	2.849E-06	5.144E-07
JUL	3.829E+00	3.829E+00	5.280E-07	5.280E-07
AUG	3.746E+00	3.746E+00	4.963E-07	4.963E-07
SEP	1.061E+01	1.061E+01	1.442E-06	5.272E-07
OCT	3.141E+00	3.141E+00	4.126E-07	4.126E-07
TOTALS	5.873E+01	5.873E+01	7.920E-06	5.280E-07

1. If no underheating/undercooling occurs in a zone, it will be reported as such and no further detail given. If the fan system does not provide all of the heating/cooling demanded by the zone

loads simulation, details will be reported for each hour/month that this occurs. Causes of this condition include:

- ✓ Insufficient supply air volume.
- ✓ Deck temperature too high/low.
- ✓ Heating/cooling coil scheduled off.

UNDERCOOLING SUMMARY

COOLING DEMAND FOR ZONE: The total energy required to cool the zone during the hours in which undercooling occurred.

COOLING PROVIDED BY FAN SYSTEM: The energy provided by the fan system to cool the zone during the hours in which undercooling occurred.

COOLING NOT PROVIDED BY FAN SYSTEM: This value is equal to the cooling demand minus the cooling provided.

PEAK NOT PROVIDED BY FAN SYSTEM: The maximum cooling not provided occurring in a given hour. Note: For Design Day simulations this will be the same numerical value as cooling not provided.

HOURS NOT PROVIDED: The number of hours that cooling demand exceeds cooling provided. Note: For Design Day simulations this value will always be 1.

A similar report is produced for underheating.

FAN SYSTEM OVERHEATING/OVERCOOLING SUMMARY

See Also:

User Reference

Produced by default when unmet loads occurs.

```
        SYSTEM NUMBER=         1, MULTIZONE
         DESIGN DAY ANY DAY                                                   SIMULATION DATE :


                                F A N   S Y S T E M   O V E R H E A T I N G
                            ******************************************************************



    FOR ZONE     1
     NO OVERHEATING FOR THIS ZONE


    FOR ZONE     2
     NO OVERHEATING FOR THIS ZONE


                                F A N   S Y S T E M   O V E R C O O L I N G
                            ******************************************************************



            HOUR    COOLING DEMAND      COOLING PROVIDED    EXCESS COOLING PRO-      EXCESS PI
                    FOR ZONE            BY FAN SYSTEM       VIDED BY FAN SYSTEM      VIDED BY
                       1000BTU             1000BTU             1000BTU                1000BTU.


    FOR ZONE     1
             9         6.829E-01           1.503E+00           8.202E-01                 8.202I
            10         4.879E-01           1.525E+00           1.037E+00                 1.037I
            12         6.324E-01           1.499E+00           8.663E-01                 8.663I
            13         5.232E-01           1.521E+00           9.979E-01                 9.979I
            14         4.767E-01           1.544E+00           1.067E+00                 1.067I
            15         8.221E-01           1.543E+00           7.205E-01                 7.205I
            24         3.686E+00           3.686E+00           4.891E-07                 4.891I
            ---------------------------------------------------------------------------------
        TOTALS         7.311E+00           1.282E+01           5.509E+00                 1.067I
```

```
          HOUR    COOLING DEMAND      COOLING PROVIDED    EXCESS COOLING PRO-      EXCESS PEAK P
                  FOR ZONE            BY FAN SYSTEM       VIDED BY FAN SYSTEM      VIDED BY FAN
                     1000BTU             1000BTU             1000BTU                1000BTU/HR


 FOR ZONE     2
             9       7.026E-01           1.503E+00           8.006E-01                8.006E-01
            10       5.041E-01           1.525E+00           1.021E+00                1.021E+00
            12       6.499E-01           1.499E+00           8.488E-01                8.488E-01
            13       5.381E-01           1.521E+00           9.830E-01                9.830E-01
            14       4.757E-01           1.544E+00           1.068E+00                1.068E+00
            15       7.888E-01           1.543E+00           7.538E-01                7.538E-01
            --------------------------------------------------------------------------------------
       TOTALS        3.659E+00           9.134E+00           5.475E+00                1.068E+00




        SYSTEM NUMBER=         1, MULTIZONE
        SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957            SIMULATION PERIOD  1J


                               F A N   S Y S T E M   O V E R H E A T I N G
                           ***********************************************************************



 FOR ZONE     1
  NO OVERHEATING FOR THIS ZONE


 FOR ZONE     2
  NO OVERHEATING FOR THIS ZONE
```

```
F A N   S Y S T E M   O V E R C O O L I N G
           ***********************************************************************
```

MONTH	COOLING DEMAND FOR ZONE 1000BTU	COOLING PROVIDED BY FAN SYSTEM 1000BTU	EXCESS COOLING PRO- VIDED BY FAN SYSTEM 1000BTU	EXCESS PEAK P VIDED BY FAN : 1000BTU/HR
FOR ZONE 1				
JAN	2.816E+02	5.627E+02	2.811E+02	1.551E+00
FEB	2.590E+02	4.254E+02	1.664E+02	1.483E+00
MAR	2.289E+02	3.984E+02	1.694E+02	1.521E+00
APR	1.942E+02	3.481E+02	1.539E+02	1.514E+00
MAY	1.714E+02	3.191E+02	1.477E+02	1.526E+00
JUN	1.340E+02	2.191E+02	8.511E+01	1.456E+00
JUL	1.422E+02	2.023E+02	6.004E+01	1.167E+00
AUG	1.290E+02	1.901E+02	6.117E+01	1.185E+00
SEP	1.384E+02	2.411E+02	1.027E+02	1.510E+00
OCT	1.672E+02	3.060E+02	1.388E+02	1.533E+00
NOV	2.295E+02	3.929E+02	1.634E+02	1.519E+00
DEC	2.471E+02	4.556E+02	2.085E+02	1.538E+00
TOTALS	2.323E+03	4.061E+03	1.738E+03	1.551E+00

MONTH	COOLING DEMAND FOR ZONE 1000BTU	COOLING PROVIDED BY FAN SYSTEM 1000BTU	EXCESS COOLING PRO- VIDED BY FAN SYSTEM 1000BTU	EXCESS PEAK P VIDED BY FAN : 1000BTU/HR
FOR ZONE 2				
JAN	2.396E+02	5.188E+02	2.792E+02	1.551E+00
FEB	2.702E+02	4.541E+02	1.840E+02	1.533E+00
MAR	2.595E+02	4.346E+02	1.751E+02	1.501E+00
APR	1.917E+02	3.525E+02	1.607E+02	1.527E+00
MAY	1.560E+02	3.129E+02	1.569E+02	1.537E+00
JUN	1.341E+02	2.191E+02	8.501E+01	1.455E+00
JUL	1.406E+02	2.006E+02	6.003E+01	1.170E+00
AUG	1.432E+02	2.257E+02	8.249E+01	1.353E+00
SEP	1.376E+02	2.753E+02	1.377E+02	1.529E+00
OCT	2.009E+02	3.490E+02	1.481E+02	1.504E+00
NOV	2.298E+02	4.063E+02	1.765E+02	1.493E+00
DEC	2.513E+02	4.646E+02	2.132E+02	1.550E+00
TOTALS	2.355E+03	4.214E+03	1.859E+03	1.551E+00

1. When the fan system provides more heating/cooling than is demanded by the zone loads simulation, fan system overheating/overcooling will be reported. Causes of this condition include:
   - ✓ Fan heat greater than heating load.
   - ✓ Improper control profile for VAV System.
   - ✓ Reheat coil scheduled off.

The values reported for each month (or hour) that this condition occurs are identical to those described in the FAN SYSTEM UNDERHEATING/UNDERCOOLING SUMMARY.

FAN SYSTEM HEATING/COOLING PROVIDED WITHOUT DEMAND SUMMARY

See Also:

User Reference

Produced by default when unmet loads occur.

```
       SYSTEM NUMBER=         1, MULTIZONE
       DESIGN DAY ANY DAY                                                  SIMULATION DATE 21JUL


                            H E A T I N G   W I T H O U T   D E M A N D
                  **********************************************************************



FOR ZONE     1
 NO HEATING WITHOUT DEMAND FOR THIS ZONE


FOR ZONE     2
 NO HEATING WITHOUT DEMAND FOR THIS ZONE


                            C O O L I N G   W I T H O U T   D E M A N D
                  **********************************************************************



FOR ZONE     1
 NO COOLING WITHOUT DEMAND FOR THIS ZONE


FOR ZONE     2
 NO COOLING WITHOUT DEMAND FOR THIS ZONE

SYSTEM NUMBER=         1, MULTIZONE
       SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957            SIMULATION PERIOD  1J


                            H E A T I N G   W I T H O U T   D E M A N D
                  **********************************************************************



FOR ZONE     1
 NO HEATING WITHOUT DEMAND FOR THIS ZONE


FOR ZONE     2
 NO HEATING WITHOUT DEMAND FOR THIS ZONE
```

COOLING WITHOUT DEMAND

MONTH	COOLING DEMAND FOR ZONE 1000BTU	COOLING PROVIDED BY FAN SYSTEM 1000BTU	EXCESS COOLING PRO- VIDED BY FAN SYSTEM 1000BTU	EXCESS PEAK P VIDED BY FAN 1000BTU/HR
FOR ZONE 1				
JAN	0.000E+00	3.945E+02	3.945E+02	1.573E+00
FEB	0.000E+00	2.530E+02	2.530E+02	1.542E+00
MAR	0.000E+00	2.404E+02	2.404E+02	1.545E+00
APR	0.000E+00	1.458E+02	1.458E+02	1.536E+00
MAY	0.000E+00	4.129E+01	4.129E+01	1.541E+00
SEP	0.000E+00	1.538E+00	1.538E+00	1.538E+00
OCT	0.000E+00	1.329E+02	1.329E+02	1.546E+00
NOV	0.000E+00	2.405E+02	2.405E+02	1.548E+00
DEC	0.000E+00	2.867E+02	2.867E+02	1.554E+00
TOTALS	0.000E+00	1.737E+03	1.737E+03	1.573E+00

MONTH	COOLING DEMAND FOR ZONE 1000BTU	COOLING PROVIDED BY FAN SYSTEM 1000BTU	EXCESS COOLING PRO- VIDED BY FAN SYSTEM 1000BTU	EXCESS PEAK P VIDED BY FAN 1000BTU/HR
FOR ZONE 2				
JAN	0.000E+00	4.011E+02	4.011E+02	1.573E+00
FEB	0.000E+00	2.811E+02	2.811E+02	1.550E+00
MAR	0.000E+00	2.886E+02	2.886E+02	1.547E+00
APR	0.000E+00	1.589E+02	1.589E+02	1.532E+00
MAY	0.000E+00	4.260E+01	4.260E+01	1.537E+00
SEP	0.000E+00	2.822E+01	2.822E+01	1.536E+00
OCT	0.000E+00	1.876E+02	1.876E+02	1.525E+00
NOV	0.000E+00	2.766E+02	2.766E+02	1.548E+00
DEC	0.000E+00	3.233E+02	3.233E+02	1.583E+00
TOTALS	0.000E+00	1.988E+03	1.988E+03	1.583E+00

1. Heating/cooling provided without demand occurs when the fan system heats/cools a zone even though there was no heating/cooling demand from the building simulation. Causes of this condition include:
   - ✓ Improper system operation schedule.
   - ✓ Improper control profile.
   - ✓ Inherent problems when using the VENTILATION option in the building description.

   The values reported for each month (or hour) that this condition occurs are identical to those described in the FAN SYSTEM UNDERHEATING/UNDERCOOLING SUMMARY.

AIR HANDLING SYSTEM LOAD SUMMARY

Produced by specifying SYSTEM LOAD in the REPORTS section of RUN CONTROL.

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***************************************************************************
**                                                                       **
**   A I R   H A N D L I N G   S Y S T E M   L O A D   S U M M A R Y    **
**                                                                       **
***************************************************************************


  SYSTEM NUMBER=         1, DDVAV
  SYSTEM LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957

  SIMULATION PERIOD  1JAN1957 - 14JAN1957

                            TOTAL DEMAND       PEAK DEMAND      TIME OF PEAK
                                1000BTU        1000BTU/HR        MO/DY/HR

SUM OF ZONE SENSIBLE
HEATING LOADS                8.70182E+03        1.73122E+02       1/14/ 6

TOTAL HEATING PROVIDED
BY SYSTEM                    9.62223E+03        1.91791E+02       1/14/ 5


SUM OF ZONE SENSIBLE
COOLING LOADS                4.87509E+03        1.30286E+02       1/ 8/24

SENSIBLE COOLING
PROVIDED BY SYSTEM           4.11930E+03        1.01880E+02       1/ 8/24

LATENT COOLING
PROVIDED BY SYSTEM           4.21930E+01        1.26681E+00       1/ 8/24

TOTAL COOLING PROVIDED
BY SYSTEM                    4.16150E+03        1.03147E+02       1/ 8/24



TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES =    5.67930E+04    1000BTU

TOTAL FLOOR AREA SERVED BY FAN SYSTEM =        1.21104E+03  FT**2


ENERGY BUDGET  (TOTAL ENERGY/FLOOR AREA) =     4.68960E+01    1000BTU /FT**2

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET
OR ANY ENERGY FOR DOMESTIC HOT WATER.  IT ALSO DOES NOT
INCLUDE THE EFFECT OF THE PLANT ON ENERGY CONSUMPTION.


 FRACTION OF OUTSIDE AIR           MAX [%]        AVG [%]        MIN [%]
 MX/MN DATES                         15.00          11.43           5.00
 (MO/DY/HR):                        1/ 2/ 1                       1/ 1/ 1

HRS SYSTEM OPERATED      TOTAL HRS OF SIMULATION
        336                       336

FRACTION OF OUTSIDE AIR VALUES ARE BASED ON SYSTEM OPERATING HOURS ONLY!
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1. The TOTAL DEMAND, PEAK DEMAND, and TIME of PEAK are reported for the actual heating and cooling demands as well as the actual heating and cooling provided by the system.

   TOTAL COOLING PROVIDED BY SYSTEM = SENSIBLE COOLING + LATENT COOLING.

2. TOTAL ENERGY CONSUMED BY SYSTEM AND ZONES: Sum of energy consumptions reported in AIR HANDLING SYSTEM ENERGY USE SUMMARY (BTU or kW-hr).

   TOTAL FLOOR AREA SERVED BY FAN SYSTEM: Sum of floor areas of zones served by fan system.

   ENERGY BUDGET: TOTAL ENERGY/TOTAL FLOOR AREA.

   SUM OF ZONE SENSIBLE HEATING LOADS: Total sensible heating load for all zones served by this system.

   TOTAL HEATING PROVIDED BY SYSTEM: Total consumption of all heating coils, reheat coils, and baseboard heaters.

   SUM OF ZONE SENSIBLE COOLING LOADS: Total sensible cooling load for all zones served by this system.

   SENSIBLE COOLING PROVIDED BY SYSTEM: Total sensible cooling load on all cooling and recool coils.

   LATENT COOLING PROVIDED BY SYSTEM: Total latent cooling load on all cooling coils. (Recool coils are assumed to be dry.)

   TOTAL COOLING PROVIDED BY SYSTEM: Total cooling load on all cooling and recool coils. This should equal sensible plus latent.

Note that the HEATING and COOLING provided by system, as reported here, are only the heating and cooling consumption of coils. Remember, though, that the fan system may provide heat through fan heat and return air heat gain, or it may provide cooling with outside air. So in many cases, it is possible for the heating and cooling "provided by system" to be <u>less</u> than the sum of the zone sensible heating and cooling loads.

EQUIPMENT PARAMETERS REPORT

Produced by specifying EQUIPMENT PARAMETERS in the REPORTS section of RUN CONTROL.

PLANT NUMBER= 1, PLANT

EQUIPMENT SIZE, AVAILABILITY (ES) DATA

E Q U I P M E N T	SIZE (KBTUH)	NUMBER INSTD	AVAIL	SIZE (KBTUH)	NUMBER INSTD	AVAIL	SIZE (KBTUH)	NUMBER INSTD	AVAIL	SIZE (KBTUH)	NUMBER INSTD	AVAIL	SIZ (KBTU
BOILER	0.1E+04	1	1										
DIESEL	0.1E+03	1	1										
CHILLER	0.1E+04	1	1										
WELL WATER CONDENSER	0.1E+04	1	1										

EQUIPMENT LOAD RATIOS (ER) DATA

(2)

E Q U I P M E N T	P A R T L O A D R A T I O S MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (DIMENSIONLESS)
BOILER	0.0100	1.0000	0.8700	0.0000
DIESEL	0.0200	1.0500	0.6000	0.0000
CHILLER	0.1000	1.0500	0.6500	0.2275
WELL WATER CONDENSER	0.0000	1.0000	0.5000	0.0120

(3)

EQUIPMENT PERFORMANCE COEFFS (EP) DATA V/

C O D E	N A M E	C O E F F 1	C O E F F 2	C
CAVL1A	CAPACITY RATIO VS GEN TEMP (1S ABSOR	1.00000000	-0.01611111	
REN1A	ENERGY I/O COEF (1-STG ABS CHILR)	0.19100000	0.91000000	
REN2A	ENERGY I/O COEF (2-STG ABS CHILR)	0.11467000	0.67212000	
REN2AE	ENERGY I/O COEF (2-STG ABS CHILR W ECON)	0.12917000	0.36902000	
RCAVHP	AVAILABLE CAPACITY RATIO (HEAT PUMP)	1.00600000	-0.01900000	
RPWR1C	ENERGY I/O COEFF (HERMETIC COMPR CHILR)	0.16017000	0.31644000	
RPWR2C	ENERGY I/O COEFF (OPEN CENT COMPR CHILR)	0.23900000	-0.04045000	
RPWR3C	ENERGY I/O COEFF (RECIPROC COMPR CHILR)	0.14940000	0.95680000	
RCAVDB	AVAILABLE CAPACITY RATIO (DBL BUNDLE)	1.00600000	-0.01900000	
RPWRDB	ENERGY I/O COEFF (DBL BUNDLE)	0.16017000	0.31644000	
ADJTDB	CONDENST COOLNG WTR TEMP ADJ(DBL BUNDLE)	95.00000000	1.19000000	
ADJEDB	ENERGY RATIO ADJSMNT FACTOR (DBL BUNDLE)	3.15800000	-3.31300000	
RELD	POWER OUT / FUEL INPUT COEFF (DIESEL)	0.09755000	0.63180000	
RJACD	JACKET HEAT/ FUEL INPUT COEFF (DIESEL)	0.39220000	-0.43670000	
RLUBD	LUBE HEAT / FUEL INPUT COEFF (DIESEL)	0.08830000	-0.13710000	
REXD	EXHAUST HEAT/FUEL INPUT COEFF (DIESEL)	0.31440000	-0.13530000	
TEXD	EXHAUST TEMP COEFF (DIESEL)	1179.39600000	59.99940000	
FUEL1G	FUEL I/O COEFF 1-3 (GAS TURBINE)	9.41000000	-9.48000000	
FUEL2G	FUEL I/O COEFF 4-6 (GAS TURBINE)	1.00440000	-0.00080000	
SOLAR	COLLECTOR PERFORMANCE COEFF (SOLAR)	0.81300000	-0.00063500	
FEXG	EXHAUST FLOW COEFF (GAS TURBINE)	15.63800000	-0.03060000	
TEX1G	EXHAUST TEMP COEFF 1-3 (GAS TURBINE)	917.00000000	308.00000000	
TEX2G	EXHAUST TEMP COEFF 4-6 (GAS TURBINE)	1.00560000	0.00180000	
ELUBG	LUBE OIL COEFF (GAS TURBINE)	0.22300000	-0.40000000	
ECPUMP	EVAP COND PUMP POWERCOEFF	1.00000000	0.00000000	
WCPUMP	WELL WATER COND PUMP POWER COEFF	1.00000000	0.00000000	
DTPUMP	DIRECT TOWER PUMP POWER COEFF	1.00000000	0.00000000	
RFUELB	ENERGY I/O COEFF (STEAM BOILER)	0.60000000	0.88888890	
ADJTHP	CNDNSR COOLB WTR TMP (HEAT PUMP	95.00000000	1.19000000	
ADJEHP	ENERGY RAT10 ADJSMNTFCTR (HEAT PUMP)	3.15800000	-3.31300000	
RPWRHP	ENERGY I/0 COEFF (HEAT PUMP)	0.16017000	0.31644000	
RFSTUR	STEAM FLOW COEFF (STEAM TURBINE)	1.00000000	0.00000000	
UACD	STACK U-FACTOR * AREA COEFF (DIESEL)	0.00952329	0.90000000	
UACG	STACK U-FACTOR * AREA COEFF (GAS TURB)	0.01907045	0.90000000	
HPUMP	HEATING PUMP POWER COEFFICIENTS	1.00000000	0.00000000	
CPUMP	COOLING PUMP POWER COEFFICIENTS	1.00000000	0.00000000	
TPUMP	C TOWER PUMP POWER COEFFICIENTS	1.00000000	0.00000000	
ADJT1C	COND COOL WTR T ADJ (HRMTC COMPR CHILR)	95.00000000	1.19000000	
RCAV1C	AVAIL CAPCTY RATIO (HRMTC COMPR CHILR)	1.00600000	-0.01900000	
ADJE1C	ENGY RATIO ADJSTMNT (HRMTC COMPR CHILR)	3.15800000	-3.31300000	
ADJT2C	COND COOL WTR T ADJ (OPN CENT CMPR CHLR)	95.00000000	1.19000000	
RCAV2C	AVAIL CAPCTY RATIO (OPN CENT CMPR CHLR)	1.00600000	-0.01900000	
ADJE2C	ENGY RATIO ADJSTMNT (OPN CENT CMPR CHLR)	3.15800000	-3.31300000	

EQUIPMENT PERFORMANCE COEFFS (EP) DATA VA

C O D E	N A M E	C O E F F 1	C O E F F 2	C
RCAV3C	AVAIL CAPCTY RATIO (RECIP COMPR CHILR)	1.00600000	-0.01900000	
ADJE3C	ENGY RATIO ADJSTMNT (RECIP COMPR CHILR)	3.15800000	-3.31300000	
CAVFCM	FREE COOL CHLR CAPC ADJ FACTR	0.00000000	0.02777778	
PWRFCM	FREE COOL CHLR POWER ADJ COEFF	0.00000000	0.00000000	
ADJTFC	FREE COOL CHLR COND COOL WTR T ADJ	95.00000000	1.19000000	
RCAVFC	FREE COOL CHLR CAPC ADJ FACTR	1.00600000	-0.01900000	
ADJEFC	FREE COOL CHLR ENERGY RATIO ADJ	3.15800000	-3.31300000	
RPWRFC	FREE COOL CHLR ENERGY I/O COEFF	0.23900000	-0.04045000	
ADJTDC	DIRECT TOWER CAPC ADJ FACTR	95.00000000	1.19000000	
RCAVDC	DIRECT TOWER POWER ADJ COEFF	1.00600000	-0.01900000	
ADJEDC	DIRECT TOWR ENERGY RATIO ADJ	3.15800000	-3.31300000	
RPWRDC	DIRECT TOWR ENERGY I/O COEFF	0.23900000	-0.04045000	
RELDC	DIESEL CHL PWR OUT /FUEL IN COEFF	0.09755000	0.63180000	
RJACDC	DIESEL CHL JACKET HEAT/FUEL IN COEFF	0.39220000	-0.43670000	
RLUBDC	DIESEL CHL LUBE HEAT/FUEL IN COEFF	0.88300000	-0.13710000	
REXDC	DIESEL CHL EXH HEAT/FUEL IN COEFF	0.31440000	-0.13530000	
TEXDC	DIESEL CHL EXHAUST TEMP COEFF	1179.39600000	59.99940000	
UACDC	DIESEL CHL STACK U-FAC AREA COEFF	0.00952329	0.90000000	
FUL1GC	GAS TUR CHLR FUEL I/O COEFF (1-3)	9.41000000	-9.48000000	
FUL2GC	GAS TUR CHLR FUEL I/O COEFF (4-6)	1.00440000	-0.00080000	
FEXGC	GAS TUR CHLR EXH FLOW COEFF	15.63519000	-0.03059999	
TEX1GC	GAS TUR CHLR EXH TEMP COEFF (1-3)	916.99190000	307.99800000	
TEX2GC	GAS TUR CHLR EXH TEMP COEFF (4-6)	1.00500000	0.00180000	
ELUBGC	GAS TUR CHLR LUEB OIL COEFF	0.22300000	-0.40000000	
UACGC	GAS TUR CHLR STACK U-FAC AREA COEFF	0.01907045	0.90000000	
ADJTAC	AIR CLD CHLR COND COOL WTR T ADJ	95.00000000	1.19000000	
RCAVAC	AIR CLD CHLR CAP ADJ FACTOR	1.00600000	-0.01900000	
ADJEAC	AIR CLD CHLR ENRGY RATIO ADJ	3.15800000	-3.31300000	
RPWRAC	AIR CLD CHLR ENERGY I/O COEFF	0.23900000	-0.04045000	
ADJTGC	GAS TUR CHLR COND COOL WTR T ADJ	95.00000000	1.19000000	
RCAVGC	GAS TUR CHLR CAPC ADJ FACTOR	1.00600000	-0.01900000	
ADJEGC	GAS TUR CHLR ENERGY RATIO ADJ	3.15800000	-3.31300000	
RPWRGC	GAS TUR CHLR ENERGY I/O COEFF	0.23900000	-0.04045000	
ADJTSC	STM TUR CHLR COND COOL WTR T ADJ	38.31800000	1.19000000	
RCAVSC	STM TUR CHLR CAPC ADJ FACTOR	1.00600000	-0.01900000	
ADJESC	STM TUR CHLR ENERGY RATIO ADJ	3.15800000	-3.31300000	
RPWRSC	STM TUR CHLR ENERGY I/O COEFF	0.23900000	-0.04045000	
STORE1	ICE STORAGE EVAPORATOR TEMPERATURE	-10.00000000	0.00000000	
STORE2	ICE STORAGE CONDENSER	100.38900000	0.66644300	
STORE3	ICE STORAGE COMPRESSOR CAPACITY	31.60250000	0.11081900	
STORE4	ICE STORAGE COMPRESSOR CAPACITY	0.26323300	-0.00810905	
STORE5	ICE STORAGE COMPRESSOR CAPACITY/POWER	0.00087179	6.49292000	
STORE6	ICE STORAGE COMPRESSOR POWER	0.01143770	-0.04792040	
STORE7	ICE STORAGE COMPRESSOR POWER	0.00009403	-0.00002473	

EQUIPMENT PERFORMANCE COEFFS (EP) DATA

CODE	NAME	COEFF 1	COEFF 2
STORE8	ICE STORAGE COMPRESSOR PART LOAD RATIO	9.26443000	-0.05816300
STORE9	ICE STORAGE COMPRESSOR PART LOAD RATIO	-2.46108000	0.00000000

SPECIAL PARAMETERS (S) DATA

CODE	NAME	VALUE(ENGLISH)
STEAM	STEAM ENTHALPY	1168.67800000
TSATUR	STEAM SATURATION TEMP	241.53020000
RFLASH	BOILER FLASH WATER/STEAM FEED (HEATREC)	0.07100000
PELCL	ELECT INP. TO CIRC. PUMP/COOLING LOAD	0.01800000
PELHT	ELECT INP. TO CIRC. PUMP/HEATING LOAD	0.00600000
PELTWR	ELEC INP TO TOWER/TOWER COOL LOAD(TOWER)	0.01300000
TOWOPR	TOWER OPERATION TYPE (TOWER)	2.00000000
TWMAKE	MAKE UP WATER TEMP (HEATREC)	55.00400000
TCOOL	CHILLED WATER TEMP	44.00600000
MXTNKT	MAXIMUM SOLAR TANK TEMP (SOLAR)	212.00000000
TTOWR	MIN LEAVE TOWER WATER TEMP (TOWER)	60.00800000
TCW	LEAVING CONDENSER WATER TEMP	110.00000000
TMINH	MIN TANK TEMP FOR HEATING (SOLUSE)	100.00400000
TMINC	MIN TANK TEMP FOR COOLING (SOLUSE)	179.99600000
TDCTWR	MIN LEAV DIRECT COOL TOWER TEMP	32.49986000
TLEAVE	BOILER STACK LEAVING TEMP (BOILER)	550.04000000
TEVAPC	MIN LEAV EVAP CONDENSER TEMP	60.00800000
TWWC	MIN LEAV WELL WATER COND TEMP	32.49986000
RAVRHDB	AVAILBL RECVRBL HT RATIO (DBUNDLE)	0.95000000
RAVRHHP	AVAILBL RECVRLB HT RATIO (HTPUMP)	0.95000000
RMXKWD	MAX EXH FLOW / KW OUTPUT (DIESEL)	1.46440000
TMINHP	MIN TANK TEMP FOR HT PUMP (SOLUSE)	79.88000000
RMXKWG	MAX EXH FLOW / KW OUTPUT (GASTURB)	11.71520000
RMXKWDC	MAX EXH FLOW / PWR OUTPUT	1.46440000
PELECND	EVAP COND PMP PWR / COND CAPC	0.01200000
PELWWC	WELL WATER COND PUMP PWR / COND CAPC	0.01200000
SRATB	AIR FUEL STOICH RATIO (BOILER)	17.00000000
HFUELB	HEAT CONTENT OF FUEL (BOILER)	20013.38000000
RHFLASH	RECOVD HEAT/FLASH STEAM ENERGY (HEATREC)	0.50000000
PSTEAM	STEAM PRESSURE	284.40990000
PSTMTUR	ENTERING STEAM PRESS (STEA M TURBINE)	6920.17100000

SPECIAL PARAMETERS (S) DATA

CODE	NAME	VALUE(ENGLISH)
TSTMTUR	ENTERING STEAM TEMP (STEAM TURBINE)	572.0000000
PEXSTUR	NOM EXH STEAM PRESS STEA M TURBINE	284.4099000
RPMNOM	NOM SPEED , RPM (STEAM TURBINE)	3600.0000000
RWSTUR	CONDENSATE/ENTERING STEAM(STEAM TURBINE)	0.9700000
TOTUEF	TOT EFFIC OF UTIL ELEC GENERATION(EFFIC)	0.3000000
TILT	SOLAR COLECTOR TILT ANGLE (SOLR H/C SYS)	40.0000000
AZMUTH	COLLECTOR ARRAY AZMUTH ANGLE (SOL H/C)	180.0000000
TNKCAP	STORAGE TANK CAP/COL. AREA (SOLAR H/C)	10.2408100
TNKTEM	INITIAL TANK TEMPERATURE (SOLAR H/C)	140.0000000
FLOWRT	MASS FLOW/COLLECTOR AREA (SOLAR H/C)	31.4698200
HTXEFF	TANK-COLLECTOR HT EXCGR EFFECTIVENESS	0.9000000
FCCTRL	FREE COOLING CHILLER CONTROL TYPE	1.0000000
FCOFF	FREE COOLING CHILLER OFF DATE	415.0000000
FCON	FREE COOLING CHILLER ON DATE	33.0000000
FCTEMP	FREE COOLING CHILLER CONTROL TEMP	50.0000000
RWCHC	TOWER WATER RATE / HERMITIC CHLR CAP	124.8227000
RWCFC	TOWER WATER RATE / FREE COOL CHLR	124.8227000
RWCRC	TOWER WATER RATE / RECIP CHLR CAP	124.8227000
RWCOC	TOWER WATER RATE / OPEN CHLR CAP	124.8227000
RWCDB	TOWER WATER RATE / DBUNDLE CHLR CAP	124.8227000
RWCHP	TOWER WATER RATE / HEAT PUMP CAP	124.8227000
RWC1A	TOWER WATER RATE / 1STG ABSORBER CAP	124.8227000
RWC2A	TOWER WATER RATE / 2STG ABSORBER CAP	124.8227000
RWC2AE	TOWER WATER RATE / 2STG ABS W/ECON CAP	124.8227000
RWCDC	TOWER WATER RATE / DIESEL CHLRCAP	124.8227000
RWCGC	TOWER WATER RATE / GTURBINE CHLR CAP	124.8227000
RWCSC	TOWER WATER RATE / STURBINE CHLR CAP	124.8227000
PELDTWR	ELEC IN D TWR / D TOWER CAP	0.0120000
EBEFF	ELECTRIC BOILER EFFICIENCY	1.0000000
RMXKWGC	MAX EXH FLOW /GTURB POWER OUT	11.7152000
PEXSTC	EXH STM PRESS FROM STEAM CHLR	739.2626000
RPMSTC	NOM SPEED STURB CHLRDRIVE	3600.0000000
RWSTC	CONDENSATE/ENTERING STEAM TO STM CHLR	0.9700000
CHLREF	SIMPLE CHILLER EFFICIENCY	3.2500000
BOILEF	SIMPLE BOILER EFFICIENCY	0.7500000
BOLELE	SIMPLE BOILER PARASETIC ELECTRIC FACTOR	0.0000000
DHWEFF	DOMESTIC HOT WATER HEATER EFFICIENCY	0.7500000
DHWLOS	DOMESTIC HOT WATER HEATER LOSS FACTOR	0.0000000
CONDTY	TYPE OF CONDENSER FOR ICE STORAGE UNIT	1.0000000
COMPCP	COMPRESSOR CAPACITY FOR ICE STORAGE UNIT	0.0000000
CONDCP	CONDENSER CAPACITY FOR ICE STORAGE UNIT	0.0000000

```
          SPECIAL      PARAMETERS          (S )    DATA


 CODE        NAME                                            VALUE(ENGLISH)

 -------     ----------------------------------------     ---------------

 PDPCCM      CHILLER CAPACITY MULTIPLIER                          1.00000000
 PDPBCM      BOILER CAPACITY MULTIPLIER                           1.00000000
 PDPEGM      ELECTRICALGENERATIONMULTIPLIER                       1.00000000
 PDPCTM                                                           1.00000000
 PHCE        PURCHASED HEATING CONVERSION EFFICIENCY              0.75000000
 REFTYP      REFRIGERANT IN ICE STORAGE SYSTEM                    2.00000000
 IHAREF      ICE HARVESTER SYSTEM EFFICIENCY                      0.06000000
 ICEPAR      PARASETIC LOAD OF ICE STORAGE SYSTEM                 0.00000000
 BGNICE      HOUR ICE STORAGE BEGINS USING STORAGE                9.00000000
 ENDICE      HOUR ICE STORAGE ENDS USING STORAGE                 16.00000000
 COMPEF      EFF OF ELECTRIC CONVERSION COMPRESSER                0.85000000
 ITLOSS      ICE STORAGE TANK HEAT LOSS FACTOR                    0.02000000
 CONDEL      ICE STORAGE CONDENSER ELECTRIC                       0.00000000
 ICECTL      ICE STORAGE CONTROL 1--SHAVE 2--SHIFT                2.00000000
 PSHAVE      THE COIL LOAD *NOT* MET BY ICE STORAGE               0.00000000
```

1. The following values are reported for each type of equipment.

   SIZE: The equipment size, specified by user.

   NUMBER INSTD: The number of equipment units installed.

   NUMBER AVAIL: The number of equipment units available for use. If not specified by user, defaults to NUMBER INSTD.

2. The MINIMUM, MAXIMUM, and OPTIMUM part load ratios are specified for each piece of equipment simulated. Also reported are the electrical input to capacity ratios.

3. EQUIPMENT PERFORMANCE COEFFS: This reports the value all equipment performance coefficients. Values not specified by user are set to program defaults.

4. SPECIAL PARAMETERS DATA: This reports the value of all special parameters. Values not specified by user are set to program defaults.

DESIGN PLANT REPORT SUMMARY

See Also:

User Reference:Design Plant Report

User Reference:Design Plant

Produced by default when the DESIGN PLANTS option is selected in RUN CONTROL.

```
**********************************************************************************************
**                                                                                          **
**       C E N T R A L   P L A N T   E Q U I P M E N T   D E S I G N   R E P O R T          **
**                                                                                          **
**********************************************************************************************

PROJECT ** REPORT EXAMPLES
```

```
                                  (HBLC) 2000 1196

PLANT NUMBER        1
PLANT TITLE ** PLANT 1



USER INPUT PARAMETERS

   CAPACITY  MULTIPLIERS
COOLING   HEATING   ELECTRIC
----------------------------
  1.0       1.0       1.0

                                                      DATE OF MAXIMUM
                                             UNITS    MONTH DAY HOUR
------------------------------------------------------------------------------------
MAXIMUM COOLING DEMAND            7.0052E+02  K BTU/HR     7   21  17  (MONDAY   )
MAXIMUM HEATING DEMAND            3.8993E+02  K BTU/HR     1   21  16  (SUNDAY   )
MAX SYSTEM/ZONE BOILER FUEL DEMAND  0.0000E+00  K BTU/HR     0    0   0
MAXIMUM ELECTRIC DEMAND           5.7230E+02  K BTU/HR     7   21  17  (MONDAY   )

      AVAILABLE              EQUIPMENT TYPE                SIZE    UNITS       PERCENT TOTAL
      ----------     ---------------------------------      ----------  -------     --------------
             1       BOILER                                 389.93  K BTU/HR        100.
             1       CHILLER                                700.52  K BTU/HR        100.


NOTE ***
USE OF THE DESIGN SYSTEM AND DESIGN PLANT FEATURES CAUSE A SIMULATION BASED ON THE USER SUPPLIED PARAMETERS
(I.E., SUPPLY AIR TEMPERATURE DIFFERENCES, COIL CONTROL TYPE, CONTROLLER THROTTLING RANGES, ETC.)
WHEN MAKING ALTERNATIVE STUDIES WITH THIS OPTION COMPARISON OF LIFE CYCLE COSTS MAY BE ERRONEOUS
DUE TO DIFFERENT CAPITAL COSTS ASSOCIATED WITH SIZING OF CENTRAL PLANT COMPONENTS.  WHEN SIMULATING THE
PERFORMANCE OF EXISTING BUILDINGS ACTUAL CONDITIONS SHOULD BE ENTERED, AND ALTERNATIVE STUDIES
SHOULD BE BASED ON INTENDED ALTERATIONS.
```

1. Input file parameters are reported for easy reference and include the project title; the plant number and title; and the design capacity multipliers (safety factors for sizing of equipment).
2. Results for the DESIGN PLANTS run are presented for this central plant.
   - MAXIMUM COOLING DEMAND **-** The peak demand for cooling from the systems served by this central plant in units of kBtu/h or kW. The month, day, hour, and day type of this peak demand is also provided.
   - MAXIMUM HEATING DEMAND **-** The peak demand for heating from the systems served by this central plant in units of kBtu/h or kW. The month, day, hour, and day type of this peak demand is also provided.
   - MAXIMUM BOILER FUEL DEMAND **-** The peak demand for boiler fuel for this central plant in units of kBtu/h or kW. The month, day, hour, and day type of this peak demand is also provided.
   - MAXIMUM ELECTRIC DEMAND **-** The peak total demand for electrical energy on the generators of this central plant (including electrical demands from the systems and zones being served by this plant) in units of kBtu/h or kW. The month, day, hour, and day type of this peak demand is also provided.
   - Equipment Sizes **-** The size for each equipment type in the central plant as determined by the DESIGN PLANTS routine in units of kBtu/h or kW. The PERCENT TOTAL column

shows what percentage of the peak load to which the equipment type has been sized. This would reflect any capacity multipliers entered in the input file.

BUILDING/FAN/PLANT ENERGY UTILIZATION SUMMARY

Information included in the default review summary report or can be produced by specifying ENERGY UTILIZATION in the REPORTS section of RUN CONTROL.

* PLANT NUMBER= 1, PLANT

DESIGN DAY ANY DAY SIMULATION DATE 21JUL1990

BUILDING/FAN ENERGY DEMANDS ++ GROSS PLANT EQ

HOUR	HOT WATER AND STEAM 1000BTU	DOMESTIC HOT WATER 1000BTU	COOLING COIL 1000BTU	ELECTRIC 1000BTU	NATURAL GAS DEMAND 1000BTU	TOTAL ENERGY DEMAND 1000BTU	++	HOT WATER AND STEAM 1000BTU	COOLING COIL DEMAND 1000BTU
1	0.00E+00	0.00E+00	1.91E+01	2.01E+02	0.00E+00	2.20E+02	++	0.00E+00	1.91E+01
2	0.00E+00	0.00E+00	1.90E+01	2.01E+02	0.00E+00	2.20E+02	++	0.00E+00	1.90E+01
3	0.00E+00	0.00E+00	1.89E+01	2.01E+02	0.00E+00	2.19E+02	++	0.00E+00	1.89E+01
4	0.00E+00	0.00E+00	1.87E+01	2.01E+02	0.00E+00	2.19E+02	++	0.00E+00	1.87E+01
5	0.00E+00	0.00E+00	1.86E+01	2.01E+02	0.00E+00	2.19E+02	++	0.00E+00	1.86E+01
6	0.00E+00	0.00E+00	1.86E+01	2.01E+02	0.00E+00	2.19E+02	++	0.00E+00	1.86E+01
7	0.00E+00	0.00E+00	1.53E+01	2.01E+02	0.00E+00	2.16E+02	++	0.00E+00	1.53E+01
8	0.00E+00	0.00E+00	9.64E+00	2.01E+02	0.00E+00	2.10E+02	++	0.00E+00	9.64E+00
9	0.00E+00	0.00E+00	7.84E+00	2.01E+02	0.00E+00	2.08E+02	++	0.00E+00	7.84E+00
10	0.00E+00	0.00E+00	5.97E+00	2.01E+02	0.00E+00	2.07E+02	++	0.00E+00	5.97E+00
11	0.00E+00	0.00E+00	1.00E+01	2.01E+02	0.00E+00	2.11E+02	++	0.00E+00	1.00E+01
12	0.00E+00	0.00E+00	8.17E+00	2.01E+02	0.00E+00	2.09E+02	++	0.00E+00	8.17E+00
13	0.00E+00	0.00E+00	6.29E+00	2.01E+02	0.00E+00	2.07E+02	++	0.00E+00	6.29E+00
14	0.00E+00	0.00E+00	6.39E+00	2.01E+02	0.00E+00	2.07E+02	++	0.00E+00	6.39E+00
15	0.00E+00	0.00E+00	6.35E+00	2.01E+02	0.00E+00	2.07E+02	++	0.00E+00	6.35E+00
16	0.00E+00	0.00E+00	1.35E+01	2.01E+02	0.00E+00	2.14E+02	++	0.00E+00	1.35E+01
17	0.00E+00	0.00E+00	1.57E+01	2.01E+02	0.00E+00	2.16E+02	++	0.00E+00	1.57E+01
18	0.00E+00	0.00E+00	1.06E+01	2.01E+02	0.00E+00	2.11E+02	++	0.00E+00	1.06E+01
19	0.00E+00	0.00E+00	1.01E+01	2.01E+02	0.00E+00	2.11E+02	++	0.00E+00	1.01E+01
20	0.00E+00	0.00E+00	9.51E+00	2.01E+02	0.00E+00	2.10E+02	++	0.00E+00	9.51E+00
21	0.00E+00	0.00E+00	1.46E+01	2.01E+02	0.00E+00	2.15E+02	++	0.00E+00	1.46E+01
22	0.00E+00	0.00E+00	1.86E+01	2.01E+02	0.00E+00	2.19E+02	++	0.00E+00	1.86E+01
23	0.00E+00	0.00E+00	1.90E+01	2.01E+02	0.00E+00	2.20E+02	++	0.00E+00	1.90E+01
24	0.00E+00	0.00E+00	1.92E+01	2.01E+02	0.00E+00	2.20E+02	++	0.00E+00	1.92E+01
TOTAL	0.00E+00	0.00E+00	3.20E+02	4.81E+03	0.00E+00	5.13E+03	++	0.00E+00	3.20E+02
							++(6)		
PEAK	0.00E+00	0.00E+00	1.92E+01	2.01E+02	0.00E+00	2.20E+02	++	0.00E+00	1.92E+01
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	++	MO/DY/HR	MO/DY/HR
	7/21/24	7/21/24	7/21/24	7/21/ 2	7/21/24	7/21/24	++	7/21/24	7/21/24

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       NON-PURCHASED ENERGY (7)     ++                                            PURCHASED ENERGY (8)
                                     ++
         WASTE       SOLAR       STORED  ++  BOILER      GAS        DIESEL     NATURAL    PURCHASED   PURCHASI
         HEAT        ENERGY      ENERGY  ++  FUEL       TURBINE     FUEL        GAS       ELECTRIC    HEATIN(
         USED        USED        USED    ++              FUEL
 HOUR    1000BTU     1000BTU     1000BTU ++ 1000BTU     1000BTU     1000BTU    1000BTU    1000BTU     1000BTU
 -----------------------------------------++--------------------------------------------------------------------
  1      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
  2      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
  3      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
  4      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
  5      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
  6      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
  7      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
  8      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
  9      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 10      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 11      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 12      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 13      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 14      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 15      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 16      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 17      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 18      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 19      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 20      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 21      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.91E+02    0.00E+0(
 22      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
 23      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
 24      0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
 -----------------------------------------++--------------------------------------------------------------------
 TOTAL   0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    7.67E+03   0.00E+00   4.59E+03    0.00E+0(
 PEAK    0.00E+00    0.00E+00    0.00E+00 ++ 0.00E+00    0.00E+00    3.20E+02   0.00E+00   1.92E+02    0.00E+0(
 AT      MO/DY/HR    MO/DY/HR    MO/DY/HR ++ MO/DY/HR    MO/DY/HR    MO/DY/HR   MO/DY/HR   MO/DY/HR    MO/DY/HI
          7/21/24     7/21/24     7/21/24 ++  7/21/24     7/21/24     7/21/22    7/21/24    7/21/24     7/21/2.

     (9)
 TOTAL ENERGY PURCHASED FOR USE IN BUILDING/FAN/PLANT = 1.23E+04 1000BTU , TOTAL FLOOR AREA SERVED BY PLAI

 ENERGY BUDGET (TOTAL ENERGY / FLOOR AREA) = 6.13E+01 1000BTU/FT**2
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NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET OR ANY RECOVERED OR PROCESS WASTE ENERGY USED IN TH

           PLANT NUMBER=         1, PLANT
 PLANT LOCATION = 14806  CHANUTE AFB, ILLINOIS 1440 1957            SIMULATION PERIOD  1JAN1957 - 31DEC1957


                                BUILDING/FAN ENERGY DEMANDS                   ++       GROSS PLANT EQUIPMEN
                                                                               ++
           HOT WATER   DOMESTIC    COOLING     ELECTRIC    NATURAL     TOTAL   ++ HOT WATER   COOLING     GEN
           AND STEAM   HOT WATER   COIL                    GAS         ENERGY  ++ AND STEAM   COIL        ELEC
                                   DEMAND                              DEMAND  ++             DEMAND
   MONTH   1000BTU     1000BTU     1000BTU     1000BTU     1000BTU    1000BTU  ++ 1000BTU     1000BTU     100
   ---------------------------------------------------------------------------++-----------------------------
0  JAN     0.00E+00    0.00E+00    4.70E+03    1.49E+05    0.00E+00   1.54E+05 ++ 0.00E+00    4.70E+03    7.4
0  FEB     0.00E+00    0.00E+00    5.20E+03    1.35E+05    0.00E+00   1.40E+05 ++ 0.00E+00    5.20E+03    6.7
0  MAR     0.00E+00    0.00E+00    6.27E+03    1.49E+05    0.00E+00   1.55E+05 ++ 0.00E+00    6.27E+03    7.4
0  APR     0.00E+00    0.00E+00    7.95E+03    1.44E+05    0.00E+00   1.52E+05 ++ 0.00E+00    7.95E+03    7.2
0  MAY     0.00E+00    0.00E+00    1.02E+04    1.49E+05    0.00E+00   1.59E+05 ++ 0.00E+00    1.02E+04    7.4
0  JUN     0.00E+00    0.00E+00    1.22E+04    1.44E+05    0.00E+00   1.57E+05 ++ 0.00E+00    1.22E+04    7.2
0  JUL     0.00E+00    0.00E+00    1.39E+04    1.49E+05    0.00E+00   1.63E+05 ++ 0.00E+00    1.39E+04    7.4
0  AUG     0.00E+00    0.00E+00    1.34E+04    1.49E+05    0.00E+00   1.63E+05 ++ 0.00E+00    1.34E+04    7.4
0  SEP     0.00E+00    0.00E+00    1.09E+04    1.44E+05    0.00E+00   1.55E+05 ++ 0.00E+00    1.09E+04    7.2
0  OCT     0.00E+00    0.00E+00    8.26E+03    1.49E+05    0.00E+00   1.57E+05 ++ 0.00E+00    8.26E+03    7.4
0  NOV     0.00E+00    0.00E+00    6.34E+03    1.44E+05    0.00E+00   1.51E+05 ++ 0.00E+00    6.34E+03    7.2
0  DEC     0.00E+00    0.00E+00    5.75E+03    1.49E+05    0.00E+00   1.55E+05 ++ 0.00E+00    5.75E+03    7.4
   ---------------------------------------------------------------------------++-----------------------------
   TOTAL   0.00E+00    0.00E+00    1.05E+05    1.76E+06    0.00E+00   1.86E+06 ++ 0.00E+00    1.05E+05    8.7
                                                                               ++
   PEAK    0.00E+00    0.00E+00    3.06E+01    2.01E+02    0.00E+00   2.31E+02 ++ 0.00E+00    3.06E+01    1.0
   AT      MO/DY/HR    MO/DY/HR    MO/DY/HR    MO/DY/HR    MO/DY/HR   MO/DY/HR ++ MO/DY/HR    MO/DY/HR    MO/
           12/31/24    12/31/24     7/20/ 8     7/20/ 8    12/31/24    7/20/ 8 ++ 12/31/24     7/20/ 8    12/
```

MONTH	NON-PURCHASED ENERGY: WASTE HEAT USED 1000BTU	SOLAR ENERGY USED 1000BTU	STORED ENERGY USED 1000BTU	PURCHASED ENERGY: BOILER FUEL 1000BTU	GAS TURBINE FUEL 1000BTU	DIESEL FUEL 1000BTU	NATURAL GAS 1000BTU	PURCHASED ELECTRIC 1000BTU	PURCHAS HEATIN 1000BTU
0JAN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.42E+05	0.00E+0
0FEB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E+05	0.00E+00	1.28E+05	0.00E+0
0MAR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.42E+05	0.00E+0
0APR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	1.35E+05	0.00E+0
0MAY	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.38E+05	0.00E+0
0JUN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	1.28E+05	0.00E+0
0JUL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.29E+05	0.00E+0
0AUG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.31E+05	0.00E+0
0SEP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	1.33E+05	0.00E+0
0OCT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.42E+05	0.00E+0
0NOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	1.38E+05	0.00E+0
0DEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	1.42E+05	0.00E+0
TOTAL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E+06	0.00E+00	1.63E+06	0.00E+0
PEAK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E+02	0.00E+00	1.92E+02	0.00E+0
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/H
	12/31/24	12/31/24	12/31/24	12/31/24	12/31/24	12/31/10	12/31/24	6/ 7/ 6	12/31/2

TOTAL ENERGY PURCHASED FOR USE IN BUILDING/FAN/PLANT = 4.43E+06 1000BTU , TOTAL FLOOR AREA SERVED BY PLA

ENERGY BUDGET (TOTAL ENERGY / FLOOR AREA) = 2.21E+04 1000BTU/FT**2

NOTE: THIS ENERGY BUDGET DOES NOT INCLUDE ANY LOADS NOT MET OR ANY RECOVERED OR PROCESS WASTE ENERGY USE

The BUILDING/FAN/PLANT ENERGY UTILIZATION SUMMARY can be produced if a central plant is simulated. This report appears in four sections and uses two pages. The report is the same for weather tapes except that reporting is monthly. The first segment of the report is for BUILDING/FAN ENERGY DEMANDS. The figure above and on the preceding page illustrates the relationship between the Central Plant and the demands imposed upon the plant by the building and fan systems for the BUILDING/FAN ENERGY DEMANDS. The second segment of the report shows the GROSS PLANT EQUIPMENT OUTPUTS. The third segment of the report is for NON-PURCHASED ENERGY. This segment simply reports the supplemental energy applied to the imposed load. This energy is not purchased and consists of waste heat from equipment within the plant, solar energy, and energy stored using the hot and cold storage equipment types. The fourth segment breaks down the PURCHASED ENERGY in the simulation. All energy purchased for use in the building, fan systems, and central plant is reported in this segment.

In order to describe the individual items in this report, each segment will be referred to by the numbers shown in the sample output.

1. The plant number and plant name. This report will be produced for each plant for each environment simulation type.
2. The location, environment, and the simulation period is identified for each report.
3. BUILDING/FAN ENERGY DEMANDS: This segment reports the energy demands imposed on the plant by the building and fan systems for each hour of design day simulations and each month of weather tapes. The values in this report do not include energy demands imposed on the central plant by equipment within the plant.

HOT WATER AND STEAM: The total hot water and steam demand from all fan systems served by the plant .

DOMESTIC HOT WATER: The domestic hot water demand specified for the plant .

COOLING COIL DEMAND: The total cooling coil demand from all fan systems served by the plant.

ELECTRIC: The total electrical demand from the building and fan systems served by the plant. This figure is the sum of the demands generated by lights and electrical loads in the building and fan power and DX condensing units in the fan systems.

NATURAL GAS: The total natural gas demand from the building and fan systems. This figure is the sum of the specified natural gas demand from the building and the natural gas demand from equipment in the fan systems.

TOTAL ENERGY DEMAND:This figure is the sum of the HOT WATER AND STEAM, DOMESTIC HOT WATER, CHILLED WATER, ELECTRIC, and NATURAL GAS demands from the building and fan systems for each hour of a design day or each month of a weather tape.

4. GROSS PLANT EQUIPMENT OUTPUTS: This segment reports the total energy output for each classification of equipment in the central plant for each hour of design day simulations and each month of weather tapes.

   HOT WATER AND STEAM: Total output of all equipment capable of producing hot water and steam. This figure includes the output of all boilers, solar equipment, waste heat, and heat storage equipment. Note that this figure also includes the output of equipment in the plant that is used within the plant, *e.g.*, heat generated by a boiler for use in an absorption chiller.

   COOLING COIL DEMAND: Total output of all water chilling or DX equipment .

   GENERATOR ELECTRIC: Total output of all electricity generating equipment in the central plant. This figure includes electricity produced by electrical generators for use by other equipment within the central plant.

   TOTAL EQUIPMENT OUTPUT: This figure is the sum of the HOT WATER AND STEAM, CHILLED WATER, and GENERATOR ELECTRIC outputs of the plant for each hour of a design day or each month of a weather tape.

5. TOTAL: This is the total for each column of the report.

6. PEAK -- AT: The values in this row give the peak value of the item in the corresponding column as well as the month, day, and hour at which the peak occurred.

7. NON-PURCHASED ENERGY: This segment reports the amount of all supplemental energy sources used by the plant in lieu of

purchased energy. The energy produced by these sources is not purchased from a utility or vendor. These values indicate the amounts used and are less than or equal to the total amounts of each type of supplemental energy available during the specified period of the simulation.

WASTE HEAT USED: The total amount of waste heat used by the plant to satisfy space heating, domestic hot water, makeup water preheat, or absorption chiller hot water and steam demands. This energy may be supplied by a variety of plant equipment types.

SOLAR ENERGY USED: This figure accounts for solar energy used to satisfy space heating, domestic hot water, and one-stage absorber hot water and steam demands. Solar energy may be supplied even when sunlight is not available because a hot storage tank is automatically modeled when a solar system is simulated in BLAST.

STORED ENERGY USED: Total amount of energy from HOT STORAGE TANK and COLD STORAGE TANK.

8. PURCHASED ENERGY: This segment is a breakdown of all energy purchased by the Central Plant for use in the building, fan systems, and plant equipment.

   BOILER FUEL: Total boiler fuel purchased.

   GAS TURBINE FUEL: Total gas turbine fuel purchased for use by gas turbine driven chillers and electric generators.

   DIESEL FUEL: Total diesel fuel purchased for use by diesel driven chillers and electric generators.

   NATURAL GAS: Total natural gas purchased for use in building and fan systems.

   PURCHASED ELECTRIC: Total electricity purchased from utility for use by building lights and scheduled equipment, fan systems, and plant equipment.

   PURCHASED HEATING: Heating purchased to satisfy hot water and steam demands on the central plant.

   PURCHASED COOLING: Cooling purchased to satisfy chilled water demands on the central plant.

   TOTAL ENERGY PURCHASED: Sum of the BOILER FUEL, GAS TURBINE FUEL, DIESEL FUEL, NATURAL GAS, PURCHASED ELECTRIC, PURCHASED HEATING, and PURCHASED COOLING for each hour of a design day or each month of a weather tape.

9. TOTAL ENERGY PURCHASED FOR USE IN BUILDING/FAN/PLANT: equal to the total of the TOTAL ENERGY PURCHASED COLUMN in the PURCHASED ENERGY segment. TOTAL FLOOR AREA SERVED BY PLANT: equal to the total floor area of all zones served by the central plant.

10. ENERGY BUDGET: the quotient of the total energy used by the plant for the period of the simulation and the total floor area served by the plant. If no floor is used in the simulation (floor area is zero), this value is not printed.

Energy Utilization Flowchart

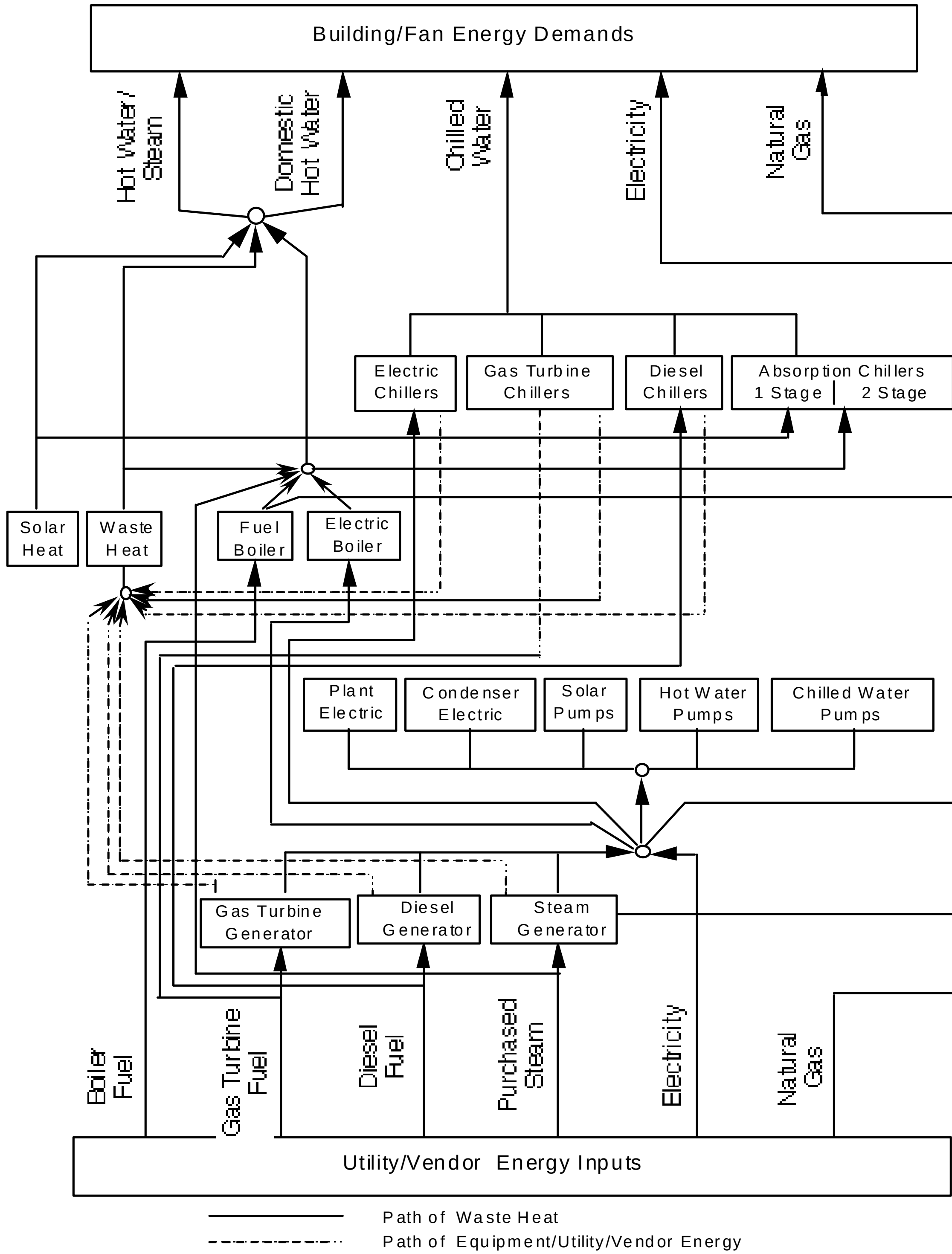
The paths traveled by the various forms of energy input and output in the BLAST plant simulation can be quite difficult to understand. The accompanying Central Plant Energy Utilization Flowchart was created to improve the BLAST user's understanding of the flow of energy in the BLAST Central Plant Simulation. The chart illustrates how energy is supplied to the Building Loads and Fan System simulations, how energy purchased from utilities and vendors is used by the plant equipment (or supplied to the Loads/Systems simulations), and how energy produced by the plant is used to drive equipment within the plant. In this representation, the utilities and vendors that supply the basic forms of energy to the plant are considered one control volume and the building and fan system are combined into another control volume. The Central Plant itself represents a third control volume.

Many important characteristics of the Central Plant are in the flowchart. To simplify the drawing, the various inputs to and outputs from the plant equipment are divided into seven basic groups. The first two groups are the Building/Fan Energy Demands (note that although domestic hot water is described as part of the Central Plant in the BLAST input, it is considered here to be part of the load imposed on the plant by the building since domestic hot water is typically utilized by persons within the building itself and not by the central plant) and the Utility/Vendor Energy Inputs discussed earlier. The next three groups account for the three types of plant equipment that can supply the demands from the Building and Fan Systems; chillers, boilers, and electricity generators. Note that the plant equipment itself can only produce hot water/steam/domestic hot water, chilled water, and electricity. In contrast, the utilities or vendors can deliver boiler fuel, gas turbine fuel, diesel fuel, and natural gas as raw fuels as well as the processed energy sources hot water/steam and electricity. Thus hot water/steam and electricity may either be produced within the plant, purchased from a utility/vendor, or may be supplied by a combination of the two. The sixth group in the chart accounts for solar heat and waste heat from plant equipment which may be used to supplement hot water/steam produced by the boilers or purchased from the utility. These heat sources are often referred to as "free" heat sources. The final group includes all of the parasitic demands of the plant. These non-productive demands include plant electric, condenser electric, solar pumps, hot water pumps, and chilled water pumps.

The flow of energy among the seven groups is most conveniently described by the flowchart. Nevertheless, the manner in which electricity and heat are used within the plant deserves closer scrutiny. Electricity is used in a more straightforward fashion than heat. It is important to note only that electrical demands originating either within the plant or within the Building/Fan simulation may be satisfied by electricity produced within the plant , electricity purchased from a utility, or by a combination of the two. Electricity from either source may be used to supply plant equipment such as chillers or an electric boiler, but the simulation does not tabulate the source of energy for a specific demand. For example, if both generated and purchased electricity are available and the Central Plant Description calls for both an electric chiller and an electric boiler , it is not possible to determine if the boiler is using purchased electricity or generated electricity, etc.

The utilization of heat in the Central Plant simulation is the most complicated element of the plant simulation. Not only can heat be produced by plant equipment such as boilers or purchased from a utility, but can it can be supplied by waste heat from several types of plant equipment or by solar collectors. Steam turbine generators, diesel generators, gas turbine generators, electric chillers, gas turbine chillers, and diesel chillers all produce waste heat which can be used to drive one- or two - stage absorption chillers and/or to supply water/steam and domestic hot water demands from the building/fan simulation. Solar energy may be used to supply all of these demands except two-stage absorption chillers. The plant can also supply the input energy for its own electrical generation since fuel boilers produce steam that can be used to drive steam turbine generators. In the flowchart, direct energy sources are denoted by solid lines and waste heat is indicated by a dotted line.

The BLAST Central Plant simulation is obviously capable of describing a highly complex interaction between various energy inputs and outputs. It is hoped that the BLAST Central Plant Energy Utilization Flowchart will promote a much better understanding of the Central Plant simulation.


Building/Fan Energy Demands
Hot Water / Steam
Domestic Hot Water
Chilled Water
Electricity
Natural Gas
Electric Chillers
Gas Turbine Chillers
Diesel Chillers
Absorption Chillers
1 Stage
2 Stage
Solar Heat
Waste Heat
Fuel Boiler
Electric Boiler
Plant Electric
Condenser Electric
Solar Pumps
Hot Water Pumps
Chilled Water Pumps
Gas Turbine Generator
Diesel Generator
Steam Generator
Boiler Fuel
Gas Turbine Fuel
Diesel Fuel
Purchased Steam
Electricity
Natural Gas
Utility/Vendor Energy Inputs
Path of Waste Heat
Path of Equipment/Utility/Vendor Energy

PLANT LOADS NOT MET SUMMARY

See Also:

User Reference

Produced by default when a plant is simulated and has unmet loads.

```
          PLANT NUMBER=         1, PLANT




          DESIGN DAY ANY DAY                                                      SIMULATION DATE 21JUL1990

                     H E A T I N G                               C O O L I N G                               E L I
0        TOTAL LOAD     PEAK LOAD                   TOTAL LOAD     PEAK LOAD                   TOTAL LOAD     PI
 MONTH   NOT MET        NOT MET        HOURS        NOT MET        NOT MET        HOURS        NOT MET        N(
         1000BTU        1000BTU/HR                  1000BTU        1000BTU/HR                  1000BTU        1(
0   1     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   2     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   3     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   4     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   5     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   6     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   7     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   8     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0   9     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0  10     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0  11     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0  12     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
0  --    ----------     ----------     -----        ----------     ----------     --------------------        -
0 TOT     0.000E+00      0.000E+00        0.         0.000E+00      0.000E+00        0.         0.000E+00      (
```

1. This report summarizes the HEATING, COOLING, and ELECTRIC demands which were not met by the plant. The TOTAL LOAD NOT MET, the PEAK LOAD NOT MET, and the number of hours which the load was not met are reported for each month and totaled for the year. Unmet loads could result from undersized equipment or bad equipment schedules.

ICE STORAGE REPORT

Produced by specifying ICE STORAGE REPORT in the REPORTS section of RUN CONTROL

PLANT NUMBER= 1, PLANT

DESIGN DAY ANY DAY SIMULATION DATI

****ICE STORAGE EQUIPMENT****

TANK CAPACITY = 3.75E+03 1000BTU C0MPRESSOR CAPACITY = 3.20E+02 (KBTUH) CONDENSER CAPACITY =

	COOLING	COOLING	STORED	STORED	++	ICE STORAGE ELECTRIC CONSUMPTION		
	ENERGY	ENERGY	ENERGY	TANK	++	COMPRESSOR	CONDENSER	PARASITIC
	STORED	USED	LOST	CAPACITY	++	ELECTRIC	ELECTRIC	ELECTRIC
HOUR	1000BTU	1000BTU	1000BTU	1000BTU	++	1000BTU	1000BTU	1000BTU
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
8	1.30E+02	0.00E+00	4.05E+00	1.26E+02	++	3.07E+01	1.11E+00	4.50E+00
9	0.00E+00	0.00E+00	4.05E+00	1.22E+02	++	0.00E+00	0.00E+00	0.00E+00
10	0.00E+00	7.38E+00	4.05E+00	1.11E+02	++	0.00E+00	0.00E+00	0.00E+00
11	0.00E+00	8.37E+00	4.05E+00	9.85E+01	++	0.00E+00	0.00E+00	0.00E+00
12	0.00E+00	1.15E+01	4.05E+00	8.30E+01	++	0.00E+00	0.00E+00	0.00E+00
13	0.00E+00	8.02E+00	4.05E+00	7.09E+01	++	0.00E+00	0.00E+00	0.00E+00
14	0.00E+00	7.11E+00	4.05E+00	5.97E+01	++	0.00E+00	0.00E+00	0.00E+00
15	0.00E+00	7.17E+00	4.05E+00	4.85E+01	++	0.00E+00	0.00E+00	0.00E+00
16	0.00E+00	9.86E+00	4.05E+00	3.46E+01	++	0.00E+00	0.00E+00	0.00E+00
17	0.00E+00	1.38E+01	4.05E+00	1.67E+01	++	0.00E+00	0.00E+00	0.00E+00
18	0.00E+00	1.27E+01	4.05E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	0.00E+00	0.00E+00	0.00E+00
TOTAL	1.30E+02	8.59E+01	4.46E+01	----	++	3.07E+01	1.11E+00	4.50E+00
PEAK	1.30E+02	1.38E+01	4.05E+00	1.26E+02	++	3.07E+01	1.11E+00	4.50E+00
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	++	MO/DY/HR	MO/DY/HR	MO/DY/HR
	7/21/ 8	7/21/17	7/21/10	7/21/ 8	++	7/21/ 8	7/21/ 8	7/21/ 8

1. The design day ice storage output report is shown above. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the storage tank capacity, the compressor capacity, and the condenser capacity are given. An explanation of each of the columns is given below.

Column	Description
Cooling Energy Stored	The amount of energy that the ice storage device has stored during this hour.
Cooling Energy Used	The amount of energy that the ice storage device has used for cooling purposes during this hour.
Stored Energy Lost	The amount of energy that the ice storage device has lost to the surroundings during this hour.
Compressor Electric	The electric consumption of the compressor during this hour.

Condener Electric

Condenser Electric	The electric consumption of the condenser during this hour.
Parasitic Electric	The parasitic electric consumption during this hour.
Total Electric	The total electric consumption of the ice storage device during this hour. This should be equal to the sum of the compressor, condenser, and parasitic electric consumptions.

STRATIFIED TANK REPORT

Produced by specifying STRATIFIED TANK REPORT in the REPORTS section of RUN CONTROL.

```
PLANT NUMBER=         2, THERMALLY STRATIFIED TANK



DESIGN DAY CHICAGO ILLINOIS SUMMER                      SIMULATION DATE 21JUL1993 (MONDAY   )

                                       ****STRATIFIED THERMAL STORAGE TANK EQUIPMENT****
IDEAL TANK CAPACITY = 4.94E+031000BTU


              ENERGY      ENERGY      CURRENT   ++   STRATIFIED STORAGE ELECTRIC CONSUMPTION
              STORED      USED        TANK      ++        PUMP                PARASITIC
              THIS HOUR   THIS HOUR   CAPACITY  ++        ELECTRIC            ELECTRIC
      HOUR    1000BTU     1000BTU     1000BTU   ++        1000BTU             1000BTU
      ------------------------------------------++-----------------------------------
         1    1.94E+02    0.00E+00    1.28E+03  ++        3.14E+00            9.88E-01
         2    1.94E+02    0.00E+00    1.46E+03  ++        3.14E+00            9.88E-01
         3    1.94E+02    0.00E+00    1.64E+03  ++        3.14E+00            9.88E-01
         4    1.94E+02    0.00E+00    1.82E+03  ++        3.14E+00            9.88E-01
         5    1.94E+02    0.00E+00    2.00E+03  ++        3.14E+00            9.88E-01
         6    1.94E+02    0.00E+00    2.18E+03  ++        3.14E+00            9.88E-01
         7    0.00E+00    1.12E+02    2.09E+03  ++        1.82E+00            9.88E-01
         8    0.00E+00    1.52E+02    2.00E+03  ++        2.46E+00            9.88E-01
         9    0.00E+00    1.85E+02    1.83E+03  ++        3.00E+00            9.88E-01
        10    0.00E+00    2.14E+02    1.65E+03  ++        3.47E+00            9.88E-01
        11    0.00E+00    2.27E+02    1.48E+03  ++        3.68E+00            9.88E-01
        12    0.00E+00    2.47E+02    1.30E+03  ++        4.00E+00            9.88E-01
        13    0.00E+00    2.44E+02    1.13E+03  ++        3.95E+00            9.88E-01
        14    0.00E+00    2.60E+02    8.82E+02  ++        4.22E+00            9.88E-01
        15    0.00E+00    2.64E+02    6.37E+02  ++        4.27E+00            9.88E-01
        16    0.00E+00    2.58E+02    4.08E+02  ++        4.17E+00            9.88E-01
        17    0.00E+00    2.28E+02    2.12E+02  ++        3.70E+00            9.88E-01
        18    0.00E+00    0.00E+00    2.14E+02  ++        3.70E+00            9.88E-01
        19    1.94E+02    0.00E+00    3.96E+02  ++        3.14E+00            9.88E-01
        20    1.94E+02    0.00E+00    5.78E+02  ++        3.14E+00            9.88E-01
        21    1.94E+02    0.00E+00    7.61E+02  ++        3.14E+00            9.88E-01
        22    1.94E+02    0.00E+00    9.43E+02  ++        3.14E+00            9.88E-01
        23    1.94E+02    0.00E+00    1.12E+03  ++        3.14E+00            9.88E-01
        24    1.94E+02    0.00E+00    1.31E+03  ++        3.14E+00            9.88E-01
      ------------------------------------------++-----------------------------------
      TOTAL   2.33E+03    2.39E+03    ----      ++        8.02E+01            2.37E+01

      PEAK    1.94E+02    2.64E+02    2.18E+03  ++        4.27E+00            9.88E-01
      AT       7/21/24     7/21/15     7/21/ 6  ++         7/21/15             7/21/24
```

1. The design day stratified tank report is shown above. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the

ideal stratified tank capacity is given. An explanation of each column is given below.

Column	Description
Energy Stored This Hour	The amount of energy added to the tank this hour based on the enthalpy of the water introduced at the tank inlet.
Energy Used This Hour	The amount of energy removed from the tank this hour based on the enthalpy of the water removed at the tank outlet.
Current Tank Capacity	The energy capacity of the tank is reported as a change in internal energy. It is important to note that the reference for the tank capacity calculations is different from the energy stored and energy used calculations. Therefore, one can not subtract or add the energy stored or energy used to obtain the tank capacity.
Pump Electric	The pump electric consumption during this hour.
Parasitic Electric	Parasitic electric consumption during this hour.

Produced by specifying STRATIFIED TANK REPORT in REPORTS

```
|PLANT NUMBER=         2, THERMALLY STRATIFIED TANK
|
|
|
|
|PLANT LOCATION = *****  OHARE  DESIGN WEEK                          SIMULATION PERIOD 24JUL1993 - 30
|
|                                            ****STRATIFIED THERMAL STORAGE TANK EQUIPMENT****
|IDEAL TANK CAPACITY = 4.94E+031000BTU
|
|
|       ++                                                            ELECTRIC CONSUMPTION  ++ STRATI
|       ++       ON-PEAK HRS                   OFF-PEAK HRS           ON-PEAK OFF-PEAK HRS  ++   TOTA
|       ++       TANK STORAGE                  TANK STORAGE              TOTAL   TOTAL      ++   HOUR
|       ++  ENERGY STROED  ENERGY USED   ENERGY STORED  ENERGY USED                         ++  NOT M
|  MONTH ++   1000BTU        1000BTU      1000BTU        1000BTU         1000BTU  1000BTU    ++
| -------++---------------------------------------------------------------------------------++-------
|0  JAN  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  FEB  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  MAR  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  APR  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  MAY  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  JUN  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  JUL  ++  0.00E+00       1.52E+04      1.61E+04       0.00E+00       4.04E+02  3.72E+02   ++     0
|0  AUG  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  SEP  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  OCT  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  NOV  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
|0  DEC  ++  0.00E+00       0.00E+00      0.00E+00       0.00E+00       0.00E+00  0.00E+00   ++     0
| -------++---------------------------------------------------------------------------------++-------
| TOTALS ++  0.00E+00       1.52E+04      1.61E+04       0.00E+00       4.04E+02  3.72E+02   ++     0
```

1. The annual stratified tank report is shown above. As with all BLAST output reports, the plant number and title, the plant location, and the simulation period are given. In addition, the ideal stratified tank capacity is given. An explanation of each column is given below.

Column	Description

Energy Stored	The amount of energy added to the tank based on the enthalpy of the water introduced at the tank inlet.
Energy Used	The amount of energy removed from the tank based on the enthalpy of the water removed at the tank outlet.
Electric Consumption	Total electric consumption of the stratified tank storage.
Total Hours Not Met	The number of hours that the stratified tank did not meet the required demand.
Total Consume Not Met	The total consume that the stratified storage tank did not meet.

PLANT EQUIPMENT ENERGY INPUT BREAKDOWN

Produced by specifying PLANT LOADS in the REPORTS section of RUN CONTROL.

PLANT NUMBER= 1, PLANT

DESIGN DAY ANY DAY SIMULATION DATE 21JU

CHILLED WATER EQUIPMENT ENERGY INPUT BREAKDOWN

HOUR	DIESEL CHILLER 1000BTU	GAS TURBINE CHILLER 1000BTU	ELECTRIC CHILLER 1000BTU	ABSORBER CHILLER HW/STEAM 1000BTU	ABSORBER PARASITIC ELECTRIC 1000BTU	CONDENSER ELECTRIC 1000BTU	CHIL WAT PUM 1000
1	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.24E+00	1.80
2	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.24E+00	1.80
3	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.24E+00	1.80
4	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.24E+00	1.80
5	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.23E+00	1.80
6	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.23E+00	1.80
7	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.15E+00	1.80
8	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.01E+00	1.80
9	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	1.96E+00	1.80
10	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	1.92E+00	1.80
11	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.02E+00	1.80
12	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	1.97E+00	1.80
13	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	1.92E+00	1.80
14	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	1.93E+00	1.80
15	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	1.93E+00	1.80
16	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.10E+00	1.80
17	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.16E+00	1.80
18	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.03E+00	1.80
19	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.02E+00	1.80
20	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.01E+00	1.80
21	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.13E+00	1.80
22	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.23E+00	1.80
23	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.24E+00	1.80
24	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.25E+00	1.80
TOTAL	0.00E+00	0.00E+00	1.70E+03	0.00E+00	0.00E+00	5.04E+01	4.32
(5)							
PEAK	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.25E+00	1.80
AT	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/DY/HR 7/21/24	MO/D 7/2

(6) (7)

HOT WATER/STEAM AND SOLAR EQUIPMENT ENERGY INPUT BREAKDOWN ++ ELECTRIC GENERATOR ENER

HOUR	ELECTRIC BOILER 1000BTU	FUEL BOILER 1000BTU	FUEL BOILER ELECTRIC 1000BTU	HOT WATER PUMPS 1000BTU	SOLAR PUMP ELECTRIC 1000BTU	TOTAL HW/STEAM INPUT 1000BTU	++	DIESEL FUEL 1000BTU	GAS TURBINE FUEL 1000BTU	1
1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
8	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
9	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
12	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
13	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
15	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
17	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
18	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
20	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
21	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
22	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
23	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
TOTAL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	7.67E+03	0.00E+00	0
PEAK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	++	3.20E+02	0.00E+00	0
AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	++	MO/DY/HR	MO/DY/HR	M
	7/21/24	7/21/24	7/21/24	7/21/24	7/21/24	7/21/24	++	7/21/22	7/21/24	

PLANT NUMBER= 1, PLANT

PLANT LOCATION = 14806 CHANUTE AFB, ILLINOIS 1440 1957 SIMULATION PERIOD 1JAN195

CHILLED WATER EQUIPMENT ENERGY INPUT BREAKDOWN

	MONTH	DIESEL CHILLER 1000BTU	GAS TURBINE CHILLER 1000BTU	ELECTRIC CHILLER 1000BTU	ABSORBER CHILLER HW/STEAM 1000BTU	ABSORBER PARASITIC ELECTRIC 1000BTU	CONDENSER ELECTRIC 1000BTU	CHIL WAT PUM 1000
0	JAN	0.00E+00	0.00E+00	5.26E+04	0.00E+00	0.00E+00	1.43E+03	1.34
0	FEB	0.00E+00	0.00E+00	4.75E+04	0.00E+00	0.00E+00	1.32E+03	1.21
0	MAR	0.00E+00	0.00E+00	5.26E+04	0.00E+00	0.00E+00	1.47E+03	1.34
0	APR	0.00E+00	0.00E+00	4.84E+04	0.00E+00	0.00E+00	1.41E+03	1.30
0	MAY	0.00E+00	0.00E+00	4.84E+04	0.00E+00	0.00E+00	1.46E+03	1.34
0	JUN	0.00E+00	0.00E+00	4.12E+04	0.00E+00	0.00E+00	1.34E+03	1.30
0	JUL	0.00E+00	0.00E+00	3.92E+04	0.00E+00	0.00E+00	1.33E+03	1.34
0	AUG	0.00E+00	0.00E+00	4.16E+04	0.00E+00	0.00E+00	1.37E+03	1.34
0	SEP	0.00E+00	0.00E+00	4.66E+04	0.00E+00	0.00E+00	1.44E+03	1.30
0	OCT	0.00E+00	0.00E+00	5.22E+04	0.00E+00	0.00E+00	1.51E+03	1.34
0	NOV	0.00E+00	0.00E+00	5.09E+04	0.00E+00	0.00E+00	1.43E+03	1.30
0	DEC	0.00E+00	0.00E+00	5.26E+04	0.00E+00	0.00E+00	1.46E+03	1.34
	TOTAL	0.00E+00	0.00E+00	5.74E+05	0.00E+00	0.00E+00	1.70E+04	1.58
	PEAK	0.00E+00	0.00E+00	7.07E+01	0.00E+00	0.00E+00	2.39E+00	1.80
	AT	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/DY/HR	MO/D
		12/31/24	12/31/24	12/31/24	12/31/24	12/31/24	6/ 7/ 6	12/3

		HOT WATER/STEAM AND SOLAR EQUIPMENT ENERGY INPUT BREAKDOWN						ELECTRIC GENERATOR ENERGY INP		
	MONTH	ELECTRIC BOILER 1000BTU	FUEL BOILER 1000BTU	FUEL BOILER ELECTRIC 1000BTU	HOT WATER PUMPS 1000BTU	SOLAR PUMP ELECTRIC 1000BTU	TOTAL HW/STEAM INPUT 1000BTU	DIESEL FUEL 1000BTU	GAS TURBINE FUEL 1000BTU	STEAM 1000BTU
0	JAN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
0	FEB	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.15E+05	0.00E+00	0.00E+0
0	MAR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
0	APR	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	0.00E+0
0	MAY	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
0	JUN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	0.00E+0
0	JUL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
0	AUG	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
0	SEP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	0.00E+0
0	OCT	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
0	NOV	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.30E+05	0.00E+00	0.00E+0
0	DEC	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.38E+05	0.00E+00	0.00E+0
	TOTAL	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.80E+06	0.00E+00	0.00E+0
	PEAK	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.20E+02	0.00E+00	0.00E+0
	AT	MO/DY/HR 12/31/24	MO/DY/HR 12/31/24	MO/DY/HR 12/31/24	MO/DY/HR 12/31/24	MO/DY/HR 12/31/24	MO/DY/HR 12/31/24	MO/DY/HR 12/31/10	MO/DY/HR 12/31/24	MO/DY/H 12/31/2

The PLANT EQUIPMENT ENERGY INPUT BREAKDOWN is produced by specifying PLANT LOADS in REPORTS. This report appears in three sections and uses two pages. The preceding figure shows an example of the report for a design day. The report is the same for weather tapes except that reporting is monthly.

1. The plant number and plant name. This report will be produced for each plant for each environment simulation type.
2. The location, environment, and the simulation period is identified for each report.
3. CHILLED WATER EQUIPMENT ENERGY INPUT BREAKDOWN: This segment reports the energy input to each type of chilled water equipment in use in the plant and of condenser electric and chilled water pumps.

DIESEL CHILLER: Total diesel fuel input to diesel driven chillers.

GAS TURBINE DRIVEN CHILLER: Total gas turbine fuel input to gas turbine driven chillers.

ELECTRIC CHILLER: Total electrical input to electrically driven chillers.

ABSORBER CHILLER HW/STEAM: Total hot water/steam input to one- and two-stage absorption chillers.

ABSORBER PARASITIC ELECTRIC: Total parasitic electrical input to absorption chillers.

CONDENSER ELECTRIC: Total electrical input to condensers serving all chillers.

CHILLED WATER PUMPS: Total electrical input to chilled water pumps.

TOTAL CW INPUT: Total energy consumed by plant to generate chilled water. This figure is the sum of DIESEL CHILLER, GAS TURBINE CHILLER, ELECTRIC CHILLER, ABSORBER

CHILLER HW/STEAM, ABSORBER PARASITIC ELECTRIC, CONDENSER ELECTRIC, AND CHILLED WATER PUMPS for each hour of a design day or each month of a weather tape.

4. TOTAL: This is the total for each column of the report.

5. PEAK -- AT: The values in this row give the peak value of the item in the corresponding column as well as the month, day, and hour at which the peak occurred.

6. HOT WATER/STEAM AND SOLAR EQUIPMENT ENERGY INPUT BREAKDOWN: This segment reports the energy input to hot water and steam generating equipment in the central plant.

ELECTRIC BOILER: Total electrical input to electric boilers.

FUEL BOILER: Total boiler fuel input to fuel fired boilers.

FUEL BOILER ELECTRIC: Total parasitic electrical input to fuel fired boilers.

HOT WATER PUMPS: Total electrical input to hot water pumps.

SOLAR PUMP ELECTRIC: Total electrical input to pumps for solar energy systems.

TOTAL HW/STEAM INPUT: Total energy input to the plant to generate hot water and steam. This figure is the sum of ELECTRIC BOILER, FUEL BOILER, FUEL BOILER ELECTRIC, HOT WATER PUMPS, and SOLAR PUMP ELECTRIC for each hour of a design day or each month of a weather tape.

7. ELECTRIC GENERATOR ENERGY INPUT BREAKDOWN: This segment reports the energy input to electricity generating equipment.

DIESEL FUEL: Total diesel fuel consumed by diesel driven electric generators.

GAS TURBINE FUEL: Total gas turbine fuel consumed by gas turbine driven electric generators.

STEAM: Total steam consumed by steam turbine driven electric generators.

TOTAL GENERATOR INPUT: Total energy input to plant to generate electricity. This figure is the sum of DIESEL FUEL, GAS TURBINE FUEL, and STEAM for each hour of a design day or each month of a weather tape.

EQUIPMENT USE STATISTICS

Produced by EQUIPMENT STATS in the REPORTS section of RUN CONTROL.

```
************************************************************************************************************
**                                                                                                        **
**                            E Q U I P M E N T   U S E   S T A T I S T I C S                             **
**                                                                                                        **
************************************************************************************************************


           PLANT NUMBER=         1, PLANT 1



           DESIGN DAY CHANUTE AFB ILLINOIS SUMMER                       SIMULATION DATE 21JUL1998 (MONDAY   )

 ------------------          -----   -------  --------   ------------------
                              AVG      MAX    MN
 E Q U I P M E N T           OPER     LOAD       DY        SIZE       OPER
                             RATIO   (KBTUH)        HR    (KBTUH)     HOURS
 ------------------          -----   -------  -- -- --   ---------   ------

 BOILER                      0.000   0.0E+00   7 21 24       400.         0

 DIESEL                      0.895   0.2E+03   7 21 24       230.        24

 CHILLER                     0.677   0.4E+03   7 21 24       400.        18

 EVAPORATING CONDENSER       2.088   0.5E+03   7 21 16       200.         0

 HOT WATER HEATER (FUEL)     0.000   0.0E+00   0  0  0       120.         0
```

1. The following values are reported for each piece of plant equipment used.

   AVG OPER RATIO: The total load divided by the number of hours of operation divided by the nominal capacity.

   MAX LOAD: The maximum load occurring on equipment.

   MN-DY-HR: The month, day and hour when MAX LOAD occurs.

   SIZE: Equipment size as specified by user.

   OPER HOURS: The number of hours which equipment is operating. When there is more than one piece of equipment for a given size, the OPER HOURS is the combined total for all of the pieces. For example: if 2 chillers of size 1000 both operate for 24 hours, then OPER HOURS = 48.

PSYCHROMETRIC ERROR SUMMARY

See also:

User Reference:Default Reports.

Produced by default.

```
PSYCHROMETRIC ERROR SUMMARY  CUMULATIVE FOR ENTIRE RUN

 ROUTINE      NUMBER OF ERRORS

   PSYDPT            0
   PSYRHT            0
   PSYTWD            0
   PSYVTW            0
   PSYWDP            0
   PSYWTH            0
```

```
PSYWTP              21
PSYWTR               0
SATUPT               6
SATUTH               0
SATUTP               0
```

Psychrometric Errors

See Also:

Psychrometric Error Summary

Psychrometric errors are reported by BLAST when the calculated properties of moist air are thermodynamically inconsistent. In general, these errors may be separated into three types:

1. Warnings that occur when calculated property values do not fall within the range of validity for a given equation. The saturation property subroutines, for example, are all valid over specified ranges of temperature, pressure, and enthalpy. When calculated properties exceed these ranges a warning message is printed. BLAST continues to execute using the best calculated approximation of the property.
2. Warnings that occur when a calculated property is thermodynamically or physically invalid. Some examples of invalid property values are wet-bulb temperatures that are greater than dry-bulb temperatures and humidity ratios or specific volumes that are less than zero. When these errors occur, BLAST prints the calculated property value as well as the property value that it uses for the simulation.
3. Warnings and "Severe" error messages that occur when an iterative calculation does not converge. When these errors occur, BLAST continues to execute with either the last value of the iteration or an average property value.

As noted above, psychrometric errors do not cause the BLAST program to abort. To obtain an accurate simulation, however, the user should modify his input parameters to eliminate psychrometric errors in the simulation. In order to identify these errors, a complete listing of psychrometric error messages is shown in the following paragraphs. Each error message shows in parenthesis the BLAST routine in which the error occurs.

One of the following errors occurs if the humidity ratio or specific volume is less than zero.

"WARNING. CALC. HUM. RATIO INVALID (PSYWTP)"

"WARNING. CALC. HUM. RATIO INVALID (PSYWTR)"

"WARNING. CALC. HUM. RATIO INVALID (PSYWTH)"

"WARNING. CALC. OF SPECIFIC VOL. RESET (PSYVTW)"

If the dew point temperature is calculated to be greater than the wet-bulb temperature, the following error message is printed:

"WARNING. CALC. OF DEWPOINT TEMP BEING RESET (PSYDPT)"

If the wet-bulb temperature is calculated to be greater than the dry-bulb temperature, the error message is:

"WARNING. CALC. OF WET-BULB TEMP INVALID (PSYWTP)"

Both the saturation temperature and the wet-bulb temperature are calculated by an iterative procedure. If the solutions do not converge, one of the following error messages is printed:

"WARNING. CALC. OF WET-BULB DID NOT CONVERGE(PSYTWD)"

"SEVERE. T DOES NOT CONVERGE (SATUTH)

All of the saturation properties must fall within BLAST specified ranges. If any of the calculated properties are not within these ranges one of the following error messages is printed:

"WARNING. TEMPERATURE OUT OF RANGE (SATUPT)"

"WARNING. PRESSURE OUT OF RANGE (SATUTP)"

"WARNING. ENTHALPY OUT OF RANGE (SATUTH)"

Eliminating Psychrometric Errors

Although the causes of psychrometric errors are often difficult to determine, they can often be traced to inconsistent parameter values in the Cooling Coil Design Parameters Block. This BLAST input data block is shown below:

```
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE = CHILLED WATER;
    AIR VOLUME FLOW RATE=1500;
    BAROMETRIC PRESSURE=405.5;
    AIR FACE VELOCITY=492.1;
    ENTERING AIR DRY BULB TEMPERATURE=74.9;
    ENTERING AIR WET BULB TEMPERATURE=64.0;
    LEAVING AIR DRY BULB TEMPERATURE=55.0;
    LEAVING AIR WET BULB TEMPERATURE=52.7;
    ENTERING WATER TEMPERATURE=45.0;
    LEAVING WATER TEMPERATURE=55.0;
    WATER VOLUME FLOW RATE=1.2657;
    WATER VELOCITY = 275.6;
END COOLING COIL DESIGN PARAMETERS;
```

The values assigned to these parameters should approximate the design operating conditions of the cooling coil in your fan system. BLAST will simulate the performance of the cooling coil based on these parameters. In order to obtain an accurate simulation, reasonable numbers must be used. The following guidelines should be followed in specifying cooling coil design parameters.

1. The design air volume flow rate should be equal to (or at least close to) the actual fan system supply air volume.
2. The user should make sure that there is an energy balance between the water side and the air side of the cooling coil (i.e. the heat transfer to the water is equal to the heat transfer from the air).
3. Finally, the user should make sure that the temperatures are possible (i.e. the wet-bulb temperature must be less than the dry-bulb temperature.)

Cooling Coil Condensation

The cooling coil performance is calculated in BLAST by performing an enthalpy balance on the cooling coil. Under certain conditions, the air entering the cooling coil may be super-saturated. This is due to the fact that in the BLAST simulation, the cooling coil is the only place where condensation is allowed to occur. When super-saturated air enters the cooling coil, BLAST assumes that some condensation has already occurred (in the ducts or on windows, for example) and adjusts the humidity ratio at the cooling coil inlet to the saturated condition. BLAST reports this adjustment in the cooling coil entering humidity ratio with the following message:

"IN COOLING COIL, THE INPUT HUMIDITY RATIO, WE = ### IS LARGER THAN DRY-BULB SATURATION HUMIDITY RATIO WEMX = ####, HENCE WE=WEMX HAS BEEN PERFORMED."

This condition may be caused by unreasonably large latent loads in the building loads simulation. Large latent loads could increase the zone air humidity ratio beyond the saturation point. The user should check to make sure that the latent loads in the building are in the correct units and of reasonable magnitude.

The message may also indicate an error introduced by the calculation of the outside air humidity ratio. For design day simulations, the wet-bulb temperature is used with the maximum dry bulb temperature to determine the humidity ratio. This humidity ratio is used for the entire day. If the calculated humidity ratio exceeds the saturated humidity ratio at the dry-bulb temperature for a given hour, then the above error message will be printed. Since the humidity ratio is included in the weather data for an annual simulation, the weather file should be checked for bad data if the error occurs in a weather tape (annual) simulation.

LCC Reports

Produced by specifying LCC or LCC CONDENSED in the REPORTS section of RUN CONTROL. This output is suited for entering data or importing into a Life Cycle Cost Analysis program such as WinLCCID. It is not truly a "report" but is a file that is specially formatted. It includes the consumption (preferably annual) of each of the equipments in each PLANT in the simulation.

The CONDENSED option produces one line total for each equipment type. The plain LCC produces one line for each hour as well as the totals found in the CONDENSED program. This file can be used in the WinLCCID program as well as in the Pollution Analysis portion of the HBLC program.

An example CONDENSED file is shown in its entirety.

```
** LCC FILE CONDENSED
NUMBER OF PLANTS  1
NUMBER OF DAYS  365
UNITS ARE    ENGLISH (   1000BTU  )


PLANT         1
PLANT #1
TOTAL ELECTRIC DEMAND      0.545E+06
PURCHASED ELECTRIC         0.545E+06
PURCHASED NATURAL GAS      0.000E+00 (INCLUDES BUILDING AND FAN DEMANDS ONLY)
PURCHASED DIESEL FUEL      0.000E+00
PURCHASED GAS TURBINE FUEL 0.000E+00
PURCHASED BOILER FUEL      0.111E+07 (PLANT DEMANDS ONLY)
PURCHASED STEAM            0.000E+00
```

There was one plant in this simulation. The electric demand is shown in the first line after the plant title ("PLANT #1"). Because BLAST does not know what kind of fuel the boiler is using, the line "PURCHASED BOILER FUEL" shows this amount.

BTEXT User Guide

Introduction to BTEXT

The BLAST text input processor (BTEXT) is an automated technique for producing an energy analysis model of a single building. BTEXT is interactive with online help available. BTEXT is menu structured so that a user inputs in a free-lance fashion where defaults take precedence when critical data is not input. A BLAST input deck can be created in parts as well as all at once. Also, an old building model created by BTEXT can be changed or updated.

Chapter 2 describes the characteristics of the BLAST text input processor. Chapter 3 describes how the organization of BTEXT appears to the user. Chapter 4 lists limits on BTEXT input.

With a general knowledge of BLAST any individual can learn to use BTEXT after one to two hours of description and demonstration by an experienced user. An individual can also learn to use BTEXT by reading this manual, using online help, and doing several practice runs.

Characteristics

Before discussing the menu structure, there are a few characteristics of BTEXT that the user should understand. BTEXT has general features of online help, storage of a project or partial project, some mandatory project input, and the ability to stop a session without saving information. The following conventions are used throughout the BTEXT User Guide:

`COMPUTER OUTPUT` - indicates all computer generated information

user literal input - indicates commands or keywords which must be typed in literally by the user

<cr> - is the convention used for "return"

In this and other sections, C: will illustrate computer prompts or responses and U: will illustrate user inputs. **<cr>** illustrates the user pressing the return key as the response.

Online Help

For each question (or prompt) in BTEXT there are two kinds of online help available. The two different kinds (or levels) of help are: 1) How the question relates to BLAST and 2) What BTEXT requires as an answer. These helps are accessed by the user by inputting @ or #, respectively. BLAST help (@) gives the user help with reference to the BLAST program and specifies the units of input English and metric (metric in parenthesis) when applicable. BTEXT help (#) gives the user help in defining what the user can input such as integer, real number, words, number of characters, etc.

An example of online help in BTEXT (taken from a material definition) is:

```
K=?

@

Conductivity of material, Btu/hr-ft-F (or W/m-K)

K=?

#

Decimal conductivity (0.01 to 100)

K=?
```

In the above example, BTEXT asked for the K parameter of a MATERIAL definition. The user input @ asking for BLAST help (asking what is K). The response was that K is conductivity with English units of Btu/[hr.*ft.* degrees Fahrenheit]. The metric units are watts/[meter*degrees Kelvin] which are shown in parenthesis. The user then input # asking for BTEXT help. The response was that the expected value is a real number with a range of 0.01 to 100. Notice that after the help is given the same prompt for C: K=? appears (i.e. online help does not change the position of the input in the program). Another example of help is:

```
    SOLAR DISTRIBUTION = -1

    @
Solar Distribution constant, used by BLAST to determine the method
of distributing solar radiation within the zones.
0 = Shadow patterns on exterior surfaces caused by detached
shading,
    wings, overhangs, and exterior surfaces are all computed.  Beam
    sunlight through the windows is assumed incident on the floor,
    where it is absorbed according to the floor material's solar
    absorbance.  Any beam not absorbed is added to the zone diffuse
    radiation and distributed uniformly to all interior surfaces.
1 = The beam radiation falling on each surface in the zone is
    calculated by BLAST from the projection of the sun's rays
through
    the windows.  This radiation will be absorbed according to the
    surface material's solar absorbance.  The user must ensure that
    the surfaces describing the zone enclose a space.
-1= Detached shading surfaces and zone surfaces have no effect on
the
    shading calculated by BLAST.  Shading effects of wings and
over-
    hangs are properly calculated if the relative position of the
    wing or overhang is correctly represented.

    SOLAR DISTRIBUTION = -1

    #
Must be one of the allowable Solar Distribution values (-1, 0 or
1).
```

SOLAR DISTRIBUTION = -1

Here the current value of SOLAR DISTRIBUTION is displayed to the user. The user may enter **<cr>** to keep this value or enter the desired value.

DBASE

After each time BTEXT is used a database (DBASE) of the building model is created for later access and/or model modification. The DBASE file allows the user to build a model in multiple sessions. The building model is referred to as a project.

At the beginning of each BTEXT run a DBASE name is requested.

DBASE NAME?

There are three simple rules to follow in response.

(1) If the run is a completely new project, respond with a new and unique DBASE project ID, respond with a Y (for yes) to the next prompt asking if the run is new, then respond with a N (for NO) to the next prompt asking if a modification of an old DBASE is desired. If you wish to view all .BS files in your directory, type a "?" or “LIST”. An example is:

DBASE NAME ?

LIST

TEST1.BS

TEST2.BS

DBASE NAME ?

NRUN

NEW RUN? (Y/N)

Y

WISH TO START WITH AN OLD RUN ? (Y/N)

N

(2) If the run is a modification of an old run and the old run is no longer needed then respond with the old DBASE project ID remembering that the old DBASE file will no longer be available as it was, but will be changed just as changes are made in the run (however, if no changes are made in the run the DBASE file will remain the same). An example is:

DBASE NAME ?

ORUN

ORUN.BS RETRIEVED

(3) If the run is a modification of an old run but you wish to keep the old DBASE as it is, then respond with a new and unique project ID and respond with a Y (for yes) to the next prompt asking if the run is new as in (1), then respond with a Y to the next prompt asking if a modification of an old DBASE is desired, then the next prompt will ask for the old DBASE project ID for which you respond with the DBASE to be modified. This sequence will

create a new DBASE file along with saving the old one. An example is:

```
 DBASE NAME ?
NRUN
 NEW RUN ?
Y
 WISH TO START WITH AN OLD RUN ?
Y
 OLD DBASE NAME ?
ORUN
 ORUN.BS RETRIEVED
```

If at any time BTEXT cannot read or write a DBASE file (denoted an by error message), your local support office should be contacted for possible solutions. Contact your ADP department first, then the BLAST support office.

Mandatory Input

At the beginning of each BTEXT run there are some simple but mandatory input prompts that must be answered. In order of occurrence they are:

(1) INSTRUCTIONS?

The user should respond with a Y or N. An experienced user will usually respond with N. Y should be the response for first time users and users who wish to refresh themselves with brief instructions to the program.

(2) DBASE NAME?

The sequence should be entered as discussed in section 2.2.

The following mandatory inputs occur only at the beginning of a new project:

(3) E=ENGLISH,M=METRIC

INPUT UNITS=E

The user has one and only one chance to decide if English or metric units will be used for input units. If English units are desired the response should either be E or a carriage return (accepting the default of E). If metric units are desired the response should be M. On this and subsequent runs of BTEXT, all units of input remain unchanged. (Note: Do not confuse with output units discussed later).

(4) FULL MENU ? (Y/N)

This prompt allows the user to select full menus. A very experienced user may elect to not see the menus at each mode if the menus can be remembered or a hardcopy (printout) of the menus are available. A new or intermediate user should get familiar with the program by inputting Y to see the menus at each mode. The full menu toggle can be changed at any mode as discussed in Chapter 3.

After the mandatory input has been answered as desired by the user, input is then advanced to the main menu mode where the user will input via the menu structure (chapter 3). The full menu toggle will default to on for modifications of previous projects. The full menu toggle option, X, is available at each menu to toggle the full menu on or off (also discussed in chapter 3).

Program Control Break and Save Options

BTEXT has been incorporated with an autosave option that will save all data in a file every so many key strokes. If a user wishes to disconnect this option, the command NOSAVE can be entered at any point in the program and the autosave option will not be invoked. Once the NOSAVE option has been employed, the file can be saved by using the command SAVE at any point in the program. The save command will also invoke the AUTOSAVE option again. If a user wants to abort BTEXT for any reason, this may done by inputting ABORT at any point in the program. The abort command will discard any changes from the last save command and allows for a smooth exit from the BTEXT. The amount of data saved from an aborted run will depend on how the AUTOSAVE and SAVE options were used.

Organization

In sections 3.1-3.7 the different modes of input in BTEXT are described, but first the user should have a basic understanding of the main menu mode and BTEXT's menu driven tree structure.

After completing the preliminary and mandatory input as discussed in section 2.3, input is then taken to the main menu mode. If the full menu toggle is on, the main menu will be displayed as follows:

```
     MAIN MENU CHOICES
 X = Full Menu (off/on)
 T = Define  TEMPORARY walls, schedules, controls, design days,
etc.)
 B = Specify BUILDING and zone description
 S = Specify SCHEDULED zone loads & controls
 F = Specify FAN SYSTEMS
 C = Specify CENTRAL PLANTS
 L = Specify LEAD INPUT (reports, location, etc.)
 I = Create  BLAST INPUT FILE
 D = Display ZONES, SYSTEMS, & PLANTS
 N = Start   NEW PROJECT
 <cr> = exit PROGRAM
 ==MAIN MENU MODE==
```

If the full menu toggle is off, the display will simply be:

```
==MAIN MENU MODE==
```

The user must then choose one of the corresponding letters as input (i.e., if the user wants to enter the TEMPORARY Menu, T is entered).

At each mode the user will choose the path of input by choosing one of several options. Some options will lead to further modes while others lead directly into required input. After the user finishes the input for a particular subject (i.e., create temporary entries), the program will return to that particular mode. The user can then elect to choose another subject or to exit that mode by pressing a carriage return. When a user exits a mode, input is then transferred to the next higher mode (i.e., the main menu mode is higher than the create temporary entries mode). An exit from the main menu is an exit from BTEXT completely. BTEXT is both menu driven at each mode and tree structured. The main menu mode can be considered as the base of a tree while the lower modes are branches. Therefore, if a user is in the fan systems mode and wishes to get into the central plants mode, input must first exit the fan systems mode (putting input back into the main menu mode) and then enter the central plants mode. Main menu choices will be described in more detail in sections 3.1-3.7.

At each mode, one of the choices is always X = Full Menu, therefore the full menu toggle can be switched to on or off at any mode in BTEXT by entering an X. If a user wishes not to switch the full menu toggle but to only display the menu at that mode, the user simply enters a ?. The menu is displayed and the full menu toggle remains the same regardless of if the toggle was on or off.

Create Temporary Entries

If T is chosen from the main menu mode, input is taken to the create temporary entries mode. Full menu display of create temporary entries menu is:

```
 CREATE TEMPORARY ENTRIES
X = Full Menu (off/on)
L = LOCATIONS (latitude, longitude, and time zone)
D = DESIGN DAYS (daily external conditions)
M = MATERIALS (define construction layers)
B = BUILDING ELEMENTS (walls, roofs, windows, etc.)
S = SCHEDULES (specify hourly profiles)
C = CONTROLS (define system control for zones)
<cr> = exit TEMPORARY ENTRIES MODE
==TEMPORARY ENTRIES MODE==
```

The create temporary entries mode is used to add (define) a temporary library element (i.e., location, design day, material, etc. depending on choice of L, D, M, etc.), or to display and/or delete a previously defined library element. After a library element is chosen (i.e., D for design days) the user can choose to add, display, or delete. For example, suppose D was chosen in the create temporary entries mode; BTEXT will respond with:

```
--TEMPORARY DESIGN DAYS--
A=ADD
D=DELETE
X=DISPLAY (by #)
<cr> = exit
```

If A (for add) is chosen, the user will define a new temporary Design day by responding to the following prompts as follows:

```
 ENTER DESIGN DAY NAME FOR DESIGN # 3

SAMPLEDAY

 DESIGN DAY = SAMPLEDAY

 HIGH= 95.00?

84

 LOW= 52.00?
```

```
44.34
 WB= 78.00?
<cr>
 DATE=21JUL?
20JUN
 PRES=    405.00?
<cr>
 WS=660.00?
<cr>
 DIR=270.00?
<cr>
 CLEARNESS= 1.00?
<cr>
 DAY=WEEKDAY  ?
<cr>
 (S=SNOW,R=RAIN,N=Neither rain nor snow)
 PRECIPITATION = N
<cr>
```

Notice that when default values are given, a **<cr>** will keep the value. If <cr> is chosen after the add, delete, display prompt, the input will simply be directed back to the create temporary entries mode. If X is chosen, all previously defined temporary design days will be displayed by number. If D is chosen, the user can delete a previously defined temporary design day by inputting the number (if not known, the display (X) will show the number) after the prompt: C: PICK NUMBER (0 FOR NO DELETIONS) Notice that 0 will do nothing. One caution is that if a design day is deleted, all higher numbered design days are decremented by 1 (i.e., if #3 is deleted then #4 becomes #3, #5 becomes #4, etc.). Even though the definitions for location (L), materials (M), building elements (B), schedules (S), and controls (C) have different prompts, their discussion will be omitted because they take on a similar input pattern (all having the add, delete, display method).

Building Description

If B is chosen from the main menu mode, input is taken to the building and zone mode. The full menu display of the building and zone menu is:

```
     BUILDING AND ZONE CHOICES
 X = Full Menu (off/on)
 B = Specify  NAME of building
 N = Specify  NORTH AXIS of building (in degrees)
 M = Specify  DEFAULT names for surface and subsurfaces
 L = Specify  DETAIL LEVEL (method of inputting zone surfaces
 Z = Input    ZONE surface and subsurface attributes
 D = Delete   ZONES and SURFACES
 Y = Display  ZONES and SURFACES
 C = Change   ZONE ATTRIBUTES and add surfaces
 G = Reassign SURFACE CONSTRUCTIONS globally
 S = Specify  SOLAR radiation distribution
 H = Specify  DETACHED SHADING (trees, buildings, etc.)
 A = Generate ASHRAE heating report
```

```
T = Generate THERMAL COMFORT report
R = Toggle   HIGH INTENSITY RADIANT heaters (on/off)
<cr> = exit BUILDING AND ZONE MODE
==BUILDING AND ZONE MODE==
```

The user then chooses the path of input to describe a building or to display and/or change existing parts of a building.

Option B allows the user to give a building name where NONE is the default. Option N allows the user to view and change the north axis of the building (the default is 0 degrees). Sections 3.2.1-3.2.9 describe the other building and zone mode choices. An example of option B is:

```
BUILDING NAME = NONE
```

NEW BUILDING

The user entered the building title of NEW BUILDING. An example of option N is:

```
BUILDING NORTH AXIS =    0.00
```

180.0

The user changed the default value of 0 degrees to 180 degrees.

Radiant View Factors

Option R toggles Radiant View Factors between the off/on positions. The default when you first enter BTEXT is for Radiant View Factors to be off.

If Radiant View Factors is on, BTEXT will prompt for view factors for each surface specified. If the user turns Radiant View Factors on then under zone description after each surface is described he/she will be prompted as follows:

```
VIEW FROM PERSON = 0.0
```

0.25

```
VIEW FROM RADIANT SOURCE = 0.0
```

0.25

Solar Distribution

Option S gives the user a chance to choose the solar distribution constant. Allowable values are 1, 0, and -1. For each new project, -1 is the default. If 0 is used, beam sunlight through windows are assumed incident on the floor. Any beam not absorbed by the floor is added to the zone diffuse radiation and distributed uniformly to all interior surfaces. If -1 is used in BLAST, then detached shading surfaces and zone walls will have no effect on shading. If 1 is used, BLAST will calculate the amount of beam radiation falling on each surface by projecting the sun's rays through windows. An example of option S is:

```
SOLAR DISTRIBUTION = -1
```

<cr>

The user viewed the solar distribution value of -1 and decided to keep the value (thus, pressing the carriage return).

ASHRAE Heating

Option A allows the user to add, delete, and display ASHRAE heating parameters. At least one zone must be defined before the user can enter building parameters. The four ASHRAE heating building parameters are: ASHRAE heating outdoor temperature, ASHRAE heating indoor temperature, ASHRAE heating infiltration and ASHRAE heating ground temperature. In addition, separate indoor temperature and infiltration values can be added for each existing zone. The entered ASHRAE heating parameters allow the user to run the ASHRAE Heating Report. The ASHRAE heating building parameters must be entered for the ASHRAE Heating Report. The full menu display of the ASHRAE heating choices menu is:

```
        ASHRAE HEATING CHOICES
 X = Full Menu (off/on)
 Y = Display entered parameters
 D = Delete entered parameters
 B = Enter building parameters
 Z = Enter zone parameters
 <cr> = exit ASHRAE HEATING MODE
 ==ASHRAE HEATING MODE==
```

Display Entered Parameters

Option Y allows the user to display all entered ASHRAE heating building and zone parameters. Once option Y has completed, the user is returned to the ASHRAE Heating Choices Menu.

Delete Entered Parameters

Option D allows the user to delete building or zone ASHRAE heating parameters. The full menu display of the ASHRAE deletion menu is:

```
        ASHRAE DELETION CHOICES
 X = Full Menu (off/on)
 B = Delete building parameters
 Z = Delete zone parameters
 <cr> = exit ASHRAE DELETION MODE
 ==ASHRAE HEATING MODE==
```

If B is chosen, the four building parameters are deleted. If option Z is chosen, the user is prompted for the zone from which the two ASHRAE heating zone parameters are removed.

Enter Building Parameters

Option B allows the user to add the four ASHRAE heating building parameters. The following is an example of option B:

```
 ENTER ASHRAE HEATING OUTDOOR TEMP
60
 ENTER ASHRAE HEATING INDOOR TEMP
70
 ENTER ASHRAE HEATING INFILTRATION(cr = 0.0)
<cr>
 ENTER ASHRAE HEATING GROUND TEMPERATURE(cr = 55)
<cr>
```

After the four parameters have been added, the user is returned to the ASHRAE Heating Choices Menu.

Enter Zone Parameters

Option Z allows the user to add the two ASHRAE heating zone parameters to any existing zone. The following is an example of option Z for a building with five zones:

```
 ENTER ZONE (1 - 5)
1
 ENTER ASHRAE HEATING ZONE INDOOR TEMP
68
 ENTER ASHRAE HEATING ZONE INFILTRATION(cr = 0.0)
0.1
```

Here, the user has added the two ASHRAE heating zone parameters for zone one. The zone parameters will override the global values defined in option B, enter building parameters.

Thermal Comfort

Option T allows the user to add, delete, or display thermal comfort parameters. At least one zone must be defined before the user can enter thermal comfort parameters. The thermal comfort parameters are Relative Velocity, Relative Humidity, Metabolic Rate, Work Efficiency, and Clothing Insulation. In addition, the user is prompted for the report type. The reports must be specified to activate any or all of the thermal comfort models. The full menu display of the Thermal Comfort Menu:

```
--THERMAL COMFORT--
A = ADD
D = DELETE
X = DISPLAY (by #)
<cr> = exit
```

Add Thermal Comfort Parameters

Option A allows the user to add the Thermal Comfort Parameters. The following is an example of option A:

```
 RELATIVE VELOCITY = 0.137m/s
<cr>
 SCHEDULE = CONSTANT
<cr>
 RELATIVE HUMIDITY = 0.35
<cr>
 SCHEDULE= CONSTANT
<cr>
 METABOLIC RATE = 1.0
<cr>
 SCHEDULE = CONSTANT
<cr>
 WORK EFFICIENCY = 0.0
<cr>
 SCHEDULE = CONSTANT
```

```
<cr>
 CLOTHING INSULATION = 1.0
<cr>
 SCHEDULE = CONSTANT
<cr>
 THESE DATES WILL BE USED FOR ALL THE THERMAL COMFORT
 VARIABLES IN THE ZONES YOU ARE WORKING IN
<cr>
 FROM = 01JAN
<cr>
 TO = 31DEC
<cr>
 ENTER REPORT CODES SEPERATED BY COMMAS   (i.e.
KS,FN,PR,...)
   KS = KSU, FN = FANGER, PR = PIERCE
KS
```

After the parameters have been added, the user is returned to the BUILDING AND ZONE CHOICES menu. Note: The annual Thermal Comfort report must be generated separately. See *Thermal Comfort in* the BLAST User Reference.

Delete Thermal Comfort Parameters

Option D allows the user to delete Thermal Comfort parameters from a zone. The user is prompted as follows:

```
 PICK A ZONE (0 FOR NO DELETIONS)
1
---WARNING---
IF YOU DO NOT WISH TO SIMULATE THERMAL COMFORTS
MAKE SURE TO DELETE THE KS, FN, AND PR OPTIONS FROM
THE REPORTS.  THIS CAN BE DONE BY SELECTING L FOR
LEAD INPUT MODE, FOLLOWED BY R FOR REPORTS.
```

After specifying a zone the user is returned to the THERMAL COMFORT menu.

The user must be sure to heed the warning. The L option for Lead Input is in the first menu of BTEXT called MAIN MENU CHOICES.

Display Thermal Comfort Parameters

Option X allows the user to display the Thermal Comfort parameters. The user is prompted for a zone number. After option X is completed the user is returned to the THERMAL COMFORT Menu.

Detached Shading

Option H allows the user to add a detached shading or to display and/or delete existing detached shadings. The add, delete, display scheme is the same as for the options in the create temporary entries mode. An example of using option H to add a detached shading is as follows:

```
--DETACHED SHADINGS--
```

```
A=ADD
D=DELETE
X=DISPLAY(by #)
<cr>=exit
```

```
   A
    DETACHED SHADING TITLE
   SAMPLE SHADING
    DIMENSIONS (2 VALUES SEPARATED BY COMMAS)
   10,5
    STARTING AT (3 VALUES SEPARATED BY COMMAS)
   8,8,4
    FACING WHICH ANGLE
   90
    TILT = 90
   <cr>
```

The detached shading title, dimensions, values starting at (relative to the building origin), and facing angle were supplied by the user when prompted for, as described in the BLAST users manual volume supplement (version 3.0). The user accepted the default of 90 degrees tilt with a **<cr>**.

Detail Level

Option L allows several alternatives for describing zone surfaces. The user can choose between 5 different levels of zone description. Levels 1 and 2 are the simple levels and are thus limited in complexity. Levels 2 and 3 are the intermediate levels that allow the user to describe a more complex zone. Level 5 is the most detailed level. Level 5 allows the user to describe a zone in great detail, thus allowing for a more complex zone description. A BLAST user with even a small amount of experience should have no problem learning to use level 5. Level 1 is the default and is recommended because of its ease of use, however, the other 4 levels will always be available and may be preferred by some users in describing certain zones. Section 3.2.6 will describe the capabilities of each of the 5 levels.

Levels 1 and 2

Levels 1 and 2 are restricted to describing rectangular zones. The user is always prompted for a zone height. Next, the user is prompted for four vertical surfaces (walls, partitions, etc.), one at a time, in a 360 degree rotation. STARTING ATS for the surfaces are calculated by BTEXT using previous inputs. Subsurfaces can be attached to a surface but will be positioned on the surface's origin (relative to the building origin). Next, a floor then, a ceiling/roof is requested. It should be noted that the positioning of a window on a wall has no effect on BLAST calculations if -1 is used for solar distribution (section. 3.2.2) unless overhangs are also input. Overhangs must retain relative positioning even when solar distribution is -1. The only difference in level 1 and level 2 is that surface length is used for input of each vertical surface in level 1 while surface area is used for input in level 2. In each case, the area of the floor and the area of the ceiling/roof are both calculated by BTEXT.

Levels 3 and 4

Levels 3 and 4 allow a more complex zone layout. SAME AS may be used in describing zones as well as zone mirroring. The user is prompted for a zone height before describing surfaces. STARTING ATS are again calculated by previous inputs but may be overridden. BTEXT does not automatically request any surface. It is up to the user to supply all surfaces. The difference in levels 3 and 4 is identical to the difference in levels 1 and 2. In level 3, length is an input for describing vertical surfaces whereas in level 4 area is used. As in levels 1 and 2, subsurfaces are attached to surfaces at the surface origin; therefore, -1 should be used for solar distribution.

Level 5

Level 5 allows the most detail in describing zones and requires more information from the user. Again, SAME AS and zone mirroring are allowed, and the user describes surfaces in any order. STARTING ATS are supplied by the user along with surface dimensions (there is no one set zone height). Tilted surfaces are allowed and subsurfaces will be positioned on surfaces exactly where the user wants (i.e., the user positions subsurfaces-only in level 5).

Surface/Subsurface Defaults

In describing surfaces in BTEXT (section 3.2.8), surface and subsurface names are chosen by the user. The user has the choice of keeping a default surface name (with a **<cr>**) or supplying another surface name. The default surface and subsurface names are preset and may be changed during a BTEXT session by choosing option M in the building and zone mode (also in the zone description mode). The following is an example of using option M.

```
--SURFACE/SUBSURFACE DEFAULTS--
W=WALLS
F=FLOORS
R=ROOFS (OR CEILINGS)
I=INTERNAL MASS
S=SUBSURFACES
<cr>=exit

   W
EXTERIOR WALLS = EXTERIOR
PARTITIONS = INTERIOR
WALL TO UNCOOLED SPACES = INTERIOR
BASEMENT WALLS = SLAB WALL
INTERZONE PARTITIONS = INTERIOR
Do you wish to make change(s)?

   Y
EXTERIOR WALLS = EXTERIOR
enter to change, <cr> to keep

   EXTWALL04
PARTITIONS = INTERIOR
enter to change, <cr> to keep

   <cr>
WALL TO UNCOOLED SPACES = INTERIOR
enter to change, <cr> to keep

   <cr>
BASEMENT WALLS = SLAB WALL
enter to change, <cr> to keep

   <cr>
INTERZONE PARTITIONS = INTERIOR
enter to change, <cr> to keep

   <cr>
```

In the above example, the user viewed the current default names for walls and chose to change the defaults for exterior walls (to EXTWALL04) and partitions (to PARTITION18).

Option Z allows the user to describe a new zone. The first three prompts of a zone description at all levels request from the user the zone's name, north axis, and origin. The default for north axis is 0 while the default for zone origin is 0,0,0. They may be overridden by the user (and probably will be many times). In levels 1-4 the next prompt will be to define a zone height. In levels 1 and 2 the user is limited in freedom of zone description and is next prompted for the six surfaces (rectangular zone) starting with the south wall, while in levels 3-5 input will be taken to the zone description mode. The zone description menu is as follows:

```
     ZONE DESCRIPTION CHOICES
 X = Full Menu (off/on)
 A = Same as
 S = Surface (and Subsurfaces)
 M = Surface/Subsurface Defaults
 W = To describe a NEW zone
<cr> = exit ZONE DESCRIPTION MODE
 ==ZONE DESCRIPTION MODE==
```

If the user chooses option A, SAME AS WHICH ZONE? will be asked. After the user responds, BTEXT will then ask MIRROR X? then MIRROR Y? (two yes/no questions). If both answers are no (i.e., no mirroring) the user will be returned to the zone description choices and can finish describing the zone (i.e., the user can describe a surface thus the SAME AS will become SAME AS EXCEPT). An important fact to remember is that when the user returns to the building and zone mode (not the zone description mode), that particular zone's description is complete. The only way to add to or delete from a zone is through options D and C in the building and zone mode (section. 3.2.9 and 3.2.11). Option M is the same as option M in the building and zone mode (section 3.2.7). Option W allows the user to describe another zone without exiting back to the building and zone mode and reentering the zone description mode.

Surface and Subsurface Codes

In describing surfaces using BTEXT (option S in ZONE DESCRIPTION CHOICES), the user must understand the use of two-letter surface (wall, roof/ceiling, floor) and subsurface codes. In levels 1 and 2 the user will describe four walls, one floor, and one roof (ceiling). In levels 3-5 the user will input surfaces free-lance by repeatedly using the following options until finishing:

```
 --SURFACES--
 W=WALL
 F=FLOOR
 R=ROOF (OR CEILING)
 I=INTERNAL MASS
 <cr>=exit
```

While describing a surface (a wall for example), BTEXT will ask the user for a wall code as follows:

```
WALL CODE (? will list)
```

using levels 1 and 2 or

```
WALL CODE (? will list, <cr> to exit)
```

using levels 3, 4 and 5. The user must respond with a two-letter wall code or a '?' to list the codes. The codes are as follows:

```
WALL CODES
       EW = Exterior Wall
       PA = Partition
       WU = Wall to Uncooled Space
       BW = Basement Wall
       IP = Interzone Partition
FLOOR CODES
       FL = Floor
       SG = Slab on Grade Floor
       FC = Floor over Crawl Space
       AF = Attic Floor
       EF = Exposed Floor
       IF = Interzone Floor
ROOF(CEILING) CODES
       RF = Roof
       CL = Ceiling
       CA = Ceiling Attic
       CC = Crawlspace Ceiling
       IC = Interzone Ceiling
```

Notice that **<cr>** is used to exit that particular surface description just as though the user had not started describing it for levels 3-5 only because they have free-lance surface description whereas levels 1 and 2 describe surfaces in order (i.e., south wall, east wall, etc.).

The last prompt when describing a surface in all levels is:

```
SUBSURFACE CODE (? will list, <cr> to exit)
```

If the user wishes to put a subsurface on the surface, the user inputs a subsurface code (which will lead to a subsurface description). The user inputs a **<cr>** after describing all of the subsurfaces (or immediately if no subsurfaces are desired). '?' will list the subsurface codes. The subsurface codes are:

```
--SUBSURFACES--
       WI = Window
       DO = Door
       WG = Wing
       OH = Overhang
```

Surface Descriptions

The following three examples of option S show how users describe surfaces using levels 2, 3, and 5. The example problem in chapter 5 will describe zones using levels 1, 3 and 5.

The following example shows a user's description of the south wall using level 2 (the zone height-8 has already been input).

```
 -SOUTH WALL-
 AREA
160
 WALL CODE (? will list)
EW
 SURFACE NAME = EXTERIOR
 (? will list, <cr> to keep)
EXTWALL04
 SUBSURFACE CODE (? will list, <cr> to exit)
<cr>
```

The user described an exterior wall (EXTWALL04) 20 by 8. There are no subsurfaces (doors, windows, etc.) on the wall therefore a <cr> was input after the prompt that asked for a subsurface code. Notice that the user did not accept the default surface name of EXTERIOR but entered EXTWALL04. The user can make EXTWALL04 the default by using option M in either the building and zone mode or the zone description mode (as described in section 3.2.6).

The following example shows a user's description of a partition using level 3 (the zone height-8 has already been input).

```
--SURFACES--
W=WALL
F=FLOOR
R=ROOF (OR CEILING)
I=INTERNAL MASS
<cr>=exit
```

W

```
WALL CODE (? will list)
```

PA

```
SURFACE NAME = INTERIOR
(? will list, <cr> to keep)
```

PARTITION18

```
STARTING AT=      0.00,      0.00,     0.00
```

<cr>

```
DEGREES FACING
```

90

```
LENGTH
```

20

```
SUBSURFACE CODE (? will list, <cr> to exit)
```

<cr>

The user described a partition (PARTITION18) 20 by 8. The STARTING AT values of 0, 0, 0 was accepted with a <cr>. The facing angle was input as 90 degrees. There were no subsurfaces (doors, windows, etc.) on the partition. The following example shows a user's description of an exterior wall with a window using level 5.

```
--SURFACES--
W=WALL
F=FLOOR
R=ROOF (OR CEILING)
I=INTERNAL MASS
<cr>=exit
```

W

```
WALL CODE (? will list)
```

EW

```
SURFACE NAME = EXTERIOR
(? will list, <cr> to keep)
```

EXTWALL04

```
STARTING AT (3 VALUES SEPARATED BY COMMAS)
```

0,0,0

```
DEGREES FACING
```

180

```
 DEGREES TILT=  90
<cr>
 DIMENSIONS(WIDTH,HEIGHT)
20,8
 SUBSURFACE CODE (? will list, <cr> to exit)
WI
 SUBSURFACE NAME = SINGLE PANE HW WINDOW
<cr>
 POSITION ON SURFACE (2 VALUES SEPARATED BY COMMAS)
4,4
 DIMENSIONS(WIDTH,HEIGHT)
4,4
 REVEAL=0?
<cr>
 SUBSURFACE CODE (? will list, <cr> to exit)
<cr>
```

The user described an exterior wall (EXTWALL04) 20 by 8. The STARTING AT values of 0, 0, 0 and a facing angle of 90 degrees were input. The default value of 90 for wall tilt (upright) was accepted. The SINGLE PANE HW WINDOW was 4 by 4 and positioned on the wall at 4, 4 (relative to the wall's origin). The default of 0 for reveal was accepted. The surface was completed by inputting a <cr> at the last prompt (i.e., no more subsurfaces).

Displays and Deletions

Option Y (Displays) in the building and zone mode will allow the user to display parts of a building that have already been defined. If the user uses this option the following will be displayed:

```
 -DISPLAYS-
 Z=ZONES
 S=SURFACES (and Subsurfaces)
 X=ZONES (with Surfaces and Subsurfaces)
 <cr>=exit
```

Z will show the user a particular zone's (or all zones') name, north axis, and origin, as well as SAME AS, if applicable. S will show the user all surfaces of a particular type (i.e., exterior wall) in a particular zone. X will show the user a complete zone (all surfaces and subsurfaces). All zones, surfaces, and subsurfaces will be shown to the user by number for the purpose of possible deletions or additions. The following is an example of this numbering scheme:

```
        STARTING AT ( 0.00, 0.00, 0.00)
        FACING (  0.00)  TILTED ( 90.00)
        (12.00 BY 8.00)
           5 =WINDOW  -SINGLE PANE HW WINDOW
               AT (2.00, 2.00)  (8.00 BY 4.00)
               REVEAL(0.00)
           6 =OVERHANG
               AT ( 0.00, 8.00)  (12.00 BY 3.00)
  7 =EXTWALL04
      STARTING AT (0.00, 25.00, 0.00)
      FACING (270.00)  TILTED ( 90.00)
      (25.00 BY 8.00)
```

All surfaces will be displayed with all associated subsurfaces. In the preceding example the exterior wall (#4) has a window (#5) and an overhang (#6) on it while the exterior wall (#7) has no subsurfaces on it.

Option D (Deletions) in the building and zone mode will allow the user to delete parts of a building that have already been defined. If the user uses this option the following will be displayed:

```
-DELETIONS-
Z = ZONES
S = SURFACES and/or SUBSURFACES
<cr>=exit
```

Z will allow the user to delete an entire zone by responding to the following prompt.

```
DELETE WHICH ZONE?(0 OR NO DELETIONS)
(? WILL LIST)
```

The user inputs the zone number. '?' will list the zones. Option S will allow the user to delete a surface or a subsurface by giving the zone number and surface or subsurface number. Note that if a surface is deleted, all of its subsurfaces will also be deleted (as expected). A note of caution is that after a deletion of a zone, all zones with a higher number will be decremented (i.e., if zone #1 is deleted, zone #2 will now become zone #1). Surfaces and Subsurfaces are also affected in the same way. It is always a good policy to display a zone or surface to be deleted before actually deleting it. This may eliminate the possibility of deleting the wrong zone, surface, or subsurface.

Global Surface Name Changes

Option G in the building and zone mode will allow the user to make global changes to previously defined surface names. The user can change all surface names or surface names of a certain type (i.e., exterior walls) either for a particular zone or for all zones. The following is an example of a global surface name change.

```
--GLOBAL SURFACE NAME CHANGES--
W=WALLS
F=FLOORS
R=ROOFS (OR CEILINGS)
I=INTERNAL MASS
S=SUBSURFACES
X=ALL SURFACES
<cr>=exit
```

```
   W
    WALL CODE (? will list, <cr> to exit)
   EW
    ZONE RANGE IS 1-  4
    PICK A ZONE TO MODIFY ('X' for all zones, 0 for none)
   1
    ENTER SURFACE NAME TO BE CHANGED (<cr> to exit)
   EXTWALL04
    ENTER NEW SURFACE NAME (<cr> to exit)
   EXTWALL88
       2 SURFACE NAME(S) CHANGED IN ZONE  1
         OLD SURFACE NAME = EXTWALL04
```

```
NEW SURFACE NAME = EXTWALL88
```

In the above example the user chose to replace all exterior walls with surface name EXTWALL04 in zone 1 to have surface name EXTWALL88. Following the changes, BTEXT will list the number of surface names change, the zone number (or all zones if chosen), the old surface name, and the new surface name chosen.

Changes And Additions

Option C in the building and zone mode will allow the user to make changes and/or additions to a particular previously defined zone. The first prompt will ask the user for the zone number. After the user responds with an existing zone number, changes and additions may be made. The change and add menu is:

```
    CHANGE AND ADD CHOICES
X = Full Menu (off/on)
Z = Change Zone Name
N = Change North Axis
O = Change Origin
A = Change Same As
M = Change Surfaces/Subsurfaces
S = Add Surface
T = Add Subsurfaces
W = For a DIFFERENT Zone
<cr> = exit CHANGE AND ADD MODE
==CHANGE AND ADD MODE==
```

Options Z, N, and O are self-explanatory and may be used to rename, reorient, or reposition the zone. Option A allows the user to make the zone SAME AS another zone, change the SAME AS zone number or make a zone to be SAME AS no other zone. Option M allows the user to change the attributes of a particular surface or subsurface such as starting at values, dimensions, etc. The user must supply a surface number (surface/subsurface listing by number is available). Options S and T may be used to add to a particular zone (maybe a surface or subsurface was not described in the initial zone description). When adding a surface to a zone, the user is temporarily moved to detail level 5. After the surface has been input, the user is returned to the current detail level. The detail level will not automatically change for subsurfaces. To add a subsurface (T) to a surface, the user must supply the surface number on which to add the subsurface (? will list the options if the user does not know). Option W allows the user to switch zones without exiting back to the building and zone mode and reentering the change and add mode.

Scheduled Zone Loads and Controls

Option S (Scheduled Zone Loads and Controls) at the main menu mode will allow the user to schedule various loads to an existing zone. This option has the add, delete, display scheme as follows:

```
-SCHEDULED LOADS-
A=ADD
D=DELETE
X=DISPLAY(by #)
<cr>=exit
```

X will display the existing scheduled loads by number. D will allow the user to delete an existing scheduled load by supplying the number (if not known, use X to display). If A (for additions) is chosen the first prompt will request for an existing zone number. After the zone number has been supplied the user is then in the scheduled loads mode. The full menu display of scheduled loads is:

```
       SCHEDULED LOADS CHOICES
X = Full Menu (off/on)       M = Mixing
```

```
P = People                    N = Crossmixing
L = Lights                    D = Daylighting
C = Controls                  V = Ventilation
B = Baseboard Heating         I = Infiltration
G = Gas Equipment             O = Other Loads
E = Electric Equipment        R = Scheduled Radiant
W = For a DIFFERENT zone
<cr> = exit SCHEDULED LOADS MODE
==SCHEDULED LOADS MODE==
```

The user can then choose to schedule any of the loads in the menu. Two or more of the same load may be scheduled in the same zone. An example of scheduling a load (Infiltration-option I) is:

```
 SCHEDULED LOAD #  5

 INFILTRATION FOR ZONE  1

 PEAK INFILTRATION = 0

20

 SCHEDULE = CONSTANT

<cr>

 COEFFICENTS = 0.606000,0.020200,0.000598,0.000000

<cr>

 FROM = 01JAN

01MAY

 TO = 31DEC

20AUG
```

In the preceding example the new load number is 5. The user had previously chosen zone 1. The user kept some defaults with a <cr> while changing others. Note that coefficients were asked for which are rarely used by BLAST users. The default values in BTEXT scheduled loads are the values that BLAST uses if not specified differently. Remember that if a scheduled load is deleted (using D for delete) then all scheduled loads with a higher number are now decremented by one. Scheduled loads are numbered by order of input (for deleting purposes). Option W allows the user to schedule loads to another zone without exiting back to the main menu mode and reentering the schedule loads mode.

Fan Systems

Option F (Fan Systems) at the main menu mode will allow the user to describe a fan system to serve one or more zones. These zones must exist before describing the system. This option has the add, delete, display scheme as follows:

```
-FAN SYSTEMS-
A=ADD
D=DELETE
X=DISPLAY(by #)
0=SYSTEM OPTIONS
<cr>=exit
```

X will display the existing fan systems by number, while D will allow the user to delete an existing fan system by supplying the number (if not known, use X to display).

O will display the following system options menu:

```
--FAN SYSTEM OPTIONS--
 E=EVAP COOLER (on/off)
 L=SYSTEM DETAIL LEVEL
 <cr>=exit
```

From this menu, the evaporative cooler model can be added to or removed from the system by selecting E. The amount of parameters in the input file can be adjusted by selecting L. System detail level 1 generates the basic parameters needed for a simulation. Level 1 is designed to give the other system parameters data block and the equipment schedule block. Detail level 2 generates all parameters in level 1 plus the cooling coil parameters and heat recovery parameters blocks of input.

Describing a fan system is very simple in BTEXT. After choosing A (to add), the user is prompted for a fan system title. After entering a title the user is then in the fan system mode. The full menu display of the fan system is:

```
           FAN SYSTEM CHOICES
 X   = Full Menu (off/on)     TDM = Three Deck Multizone
 MTZ = Multizone              DDV = Dual Duct Variable Volume
 TRH = Terminal Reheat        SZD = Single Zone Draw Thru
 VAV = Variable Volume        TPF = Two Pipe Fan Coil
 UVN = Unit Ventilator        FPF = Four Pipe Fan Coil
 SRH = Subzone Reheat         TPI = Two Pipe Induction
 DXP = DX Packaged Unit       FPI = Four Pipe Induction
 1HP = 3.5 Ton Heat Pump      2HP = 5 Ton Heat Pump
 3HP = 10 Ton Heat Pump       4HP = 20 Ton Heat Pump
 WHP = Water Loop Source HP   UHE = Unit Heater
  ==FAN SYSTEM MODE==
```

To describe a fan system the user chooses a fan system type by supplying the corresponding three-letter code and proceeding as follows:

```
 SERVING WHICH ZONE (<CR> TO QUIT)

 1

 ENTER SUPPLY AIR VOLUME

 400

 SERVING WHICH ZONE (<CR> TO QUIT)

 2

 ENTER SUPPLY AIR VOLUME

 500

 SERVING WHICH ZONE (<CR> TO QUIT)

 <cr>

Now, select options for this FAN SYSTEM

  SYSTEM DESCRIPTION LEVEL = 1

 1

 Evap Cooler with this System? (y/N)

 N
```

In the preceding example the user described the fan system to serve zone 1 with an air volume of 400 and to serve zone 2 with an air volume of 500. The user desired to serve no more zones so the fan description was ended with a <cr>. The options desired by the user were a minimum amount of data in the input deck and no evaporative cooler operation.

Central Plants

Option C (Central Plants) at the main menu mode will allow the user to describe a central plant to serve one or more fan systems. These fan systems must first exist. This option also has the add, delete, display scheme as follows:

```
 -CENTRAL PLANTS-
 A=ADD
 D=DELETE
 X=DISPLAY(by #)
 L=DETAIL LEVEL
 <cr>=exit
```

X will display the existing central plants by number, while D will allow the user to delete an existing central plant by supplying the number (if not known, use X to display). L will allow the user to set a central plant detail level, which controls the amount of parameters generated by BTEXT. Detail level 1 is designed to give you equipment selection, part load ratios and system multiplier blocks of input. Level 2 is designed to give all level 1 blocks plus special parameters and equipment performance parameters blocks of input.

Describing a central plant is also very simple in BTEXT. After choosing A (to add), the user is then prompted for a central plant title. After the title has been supplied, the user then inputs the fan systems (by number) that the central plant serves. Next, the user is in the central plant mode and proceeds to describe the central plant. The full menu display of the central plant menu is:

```
                        CENTRAL PLANT CHOICES
 X   = Full Menu (off/on)
 BOL = Boiler                           IHR = Ice Storage: Ice
Harvestor
 EBL = Electric Boiler                  IOC = Ice Storage: Ice on
Coil
 SFB = Simple Fuel Boiler               ICT = Ice Container
 ACC = Air Cooled Chiller               ITK = Ice Tank
 CHL = Chiller                          TST = Stratified Thermal
Storage Tank
 DSC = Diesel Chiller                   EVC = Evaporative
Condenser
 DBC = Double Bundle Chiller            WWC = Well Water Condenser
 FCC = Free Cooling Chiller             CLT = Cooling Tower
 GTC = Gas Turbine Chiller              DCT = Direct Cooling Tower
 OCH = Open Chiller                     FHW = Fuel Domestic Hot
Water Heater
 RCH = Reciprocating Chiller            EHW = Elec. Domestic Hot
Water Heater
 SCH = Simple Chiller                   PHT = Purchased Heating
 OSA = One Stage Absorber               PCL = Purchased Cooling
 TSA = Two Stage Absorber               DSG = Diesel Generator
 TSE = Two Stage Absorber W/Econ        GTG = Gas Turbine
Generator
 HTP = Heat Pump  (water to water)      STG = Steam Turbine
Generator
 W   = To Enter a NEW Central Plant
 <cr> = exit CENTRAL PLANT MODE
  ==CENTRAL PLANT MODE==
```

To describe a central plant, the user repeatedly chooses central plant equipment by supplying the corresponding three-letter equipment codes until finishing (then the user exits the central plant mode). After each equipment selection the user will also supply the size and amount (how many) of the equipment type. The following is an example of describing (adding) a central plant (with the full menu toggle off).

```
--DEFINING A NEW CENTRAL PLANT--

PLANT TITLE FOR PLANT #  2 (<CR> TO EXIT)
```

SAMPLE PLANT

```
 SERVING WHICH SYSTEM (<CR> TO QUIT,? WILL LIST)
1
 SERVING WHICH SYSTEM (<CR> TO QUIT,? WILL LIST)
2
 SERVING WHICH SYSTEM (<CR> TO QUIT,? WILL LIST)
<cr>
 ==CENTRAL PLANT MODE==
BOL
 SIZE?
200
 HOW MANY?
1
 ==CENTRAL PLANT MODE==
CHL
 SIZE?
120
 HOW MANY?
2
 ==CENTRAL PLANT MODE==
<cr>
Now, select options for this CENTRAL PLANT
  PLANT DESCRIPTION LEVEL = 1
1
 ==CENTRAL PLANT MODE==
```

In the preceding example the user described the central plant to serve fan systems 1 and 2. The user was then in the central plant mode (remember if the full menu toggle was on, a menu would be displayed every time ==CENTRAL PLANT MODE== appears). The user described the central plant to have 1 boiler of size 200 and 2 chillers of size 120. The description was terminated with a **<cr>**. The plant detail level is set at the end of the description block. Option W allows the user to describe another central plant without exiting back to the main menu mode and re-entering the central plant mode.

Create BLAST Input File

If option I is chosen from the main menu mode, the user enters the create BLAST input mode. Before the actual creation of the BLAST deck can proceed, a couple of questions will have to answered. The first prompt will always be:

```
ANNUAL SIMULATION? (y/n) .
```

If the user wants a BLAST run requiring a weather tape, a Y is entered. If the user wants design days only, an N is entered. The second prompt is:

```
DESIGN DAY SIMULATION? (y/n).
```

If the user wishes to use design days, a Y is input. The design days used will be the design days chosen in the project data mode. If a zone has previously been chosen, the user must answer Y to one of the preceding prompts or an error message will be issued and the user will be transferred back to the create BLAST input mode. Also if the user did not define a location in the project data mode, an error warning will also be issued. An example of an input deck creation would go as follows (The DBASE name for the for the following example is SAMP1):

```
ANNUAL SIMULATION? (y/N)

N

DESIGN DAY SIMULATION? (Y/n)

Y

MAKING BLAST INPUT DECK -- PLEASE WAIT

   Enter desired project code

  or press RETURN to put BLAST file on code BTEXT (file
name: SAMP1.bin)

BLAST INPUT DECK COMPLETE
```

In the above example the user chose a design day simulation only. The BLAST input deck was then created. Notice that since the DBASE name for this BTEXT run was SAMP1 and the blast input deck was named SAMP1.bin. Now SAMP1.bin (Input deck-first generation) is ready to use to run BLAST. On the PC versions the extension is .bin. Output files are not created for either of these versions. Old input files are written over without being prompted. Also, BTEXT will issue any needed warning errors while creating the BLAST Input deck such as: WARNING--NO ZONES DEFINED.

Lead Input

If option L is chosen from the main menu mode, the user enters the Lead Input Choices mode. The full menu display of the Lead Input Choices is:

```
     LEAD INPUT CHOICES
 X = Full Menu (off/on)
 P = Project Data (location, etc.)
 R = Run Control (reports, etc.)
 <cr> = exit LEAD INPUT MODE
 ==LEAD INPUT MODE==
```

The user then chooses the path of input.

Project Data

If P is chosen while in the lead input choices mode, input is taken to the project data mode. The full menu display of the project data menu is:

```
 X = Full Menu (off/on)
 U = Output Units
 P = Project Title
 L = Locations
 D = Design Days
 W = Weather Tape Duration
 G = Ground Temperatures
 B = Building Category Code
 <cr> = exit PROJECT DATA MODE
 ==PROJECT DATA MODE==
```

The user then chooses the path of input.

If U (for output units) is chosen, the user can choose the units desired (E for English, M for metric) for the BLAST output (caution: this is not input units) by responding to the following prompt:

```
E=ENGLISH,M=METRIC

OUTPUT UNITS = E
```

The default value for output units is the value of the input units chosen by the user in BTEXT's mandatory input. Choice P will allow the user to give the project (BLAST model) a project title. If omitted the default is NONE SPECIFIED. Choices L and D allow the user to choose a location and design days to be used by BLAST. The user should not confuse these options with locations (L) and design days (D) of the create temporary entries mode. The create temporary entries mode is used to temporarily add to the BLAST library, while the project data mode is the actual parameters used by BLAST. Only one location can be specified in the project data mode while a maximum of 12 design days can be used. The location chosen in the project data mode must either be defined in the BLAST library or defined in the create temporary entries mode. If the user wants to specify weather tape duration for runs requiring weather tapes, option W is available. The defaults are from 01JAN thru 31DEC. If a BLAST library location available in BTEXT has been chosen using option L (location), the default ground temperatures are calculated by taking the average undisturbed earth temperature for that location for a given season and averaging it with the interior temperature. These interior temperatures are set by the user and are the average temperature of the building over a season. The following input sequence shows how to select a location in BTEXT with undefined ground temperatures (temperatures not already defined in BTEXT):

```
    PROJECT DATA CHOICES
X = Full Menu (off/on)
U = Output Units
P = Project Title
L = Location
D = Design Days
W = Weather Tape Duration
G = Ground Temperatures
B = Building Category Code
<cr> = exit PROJECT DATA MODE

   L
 ==PROJECT DATA MODE==
PROJECT LOCATION =BIRM
(? will list)

   ?
1) ALBANY             (Albany NY)
2) ALBSOL             (Albuquerque NM)
3) ALBTMY             (Albuquerque NM)
4) ALBUQ              (Albuquerque NM)
5) AMA                (Amarillo TX)
6) APCOLA             (Apalachicola FL)
7) ATLANTA      (Atlanta GA)
8) BARKS              (Barksdale AFB LA)
9) BIRM               (Birmingham AL)
10) BIS               (Bismarck ND)
11) BISTMY            (Bismarck ND)
12) BLYARK       (Blytheville AR)
13) BOISE             (Boise ID)
14) BOSTMY       (Boston MA)
15) BOSTON       (Boston MA)
MORE (Y/n)?

   n
```

```
PROJECT LOCATION =BIRM
(? will list)
```

3

```
Location determined is ALBTMY
Ground Temperatures for this location are not defined.
You will be requested to define them.
GROUND TEMPS = ( 55, 55, 55, 55, 55, 55, 55, 55, 55, 55, 55, 55)
DO YOU WISH TO MAKE CHANGES? y/N
```

y

```
ENTER SOIL TEMPERATURES
JAN,APR,JUL,OCT
```

32,44,55,45

```
ENTER BUILDING TEMPERATURE FOR HEATING,COOLING
```

75,75

```
ENTER MONTHS WHEN COOLING USUALLY OCCURS
ENTER START, END MONTH (E.G. 5,9)
```

5,9

```
MAKE MONTHLY CHANGES (<cr> to keep)

JAN =  54

FEB =  56

MAR =  58

APR =  60

MAY =  61

JUN =  63

JUL =  65

AUG =  63

SEP =  62

OCT =  60

NOV =  58

DEC =  56
```

Option G (Ground Temperatures) can be used to view the ground temperatures and change them if desired. The following is an example of option G:

```
GROUND TEMPS = ( 55, 55, 55, 55, 55, 55, 55, 55, 55, 55, 55,
55)

DO YOU WISH TO MAKE CHANGES?
```

Y

```
ENTER SOIL TEMPERATURES

JAN,APR,JUL,OCT
```

40,55,70,55

```
ENTER MONTHS WHEN COOLING USUALLY OCCURS

ENTER START, END MONTH (E.G. 5,9)
```

5,10

```
MAKE MONTHLY CHANGES (<cr> to keep)

JAN = 53
```

```
<cr>
 FEB = 55
<cr>
 MAR = 58
57
 APR = 60
59
```

The ground temperatures were viewed by the user to be 55 for all months. The user wished to change them. BTEXT then asked three general questions concerning ground temperatures and calculated the ground temperatures for the user. These calculated values can be accepted with a **<cr>** or changed by substituting a number as shown in the example. Note that the user can simply answer the three general questions with dummy numbers (i.e., all ones) and fill in the ground temperatures by month if desired. The BLAST users manual and online help in BTEXT will serve as references for defining ground temperatures. The last option B is used to input the five-digit building category code. Incorrect code numbers will not be accepted. The default is no category code.

Run Control

If R is chosen while in the lead input choices mode, input is taken to the run control mode. The full menu display of the run control menu is:

```
    RUN CONTROL CHOICES
X = Full Menu (off/on)
R = Reports
L = Print Library
S = Design System
P = Design Plant
W = Report Writer
<cr> = exit RUN CONTROL MODE
==RUN CONTROL MODE==
```

BLAST Reports

Option R allows the user to add, delete, or display BLAST reports. If option R is chosen the user will see the add, delete, display scheme as follows:

```
--REPORTS--
A=ADD
D=DELETE
X=DISPLAY(by #)
<cr>=exit
```

If A (to add) is chosen the user can pick reports by supplying two-letter report codes to the following prompt:

```
ENTER REPORT CODE(S) SEPARATED BY COMMAS (i.e. ZN,ZL,SY,...)
(? will list,<cr> to exit)
```

Notice that ? will list the codes if needed. The report codes are:

```
     REPORT CODES
ZL = ZONE LOADS                   WL = WALLS
SL = SYSTEM LOADS                 ZN = ZONE
PL = PLANT LOADS                  SH = SHADE
CL = COIL LOADS                   SY = SYSTEM
KS = KSU                          FN = FANGER
PR = PIERCE                       EP = EQUIPMENT PARAMETERS
DD = DESIGN DAYS                  HL = ASHRAE HEATING LOADS
HU = HUMIDITY REPORT              EV = EVAPORATIVE REPORT
IC = ICE STORAGE                  AC = ANNUAL COMFORT REPORT
LD = LCC FILE (Hourly)            LC = LCC FILE (Summary)
WH = WATER LOOP HEAT PUMP         ST = STRATIFIED TANK
```

```
ZS = ZONE SUMMARY                HP = HOURLY PROFILES
SV = SURFACE VERTICES...........ZV = ZONE VIEW
```

After choosing the report codes, BTEXT will display back to the user the reports chosen and then return back to the add, delete, display prompt. D (delete) will allow the user to delete reports previously chosen, and X (display) displays the reports. Only 13 reports can be chosen at once.

Report Writer

Option W allows the user to add, delete, or display BLAST report writer variables. If option W is chosen the user will see the following options:

```
--REPORT WRITER OPTIONS--
Z=ZONE
X=ZONE IN FAN SYSTEM
S=FAN SYSTEMS
P=CENTRAL PLANTS
A=REPORT FILE
<cr>=exit
```

If Z, X, S, P is chosen the user can pick variables to be reported using the following add, delete, and display menu:

```
A=ADD
D=DELETE
X=DISPLAY(by #)
```

The following is an example of how to select variables for use in report writer.

```
--REPORT WRITER OPTIONS--
Z=ZONE
X=ZONE IN FAN SYSTEM
S=FAN SYSTEMS
P=CENTRAL PLANTS
A=REPORT FILE
<cr>=exit

    z
--ZONE VARIABLES--
A=ADD
D=DELETE
X=DISPLAY(by #)
<cr>=exit

    a

    ENTER ZONE NUMBER(<CR> TO QUIT,? WILL LIST)

    1

    --ADDITIONS--

    Enter Variable Number, "?" To List, or <cr>=exit

    ?
1 = Number of Occupants;                     NOFOCC
2 = Convected Heat Gain from People;         QOCCON
3  = Radiated Heat Gain from People;         QOCRAD
4 = Latent Heat Gain from People;            QOCLAT
5 = Electric Demand for Lights;              QLTTOT
6 = Convected Heat Gain from Lights;         QLTCON
7 = Radiated Heat Gain from Lights;          QLTRAD
8 = Visible Heat Gain from Lights;           QLTVIS
9 = Return Air Gain from Lights;             QLTCRA
10 = Electric Demand from Elec. Equip;       QEETOT
11 = Convected Heat Gain from Elec Equip;    QEECON
12 = Radiated Heat Gain from Elec Equip;     QEERAD
13 = Latent Heat Gain from Elec. Equip;      QEELAT
14 = Gas Demand from Gas Equipment;          QGETOT
15 = Convected Heat Gain from Gas Equip;     QGECON
16 = Radiated Heat Gain from Gas Equip;      QGERAD
    More Variables?  Yes=Y or No=N

    y
17 = Latent Heat Gain from Gas Equip;        QGELAT
```

```
18 = Convected Heat Gain from Other Eq;      QOECON
19 = Radiated Heat Gain from Other Equip;    QOERAD
20 = Latent Heat Gain from Other Equip;      QOELAT
21 = Convected Baseboard Heat Load;          QBBCON
22 = Radiated Baseboard Heat Load;           QBBRAD
23 = Mean Radiant Temperature;               MRT
24 = Zone Temperature;                       MAT
25 = Zone Sensible Cooling Load;             SNLOAD
26 = Zone Latent Load;                       LALOAD
27 = Zone Return Air Heating Load;           RALOAD
28 = Zone Baseboard Heating Load;            BBLOAD
29 = Zone Electrical Load;                   EELOAD
30 = Zone Gas Load;                          GELOAD
31 = Zone Infiltration;                      INFVFR
32 = Outside Dry Bulb Temperature;           ODB
      More Variables?  Yes=Y or No=N

    y
 33 = Outside Wet Bulb Temperature;       OWB
 34 = Outside Barometric Pressure;        OBP
 35 = Outside Humidity Ratio;             OHR
 36 = Wind Speed;                         SPD
 37 = Wind Direction;                     DIR
 38 = Sky Temperature;                    SKY
 39 = Solar Beam Radiation Normal to Rays;SRADBM
 40 = Solar Diffuse Sky Rad. Intensity;   SRADDF
 41 = Solar Ground Reflected Rad. Intsty.;SRADGR
Enter Variable Number, "?" To List, or <cr>=exit

    2
 --ADDITIONS--
Enter Variable Number, "?" To List, or <cr>=exit

    3
--ADDITIONS--
Enter Variable Number, "?" To List, or <cr>=exit
--ZONE VARIABLES--
A=ADD
D=DELETE
X=DISPLAY(by #)
< cr>=exit

    ?

    x

    ENTER ZONE NUMBER(<CR> TO QUIT,? WILL LIST)

    1
--CURRENT ZONE VARIABLES CHOSEN--
  32,     2,     3,
```

After choosing the variable codes, the user should go back to the options menu and select ‘A’ which will allow the selection of a report variable duration. (Ex. 01JAN TO 31JUL)

```
 --REPORT WRITER OPTIONS--
 Z=ZONE
 X=ZONE IN FAN SYSTEM
 S=FAN SYSTEMS
 P=CENTRAL PLANTS
 A=REPORT FILE
 <cr>=exit
```

Other Run Control Options

The run control mode also has options L, S, and P. Option L can be used in a BLAST input deck to print parts or all of the BLAST library. Option S is used if the user wants to create a BLAST input deck to calculate air volume flow rates. This option can be used with all systems but air to air heat pumps. Option P is used if the user wants to create a BLAST input deck to size central plant components. (If option P is chosen the user will answer prompts concerning central plant equipment at BLAST input deck creation time (section

3.6.3)). This option is not applicable when Ice Storage equipment has been selected.

Exiting BTEXT

To exit BTEXT (for whatever reason) the user simply hits a <cr> at the main menu mode. When a user exits BTEXT he will see:

```
END OF PROGRAM

DBASE SAMP1 saved in file SAMP1.BS

Execution Complete
```

Dbase SAMP1 can now be used later for additions or modifications.

Display Zones, Systems, Plants

Option D allows the user to get a brief overview of the data entered in the BTEXT data file. If option D is chosen from the main menu mode, the program will display the entered project title, zones, fan systems and central plants. The zones, fan systems and central plants are all displayed in numerical order. The zones are displayed with only the zone names. For each fan system displayed, the fan type, fan system title, zones served, and supply air volume to each zone, evaporative cooler mode and detail level is displayed. For each central plant displayed, the central plant title, detail level and fan systems served are displayed. All information is displayed one screen at a time. Upon completion, the user is returned to the main menu. To obtain more detailed information, the user must select the display option in the appropriate sub-menu.

Next Project

Option N (Next Project) at the main menu mode will allow the user to complete a BTEXT run and begin another run without exiting the program. An example of this feature is as follows:

```
     ==MAIN MENU MODE==

   N
DBASE SAMP1 saved in file SAMP1.BS
** STARTING COMPLETELY NEW RUN **
DBASE NAME ?

   SAMP2

   .

   .

   .
```

The user finished using project SAMP1 and proceeded to start on project SAMP2 without ever exiting the program.

Limits on Input

This chapter is a listing of limits of input on certain BLAST elements in BTEXT (i.e., 20 zones are allowed). Most limits are set high and should be sufficient for even large BLAST runs. If the user exceeds any of the limits, no harm to the run will be caused (only an error message will be supplied).

Limits are as follows:

CREATE TEMPORARY ENTRIES MODE

- 15 temporary design days
- 15 temporary locations
- 15 temporary materials
- 15 temporary building elements
  - 10 layers (materials) per building element
- 15 temporary schedules
- 15 temporary controls
  - 10 profiles per control

PROJECT PARAMETER MODE

- 12 design days
- 1 location
- 20 reports

BUILDING AND ZONE MODE

- 12 detached shadings
- 20 zones
- 240 surfaces and subsurfaces (total)

SCHEDULE LOADS MODE

- 32 schedule loads (total)

FAN SYSTEMS MODE

- 20 fan systems

CENTRAL PLANT MODE

- 20 central plants

Chiller User Guide

Introduction

This guide gives you practical information on how to apply the Chiller program and create EQUIPMENT PERFORMANCE PARAMETERS needed to model chillers in BLAST. The BLAST chiller models use quadratic equations to model chiller performance. The coefficients of these equations are calculated from manufacturer's catalog data and entered into BLAST as EQUIPMENT PERFORMANCE PARAMETERS. The determination of these coefficients is not a simple and straight forward procedure and the values of the coefficients are such that no obvious conclusions can be drawn concerning their correctness. The Chiller program has been written to calculate these parameters more quickly, and accurately test their validity.

The Chiller program is designed to take typical manufacturer's catalog data, convert it into the chiller parameters used in the EQUIPMENT PERFORMANCE PARAMETERS section in BLAST, and then test these parameters. The program is simple to use and includes on-line help. Users are prompted for applicable chiller performance data, which is used to calculate the chiller coefficients and part load statements for BLAST. The coefficients and the part load data are written to a file in the proper BLAST syntax. A work file containing all user input is saved and may be recalled for modification at a later time. At the user's request, the parameters may be tested, producing a table showing chiller power consumption over a range of cooling loads and condenser temperatures. This table should indicate to the user any blatant errors or trends which seem inconsistent with known chiller operation.

The Chiller Program deals only with the vapor-compression chillers used in BLAST and not absorption cycles.

Memory Requirements: 150 K Bytes RAM

Disk Requirements: 130 K Bytes

Installation Instructions

The Chiller program is automatically installed with the rest of the BLAST Family of Programs. It is accessible from the HBLC program or from an MS-DOS™ window. By default, it is installed in the C:\BLASTSYS\CHILLER directory.

Overview of the Program

BLAST has a default set of EQUIPMENT PERFORMANCE PARAMETERS that are provided for each chiller and they are a good approximation for a rough estimate of the energy consumed by that chiller. To go beyond this first approximation, a better chiller model is needed. To improve the model, a new set of coefficients for the quadratic equations must be calculated from manufacturer's catalog data. The data is easily organized by filling out the Chiller Worksheet (see table below) and then entered into the program.

When the program is first started, it goes through a brief introduction and then asks for an input file name of 6 characters or less. The program automatically assumes a file extension for the input file of **.CIN**; this can either be a new run or an old one. Then the data from the worksheet is entered into the program by menu prompts. After the data is entered it can then be reviewed, checked for accuracy, and modified if necessary. The program will now ask you to create a parameter file and will automatically create an output file with the same name as the input file and will assign an extension of **.COT**. The output file contains the Equipment Performance Parameters and the Part Load Ratios statement. From here you can once again go back and modify your input data, or go on and save a session summary and test the parameters. The session summary will also create a file with the same name as the input file but will assume an extension of **.CSS**. In the session summary file is all the information from the input file, the output file, and the tests run at the different chilled water temperatures.

After the session summary is complete you can once again go back and modify your input or start on another chiller project. You can then print out the output file for the chiller parameters or the session summary file using standard DOS commands to review the information. The EQUIPMENT PERFORMANCE PARAMETERS and the PART LOAD RATIOS information in the .COT file can then be put into the BLAST input file.

Also, at any time, if you need assistance in answering a question or are uncertain as to what kind of information the program is expecting, type: **@**. If you get lost or feel you have made too many mistakes, type: **ABORT -** to TERMINATE the program without saving any information.

Obtaining Data for Program Input

Data is obtained from the chiller manufacturer's catalog for the chiller you are modeling. Information needed is: the performance points at load, chilled water temperature and condenser temperature referred to as map points, and part load information. The part load curve is the hardest information to obtain. Normally only one representative curve is shown for all the chillers, this information will have to be used until the manufacturers provide more accurate data.

Practice Chiller Session

This practice session works through the steps required to model a typical chiller. Typical manufacturer's catalog data is provided along with the procedure for filling out the chiller worksheet. The worksheet contains the proper data that is needed to enter into the program.

Table 68. TYPICAL MANUFACTURER'S DATA:
130 NOMINAL TONS / 182 KW COMP. AIR COOLED CONDENSER

LEAVING CHILLED WATER (F)	**TEMPERATURE OF AIR ENTERING CONDENSER 3-PASS (TONS/KW)**			
	85	**95**	105	115
40	123/163	111/161	96/156	
42	133/172	124/173	109/170	
44	139/176	128/179	116/176	
45	142/178	**130/180**	119/179	103/173
46	144/181	132/182	122/182	106/177

(Bold print above indicates the nominal conditions)

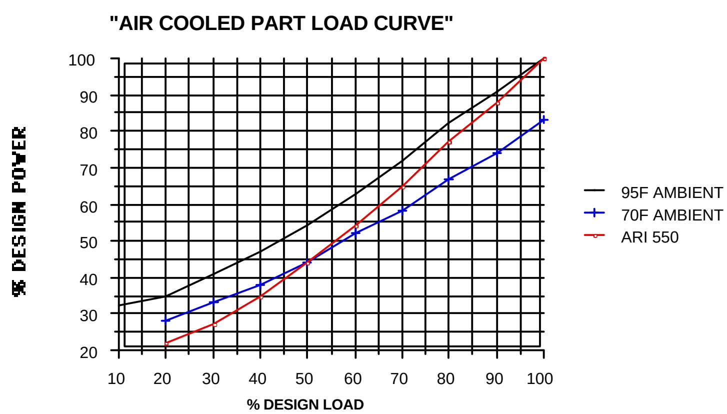


Table 69. Air Cooled Chiller part load curve

Chiller - Worksheet

Information needed to complete the Chiller Program is outlined below:

Table 70. Chiller Program Worksheet

```
Chiller Type:_______________
Nominal Capacity:_______________
Nominal Power (KW) :____________________
Nominal Entering Condenser Water Temp.:_______________
Nominal Leaving Chilled Water Temp.:_______________
Second Entering Condenser Water Temp.:_______________
Second Leaving Chilled Water Temp.:_______________
Maximum Part Load Ratio:_______________
Minimum Part Load Ratio:_______________
Best Part Load Ratio:_______________
Map Pt. Available  Available  Condenser  Chilled
    Capacity   Power   Water Temp Water Temp
1   ________   ________   ________   ________
2   ________   ________   ________   ________
3   ________   ________   ________   ________
4   ________   ________   ________   ________
5   ________   ________   ________   ________
6   ________   ________   ________   ________
7   ________   ________   ________   ________
8   ________   ________   ________   ________
9   ________   ________   ________   ________
10  ________   ________   ________   ________
Fraction of Full Load Ratio vs. Part Load Ratio
Point   FFL PLR
1   _________  _________
2   _________  _________
3   _________  _________
4   _________  _________
5   _________  _________
6   _________  _________
7   _________  _________
8   _________  _________
9   _________  _________
10  _________  _________
```

Filling Out the Practice Worksheet

Chiller Type

The first field, chiller type, is described in the Reference section called "Chiller Operation and Modeling". Our example is an "Air Cooled Condenser Chiller" which will be entered as **AC** for Air Cooled.

Nominal Capacity

This is the nominal or design cooling capacity of the chiller and can be entered in either Tons or KW. In this example, the nominal power is **130 Tons**.

Nominal Power

This is the nominal full load chiller power consumption at nominal capacity and can be entered in KW only. Electric motors from manufacturers are normally rated in KW so a conversion is not required. In this example, the nominal power is **182 KW**.

Nominal Entering Condenser Water Temperature

This is the temperature of the water/air entering the condenser under nominal conditions. To find the value for this in our data we have to locate the nominal conditions in the table of manufacturer's data. A Map Point is a value of chiller capacity and power consumption at a given condenser temperature and leaving chilled water temperature. Now the nominal condition map point must be identified. For this example, it most closely corresponds to 130 tons and 180 KW at a 95 degree F condenser temperature and a 45 degree F chilled water temperature. Manufacturers try to provide a map point at or very close to nominal conditions and sometimes it takes a little judgement to decide which point is closest to the nominal conditions. Otherwise, a couple of points can be selected and a run done for each to determine which results most accurately represent the data provided. In this example, the nominal condenser air temperature is **95 degree F**.

Nominal Leaving Chilled Water Temperature

This is the temperature of the chilled water leaving the chiller at nominal operating conditions. This is the chilled water temperature at the nominal conditions map point. In this example, the nominal chilled water temperature is **45 degree F**.

Second Entering Condenser Temperature

This is the temperature of water/air entering the condenser at a second operating point which is still at the nominal capacity but not at nominal temperatures or nominal power. You may have to interpolate to find this point. In our example the point chosen is at 85 degree F condenser temperature and between 40 & 42 degree F chilled water temperature to find a value of 132 tons nominal capacity. In this example the second entering condenser temperature is **85 degree F**.

Second Chilled Water Temperature

This is the temperature of chilled water leaving the chiller at a second operating point that is at the nominal capacity but not at nominal temperatures or nominal power. This point may have to be interpolated. Normally this point, or the second entering condenser temperature, has to be interpolated but not both. The same point is being used as in 6 except now the interpolation will have to be performed to find the chilled water temperature. In this example, after performing the interpolation, the value for the second chilled water temperature is **41.4 degree F**.

The second temperatures at nominal capacity and the nominal values are used in calculating the equivalent temperature (Teq). Teq is used to quantify the departure of actual temperatures from their nominal values, in a single variable as a function of entering condenser temperature and leaving chilled water temperature.

Maximum Part Load Ratio

This is the maximum part load ratio, or the ratio of the maximum capacity to the nominal capacity that the chiller can obtain with the compressor motor specified. This is normally determined from the map points given by the manufacturer if not explicitly specified. In this example, the nominal capacity is 130 tons, but the maximum capacity from the data is 144 tons. The ratio of the maximum capacity to the nominal capacity in this example is 1.107 or approximately **1.11**.

Minimum Part Load Ratio

This is the minimum part load ratio under which power consumption is constant. This is the point where your chilled water demand becomes smaller and smaller, but the power to operate the compressor remains constant. In this example using the part load curves, they approach a limit at approximately **0.2**.

Best Part Load Ratio

This is the most efficient or the best part load ratio at which the chiller can operate. The best part load ratio is used when there is more than one chiller in operation. BLAST will operate the first chiller up to the best part load ratio, then start operation of the second chiller up to its best part load ratio until the final chiller is in operation. Then all the chillers are increased to their full capacity. The best part load ratio can be determined from the part load ratio curve, this can be estimated visually or can be determined mathematically. The BLAST default best part load ratio is 0.65, in our example the value chosen is the BLAST default **0.65**.

Map Points

The next inputs are in groups of 4, all corresponding to the same operating point or map point. Three map points must be entered, but no more than 10 points may be entered. The set consists of:

Available Capacity (Tons or kW): The full load cooling capacity at a given operating point.

Power Consumption (kW): The chiller power consumption at full load operation for a given operating point.

Condenser Water Temperature (F or C): The temperature of water entering the condenser at a given operating point.

Chilled Water Temperature (F or C): The temperature of chilled water leaving the chiller at a given operating point.

Map Point	**Available Capacity**	**Power Consumption**	**Condenser Temperature**	**Chilled Water**
1	123	163	85	40
2	144	181	85	46
3	96	156	105	40
4	122	182	105	46

Table 71. Air Cooled Chiller map points

These are the values chosen for the Typical Air Cooled Chiller and entered into the program. The point selection scheme follows the evaluation made in the Map Point Evaluation Table in the Chiller Reference Guide and is case (k).

Part Load Curve

The next inputs correspond to the coordinate pairs for points on a Part Load Curve. Values for at least three, but no more than ten, points are entered.

Fraction of Full Load: This is the ratio of actual power consumption to full load power consumption.

Part Load Ratio: This is the ratio of the cooling load on the chiller to the full load chiller capacity.

Point	Fraction of Full Load	Part Load Ratio
1	0.30	0.34
2	0.50	0.56
3	0.70	0.74
4	0.90	0.92
5	1.0	1.0

Table 72. Air Cooled Chiller Part Load Curve data points

These points were obtained from the Part Load Curve where the abscissa is the FFL and the ordinate is the PLR. Five points were used to describe the curve. The distribution of points should be as broad as possible, and areas of the curve with greatest change of slope should have more points to describe the curve.

Completed Worksheet

The completed chiller worksheet from this example should look like:

Chiller - Worksheet

Information needed to complete the Chiller Program is outlined below:

Chiller Type: **ACC**

Nominal Capacity: **130**

Nominal Power (KW): **182**

Nominal Entering Condenser Water Temp.: **95.0**

Nominal Leaving Chilled Water Temp.: **45.0**

Second Entering Condenser Water Temp.: **85.0**

Second Leaving Chilled Water Temp.: **41.4**

Maximum Part Load Ratio: **1.11**

Minimum Part Load Ratio: **0.20**

Best Part Load Ratio: **0.65**

Map Point	Available Capacity	Available Power	Condenser Water Temp	Chilled Water Temp
1	**123**	**163**	**85**	**40**
2	**144**	**181**	**85**	**46**
3	**96**	**156**	**105**	**40**
4	**122**	**182**	**105**	**46**
5				
6				
7				
8				
9				
10				

Fraction of Full Load Ratio vs. Part Load Ratio

Point	FFL	PLR
1	**0.30**	**0.34**
2	**0.50**	**0.56**
3	**0.70**	**0.74**
4	**0.90**	**0.92**
5	**1.0**	**1.0**

6		
7		
8		
9		
10		

Entering the Data into Chiller

The worksheet information is then input into the chiller program by menus in the order that is presented below from the worksheet. This information can then be modified from many points in the program as demands dictate.

```
CHILLER TYPE: AC
 INPUT UNITS: E
 OUTPUT UNITS: E
 NOMINAL CAPACITY:  130.0
 NOMINAL POWER (KW):  182.0
 NOMINAL ENTERING CONDENSER WATER TEMPERATURE:  95.0
 NOMINAL LEAVING CHILLED WATER TEMPERATURE:    45.0

 SECOND ENTERING CONDENSER WATER TEMPERATURE:   85.0
 SECOND LEAVING CHILLED WATER TEMPERATURE:     41.4

 MAXIMUM PART LOAD RATIO: 1.11
 MINIMUM PART LOAD RATIO:  .20
 BEST PART LOAD RATIO:  .65

  MAP    AVAILABLE   AVAILABLE   CONDENSER    CHILLED
 POINT   CAPACITY      POWER     WATER TEMP  WATER TEMP
    1     123.0        163.0        85.0       40.0
    2     144.0        181.0        85.0       46.0
    3     96.00        156.0        105.       40.0
    4     122.0        182.0        105.       46.0

 PART LOAD RATIO vs FRACTION OF FULL LOAD
 POINT         FFL             PLR
    1          .30             .34
    2          .50             .56
    3          .70             .74
    4          .90             .92
    5          1.0             1.0
```

Generating Output from the Data

From the information above, the output generated below will be placed in the .COT file which may then be copied into the appropriate section of the BLAST input file for the chiller modeled. Then a BLAST run can be completed with these customized parameters to more accurately obtain chiller power consumption.

```
EQUIPMENT PERFORMANCE PARAMETERS:
     ADJTAC ( 95.00000000,  2.77777900, 45.00000000);
     RCAVAC (   .99627790,  -.02601467,  -.00044516);
     ADJEAC (  1.90651100, -1.20207100,   .26190160);
     RPWRAC (   .03302903,   .68520780,   .28177790);

PART LOAD RATIOS:
    CHILLER (MIN =  .20, MAX =1.11, BEST = .65, ELECTRICAL = .3980
);
```

Testing the Data

Since the values of the coefficients are such that no obvious conclusions can be drawn to their physical correctness, chiller models from BLAST are included to test the coefficients and check the valid range of performance. Tables at different chilled water temperatures at a range of chiller loads and condenser temperatures are calculated so you can check the BLAST calculated data with the actual manufacturer's performance data. In the table below, if asterisks appear in a field, this indicates that the required cooling demand is greater than the available capacity of the chiller at those conditions. In reality, the chiller would be operating at maximum capacity but would not meet the total cooling demand. This gives the user a graphical representation of the limits of the chiller's capabilities.

```
                            CHILLER POWER CONSUMPTION (KW)
CHILLED WATER TEMPERATURE (F) =  40.0
MINIMUM PART LOAD RATIO =  .200
MAXIMUM PART LOAD RATIO =  1.11

        :-------------------------------------------------------------------
CHILLER :               ENTERING CONDENSER WATER TEMPERATURE (F)
 LOAD   :-------------------------------------------------------------------
(TONS)  :     80.       85.       90.       95.      100.      105.      110.
--------:-------------------------------------------------------------------
    26. :     32.       33.       34.       35.       36.       37.       39.
    38. :     45.       46.       48.       50.       52.       54.       57.
    50. :     59.       61.       63.       66.       69.       72.       76.
    61. :     74.       76.       79.       83.       87.       92.       97.
    73. :     89.       93.       97.      101.      106.      112.      119.
    85. :    105.      110.      115.      120.      127.      134.      143.
    97. :    123.      128.      134.      141.      149.   *******   *******
   109. :    141.      147.      154.      162.   *******   *******   *******
   121. :    159.      167.   *******   *******   *******   *******   *******
   132. : *******   *******   *******   *******   *******   *******   *******
   144. : *******   *******   *******   *******   *******   *******   *******

                            CHILLER POWER CONSUMPTION (KW)
CHILLED WATER TEMPERATURE (F) =  44.0
MINIMUM PART LOAD RATIO =  .200
MAXIMUM PART LOAD RATIO =  1.11

        :-------------------------------------------------------------------
CHILLER :               ENTERING CONDENSER WATER TEMPERATURE (F)
 LOAD   :-------------------------------------------------------------------
(TONS)  :     80.       85.       90.       95.      100.      105.      110.
--------:-------------------------------------------------------------------
    26. :     33.       32.       32.       32.       33.       35.       36.
    38. :     42.       43.       45.       46.       48.       49.       51.
    50. :     55.       57.       58.       60.       63.       65.       68.
    61. :     68.       71.       73.       76.       79.       82.       86.
    73. :     83.       85.       88.       92.       96.      100.      105.
    85. :     97.      101.      105.      109.      114.      119.      125.
    97. :    113.      117.      121.      127.      132.      139.      147.
   109. :    129.      134.      139.      145.      152.      160.   *******
   121. :    146.      152.      158.      165.   *******   *******   *******
   132. :    164.      170.   *******   *******   *******   *******   *******
   144. : *******   *******   *******   *******   *******   *******   *******
```

Using the Chiller Output in BLAST

The EQUIPMENT PERFORMANCE PARAMETERS and PART LOAD RATIOS data blocks which are produced in the Chiller .COT files are to be used in a BLAST input file. Using a text editor, insert these lines in the appropriate place in the BLAST CENTRAL PLANT DESCRIPTION.

Additional Information about the Chiller Program

In general, the program works well. The data is within the error set in the technical reference section of the documentation. The accuracy of the data is very dependent on the amount, accuracy, and distribution of the manufacturer's data.

Presently, the hardest information to obtain is the part load curves. The curves that the manufacturers print in the catalogs are normally at just one condenser temperature and for all the chillers in the catalog. The curve is just put in as an example, but it can be a better representation than the default part load ratio curves. As stated in the documentation, "The part load curve used for power consumption calculation is based on particular condenser temperatures, but is assumed to be constant for all operating conditions. This is not a true representation of reality, but the part load chiller performance should not drastically change at different condenser water temperatures." In the November 1987 *ASHRAE Journal* there is an article titled "Partial Load HVAC Equipment Requirements" stating that ASHRAE has proposed a new ratings standard for refrigeration and air conditioning equipment used commercially. In ASHRAE/IES Standard 90.1P, important part load ratio operating characteristics will be incorporated into the minimum equipment performance requirements specification which should make obtaining part load ratio information much easier.

Performance data is more readily available in manufacturers' catalogs, and when inputting this data, a wide range of chilled water and condenser water temperatures should be used. As stated in the manufacturers' data and the chiller documentation, data that is interpolated is more accurate. If data is extrapolated, it could give erroneous results.

If asterisks appear in a field in the test output, this indicates that the required cooling demand was greater then the available capacity of the chiller at those conditions. In reality, the chiller would be operating at maximum capacity but would not meet the total cooling demand. This gives the user a graphical representation of the limits of the chiller's capabilities.

The BLAST default performance parameters are a good place to start to make initial runs, but the ELECTRICAL default in the PART LOAD RATIOS statement should ***always*** be changed to reflect the nominal power of the compressor being modeled. (The BLAST default for a 200-Ton compressor is 160 KW, which is close for a standard Hermetic Centrifugal Chiller.) This chiller program can be very useful to more accurately define the chiller coefficients when modeling a chiller with BLAST.

Chiller Version 1.0 Level 9 Sample Session

```
CHILLER VERSION 1.0
LEVEL  9
```

```
DEVELOPED BY CRAIG CLARK
WOULD YOU LIKE INSTRUCTIONS ?

    Y
This is the BLAST CHILLER Program.  It allows you to create the
EQUIPMENT PERFORMANCE PARAMETERS needed to model a chiller in BLAST.
The input to this program may be obtained from most manufacturer's
chiller catalogs. The output from this program will be in acceptable
  BLAST format, but will have to be copied into the appropriate section
of your BLAST input deck. See the BLAST User's Manual for further
details.

  The minimum information needed as input to this program is:
     1) Nominal Capacity (tons or kW)
     2) Nominal Power Consumption (kW)
     3) Nominal Entering Condenser Water Temperature (F or C)
     4) Nominal Leaving Chilled Water Temperature (F or C)
     5) Values of Condenser and Chilled Water Temperatures other than
        Nominal at a point where the Available Capacity is equal to the
        Nominal Capacity ( You may have to interpolate)
     6) Available Capacity, Power Consumption, Condenser and Chilled
        Water Temperatures at 3 'Map Points'. These points may include
        the Nominal operating point and the point used in 5). Up to
        10 points may be entered.
     7) Fraction of Full Load vs. Part Load Ratio. At least 3, but
        no more than 10 sets.
Pause.
Please press <return> to continue.

    <CR>
    8) Maximum Part Load Ratio that is allowed, the Minimum Part
       Load Ratio under which power consumption is constant, and
       the Best Part Load Ratio. This Information should be
obtained
       from the manufacturers catalog.

 If you need assistance in answering a question or are uncertain as
 to what kind of information the program is expecting type: @

   Also, if you get lost or feel you have made too many mistakes:
   Type:   ABORT - To TERMINATE the program without saving any
                   information.

     INPUT FILE NAME 6 CHARACTERS OR LESS ?

    C612

    FULL INPUT FILE NAME C612.CIN

    IS THIS A NEW RUN ?

    Y

    DO YOU WISH TO START WITH AN OLD INPUT FILE ?

    N
 CODE    CHILLER TYPES :
  DB  :  DOUBLE BUNDLE
  1C  :  HERMETIC COMPRESSION (CENTRIFUGAL)
  2C  :  OPEN CENTRIFUGAL
  3C  :  RECIPROCATING
  AC  :  AIR COOLED
  FC  :  FREE COOLING
  DC  :  DIESEL DRIVEN
  GC  :  GAS TURBINE DRIVEN
  HP  :  HEAT PUMP
CHILLER TYPE ?

    1C
CHILLER TYPE = 1C
UNITS (E=ENGLISH, M=METRIC) ?

    E
UNITS = E
ENTER NOMINAL VALUES OF CAPACITY, POWER CONSUMPTION,
CONDENSER WATER TEMPERATURE AND CHILLED WATER TEMPERATURE
NOMINAL CAPACITY (TONS OR KW) ?

    612
```

```
NOMINAL CAPACITY =  612.0
NOMINAL FULL LOAD POWER (KW) ?
```

458

```
NOMINAL FULL LOAD POWER (KW) =  458.0
NOMINAL ENTERING CONDENSER WATER TEMPERATURE(F OR C) ?
```

85

```
NOMINAL ENTERING CONDENSER WATER TEMPERATURE =   85.000
NOMINAL LEAVING CHILLED WATER TEMPERATURE (F OR C) ?
```

44

```
NOMINAL LEAVING CHILLED WATER TEMPERATURE =   44.000
SECOND ENTERING CONDENSER WATER TEMPERATURE(F OR C) ?
```

80

```
SECOND ENTERING CONDENSER WATER TEMPERATURE =   80.000


SECOND LEAVING CHILLED WATER TEMPERATURE (F OR C) ?
```

41.7

```
SECOND LEAVING CHILLED WATER TEMPERATURE =   41.700
ENTER VALUES OF CAPACITY, POWER CONSUMPTION, CONDENSER WATER
TEMPERATURE
AND CHILLED WATER TEMPERATURE AT EACH MAP POINT.
YOU MUST ENTER VALUES FOR AT LEAST 3, BUT NO MORE THAN 10 MAP
POINTS.
YOU MAY RE-ENTER THE NOMINAL CAPACITY POINTS
INPUT FOR MAP POINT  1
AVAILABLE CAPACITY (TONS OR KW) FOR MAP POINT  1 ?
```

608

```
AVAILABLE CAPACITY =  608.0
FULL LOAD POWER CONSUMPTION (KW) FOR MAP POINT  1?
```

458

```
FULL LOAD POWER CONSUMPTION (KW) =  458.0
ENTERING CONDENSER WATER TEMPERATURE (F OR C) FOR MAP POINT  1 ?
```

75

```
ENTERING CONDENSER WATER TEMPERATURE =   75.000
LEAVING CHILLED WATER TEMPERATURE (F OR C) FOR MAP POINT  1 ?
```

40

```
LEAVING CHILLED WATER TEMPERATURE =   40.000
INPUT FOR MAP POINT  2
AVAILABLE CAPACITY (TONS OR KW) FOR MAP POINT  2 ?
```

685

```
AVAILABLE CAPACITY =  685.0
FULL LOAD POWER CONSUMPTION (KW) FOR MAP POINT  2?
```

458

```
FULL LOAD POWER CONSUMPTION (KW) =  458.0
ENTERING CONDENSER WATER TEMPERATURE (F OR C) FOR MAP POINT  2 ?
```

75

```
ENTERING CONDENSER WATER TEMPERATURE =   75.000
LEAVING CHILLED WATER TEMPERATURE (F OR C) FOR MAP POINT  2 ?
```

48

```
LEAVING CHILLED WATER TEMPERATURE =   48.000
INPUT FOR MAP POINT  3
AVAILABLE CAPACITY (TONS OR KW) FOR MAP POINT  3 ?
```

553

```
AVAILABLE CAPACITY =  553.0
FULL LOAD POWER CONSUMPTION (KW) FOR MAP POINT  3?
```

458

```
FULL LOAD POWER CONSUMPTION (KW) =  458.0
ENTERING CONDENSER WATER TEMPERATURE (F OR C) FOR MAP POINT  3 ?
```

90

```
ENTERING CONDENSER WATER TEMPERATURE =   90.000
LEAVING CHILLED WATER TEMPERATURE (F OR C) FOR MAP POINT  3 ?
```

```
    40
LEAVING CHILLED WATER TEMPERATURE =   40.000
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?

    Y
INPUT FOR MAP POINT  4
AVAILABLE CAPACITY (TONS OR KW) FOR MAP POINT  4 ?

    625
AVAILABLE CAPACITY =  625.0
FULL LOAD POWER CONSUMPTION (KW) FOR MAP POINT  4?

    458
FULL LOAD POWER CONSUMPTION (KW) =  458.0
ENTERING CONDENSER WATER TEMPERATURE (F OR C) FOR MAP POINT  4 ?

    90
ENTERING CONDENSER WATER TEMPERATURE =   90.000
LEAVING CHILLED WATER TEMPERATURE (F OR C) FOR MAP POINT  4 ?

    48
LEAVING CHILLED WATER TEMPERATURE =   48.000
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?

    Y
INPUT FOR MAP POINT  5
AVAILABLE CAPACITY (TONS OR KW) FOR MAP POINT  5 ?

    625
AVAILABLE CAPACITY =  625.0
FULL LOAD POWER CONSUMPTION (KW) FOR MAP POINT  5?

    458
FULL LOAD POWER CONSUMPTION (KW) =  458.0
ENTERING CONDENSER WATER TEMPERATURE (F OR C) FOR MAP POINT  5 ?

    82.5
ENTERING CONDENSER WATER TEMPERATURE =   82.500
LEAVING CHILLED WATER TEMPERATURE (F OR C) FOR MAP POINT  5 ?

    54
LEAVING CHILLED WATER TEMPERATURE =   54.000
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?

    N
MAXIMUM PART LOAD RATIO ALLOWED  ?

    1.1
MAXIMUM PART LOAD RATIO =1.10
MINIMUM PART LOAD RATIO BELOW WHERE ENERGY
CONSUMPTION IS CONSTANT ?

    0.1
MINIMUM PART LOAD RATIO = .10
MOST EFFICIENT (BEST) PART LOAD RATIO ?

    0.65
BEST PART LOAD RATIO = .65
ENTER VALUES OF FRACTION OF FULL LOAD AND PART LOAD RATIO AT EACH
PART LOAD POINT.
YOU MUST ENTER VALUE FOR AT LEAST 3, BUT NO MORE THAN 10 PART LOAD
POINTS.
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
1
FRACTION OF FULL LOAD FOR PART LOAD POINT  1 ?

    0.2
FRACTION OF FULL LOAD =   .20
PART LOAD RATIO FOR PART LOAD POINT  1 ?

    0.1
PART LOAD RATIO =   .10
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
2
FRACTION OF FULL LOAD FOR PART LOAD POINT  2 ?

    0.25
```

```
FRACTION OF FULL LOAD =   .25
PART LOAD RATIO FOR PART LOAD POINT  2 ?
```

0.2

```
PART LOAD RATIO =   .20
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
3
FRACTION OF FULL LOAD FOR PART LOAD POINT  3 ?
```

0.33

```
FRACTION OF FULL LOAD =   .33
PART LOAD RATIO FOR PART LOAD POINT  3 ?
```

0.3

```
PART LOAD RATIO =   .30
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?
```

Y

```
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
4
FRACTION OF FULL LOAD FOR PART LOAD POINT  4 ?
```

0.41

```
FRACTION OF FULL LOAD =   .41
PART LOAD RATIO FOR PART LOAD POINT  4 ?
```

0.4

```
PART LOAD RATIO =   .40
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?
```

Y

```
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
5
FRACTION OF FULL LOAD FOR PART LOAD POINT  5 ?
```

0.5

```
FRACTION OF FULL LOAD =   .50
PART LOAD RATIO FOR PART LOAD POINT  5 ?
```

0.5

```
PART LOAD RATIO =   .50
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?
```

Y

```
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
6
FRACTION OF FULL LOAD FOR PART LOAD POINT  6 ?
```

0.58

```
FRACTION OF FULL LOAD =   .58


PART LOAD RATIO FOR PART LOAD POINT  6 ?
```

0.6

```
PART LOAD RATIO =   .60
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?
```

Y

```
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
7
FRACTION OF FULL LOAD FOR PART LOAD POINT  7 ?
```

0.67

```
FRACTION OF FULL LOAD =   .67
PART LOAD RATIO FOR PART LOAD POINT  7 ?
```

0.7

PART LOAD RATIO =   .70

```
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?
```

Y

```
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
8
FRACTION OF FULL LOAD FOR PART LOAD POINT  8 ?
```

0.77

```
FRACTION OF FULL LOAD =   .77
PART LOAD RATIO FOR PART LOAD POINT  8 ?

    0.8
PART LOAD RATIO =   .80
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?

    Y
ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
9
FRACTION OF FULL LOAD FOR PART LOAD POINT  9 ?

    0.88
FRACTION OF FULL LOAD =   .88
PART LOAD RATIO FOR PART LOAD POINT  9 ?

    0.9
PART LOAD RATIO =   .90
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?

    Y


ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
10
FRACTION OF FULL LOAD FOR PART LOAD POINT 10 ?

    1.0
FRACTION OF FULL LOAD =   1.0
PART LOAD RATIO FOR PART LOAD POINT 10 ?

    1.0
PART LOAD RATIO =   1.0
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?

    N
WOULD YOU LIKE TO REVIEW INPUT ?

    Y
CHILLER TYPE: 1C
INPUT UNITS: E
OUTPUT UNITS: E
NOMINAL CAPACITY:  612.0
NOMINAL POWER (KW):  458.0
NOMINAL ENTERING CONDENSER WATER TEMPERATURE:  85.0
NOMINAL LEAVING CHILLED WATER TEMPERATURE:    44.0
SECOND ENTERING CONDENSER WATER TEMPERATURE:   80.0
SECOND LEAVING CHILLED WATER TEMPERATURE:     41.7
MAXIMUM PART LOAD RATIO: 1.10
MINIMUM PART LOAD RATIO:  .10
BEST PART LOAD RATIO:  .65
       MAP    AVAILABLE      AVAILABLE      CONDENSER      CHILLED
       POINT  CAPACITY       POWER  WATER TEMP     WATER TEMP
       1      608.0  458.0  75.0   40.0
       2      685.0  458.0  75.0   48.0
       3      553.0  458.0  90.0   40.0
       4      625.0  458.0  90.0   48.0
       5      625.0  458.0  82.5   44.0
Pause.
Please press <return> to continue.

    <CR>
PART LOAD RATIO vs FRACTION OF FULL LOAD
       POINT  FFL    PLR
       1      .20    .10
       2      .25    .20
       3      .33    .30
       4      .41    .40
       5      .50    .50
       6      .58    .60
       7      .67    .70
       8      .77    .80
       9      .88    .90
       10     1.0    1.0
WOULD YOU LIKE TO MAKE FURTHER MODIFICATIONS ?
```

```
    Y
 CODE    CHILLER TYPES :
  DB  :  DOUBLE BUNDLE
  1C  :  HERMETIC COMPRESSION (CENTRIFUGAL)
  2C  :  OPEN CENTRIFUGAL
  3C  :  RECIPROCATING
  AC  :  AIR COOLED
  FC  :  FREE COOLING
  DC  :  DIESEL DRIVEN
  GC  :  GAS TURBINE DRIVEN
  HP  :  HEAT PUMP
CHILLER TYPE ?
CURRENT CHILLER TYPE = 1C
<CR> TO KEEP

    <CR>
CHILLER TYPE = 1C
INPUT UNITS (E=ENGLISH, M=METRIC) ?
CURRENT INPUT UNITS = E
<CR> TO KEEP

    <CR>
INPUT UNITS = E
OUTPUT UNITS (E=ENGLISH, M=METRIC) ?
CURRENT OUTPUT UNITS = E
<CR> TO KEEP

    <CR>
OUTPUT UNITS = E
ENTER NOMINAL VALUES OF CAPACITY, POWER CONSUMPTION,
CONDENSER WATER TEMPERATURE AND CHILLED WATER TEMPERATURE
                 VALUES AT NOMINAL CONDITIONS
 MAP    AVAILABLE     POWER     CONDENSER    CHILLED
POINT   CAPACITY   CONSUMPTION  WATER TEMP  WATER TEMP
NOMINAL  612.0       458.0       85.0          44.0
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 X   TO END MODIFICATIONS AND CONTINUE

    <CR>
ENTER VALUES OF CAPACITY, POWER CONSUMPTION, CONDENSER WATER
TEMPERATURE
AND CHILLED WATER TEMPERATURE AT EACH MAP POINT.
YOU MUST ENTER VALUES FOR AT LEAST 3, BUT NO MORE THAN 10 MAP
POINTS.
YOU MAY RE-ENTER THE NOMINAL CAPACITY POINTS
INPUT FOR MAP POINT  1
            VALUES AT MAP POINT  1
 MAP    AVAILABLE     POWER     CONDENSER    CHILLED
POINT   CAPACITY   CONSUMPTION  WATER TEMP  WATER TEMP
   1     608.0       458.0       75.0          40.0
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 D   TO DELETE VALUES AND CONTINUE
 X   TO END MODIFICATIONS AND CONTINUE
?

    <CR>
INPUT FOR MAP POINT  2
            VALUES AT MAP POINT  2
 MAP    AVAILABLE     POWER     CONDENSER    CHILLED
POINT   CAPACITY   CONSUMPTION  WATER TEMP  WATER TEMP
   2     685.0       458.0       75.0          48.0
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 D   TO DELETE VALUES AND CONTINUE
 X   TO END MODIFICATIONS AND CONTINUE
?
<CR>


INPUT FOR MAP POINT  3
            VALUES AT MAP POINT  3
 MAP    AVAILABLE     POWER     CONDENSER    CHILLED
POINT   CAPACITY   CONSUMPTION  WATER TEMP  WATER TEMP
```

```
   3     553.0       458.0       90.0          40.0
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 D   TO DELETE VALUES AND CONTINUE
 X   TO END MODIFICATIONS AND CONTINUE
?
```

<CR>

```
INPUT FOR MAP POINT  4
            VALUES AT MAP POINT  4
 MAP    AVAILABLE     POWER     CONDENSER    CHILLED
POINT   CAPACITY   CONSUMPTION  WATER TEMP  WATER TEMP
   4     625.0       458.0       90.0          48.0
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 D   TO DELETE VALUES AND CONTINUE
 X   TO END MODIFICATIONS AND CONTINUE
?
```

<CR>

```
INPUT FOR MAP POINT  5
            VALUES AT MAP POINT  5
 MAP    AVAILABLE     POWER     CONDENSER    CHILLED
POINT   CAPACITY   CONSUMPTION  WATER TEMP  WATER TEMP
   5     625.0       458.0       82.5          54.0
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 D   TO DELETE VALUES AND CONTINUE
 X   TO END MODIFICATIONS AND CONTINUE
?
```

M

```
AVAILABLE CAPACITY (TONS OR KW) FOR MAP POINT  5 ?
CURRENT AVAILABLE CAPACITY =  625.0
<CR> TO KEEP
```

<CR>

```
AVAILABLE CAPACITY =  625.0
```

```
FULL LOAD POWER CONSUMPTION (KW) FOR MAP POINT  5?
CURRENT FULL LOAD POWER CONSUMPTION (KW) =  458.0
<CR> TO KEEP
```

<CR>

```
FULL LOAD POWER CONSUMPTION (KW) =  458.0
ENTERING CONDENSER WATER TEMPERATURE (F OR C) FOR MAP POINT  5 ?
CURRENT ENTERING CONDENSER WATER TEMPERATURE =   82.500
<CR> TO KEEP
```

<CR>

```
ENTERING CONDENSER WATER TEMPERATURE =   82.500
LEAVING CHILLED WATER TEMPERATURE (F OR C) FOR MAP POINT  5 ?
CURRENT LEAVING CHILLED WATER TEMPERATURE =   54.000
<CR> TO KEEP
```

44

```
LEAVING CHILLED WATER TEMPERATURE =   44.000
WOULD YOU LIKE TO ENTER ANOTHER DATA POINT ?
```

N

```
MAXIMUM PART LOAD RATIO ALLOWED  ?
CURRENT MAXIMUM PART LOAD RATIO =1.10
<CR> TO KEEP
```

<CR>

MAXIMUM PART LOAD RATIO =1.10

MINIMUM PART LOAD RATIO BELOW WHERE ENERGY
```
CONSUMPTION IS CONSTANT ?
CURRENT MINIMUM PART LOAD RATIO = .10
<CR> TO KEEP
```

<CR>

```
MINIMUM PART LOAD RATIO = .10
MOST EFFICIENT (BEST) PART LOAD RATIO ?
```

```
CURRENT BEST PART LOAD RATIO = .65
<CR> TO KEEP

    <CR>
BEST PART LOAD RATIO = .65
ENTER VALUES OF FRACTION OF FULL LOAD AND PART LOAD RATIO AT EACH
PART LOAD POINT.
YOU MUST ENTER VALUE FOR AT LEAST 3, BUT NO MORE THAN 10 PART LOAD
POINTS.

ENTER FRACTION OF FULL LOAD AND PART LOAD RATIO FOR PART LOAD POINT
1
PART     PART      FRACTION
LOAD     LOAD      OF FULL
POINT    RATIO       LOAD
  1     .20         .10
<CR> TO KEEP VALUES
 M   TO MODIFY VALUES
 D   TO DELETE VALUES AND CONTINUE
 X   TO END MODIFICATIONS AND CONTINUE
?

    X
WOULD YOU LIKE TO REVIEW INPUT ?

    N
WOULD YOU LIKE TO MAKE FURTHER MODIFICATIONS ?

    N
WOULD YOU LIKE TO CREATE PARAMETER FILE ?

    Y
FULL OUTPUT FILE NAME  C612.COT
WOULD YOU LIKE TO REVIEW OUTPUT ?

    Y
    EQUIPMENT PERFORMANCE PARAMETERS:
         ADJT1C ( 85.00000000,  2.17391400, 44.00000000);
         RCAV1C (   .99527320,  -.01455840,  -.00001061);
         ADJE1C (  2.95543600, -2.90030400,   .94514490);
         RPWR1C (   .13666580,   .55576160,   .30302680);

    PART LOAD RATIOS:
        CHILLER (MIN =  .10, MAX =1.10, BEST = .65, ELECTRICAL =
.2128 );
WOULD YOU LIKE TO MAKE FURTHER MODIFICATIONS ?

    N
WOULD YOU LIKE TO SAVE A SESSION SUMMARY ?

    Y
SESSION SUMMARY FILE NAME C612.CSS
WOULD YOU LIKE TO TEST THESE PARAMETERS ?

    Y
ENTER THE DESIRED CHILLED WATER TEMPERATURE (F).
DEFAULT VALUE =  44.0     F
<CR> TO KEEP DEFAULT.
?

    <CR>
```

```
CHILLED WATER TEMPERATURE =  44.0     F
                           CHILLER POWER CONSUMPTION (KW)
CHILLED WATER TEMPERATURE (F) =  44.0
MINIMUM PART LOAD RATIO =  .100
MAXIMUM PART LOAD RATIO =  1.10
       :----------------------------------------------------------------------
CHILLER:               ENTERING CONDENSER WATER TEMPERATURE (F)
LOAD   :----------------------------------------------------------------------
TONS)  :     70.       75.       80.       85.       90.       95.      100.
-------:----------------------------------------------------------------------
   61. :     89.       89.       89.       90.       91.       92.       93.
  122. :    114.      115.      117.      119.      122.      124.      126.
  184. :    143.      146.      149.      152.      156.      159.      164.
  245. :    174.      178.      183.      187.      193.      198.      204.
```

```
  306. :    208.      213.      219.      226.      233.      240.      248.
  367. :    244.      251.      258.      267.      276.      285.      296.
  428. :    282.      291.      300.      310.      322.      334.      347.
  490. :    322.      333.      344.      357.      371.      385.      401.
  551. :    365.      378.      392.      406.      423.      440.   *******
  612. :    411.      425.      441.   *******   *******   *******   *******
  673. : *******   *******   *******   *******   *******   *******   *******
IF A POWER HAS ASTERISKS IN THE FIELD, THAT MEANS THE COOLING LOAD
REQUIRED IS GREATER THEN THE AVAILABLE MAXIMUM CAPACITY OF THE CHILLER
AT A GIVEN CONDENSER & CHILLED WATER TEMPERATURE.
                              WOULD YOU LIKE TO TRY ANOTHER CHILLED WATER TEMP ?

                                  N
                              WRITING INPUT TO FILE C612.CIN
                              WOULD YOU LIKE TO LEAVE PROGRAM ?

                                  Y
                              NOW LEAVING CHILLER
                              Stop - Program terminated.
```

Chiller Reference Guide

Introduction

The purpose of most building energy analyses is to calculate the total energy (i.e. electric power, fuel, etc.) required to provide the desired heating and cooling in a specified zone or zones. In order to do this the heating and cooling requirements in a given space must first be determined for a specific period of time. In computer programs like BLAST (Building Load Analysis and System Thermodynamics) [1], hourly loads for a given zone or zones are calculated based on weather data and any user specified input (e.g. lights, people, etc.). These loads, along with weather data and a description of the air handling system, are translated into the hot water, chilled water, steam, gas or electric power demands. The plant simulation then uses these demands, along with weather data and a description of the boilers, chillers, electric generators, etc. to calculate the final electric power, gas, steam, and fuel consumptions.

Plant simulation is a necessary and important part of a building energy analysis. One plant may provide heating and/or cooling to part of a single building, an entire building, or several buildings. The components of a central plant not only have very large capital costs, but are also the major consumers of energy in most HVAC systems. Simulation of plants can aid designers in sizing and selecting the appropriate equipment on the basis of energy consumption, resulting in optimum energy savings and avoidance of costly design errors. The simulation of existing plants is helpful in the development of operating strategies which further reduce energy consumption, and yield a better overall understanding of how the system operates.

There are several important factors to be considered when simulating a central plant. The process of converting the system demands into the total energy consumption requires that the plant equipment performance be defined over the entire range of operating conditions. The actual conditions that affect performance depend on the type of equipment being modeled. Ambient air temperature, fuel heat capacity, and desired water temperature are a few of the factors which may have a significant effect on the performance of a particular type of plant equipment. Plant equipment is selected and sized based on performance at nominal or design conditions, but rarely is it actually operated at those conditions. Variations in the heating and cooling loads necessitate the operation of central plants at other than full capacity. The parameter commonly used to describe plant operation is the part-load ratio, defined as the actual load divided by the nominal load. The coefficient of performance (or efficiency) of a piece of machinery usually varies with the part-load ratio. It is therefore very important to take into account the part load behavior of any equipment being modeled.

There are several distinctly different approaches that can be taken when modeling central plants. The first of these is a purely theoretical approach involving very detailed and exact descriptions of all components involved. Fundamental equations of heat, mass and momentum transfer form the basis for most calculations, while thermodynamic and material properties must be included for all applicable substances. This technique requires a very complex model and a great deal of input in order to simulate the interaction of all components (i.e. compressors, motors, heat exchangers, etc.).

A second modeling approach is to use purely empirical techniques to relate the input to the desired output. Results from this type of model would be based on specific test data for the equipment being simulated. Test results would have to be obtained for points over the entire range of operation and interpolation used between points. A model like this would probably require less input than the theoretical approach, but detailed test results are not easily obtained for most machinery.

The most common (and probably most efficient) method of plant modeling utilizes factors from both theoretical and empirical techniques. This approach would result in a simplified model while also reducing the number of data points required. A useful plant model must achieve a balance of accuracy, efficiency, and availability of required input.

Chiller Operation and Modeling

There are two basic types of water chillers in common use today; those utilizing a vapor-compression cycle and those utilizing an absorption cycle. Absorption chillers have the potential to be driven by any heat source (including solar), but vapor-compression chillers are by far the most widely used. This paper deals solely with vapor-compression chillers, but a brief description of the absorption cycle is included.

In a standard vapor-compression cycle, vapor is first compressed, then condensed to a liquid, expanded to a lower pressure, and finally allowed to evaporate. The basic components of a chiller utilizing this cycle are a compressor, a condenser, an expansion device and an evaporator. The figure "Typical schematic of a vapor-compression cycle" shows a schematic of this configuration and figure "Standard vapor-compression cycle on a pressure-enthalpy diagram" shows the standard cycle on a pressure-enthalpy diagram. Work is added to the compressor in order to increase the pressure of the refrigerant vapor. Heat is rejected at the condenser, converting the vapor to a liquid at a constant pressure. The expansion valve drops the pressure of the liquid while maintaining constant enthalpy. Heat is absorbed at the evaporator, converting the liquid to a vapor at a constant pressure.

In a typical window air-conditioning unit, cooling is achieved by blowing air across the evaporator. Air is also used to carry heat away from the condenser. In most large scale cooling units, however, water is the medium used for both cooling and heat rejection. Condenser water may be supplied by a body of water (e.g. river, lake, well, etc.) or more commonly it is recirculated in a closed loop and cooled by means of a cooling tower. The chilled water is also circulated in a closed loop and used by the fan system to provide the required cooling. The figure below, "Typical configuration of a water chiller with heat rejection at a cooling tower", shows a typical configuration.

There are many different types of water chillers, but all are based on similar principles. The most common differences are in the kind of compressor used and how it is driven. The following is a brief description of several types of chillers:

<u>Double Bundle Chiller:</u> This type of chiller utilizes a double-bundle condenser. The term "double-bundle" refers to the two water loops running through the condenser (see the figure "Double Bundle Chiller" below). The additional loop is a hot water loop, which recovers the heat rejected from the refrigerant loop. This configuration is useful when both hot water and chilled water are needed simultaneously.

<u>Hermetic Compression Chiller (centrifugal):</u> Centrifugal compressors utilize spinning impellers to build up the pressure of the refrigerant gas. The term "hermetic" refers to a design where the actual compressor is housed and sealed along with the electric motor that drives it. In this case the motor is in physical contact with the refrigerant.

<u>Open Centrifugal Chiller:</u> An open compressor is one where the crankshaft driving the impellers extends through the compressor housing so that it may be coupled to an external electric motor. Seals must be used around the shaft to prevent refrigerant gas from leaking.

<u>Reciprocating Chillers:</u> This type of chiller uses a reciprocating, rather than a centrifugal compressor. A reciprocating compressor uses pistons and cylinders to compress the refrigerant and increase the pressure. A compressor of this type may be single-cylinder or multi-cylinder.

<u>Free Cooling Chiller:</u> A free cooling chiller is one which may obtain cooling with the compressor shut off, providing the condenser water temperature is low enough. A small refrigerant pump is used to circulate the refrigerant, transferring heat from the chilled water to the condenser water without a phase change.

<u>Air Cooled Chiller:</u> This type of chiller has a condenser which uses air, rather than water, as the heat rejection medium. Fans and fins are typically used to increase the heat transfer.

<u>Diesel-Driven Chiller:</u> A diesel-driven chiller is an open centrifugal chiller with a compressor driven by a diesel engine rather than an electric motor.

<u>Gas Turbine-Driven Chiller:</u> This type of chiller is an open centrifugal chiller with a compressor driven by a gas turbine.

<u>Heat Pump:</u> A heat pump is a chiller that has the ability to utilize the rejected heat. This may be achieved in a manner similar to a Double-Bundle Chiller, or by reversing the refrigerant flow and therefore reversing the functions of the condenser and the evaporator (i.e. the "condenser water" will be cooled and the

"evaporator" will reject heat). Heat pumps may therefore be used as heaters or chillers, but the primary concern of most energy analysis program is the cooling aspect.

Absorption Chiller: In an absorption chiller a compressor is not used to raise the pressure of the refrigerant vapor. Instead the low-pressure vapor from the evaporator is first absorbed by an appropriate absorbing liquid. The pressure of the liquid is then raised by means of a pump. Heat is added to the liquid in a generator, causing the refrigerant vapor to be released to the condenser at a higher pressure. The figure below, "Absorption Chiller", shows a basic absorption chiller unit. The heat added to the generator may be obtained from a number of low cost sources (e.g. solar, waste heat. etc.). Some work still has to be added to drive the pump.

Chiller designs are based on operation at given conditions (i.e. condenser water temperature, chilled water temperature, etc.). These values are known as the design or nominal conditions. The chiller capacity and power input at these conditions are known respectively as the nominal capacity and nominal power consumption. The conditions chosen as the nominal are somewhat arbitrary and used mainly as a reference point to compare different chillers. Chillers are typically designed to be operated between 10% and 105% of their nominal capacity.

When a chiller is operated at the maximum capacity for the given conditions, it is said to be operating at full load. If the cooling load is such that maximum capacity is not required, the chiller may be operated at part load. Part load operation is quantified by the part load ratio, defined as the actual capacity over the nominal capacity. Operation at less than full load is typically associated with lower condenser water temperature. This is due to the fact that during part load operation the outside wet bulb temperature is usually lower and there is less heat rejected to the condenser water. The net result is lower condenser water temperature and improved chiller performance. The efficiency of the chiller, therefore, is not constant over the range of operation. Chiller efficiency is measured in tons of refrigeration per kilowatt of power input. Most manufacturers provide a part load performance curve in their chiller catalogs. These curves show percent of nominal power as a function of the percent of nominal capacity. It is usually assumed that water temperatures are constant, but occasionally a manufacturer will provide data at several values of entering condenser water temperature. Chiller operation is typically restricted if the condenser water temperature drops too low. This is due to a decrease in compressor efficiency and an overall increase in power consumption.

As with all central plants, chillers may be modeled using a theoretical approach or by using empirical methods. When using a theoretical (or mechanistic) approach, all components and fluids must be thoroughly described and simulated. An empirical model requires performance data over the entire range of operation.

Braun et al. [2] describe a mechanistic chiller model developed at the University of Wisconsin-Madison which employs the fundamental equations of mass, momentum and energy, along with several empirical correlations. The following description of a mechanistic model is based on their work.

Both the evaporator and the condenser are modeled as standard shell and tube heat exchangers, using well established methods and equations found in the heat transfer literature. The log-mean temperature approach used is not strictly correct for the refrigerant condensing temperature, since the refrigerant entering the condenser is superheated and must first be cooled before condensing, but works fairly well since the heat transfer coefficient is lower at higher temperatures. The heat transfer coefficient must be determined from empirical correlations.

The compressor is the most complex component, and therefore the most difficult to model, in most chillers. For centrifugal compressors the dimensions, velocities and angles of the impellers must be fully described. Similar information must be provided for the pistons and cylinders in a reciprocating compressor. Both cases require the refrigerant properties at various temperatures and states, as well as the equipment efficiencies. The efficiencies cannot be determined quantitatively and therefore must be obtained empirically from test data.

An empirical chiller model is one that relies heavily on curve fits of available performance data for the chiller as a whole, while the inner workings and individual performance of each component is ignored. In this "black box" approach, details of how heat is absorbed at the evaporator and rejected at the condenser are not important; only the power required to achieve this heat transfer. The building energy analysis program BLAST uses this type of modeling technique. The actual model is discussed in detail in the following chapter.

There are advantages and disadvantages to both the theoretical and the empirical approach to chiller simulation. The theoretical approach is more rigorous and detailed, but it is also much more complex, requiring more input and computation time. This level of complexity may be required in order to investigate the effects of specific chiller modifications (e.g. changing refrigerants, impeller angles, etc.), but is probably over-kill for most building energy analysis programs. The input data required for such a model is typically not readily available from most chiller manufacturers. An empirical chiller model, however, is usually less complex, requiring less input and computation time than a theoretical model. The input can usually be obtained from a standard vendor manual, but results may be less accurate and limited to the range of the input. The type of modeling technique selected for a particular application depends greatly on the type of results desired, the availability of input data, and any computational limits.

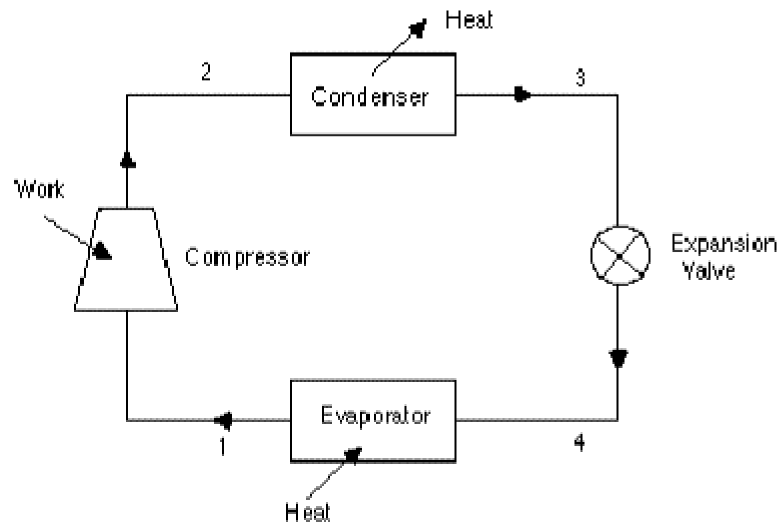


Figure 200. Typical schematic of a vapor-compression cycle

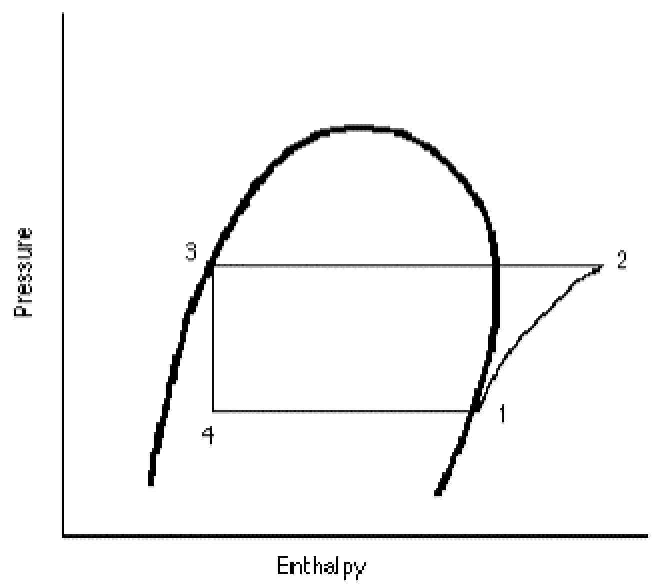


Figure 201. Standard vapor-compression cycle on a pressure-enthalpy diagram

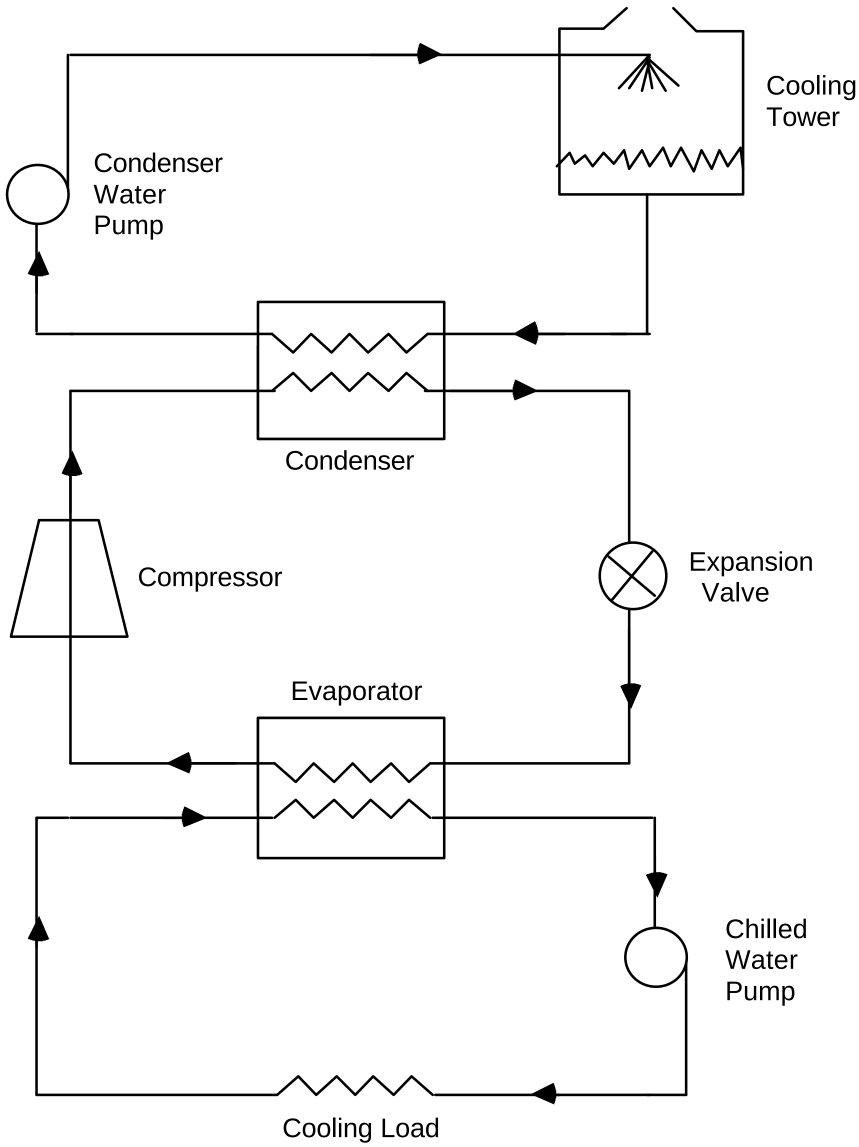


Figure 202. Typical configuration of a water chiller with heat rejection at a cooling tower

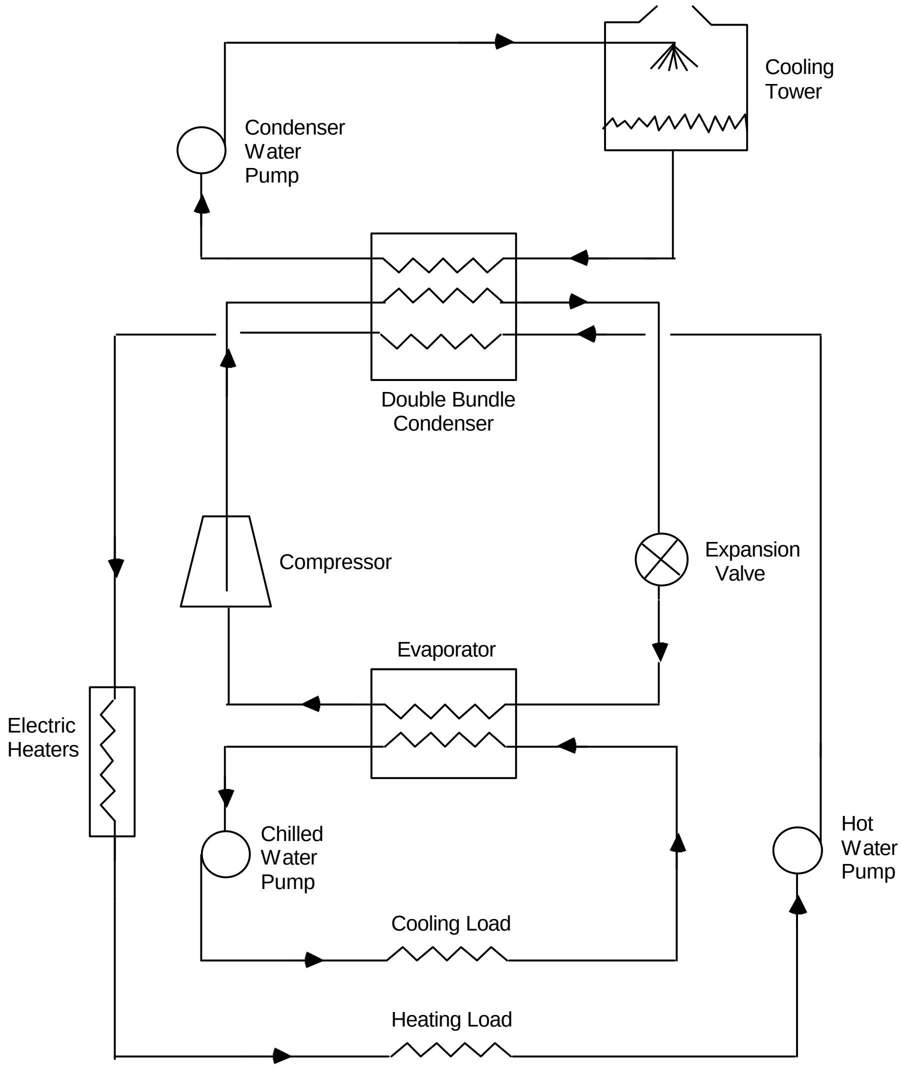


Figure 203. Double Bundle Chiller

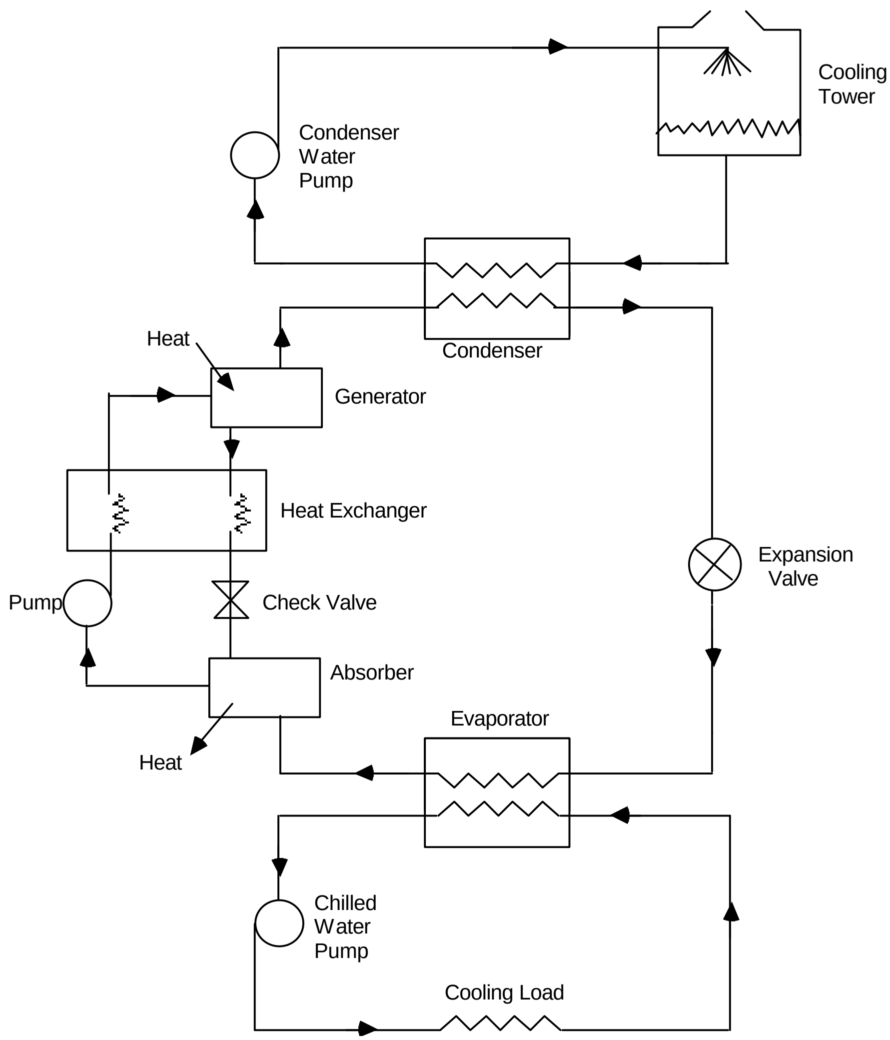


Figure 204. Absorption Chiller

The BLAST Chiller Model

There are several separate chiller subroutines in the program BLAST, but all are based on the same chiller model algorithms. The model is primarily an empirical or "black box" type, in that it does not take into account the operation and interaction of internal components and fluids. The user, therefore, is not required to provide information on specific compressors, motors, heat exchangers, refrigerants, etc. The input to the model is the cooling load on the chiller (provided by the air handling system models), the entering condenser water temperature (provided by the cooling tower model), and the desired chilled water temperature (provided by the user). The output from the model is the chiller power consumption (electric, gas, etc.) and the load on the cooling tower. The input and output are related by a series of algebraic equations with coefficients that may be calculated from available manufacturer's data.

The first step is to determine the available chiller cooling capacity as a function of condenser water temperature and chilled water temperature. It is convenient to combine the entering condenser water temperature and the leaving chilled water temperature into a single independent variable called the Equivalent Temperature, T_{EQ}. T_{EQ} is used to quantify the departure of actual temperatures from their nominal values, and is determined by performing a Taylor series expansion about the design point. The general form of this two-variable expansion is given by Kaplan [3] as:

$$F(x,y) = F(x_1,y_1) + \left[\frac{\partial F}{\partial x}(x - x_1) + \frac{\partial F}{\partial y}(y - y_1)\right]$$
$$+ \frac{1}{2!}\left[\frac{\partial^2 F}{\partial x^2}(x - x_1)^2 + 2\frac{\partial^2 F}{\partial x \partial y}(x - x_1)(y - y_1) + \frac{\partial^2 F}{\partial y^2}(y - y_1)^2\right]$$
$$+ \cdots + \frac{1}{n!}\left[\frac{\partial^n F}{\partial x^n}(x - x_1) + \cdots\right] + \cdots, \qquad (3\text{-}1)$$

with all derivatives evaluated at (x_1,y_1).

Substituting appropriate variables:

$$CAP = NCAP + \left[\frac{\partial CAP}{\partial T_{CON}}(T_{CON} - T_{NCON}) + \frac{\partial CAP}{\partial T_{CW}}(T_{CW} - T_{NCW})\right]$$
$$+ \frac{1}{2}\left[\frac{\partial^2 CAP}{\partial T_{CON}^2}(T_{CON} - T_{NCON})^2 + 2\frac{\partial^2 CAP}{\partial T_{CON}\partial T_{CW}}(T_{CON} - T_{NCON})(T_{CW} - T_{NCW})\right.$$
$$\left. + \frac{\partial^2 CAP}{\partial T_{CW}^2}(T_{CW} - T_{NCW})\right] + \cdots, \qquad (3\text{–}2)$$

Where:

CAP	= Available chiller capacity;
NCAP	= Nominal chiller capacity;
T_{CON}	= Entering condenser water temperature;
T_{NCON}	= Nominal entering condenser water temperature;
T_{CW}	= Leaving chilled water temperature;
T_{NCW}	= Nominal leaving chilled water temperature.

If we assume linear behavior about the design point, the first order partial differentials become constants, K_1 and K_2, and all higher order differentials become zero:

$$CAP = NCAP + [K_1 * (T_{CON} - T_{NCON}) - K_2 * (T_{CW} - T_{NCW})] \qquad (3\text{–}3)$$

By normalizing to design capacity, equation (3-3) becomes:

$$RCAV = 1 + Z_1 * \left[\frac{(T_{CON} - T_{NCON})}{Z_2} - (T_{CW} - T_{NCW})\right] \qquad (3\text{–}4)$$

Where:

RCAV	= Ratio of available capacity to nominal capacity.
Z_1	= K_2/NCAP

$Z_2 \quad = K_2/K_1$

It is convenient to define the quantity in brackets as an Equivalent Temperature:

$$T_{EQ} = \frac{(T_{CON} - T_{NCON})}{Z_2} - (T_{CW} - T_{NCW}) \quad \text{(3–5}$$

Z_2 is determined by assuming a capacity equal to the nominal:

$$RCAV = 1 = 1 + Z_2 * T_{EQ} \quad \text{(3–6}$$

$$\frac{(T_{CON} - T_{NCON})}{Z_2} - (T_{CW} - T_{NCW}) = 0 \quad \text{(3–7}$$

$$\therefore \quad Z_2 = \frac{(T_{CON} - T_{NCON})}{(T_{CW} - T_{NCW})} \quad \text{(3–8}$$

Z_2 is therefore defined as the ratio of the required change in condenser water temperature to a given change in chilled water temperature, which maintains the capacity at the nominal value.

The form of the linearized model is therefore:

$$RCAV = 1 + Z_2 * T_{EQ} \quad \text{(3–9}$$

To account for inaccuracies in catalog data and possible higher order effects, the final form is chosen to be:

$$RCAV = B_1 + B_2 * T_{EQ} + B_3 * T_{EQ}^2 \quad \text{(3–1}$$

Where:

$B_{1,} B_2, B_3$ = Empirically determined coefficients.

The next step is to express the full load power ratio, FLPR, as a quadratic function of the full load capacity ratio, RCAV. The form is:

$$G = C_1 + C_2 * RCAV + C_3 * RCAV^2 \quad \text{(3–1}$$

Where:

G	= Ratio of actual full load power ratio to nominal full load power ratio
	= FLPR/NFLPR;
FLPR	= Full load power ratio = FLPOW/AVCAP;
FLPOW	= Full load power consumption;
NFLPR	= Full load power ratio at nominal conditions;
$C_{1,} C_2, C_3$	= Empirically determined coefficients.

The final step is to consider operation at other than full load. The fraction of full load power, FFL, is related to the part load ratio, PLR, by the following quadratic:

$$FFL = D_1 + D_2 * PLR + D_3 * PLR^2 \quad (3\text{–}1$$

Where:

FFL	= Fraction of full load power = POW/FLPOW;
POW	= Actual power consumption;
PLR	= Part load ratio = Q_C/AVCAP;
Q_C	= Cooling load;
$D_{1,} D_2, D_3$	= Empirically determined coefficients.

The actual power consumption, POW, is obtained from the combination of Equations (3-9), (3-10) and (3-12):

$$POW = FFL * G * NFLPR * NCAP * RCAV \quad (3\text{–}1$$

Automation of Coefficient Calculation

The BLAST chiller model uses coefficients of quadratic equations calculated from manufacturers catalog data as input. The determination of these coefficients is not a simple and straightforward procedure, especially when attempted by hand. The data manipulation and curve fitting required suggests that computer automation be applied. A computer program could calculate these parameters more quickly and accurately and could also check their validity.

The computer program CHILLER was designed to take typical manufacturer's catalog data, convert it into the parameters of the model described in Chapter 3, and then test these parameters over a range of cooling loads and water temperatures. It was developed on an IBM-PC, but should be able to run on any computer with few modifications. The program is simple to use and includes on-line help. Users are prompted for applicable chiller performance data, which is then used to calculate the chiller model coefficients, which are Equipment Performance Parameters in BLAST. The coefficients are written to a file in the proper BLAST syntax. A work file containing all user input is also saved and may be recalled for modification at a later time. At the user's request the parameters may be tested, producing a table showing chiller power consumption over a range of cooling loads and condenser water temperatures. This table should indicate to the user any blatant errors in the input.

The following is a description of all interactive input required by the program CHILLER:

INPUT FILE NAME: This is the name of the computer file where all user input is written. Once created, the file may be retrieved and modified at a later time. All file names should be entered in a format acceptable to the host computer, extensions included.

OUTPUT FILE NAME: This is the computer file where the calculated BLAST Equipment Performance Parameters are written. The user may then copy these parameters into the appropriate BLAST Input section.

SESSION SUMMARY FILE NAME: This is the computer file where a summary of all user input, the calculated output, and any Equipment Performance Parameter test tables are stored.

CHILLER TYPE: The user if prompted for a two-letter code corresponding to the type of chiller being modeled. Current choices for chillers include Double Bundle, Hermetic Compression (centrifugal), Open Centrifugal, Reciprocating, Air Cooled, Free Cooling, Diesel Driven, Gas Turbine Driven and Heat Pump.

INPUT UNITS: The user must specify the type of units (English or Metric) that will be used for input values. If English is selected capacities will be in Tons of refrigeration (Tons) and temperatures in degrees Fahrenheit (°F). If Metric (or S. I.) is chosen, capacities will be in kilowatts (kW) and temperatures in degrees Celsius (°C). The power consumption should always be entered in kW regardless of the INPUT UNITS selected.

OUTPUT UNITS: The user must specify whether the calculated output parameters will be in English or Metric units. This should correspond to the INPUT UNITS specified in the BLAST Input Deck where the parameters will be used.

NOMINAL CAPACITY (Tons or kW): This is the nominal (or design) cooling capacity of the chiller.

NOMINAL FULL LOAD POWER (kW): This is the nominal chiller power consumption at full capacity.

NOMINAL CONDENSER WATER TEMPERATURE (°F or °C): This is the temperature of the water leaving the condenser under nominal conditions.

NOMINAL CHILLED WATER TEMPERATURE (°F or °C): This is the temperature of the chilled water leaving the chiller under nominal conditions.

The next two inputs are temperatures corresponding to an operating point which is still at the nominal capacity but not at the nominal temperatures. This operating point should be located approximately midway between the nominal point and the "edge" of the available data. The user may have to interpolate to find such a point (designated as the "Second" operating point). The temperatures at this point, along with the nominal values, are used to calculate the equivalent temperature (T_{EQ}) described in Chapter 3. Specifically, the temperatures at the second operating point are:

SECOND CONDENSER WATER TEMPERATURE (°F or °C): This is the temperature of the water leaving the condenser at the Second operating point.

SECOND CHILLED WATER TEMPERATURE (°F or °C): This is the temperature of the chilled water leaving the chiller at the Second operating point.

The next inputs are grouped in sets of four, all corresponding to the same operating point. Sets of values for at least three, but no more than ten operating points may be entered. The Nominal and the Second operating points may be used again here. The set consists of:

AVAILABLE CAPACITY (Tons or kW): The full load cooling capacity at a given operating point.

POWER CONSUMPTION (kW): The chiller power consumption at full load operation for a given operating point.

CONDENSER WATER TEMPERATURE (°F or °C): The temperature of water leaving the condenser at a given operating point.

CHILLED WATER TEMPERATURE (°F or °C): The temperature of chilled water leaving the chiller at a given operating point.

The next inputs correspond to the coordinate pairs for points on a Part Load Curve. Values for at least three, but no more than ten points are entered.

FRACTION OF FULL LOAD: This is the ratio of actual power consumption to full load power consumption.

PART LOAD RATIO: This is the ratio of the cooling load on the chiller to the full load chiller capacity.

The output from the program CHILLER is a file containing BLAST Equipment Performance Parameters. There are four sets of these parameters containing three values each. They are written in correct BLAST syntax and could be copied directly into a BLAST Input Deck. "Equipment Performance Parameters calculated by CHILLER", below shows a set of these parameters for a double bundle chiller. The parameters are basically the same for all types of chillers, with only the last two characters of the parameter name changing to reflect the chiller type (represented by "XX").

The values of the Equipment Performance Parameters are such that no obvious conclusions can be drawn concerning their correctness. To alleviate this, and to provide a means to detect blatant errors in user input, CHILLER gives users the option to exercise these coefficients in a typical BLAST chiller subroutine. If the option is chosen, the user is prompted for the desired chilled water temperature and the chiller power consumption is then calculated for a range of cooling loads and leaving condenser water temperatures. The range of cooling loads is from 10% to 110% of the Nominal Capacity. The range for condenser water temperatures is plus or minus 15 degrees Fahrenheit from the Nominal Condenser Water Temperature. The user may specify as many chilled water temperature as they wish, and a table, as shown in "Parameter Test Table created by CHILLER", below, will be produced for each one. The user should be alerted to trends that seem inconsistent with known chiller operation. If a table shows major unexplainable trends, the user should check the input for possible errors. Some slight inconsistencies are to be expected due to numerical error.

The first set of Equipment Performance Parameters, ADTJXX(1) **-** (3), are calculated from the user supplied water temperatures and are equivalent to T_{NCON}, Z_2 and T_{NCW} in Equation (3-5). ADJTXX(1) is equal to the Nominal Entering Condenser Water Temperature and ADJTXX(3) is equal to the Nominal Leaving Chilled Water Temperature. ADJTXX(2) is the temperature ratio defined by Equation (3-8). This parameter is based on a "second" operating point, which has an available capacity equal to the nominal capacity. There may be several "second" points which may be used and each will yield a slightly different value of ADJTXX(2). These variations should not have a large effect on the calculated power consumption of the chiller, but the user may wish to calculate ADJTXX(2) at several "second" points and take the average.

The second set of parameters, RCAVXX(1) - (3), correspond to the coefficients B_1, B_2 and B_3 in Equation (3-9). These values are determined empirically from user supplied data (condenser water temperature, chilled water temperature and full load capacity). The Equivalent Temperature, T_{EQ}, is first calculated from the condenser and chilled water temperatures. The capacity ratio, RCAV, is determined by dividing the available capacity at these temperatures by the nominal capacity. The parameters are calculated by a curve fit routine which will be described later.

The next set of parameters, ADJEXX(1) - (3), correspond to C_1, C_2 and C_3 in Equation (3-10) and are also determined empirically. The full load power consumption, FLPOW, and the available capacity, AVCAP, are input by the user at each operating point. The nominal full load power ratio, NFLPR, is the nominal full load power consumption divided by the nominal capacity, The parameters, determined by the curve fit routine, are coefficients to a quadratic equation defining the ratio of FLPR to NFLPR as a function of the capacity ratio, RCAV.

The last set of parameters, RPWRXX(1) - (3), correspond to D_1, D_2 and D_3 in Equation (3-12). These parameters define a Part Load Curve based on the fraction of full load, FFL, and part load ratio, PLR, at each point provided by the user. The curve fit routine is again used to determine the coefficients.

The curve fit routine used in the program CHILLER is a generalized least squares model. The model uses up to ten data points to calculate the coefficients of a quadratic equation which most closely fits the data. Matrix manipulations are used to solve the set of simultaneous linear equations.

The general form of the least squares solution is:

$$\mathbf{k} = (\mathbf{F}^T\mathbf{F})^{-1}\mathbf{F}^T\mathbf{y} \quad (4\text{–}1$$

Where:

$$\mathbf{k} = \begin{bmatrix} K_1 \\ K_2 \\ \vdots \\ K_m \end{bmatrix}, \quad \mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad \mathbf{F} = \begin{bmatrix} f_1(x_1) & f_2(x_1) & \cdots & f_m(x_1) \\ f_1(x_2) & & & f_m(x_2) \\ \vdots & & & \vdots \\ f_1(x_n) & f_2(x_n) & \cdots & f_m(x_n) \end{bmatrix}$$

m = number of coefficients

n = number of data points.

For a quadratic curve fit:

$$\mathbf{k} = \begin{bmatrix} K_1 \\ K_2 \\ K_3 \end{bmatrix}, \quad \mathbf{y} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix}, \quad \mathbf{F} = \begin{bmatrix} 1 & x_1 & x_1^2 \\ 1 & x_2 & x_2^2 \\ \vdots & \vdots & \vdots \\ 1 & x_n & x_n^2 \end{bmatrix} \quad (4\text{–}2$$

The model will generate the coefficients, K_1, K_2, K_3, which best fit the data points, (y_n, x_n), in the equation:

$$y = K_1 + K_2 x + K_3 x^2 \qquad (4\text{–}3$$

Figures "Available capacity and full load power for a Trane 612 Ton centrifugal chiller" and "Part Load Curve assuming constant entering condenser water temperature" show typical chiller performance data as provided in most manufacturers' catalogs. This particular data is for a Trane 612 Ton hermetic centrifugal chiller [4]. The first figure shows the cooling capacity and full load power consumption at various operating conditions. In this example the full load power consumption is constant at all operating conditions, but this is not always the case. The second figure is the Part Load Curve, relating the part load ratio to the fraction of full load. All required input to CHILLER may be obtained from this information.

The nominal capacity is shown as 612 Tons and the nominal power consumption as 458 kW. The entering condenser water temperature can be determined if either the condenser water flow rate or the condenser temperature drop is known. In this case the temperature drop across the condenser is assumed to be 10ºF. The nominal operating conditions are therefore at an entering condenser water temperature of 85ºF and a leaving chilled water temperature of 44ºF. If the nominal values are not specified, the user may select any appropriate operating point.

A second nominal operating point can be determined by interpolation. Assuming an entering condenser water temperature of 80.0ºF (i.e. leaving condenser water temperature of 90.0ºF), the nominal capacity of 906 tons should occur at a leaving chilled water temperature of 41.7ºF. Values of available capacity and full load power consumption at various map points can be taken directly from the available capacity figure and values of part load ratio versus fraction of full load from the accompanying part load curve figure.. "CHILLER Session Summary", below, shows a Session Summary that includes the input to CHILLER, the resulting Equipment Performance Parameters, and a Parameter Test Table.

```
    EQUIPMENT PERFORMANCE PARAMETERS:
         ADJT1C (  85.00000000,   2.17391400, 44.00000000);
         RCAV1C (  .99527320, -.01455840,    -.00001061);
         ADJE1C (  2.95543600, -2.90030400,   .94514490);
         RPWR1C (  .13666580, .55576160, .30302680);

    PART LOAD RATIOS:
        CHILLER (MIN =  .10, MAX =1.10, BEST = .65, ELECTRICAL =
.2128);
```

Table 73. Equipment Performance Parameters calculated by CHILLER.

```
CHILLER POWER CONSUMPTION (KW)
CHILLED WATER TEMPERATURE (F) =  44.0
MINIMUM PART LOAD RATIO =  .100
MAXIMUM PART LOAD RATIO =  1.10
       :----------------------------------------------------------------------
CHILLER:               ENTERING CONDENSER WATER TEMPERATURE (F)
LOAD   :----------------------------------------------------------------------
(TONS) :    70.       75.       80.       85.       90.       95.      100.
-------:----------------------------------------------------------------------
   61. :    89.       89.       89.       90.       91.       92.       93.
  122. :   114.      115.      117.      119.      122.      124.      126.
  184. :   143.      146.      149.      152.      156.      159.      164.
  245. :   174.      178.      183.      187.      193.      198.      204.
  306. :   208.      213.      219.      226.      233.      240.      248.
  367. :   244.      251.      258.      267.      276.      285.      296.
  428. :   282.      291.      300.      310.      322.      334.      347.
  490. :   322.      333.      344.      357.      371.      385.      401.
  551. :   365.      378.      392.      406.      423.      440.   *******
  612. :   411.      425.      441.   *******   *******   *******   *******
  673. : *******   *******   *******   *******   *******   *******   *******
```

```
IF A POWER HAS ASTERISKS IN THE FIELD, THAT MEANS THE COOLING LOAD
REQUIRED IS GREATER THEN THE AVAILABLE MAXIMUM CAPACITY OF THE CHILLER
AT A GIVEN CONDENSER & CHILLED WATER TEMPERATURE.
```

Table 74. Parameter Test Table created by CHILLER

AVAILABLE CAPACITY (In Tons) — FULL LOAD POWER CONSUMPTION (In kW)

LEAVING CHILLED WATER (F)	ENTERING CONDENSER WATER (F)						
	75	77.5	80	82.5	+ 85	87.5	90
40	608 458	601 458	595 458	587 458	575 458	563 458	553 458
42	626 458	621 458	615 458	605 458	594 458	582 458	570 458
+ 44	651 458	643 458	635 458	625 458	**612** **458**	600 458	587 458
45	660 458	653 458	645 458	634 458	622 458	610 458	596 458
46	668 458	663 458	655 458	643 458	632 458	619 458	606 458
48	685 458	682 458	674 458	667 458	651 458	638 458	625 458

Table 75. Available capacity and full load power for a Trane 612 Ton centrifugal chiller

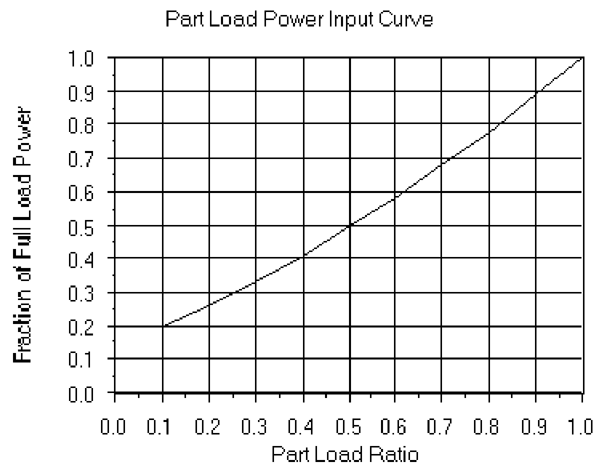


Table 76. Part Load Curve assuming constant entering condenser water temperature

```
CHILLER TYPE: 1C
INPUT UNITS: E
OUTPUT UNITS: E
NOMINAL CAPACITY:  612.0
NOMINAL POWER (KW):  458.0
NOMINAL ENTERING CONDENSER WATER TEMPERATURE:  85.0
NOMINAL LEAVING CHILLED WATER TEMPERATURE:    44.0

SECOND ENTERING CONDENSER WATER TEMPERATURE:   80.0
SECOND LEAVING CHILLED WATER TEMPERATURE:     41.7
```

Map Point	Available Capacity	Available Power	Condenser Water Temp	Chilled Water Temp
1	608.0	458.0	75.0	40.0
2	685.0	458.0	75.0	48.0
3	553.0	458.0	90.0	40.0
4	625.0	458.0	90.0	48.0

5	625.0	458.0	82.5	44.0

PART LOAD RATIO vs FRACTION OF FULL LOAD

Point	FFL	PLR
1	.20	.10
2	.25	.20
3	.33	.30
4	.41	.40
5	.50	.50
6	.58	.60
7	.67	.70
8	.77	.80
9	.88	.90
10	1.00	1.00

```
EQUIPMENT PERFORMANCE PARAMETERS:
         ADJT1C (      85.00000000,   2.17391400,    44.00000000);
         RCAV1C (      .99527320,     -.01455840,    -.00001061);
         ADJE1C (      2.95543600,    -2.90030400,   .94514490);
         RPWR1C (      .13666580,     .55576160,     .30302680);

    PART LOAD RATIOS:
        CHILLER (MIN =  .10, MAX =1.10, BEST = .65, ELECTRICAL = .2128 );

                           CHILLER POWER CONSUMPTION (KW)
CHILLED WATER TEMPERATURE (F) =  44.0
MINIMUM PART LOAD RATIO =  .100
MAXIMUM PART LOAD RATIO =  1.10
       :----------------------------------------------------------------------
CHILLER:               ENTERING CONDENSER WATER TEMPERATURE (F)
LOAD   :----------------------------------------------------------------------
(TONS) :     70.       75.       80.       85.       90.       95.      100.
-------:----------------------------------------------------------------------
   61. :     89.       89.       89.       90.       91.       92.       93.
  122. :    114.      115.      117.      119.      122.      124.      126.
  184. :    143.      146.      149.      152.      156.      159.      164.
  245. :    174.      178.      183.      187.      193.      198.      204.
  306. :    208.      213.      219.      226.      233.      240.      248.
  367. :    244.      251.      258.      267.      276.      285.      296.
  428. :    282.      291.      300.      310.      322.      334.      347.
  490. :    322.      333.      344.      357.      371.      385.      401.
  551. :    365.      378.      392.      406.      423.      440.   *******
  612. :    411.      425.      441.   *******   *******   *******   *******
  673. : *******   *******   *******   *******   *******   *******   *******
IF A POWER HAS ASTERISKS IN THE FIELD, THAT MEANS THE COOLING LOAD
REQUIRED IS GREATER THEN THE AVAILABLE MAXIMUM CAPACITY OF THE CHILLER
AT A GIVEN CONDENSER & CHILLED WATER TEMPERATURE.
```

Table 77. CHILLER Session Summary

Evaluation of Model

The program CHILLER was exercised using a wide variety of data to model several different chillers. The resulting Equipment Performance Parameters were then tested using a chiller subroutine extracted from BLAST. This test model calculates the chiller power consumption for given cooling load, condenser water temperature and chilled water temperature, using the calculated parameters. This calculation is identical to that performed in BLAST. Since no actual chiller performance data was available, results from the test model were compared to manufacturers' catalog data. Catalog data is typically only for operation at full load, and therefore no comparison of part load power consumption could be made.

Several aspects of the CHILLER input procedure require some judgement on the part of the user. The operating point selected as the "second point", the number and location of "map points", and the number and location of "part load points" are all factors which affect the calculation of the Equipment Performance Parameters. The form and amount of available performance data is certainly a consideration, but the user will ultimately have to decide which data points to enter.

The selection of a second nominal operating point is the only step that requires any manual calculation by the user. The possible locations of a second point are determined by the available performance data. For the data shown in available capacity figure, above, there are nine possible combinations of condenser water and chilled water temperatures which result in an available capacity equal to the nominal value of 612 Tons. The water temperatures are determined by straight-line interpolation. Extrapolation of a second point beyond the range of available data is not recommended. Equipment Performance Parameters were calculated and tested using each of the possible second points. The table, below, shows the average and maximum percent error in the calculated full load power consumption. Later tables show similar results for a 906-Ton centrifugal chiller. Based on these results, the effect of second point selection is not overly dramatic, but some user judgement should still be used. It appears that for best results, the user should not select a second point that is on the "edge" of the available data or one very near the nominal operating point.

Both number and location of map points input into CHILLER have a significant effect on the calculated parameters, and therefore on the accuracy of the model. The user is required to enter at least three map points, but no more than ten. Common sense dictates that the more points entered, the more accurate the model will be. This is true up to a point, but depending on the location, additional points may not improve model accuracy. The locations of selected map points should cover as large a region as possible, unless the actual chiller operating region is known to be more restricted.

The data shown in the Trane 612 Ton figures was used to evaluate the effect of map point selection. Various combinations of operating points were input as map points in CHILLER, and the calculated parameters used in the BLAST chiller test model. The calculated power consumption was then compared to the manufacturer's supplied data. The results are summarized in "Evaluation of Map Points", below, for 21 combinations of map points.

When only three map points are used (combinations (a)-(g)), the location is very important. If chiller operation is known to be limited to a given condenser or chilled water temperature, then using three map points at this temperature will give good results (combinations (a),(b),(c)). The map points should still cover as wide a range as possible (the 16.7% error for combination (a) occurred at a condenser water temperature outside the range of map points). It appears from combination (f) that a triangle is the best three point formation, and from (e) that diagonal formations could be dangerous. When four map points are used (combinations (h)-(l)), results are slightly improved. Using the "corners" of the data as map points (combination (k)) gives the best results over the largest range. Rectangular formations in general appear to give favorable results, while the diamond formation (combination (i)) seems to be the least desirable. A fifth map point improves model accuracy a little more, with the best formation appearing to be the four corners and a center point (combination (m)). Adding more map points (combinations (p)-(u)) does not greatly improve the overall model accuracy, but judging from the maximum errors, it does seem to decrease the chances of having a "bad spot". The general trends depicted have been confirmed by results obtained from other chiller data.

The selection of part load points is a more straight-forward matter. The part load curve is used directly in the power calculations and should be modeled as accurately as possible. The maximum of ten part load point should be entered into CHILLER, and they should be relatively evenly spaced, covering the entire range.

CHILLER will accept identical map points and part load points, and the curve fit routine will weight these points accordingly. This is not recommended and will probably decrease model accuracy. If there are not at least three "distinct" points entered, the program will abort.

AVAILABLE CAPACITY (In Tons)							
LEAVING CHILLED WATER (F)	ENTERING CONDENSER WATER (F)						
	75	77.5	80	82.5	+ 85	87.5	90
40	608	601	595	587	575	563	553
42	626	621	615	605	594	582	570
+ 44	651	643	635	625	**612**	600	587
45	660	653	645	634	622	610	596
46	668	663	655	643	632	619	606
48	685	682	674	667	651	638	625

Table 78. Available capacity and possible "second" point locations for a Trane 612 Ton centrifugal chiller. (+ Nominal conditions)

Second Point Location	Average % Error	Maximum % Error
A	0.7	1.8
B	0.6	1.4
C	0.5	1.7
D	0.5	1.8
E	0.7	2.4
F	0.6	1.9
G	0.6	2.0
H	0.7	2.4
I	0.7	2.5

Table 79. Evaluation of second point locations (percent error in calculates power consumption)

AVAILABLE CAPACITY (In Tons)							
LEAVING CHILLED WATER (F)	ENTERING CONDENSER WATER (F)						
	75	77.5	80	82.5	+ 85	87.5	90
40	920	920	(A) 888	881	871	850	816
42	937	937	(B) 937	(C) 937	(D) 900	869	839
+ 44	955	955	953	943	**906**	885	863
45	963	963	963	943	939	(E) 905	874
46	972	972	972	947	937	(F) 909	(G) 880
48	990	990	990	990	965	945	(H) 926

Table 80. Available capacity and possible "second" point locations for a Trane 906 Ton centrifugal chiller. + Nominal conditions

Second Point Location	Average % Error	Maximum % Error
A	2.0	12.2
B	2.0	12.0
C	2.2	11.5
D	3.0	12.6
E	3.2	14.2
F	2.6	13.1
G	1.8	11.6
H	2.0	12.2

Table 81. Evaluation of second point locations (percent error in calculated power consumption)

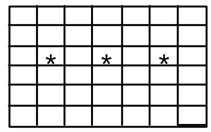
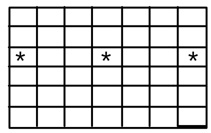
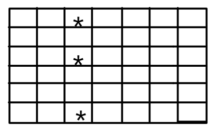
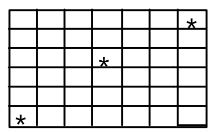
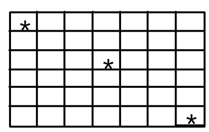
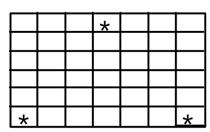
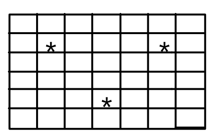
NUMBER OF MAP POINTS	LOCATION OF MAP POINTS	AVERAGE % ERROR	MAXIMUM % ERROR
(a) 3		2.4	16.7
(b) 3		1.1	2.7
(c) 3		0.8	2.6
(d) 3		0.8	2.6
(e) 3		31.0	106.7
(f) 3		0.7	1.9
(g) 3		1.4	2.4

Table 82. Map point evaluation (Example Chiller) cases (a) through (g)

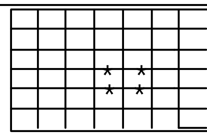
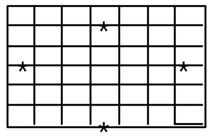
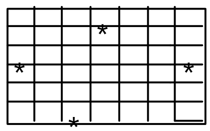
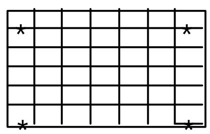
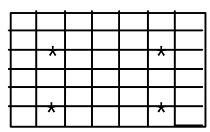
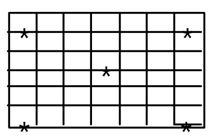
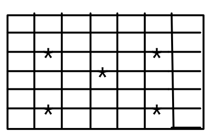
	NUMBER OF MAP POINTS	LOCATION OF MAP POINTS	AVERAGE % ERROR	MAXIMUM % ERROR
(h)	4		1.0	4.7
(i)	4		3.5	14.9
(j)	4		1.2	5.3
(k)	4		0.7	1.4
(l)	4		0.6	2.4
(m)	5		0.5	1.7
(n)	5		0.6	2.1

Table 83. Map point evaluation (Example Chiller) cases (h) through (n)

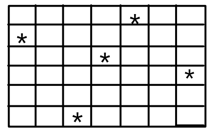
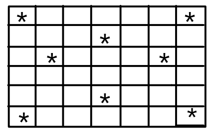
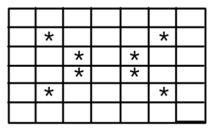
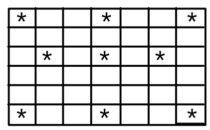
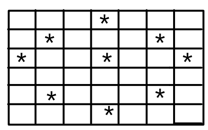
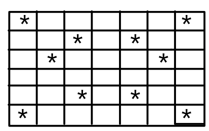
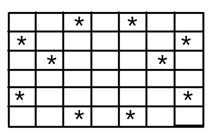
NUMBER OF MAP POINTS	LOCATION OF MAP POINTS	AVERAGE % ERROR	MAXIMUM % ERROR
(o) 5		0.7	2.9
(p) 8		0.5	1.8
(q) 8		0.7	2.4
(r) 9		0.5	2.1
(s) 9		0.7	3.0
(t) 10		0.4	2.0
(u) 10		0.5	1.8

Table 84. Map point evaluation (Example Chiller) cases (o) through (u)

Conclusions

The method for modeling water chillers discussed in this paper is an attempt to achieve a balance between accuracy and "user friendliness". The main advantage of this model is that all required input should be readily attainable from most vendors' catalogs (or from the vendors themselves). The program CHILLER is designed to automate the processing of this data into the required model parameters. The model does, however, have certain limitations. The part load curve used for power consumption calculations is based on particular water temperatures, but is assumed to be constant for all operating conditions. This is not a true representation of reality, but the part load chiller performance should not change drastically at different water temperatures. Inherent limits are also imposed by the range of performance data input to the model. Simulation of chiller operation outside of this range may be very inaccurate.

The accuracy of the manufacturers' catalog data may also be questionable. Unit efficiency and energy savings may be grossly exaggerated in order to improve sales. Based on the uncertainties in other aspects of building energy simulation, these limitations are not unreasonable.

The rapid advancement of computer technology, both in speed and memory, should allow the next generation of chiller models (and energy analysis programs in general) to be much more sophisticated. Detailed and complex models currently exist, but typically require too much computing time for most building energy analysis programs. One such model is the ORNL Heat Pump Design Model, which was modified for use in BLAST [5,6]. It is currently not feasible to implement this model into BLAST unless the computation time could be reduced by a factor of ten. Similar models for chillers (e.g. the model developed by Braun et al. discussed in Chapter 2) could also be implemented, but would also require longer run times. A possible solution to this problem would be to use these complex models as stand alone programs which could provide input data to a simpler empirical model. The chiller model described in this paper could be used in this capacity. The practicality of using more complex theoretical models goes beyond the available computing power. The input required by these models could be extremely complex and cumbersome. Equipment manufacturers are reluctant to provide much of the information which is needed, and program users may be unfamiliar with physical details of specific equipment.

Building energy analysis has been, and will continue to be, an important tool in the design, optimization and operation of heating and cooling systems. As computer technology grows, so should the sophistication of these models. The complexity of the models, however, should not exceed the availability of the required input or the expertise of the users. It is important that manufacturers provide more detailed information about their equipment, in order for existing and future models to be thoroughly tested and improved.

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Design Week Creation Program

Introduction to DWEEKC

The Design Week Creation, or DWEEKC, Program is a portion of the BLAST family of software. It is intended for use with both the BLAST (Building Loads Analysis and System Thermodynamics) and WIFE (Weather Information File Encoder) programs. The need for DWEEKC was realized after the installation of the thermal energy storage models into BLAST. It became apparent at that time that some users desired to size the thermal energy storage systems on the basis of a week rather than a single day, allowing them to use an entire weekend to charge the storage system. The users wanted the ability to define an entire week based on their own experience rather than having to hunt down an appropriate week of weather data in a weather file.

As a result of the needs created by thermal energy storage models in BLAST and the wishes of the model users, DWEEKC was created. DWEEKC is a menu-driven program which allows the user to specific an entire week of weather data. The information required to run the program is the same type of information needed to create a TEMPORARY DESIGN DAY in BTEXT. The user is given total control in the specification of the Design Week in that the seven consecutive days can be identical or different.

Basic information on executing the DWEEKC program is given below. Users are encourage to read this information and try the program. If problems are encountered or more detailed questions arise, the user should contact the technical support office listed with your installation.

Running the DWEEKC Program

The first step in creating a Design Week for use with BLAST is to execute the DWEEKC Program. Change your working directory to the directory containing the Design Week Creation program and type **dweekc**. The DWEEKC program can be broken down into three distinct parts. These are described in detail below.

DWEEKC is also available from the Programs Menu in HBLC. HBLC will open an MS-DOS window that will run the DWEEKC program in your "working directory". This will leave the resultant files in the working directory.

General Data

The program begins by offering to print program instructions to the screen. First-time users should answer "y". Notice that the "no"-response is capitalized as "N". As in BTEXT, the default answer is shown in capital letters and can be selected by simply pressing return. Note that the instructions contain one important command. As in BTEXT, the users can exit the program without saving data by typing **abort** at any prompt. However, there are no extensive helps as in BTEXT.

After the instructions have been viewed or skipped, the user begins entering general information about the design week. First, a name for the file is entered as the location name. This should be a descriptive name *that does not duplicate the name of any existing weather file or you could overwrite the existing weather file*. The location name is limited in length to 6 characters and will be used as a filename. For example, if "ohare" is entered as the location name, the weather data file that DWEEKC creates will be named "ohare.dat".

Next, the user is prompted for the latitude, longitude, and time zone of the location. DWEEKC expects the latitude to be in the range from -90 to +90 degrees, the longitude to be in the range from -180 to +180 degrees, and the time zone in the range from 0 to 23. Latitude is specified relative to the Equator with negative numbers representing latitude south of the Equator. Longitude is specified relative to Greenwich with negative numbers representing longitudes east of Greenwich. Time zones begin with 0 for Greenwich Mean Time and increase in number as one travels west. Thus, US Central Standard Time is Time Zone 6. Notice that after entering these three parameters that DWEEKC echoes the user's inputs.

Next, the user enters the starting date. The date must be entered using the "ddmmm" date convention. For example, a starting date of July 21 would be entered as **21jul** and August 8 would be inputted as **08aug**. If the date entered is accepted as "legal" by DWEEKC, it will echo the input. Otherwise, it will ask the user to input a valid date string. DWEEKC then will ask for the year of the design week as a four digit number (e.g., **1998**). Finally, the user is allowed to select either English or metric (SI) units. By answering this question, the user defines which unit system will be assumed for the rest of the program input.

Two things should be noted by the user. First, it assumes that the first day of the design week is a Monday. This assumption is based on the initialization of the thermal storage models in BLAST. All of the thermal storage models are assumed to be fully charged at the beginning of a simulation. However, BLAST will not assume that the first day is a Monday. It will determine what the first day of the Design Week is. Thus, if the user wishes to begin the Design Week on some other day, enter the proper starting day and year and remember that DWEEKC will call the first day of the Design Week "Monday". Second, DWEEKC currently does not support leap years. Thus, the design week as created by DWEEKC cannot include February 29.

Design Day Information

Once the general information has been entered, the program will begin to prompt the user for design day information. As with specifying a temporary design day in BTEXT, the user will be asked to enter the maximum temperature for the day, the minimum temperature for the day, the coincident wet bulb temperature, the barometric pressure, the wind speed, the wind direction, the clearness index (0.0 = total cloud cover, 1.0 = clear skies), and the precipitation index. The precipitation index is to be understood in the context of BLAST. In BLAST, "snow" means that the ground is covered with snow. "Rain" means that the exterior walls of the building are wet. All of the information should be entered as if the user were in BTEXT.

Once the information for the first day (Monday) has been entered, the user has the option of using the same information for the second day or entering new data for the second day. The user is allowed this option for every day. Thus, if the user desires the entire week to be the same design day, the design day information will only have to be entered once.

Modification Menu

After the user has specified the weather information for all of the days in the design week, a summary of the entered data will be sent to the screen. If the information is correct, press return and the DWEEKC program will create the necessary output files and terminate. The user will notice two new files in the current directory. Based on what the user used as the location name ("ohare" as an example), there is now an "ohare.dat" and an "ohare.win". The ".dat" file contains the weather data in BLAST ASCII format. The ".win" file is an input file that can be used with the WIFE program to create a BLAST-readable weather file.

If the information shown in the Design Week Summary is not correct, the user can enter the Modification Menu by answering yes ("y"). The user is only allowed to modify one day at a time and must specify which day is to be modified. Once the day to be modified is selected, the user is presented with various options for changing the input ranging from only one parameter to all of them. From this menu, the user can also change which day is being modified. After exiting this menu (by pressing return at the menu prompt), the Design Week Summary is printed at the screen allowing the user to see the changes that were made and identify any further need for data modification.

Using a Design Week with BLAST

In summary, there are three steps which are necessary to run BLAST using a Design Week. These are briefly reviewed in the following topics

Create Weather Data Using DWEEKC

Follow the instructions given above to create the ".dat" and ".win" file using DWEEKC.

Create Weather Tape Using WIFE

Process the weather data using WIFE. The ".win" file already exists (created by DWEEKC) so WIFE can be executed without any further editing. WIFE will create a ".wea" file which can be read directly into BLAST.

Run BLAST

Run BLAST as normal selecting the proper weather tape (“.wea”). Be certain to add the “WEATHER TAPE” syntax to the BLAST input file being used or request the "Annual Simulation" from within HBLC.

Report Writer

Report Writer Overview

The BLAST Report Writer allows the user to obtain hourly data for many BLAST variables and parameters in a format that can easily be read into a spreadsheet program and plotted or printed in tabular form. The final processing of the hourly data is not done by BLAST but by a stand-alone program called Report Writer (or RW for short). The figure below shows how the programs and user files interact with each other.

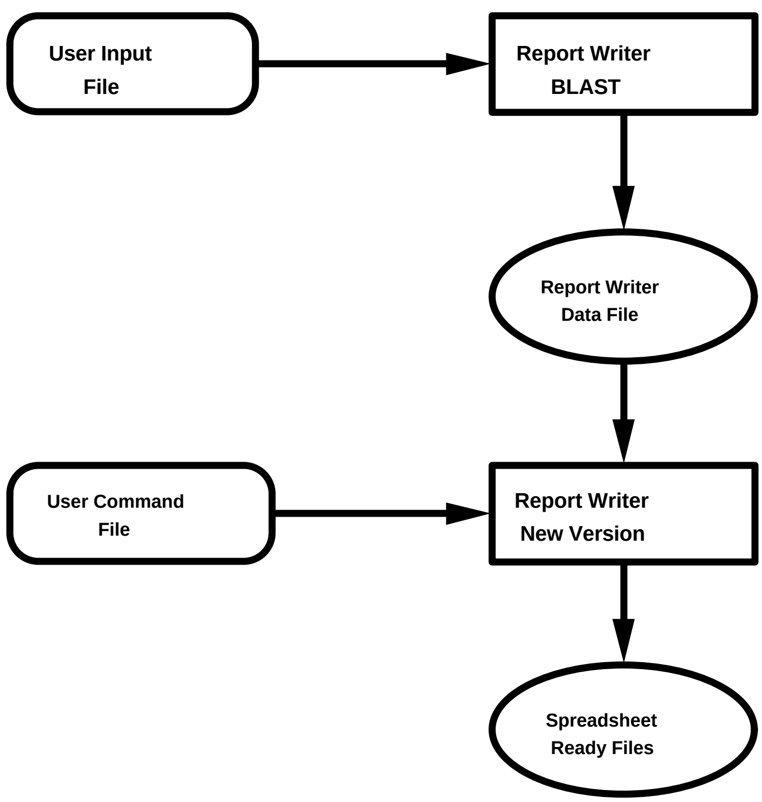

Table 85. Report Writer Overview

As shown above, the first step is to create a BLAST input file. This input file may be created using HBLC. The current version of HBLC allows users to select Report Writer variables. BLAST is then run in the same manner that it is normally executed. In addition to the BLAST output file, the user will notice the presence of files with ".rwd" extensions. These files are ready to read into the Report Writer stand-alone program and need no further processing. These files may (and probably should) be renamed. The names used by BLAST are generic names that will be used again the next time BLAST is executed. Thus, these files will be **overwritten** if they are not renamed.

The second step is the creation of a Report Writer "command" file. This file contains a series of statements which tells the Report Writer stand-alone program what processes to perform. This file, along with the Report Writer data file that is created by BLAST, is read into the Report Writer stand-alone program. Report Writer then processes the data and creates the data files that can be read into various spreadsheet programs.

This overview of Report Writer BLAST will be expanded upon in the next several sections. Section 2 will deal with the new Report Writer capabilities of BLAST. It will discuss the syntax necessary to take advantage of these capabilities and the results thereof. Section 3 will elaborate on the Report Writer (stand-alone) program. It will describe how to create a command file that controls what the program will actually do. Section 4 will briefly summarize the entire process starting with the BLAST input file and ending with data in the desired spreadsheet program. Section 5 lists all currently available Report Writer variables, and Section 6 shows which Report Writer system variables are applicable to each of the BLAST fan systems. Section 7 gives an unabridged, in-depth description of how to add more variables to the Report Writer version of BLAST. This will be a very important option for expert users who want to realize the full potential of Report Writer and BLAST itself and is only available to users who have source code.

Report Writer in BLAST

This section will discuss the procedures for using the Report Writer capabilities of BLAST. First, the syntax necessary to utilize these capabilities will be described. Then, the results of a BLAST run and the BLAST-Report Writer data files will be examined.

Report Writer in the BLAST Input File

The first step in obtaining spreadsheet ready BLAST output is specification of the desired variables in the BLAST input file.

The variables are split up into four categories: zone variables, system variables, zone in system variables, and plant variables. In each category, the variables are numbered as integers starting with 1. Currently, there are 41 zone variables, 45 system variables, 14 zone in system variables, and 40 plant variables that have been implemented in the BLAST code. Other variables may be added in the future. (See section 5 for more information on adding variables to the Report Writer version of BLAST on your own.) Note that the surface temperatures are considered zone variables and are numbered from 1001 to 1240. This corresponds to the maximum of 240 heat transfer surfaces in BLAST. A surface temperature is denoted by adding 1000 to its heat transfer surface number. (The heat transfer numbers for all surfaces that are heat transfer surfaces are shown in the BLAST Walls Report.)

BLAST Input File Syntax

The following subsections detail the syntax needed for producing BLAST data files that can be used by Report Writer. HBLC will generate syntax by choosing a report in the "Reports" form or subforms, located under the "Environment" tab of the menu bar. Syntax can also be generated using BTEXT, or placed into a pre-existing input file with a text editor.

Data for Design Days

HBLC and BLAST assume that the variables selected are desired for all design day environments. A dday__.rwd file will be created for each design day included in the input file. No further action is required from the user. As long as design days and report variables have been specified, data files are created.

Data for Annual Runs

HBLC assumes that the variables selected are desired for all environments, including annual runs. If a weather tape is specified, annual.rwd will be created. To have BLAST create a data file for an annual run or a partial annual run, include the syntax shown below. HBLC will create this syntax automatically, input files created or modified by sources other than HBLC may have to have this syntax written into them manually.

PROJECT=...

DESIGN DAYS=...

WEATHER TAPE FROM date1 TO date2;

REPORT FILE FROM date3 TO date4;

...

where **date3** and **date4** are the dates between which Report Writer data is desired. Caution should be used when defining dates in the input file. For a partial annual run, it is essential that both dates for the report file be between the dates for the weather tape. If either of the report dates are not between the weather dates, the Report Writer program may not be able to process the data file correctly. The "Reports" form will have a set of data boxes to fill in dates for reporting in an annual run. The date that has been set most recently for any report will be carried over to all other reports.

Remember that data for design days will always print out and that the REPORT FILE syntax line is only necessary for annual runs.

See Section 2.1.2 for an example of the use of Report Writer syntax in an actual BLAST input file.

Zone Variables and Surface Temperatures

The report variables line of syntax should be added to the zone description after the scheduled loads but before the "END ZONE" statement. The format is shown highlighted below.

...

```
PEOPLE=...
LIGHTS=...
REPORT VARIABLES=(var1,var2,var3,...);
END ZONE;
...
```

In this line, the symbols **var1**, **var2**, **var3**, etc. stand for the integers which represent the zone variables as listed in Appendix A. Remember that surface temperatures are considered zone variables by Report Writer. The number of variables that can be chosen by this statement is limited only by the number of variables currently available, but *common sense should be used*. The number of variables chosen will determine the size of the file that is created by BLAST. *Extremely large files can be created* when choosing a large number of variables for an annual run. Variables must be selected for each zone. BLAST will not assume that the same variables are desired for each zone.

Variables are easily selected by name and type on the reports form in HBLC. The user would only need to check the appendix for referencing the input file, which will use the variable numbers. There are zone variables available that are not available through HBLC, notably surface temperatures in the zone. These will have to be added into the input file manually. Consult the list in the following table to determine which variables are available for reporting.

Table 86. Zone Report Variable List

RW Code	Description	Variable Name	Units
1	Number of Occupants	NOFOCC	
2	Convected Heat Gain from People		Btu(W-hr)
3	Radiated Heat Gain from People		
	Latent Heat Gain from People		
	Electric Demand for Lights		
	Convected Heat Gain from Lights		
	Radiated Heat Gain from Lights		
	Visible Heat Gain from Lights		
	Return Air Gain from Lights		
	Electric Demand from Elec. Equip.		
	Convected Heat Gain from Elec Equip		
	Radiated Heat Gain from Elec. Equip.		
	Latent Heat Gain from Elec. Equip.		
	Gas Demand from Gas Equipment		
	Convected Heat Gain from Gas Equip.		
	Radiated Heat Gain from Gas Equip.		
	Latent Heat Gain from Gas Equip.		
	Convected Heat Gain from Other Eq.		
	Radiated Heat Gain from Other Equip		
	Latent Heat Gain from Other Equip.		
	Convected Baseboard Heat Load		
	Radiated Baseboard Heat Load		
	Mean Radiant Temperature		
	Zone Sensible Load		
	Zone Return Air Heating Load		
	Zone Baseboard Heating Load		
	Zone Electrical Load		
	Zone Infiltration		
	Outside Dry Bulb Temperature		
	Outside Wet Bulb Temperature		
	Outside Barometric Pressure		in. H_2O(Pa)
35	Outside Humidity Ratio	OHR	
36	Wind Speed	SPD	ft/min(m/s)
37	Wind Direction	DIR	Degrees
38	Sky Temperature	SKY	°F(°C)
39	Solar Beam Radiation Normal to Rays		Btu/hr-ft^2 (W/m^2)
	Solar Diffuse Sky Radiation Intensity		Btu/hr-ft^2 (W/m^2)
	Solar Ground Reflected Rad. Intensity		Btu/hr-ft^2 (W/m^2)
1000+HTS	Surface Temperature		°F(°C)

Zone in Fan System Variables

The form required to select zone in fan system variables is essentially the same as for zone variables. Again, the user must specify variables for each zone in each fan system for which they are needed. Report Writer does not assume any defaults based on previous zones or fan systems. To select zone in fan system variables, the REPORT VARIABLES line must be placed in the Zone Data Block of the fan system description. The syntax is:

...

FOR ZONE xxx;

...

REPORT VARIABLES=(var1,var2,var3,...);

END ZONE;

...

The same comments and restrictions for the zone variable syntax applies for the zone in fan systems variable syntax. Consult the list in the following table to determine which variables are available for reporting.

Table 87. Zone In System Report Variable List

RW Code	Description	Variable Name	Units
1	Thermostat Baseboard Heat Demand		kBtu(KW-hr)
2	Fan Coil Heat. Demand	FCHTZN	Btu(W-hr)
3	Fan Coil Cool. Demand	FCCLZN	Btu(W-hr)
4	Zone Heating Load Not Met	QHNMT	Btu(W-hr)
5	Zone Cooling Load Not Met	QCNMT	Btu(W-hr)
6	Desired Supply Air Temperature	SATEMP	°F(°C)
7	Return Air Temperature	RATEMP	°F(°C)
8	Return Air Humidity Ratio	RAZNW	
9	Supply Air Mass Flow Rate	ZNMASS	lb/hr(kg/s)
10	Return Air Mass Flow Rate	ZNMASR	lb/hr(kg/s)
11	Exhaust Air Mass Flow Rate	ZNMASE	lb/hr(kg/s)
12	Final Humidity Ratio	ZNFNLW	
13	Heat Pump Hourly Heating/Cooling Supplied	QTCAP	kBtu(KW-hr)
14	Heat Pump Energy Consumption	EPUMPT	kBtu(KW-hr)

Fan System Variables

The syntax used to select fan system variables is the same as in the previous sections. In this case, the line must be added to the Other System Parameters Block of the particular fan system for which the variables are desired. The format is again:

...

OTHER SYSTEM PARAMETERS:

...

REPORT VARIABLES=(var1,var2,var3,...);

END OTHER SYSTEM PARAMETERS;

...

The previously stated comments also apply to this line of syntax. Consult the list in the following table to determine which variables are available for reporting.

Table 88. System Report Variable List

RW Code	Description	Variable Name	Units
1	Entering Air Temp for Cooling Coil		
	Entering Humidity Ratio/Cool. Coil		
	Leaving Air Temp for Cooling Coil		
	Leaving Humidity Ratio/Cooling Coil		
	Air Mass Flow Rate thru Cool. Coil		
	Total Load on Cooling Coil		Btu(W-hr)
7	Entering Air Temp for Heating Coil		
	Leaving Air Temp for Heating Coil		
	Leaving Humidity Ratio/Heating Coil		
	Air Mass Flow Rate over Heat. Coil		
	Total Load on Heating Coil		
	Mixed Air Temperature		
	Mixed Air Humidity Ratio		
	Desired Mixed Air Temperature		
	Frac. of Mixed Air from Outside Air		
	Leaving Humid. Rat. from Humidifier		
	Total Load on Humidifier		
	Water Added by Humidifier		
	Elec. Demand of DX Condensing Unit		
	Elec. Demand of Heat Recover Device		
	Heat Recovered from Relief Air		
	Total Load on Preheat Coil		
	Exhaust Fan Power		
	Total Supply Air Mass Flow Rate		
	Total Return Air Mass Flow Rate		
	Total Exhaust Air Mass Flow Rate		
	Total Return Air Humidity Ratio		
	Total Return Air Temperature		
	Building/System Heating Load		
	Building/System Cooling Load		
	Building/System Gas Load		
	Building/System Electric Load		
	Minimum Loop Temperature		
	Maximum Loop Temperature		
	Minimum Outlet Temperature		
	Maximum Outlet Temperature		
	Minimum Tank Temperature		
	Maximum Tank Temperature		
	Heat Pump Network Electric Consumption		
	Loop Pump Electric Consumption		
	Supplemental Heating Demand		
	Supplemental Cooling Demand		
45	Cooling Tower Electric Consumption		

Central Plant Variables

The format to be used to select plant variables is identical to the syntax described in the previous sections with one exception. The plant REPORT VARIABLES line must be placed in the Other Plant Parameters Block. In almost all circumstances, this block will not be found in a user's input file. All of the following lines must be included in the BLAST input file in order to receive plant variables in the Report Writer data files:

...

OTHER PLANT PARAMETERS:

REPORT VARIABLES=(var1,var2,var3,...);

END OTHER PLANT PARAMETERS;

END PLANT;

...

All three lines must be included or else errors will occur when the BLAST Parser tries to interpret the input. Consult the list in the following table to determine which variables are available for reporting.

Table 89. Plant Report Variable List

RW Code	Description	Variable Name	Units
1	Heat. Demand from All Fan Systems And Building Loads	EHEATF	kBtu(KW-hr)
2	Cool. Demand from All Fan Systems And Building Loads	ECOOLF	kBtu(KW-hr)
3	Elec. Demand from All Fan Systems And Building Loads	EELECF	kBtu(KW-hr)
4	Fuel Demand from All Fan Systems And Building Loads	EFUELF	kBtu(KW-hr)
5	Total Heating Demand	EHEATT	kBtu(KW-hr)
6	Total Cooling Demand	ECOOL	kBtu(KW-hr)
7	Total Electric Demand	EELECT	kBtu(KW-hr)
8	Total Fuel Demand	EFUEL	kBtu(KW-hr)
9	Total Heat Recovered by Plant	ERCOVR	kBtu(KW-hr)
10	Recoverable Heat Wasted by Plant		
	Heat Available for Storage		
	Heat actually stored as and/or cold		
	Gas Turbine Exh. Heat Recoverable		
	Diesel Exhaust Heat Recoverable		
	Gas Turbine Lube Heat Recoverable		
	Diesel Lube Heat Recoverable		
	Diesel Jacket Heat Recoverable		
	Not Currently Available		
	Not Currently Available		
	Gas Turb. Chiller Exh. Heat Recov.		
	Diesel Chiller Exh Heat Recoverable		
	Gas Turb Chiller Lube Heat Recov.		
	Diesel Chill. Lube Heat Recoverable		
	Diesel Chiller Jacket Heat Recov.		
	Dble Bundle Chill. Heat Recoverable		
	Recoverable Heat Wasted by DBChill		
	Heat Pump Heat Recoverable		
	Recoverable Heat Wasted/Heat Pump		
	Chilled Water Pump Power		
	Hot Water Pump Power		
	Domest Hot Water Demand: Gas or Elec		
	Not Currently Available		
	Cooling Tower Entering Water Temp		
	Cooling Water Leaving Water Temp		
	Cool Tow Condenser Water Flow Rate		
	Evap Cond Entering Water Temp		
	Evap Condenser Leaving Water Temp		
	Evap Condenser Water Flow Rate		
	Well Water Cond Leav Water Temp		
40	Well Water Condenser Flow Rate	MFCW3	lb/hr(kg/s)

Examples of BLAST Report Writer Syntax

The figure "Input File Example"below details an example of a BLAST input file with Report Writer syntax. The example shows all of the syntax lines that were described in the previous sections. All of the Report Writer syntax has been highlighted. The example is a simple one-zone building served by one fan system and one central plant. The file has two design days and one annual run. The presence of the REPORT FILE LINE directs BLAST to produce a data file for the annual run in addition to the default files for the design days. The four REPORT VARIABLES lines tells Report Writer BLAST to print the following variables:

Zone Variables: Number of Occupants (1)

Convective Heat Gain from Occupants (2)

Convective Heat Gain from Lights (6)

Temperature of Heat Transfer Surface 2 (1002)

Zone in System Variables: Return Air Mass Flow Rate (10)

Final Humidity Ratio (12)

System Variables: Mixed Air Temperature (12)

Mixed Air Humidity Ratio (13)

Fraction of Mixed Air from Outside (15)

Plant Variables: Electric Demand from Fan System (3)

Notice in "Input File Example figure, that it was necessary to create an "Other Plant Parameters" Block. This run will create three data files. The files, "dday01.rwd" and "dday02.rwd", will correspond to the two design days specified in the input file (CHANUTE SUMMER and CHANUTE WINTER). The file, "annual.rwd", will contain the hourly data for May 1 through May 31, as specified in the REPORT FILE line. These files will be discussed in more detail in the next section.

```
BEGIN INPUT;
RUN CONTROL:
    NEW ZONES,
    NEW AIR SYSTEMS,
    PLANT,
    REPORTS(ZONE LOADS,ZONE,SYSTEM),
    UNITS(IN=ENGLISH, OUT=ENGLISH);
    PROJECT=" NONE SPECIFIED ";
    LOCATION=CHANUTE ;
    DESIGN DAYS=   CHANUTE SUMMER ,
                CHANUTE WINTER ;
    WEATHER TAPE FROM 01JAN THRU 31DEC;
    REPORT FILE FROM 01MAY THRU 31MAY;
    GROUND TEMPERATURES=(54,55,58,62,67,74,72,68,64,62,58,55);
BEGIN BUILDING DESCRIPTION;
    BUILDING="NONE ";
    NORTH AXIS=0.00;
    SOLAR DISTRIBUTION=-1;
    ZONE 10 "ZONE 10":
    ORIGIN:(0.00, 0.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EXTERIOR (30.00 BY 15.00),
    STARTING AT(30.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EXTERIOR (30.00 BY 15.00)
    WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (5.00 BY 5.00)
        REVEAL(0.00)
        AT (0.00, 0.00),
    STARTING AT(30.00, 30.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EXTERIOR (30.00 BY 15.00),
    STARTING AT(0.00, 30.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EXTERIOR (30.00 BY 15.00);
    SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 30.00, 0.00)
    FACING(180.00)
    TILTED(180.00)
    SLAB FLOOR (30.00 BY 30.00);
    ROOFS :
    STARTING AT(0.00, 0.00, 15.00)
    FACING(180.00)
    TILTED(0.00)
    ROOF31 (30.00 BY 30.00);
    PEOPLE=10,INT ,
        AT ACTIVITY LEVEL 0.45, 70.00 PERCENT RADIANT,
        FROM 01JAN THRU 31DEC;
    LIGHTS=5.00,OFFICE LIGHTING ,
        0.00 PERCENT RETURN AIR,20.00 PERCENT RADIANT,
        20.00 PERCENT VISIBLE,0.00 PERCENT REPLACEABLE,
        FROM 01JAN THRU 31DEC;
    CONTROLS=NWS2 ,
        3412000.0 HEATING, 3412000.0 COOLING,
        0.00 PERCENT MRT,FROM 01JAN THRU 31DEC;
    REPORT VARIABLES=(1,2,6,1002);
    END ZONE;
END BUILDING DESCRIPTION;
BEGIN FAN SYSTEM DESCRIPTION;
    VARIABLE VOLUME SYSTEM 101
    "FAN SYSTEM 101 FOR TESTING RW " SERVING ZONES10;
    FOR ZONE 10:
        SUPPLY AIR VOLUME=1000;
        EXHAUST AIR VOLUME=0;
        MINIMUM AIR FRACTION=0.05;
        REHEAT CAPACITY=100000;
        REHEAT ENERGY SUPPLY=HOT WATER;
```

```
        BASEBOARD HEAT CAPACITY=0.0;
        BASEBOARD HEAT ENERGY SUPPLY=HOT WATER;
        ZONE MULTIPLIER=1;
        REPORT VARIABLES=(10,12);
    END ZONE;
    OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=2.48914;
        SUPPLY FAN EFFICIENCY=0.7;
        RETURN FAN PRESSURE=0.0;
        RETURN FAN EFFICIENCY=0.7;
        EXHAUST FAN PRESSURE=1.00396;
        EXHAUST FAN EFFICIENCY=0.7;
        COLD DECK CONTROL=FIXED SET POINT;
        COLD DECK TEMPERATURE=55.04;
        COLD DECK THROTTLING RANGE=7.2;
        COLD DECK CONTROL SCHEDULE=(55 AT 90,65 AT 70);
        MIXED AIR CONTROL=FIXED PERCENT;
        DESIRED MIXED AIR TEMPERATURE=COLD DECK TEMPERATURE;
        OUTSIDE AIR VOLUME=0.0;
        PREHEAT COIL LOCATION=NONE;
        PREHEAT TEMPERATURE=46.4;
        PREHEAT ENERGY SUPPLY=HOT WATER;
        PREHEAT COIL CAPACITY=0;
        GAS BURNER EFFICIENCY=0.8;
        VAV MINIMUM AIR FRACTION=0.1;
        VAV VOLUME CONTROL TYPE=INLET VANES;
        HUMIDIFIER TYPE=NONE;
        HUMIDISTAT LOCATION=10;
        HUMIDISTAT SET POINT=50;
        SYSTEM ELECTRICAL DEMAND=0.0;
        REHEAT TEMPERATURE CONTROL=FIXED SET POINT;
        REHEAT TEMPERATURE LIMIT=140;
        REHEAT CONTROL SCHEDULE=(140 AT 0,70 AT 70);
        COOLING SAT DIFFERENCE=20;
        HEATING SAT DIFFERENCE=70;
        AIR VOLUME COEFFICIENT=1.0;
        REPORT VARIABLES=(12,13,15);
    END OTHER SYSTEM PARAMETERS;
    EQUIPMENT SCHEDULES:
        SYSTEM OPERATION=OFF,FROM 01JAN THRU 31DEC;
        EXHAUST FAN OPERATION=ON,FROM 01JAN THRU 31DEC;
        PREHEAT COIL OPERATION=ON,FROM 01JAN THRU 31DEC;
        HUMIDIFIER OPERATION=ON,FROM 01JAN THRU 31DEC;
        REHEAT COIL OPERATION=OFF,FROM 01MAY THRU 30SEP;
        COOLING COIL OPERATION=OFF,FROM 01OCT THRU 30APR;
        TSTAT BASEBOARD HEAT OPERATION=ON,FROM 01JAN THRU 31DEC;
        HEAT RECOVERY OPERATION=OFF,FROM 01JAN THRU 31DEC;
        MINIMUM VENTILATION SCHEDULE=MINOA,FROM 01JAN THRU 31DEC;
        MAXIMUM VENTILATION SCHEDULE=MAXOA,FROM 01JAN THRU 31DEC;
        SYSTEM ELECTRICAL DEMAND SCHEDULE=ON,FROM 01JAN THRU 31DEC;
    END EQUIPMENT SCHEDULES;
    END SYSTEM;
END FAN SYSTEM DESCRIPTION;
BEGIN CENTRAL PLANT DESCRIPTION;
    PLANT 5005 "PLANT 1 FOR REPORT WRITER TESTING" SERVING  ALL
SYSTEMS;
    EQUIPMENT SELECTION:
    BOILER :
        1 OF SIZE 50;
    CHILLER :
        1 OF SIZE 50;
    END EQUIPMENT SELECTION;
    PART LOAD RATIOS:
    BOILER(MIN=.0100,MAX=1.0000,BEST=.8700,ELECTRICAL=0.0000);
    CHILLER(MIN=.1000,MAX=1.0500,BEST=.6500,ELECTRICAL=.2275);
    END PART LOAD RATIOS;
    SPECIAL PARAMETERS:
        HFUELB=20013.38432100;
        PSTEAM=284.40995334;
        RFLASH=0.07100000;
        RHFLASH=0.50000000;
        SRATB=17.00000000;
        STEAM=1168.67852590;
        TCOOL=44.00600000;
```

```
        TSATUR=241.53023600;
    END SPECIAL PARAMETERS;
    EQUIPMENT PERFORMANCE PARAMETERS:
        RPWR1C (0.16017000, 0.31644000, 0.51894000);
        RFUELB (0.60000000, 0.88888889, -0.49382716);
        ADJT1C (95.00000000, 1.19000000, 43.98800000);
        RCAV1C (1.00600000, -0.01900000, 0.00022006);
        ADJE1C (3.15800000, -3.31300000, 1.15400000);
    END EQUIPMENT PERFORMANCE PARAMETERS;
    OTHER PLANT PARAMETERS:
        REPORT VARIABLES=(3);
    END OTHER PLANT PARAMETERS;
    FOR SYSTEM 101:
        SYSTEM MULTIPLIER=1;
    END SYSTEM;
    END PLANT;
END CENTRAL PLANT DESCRIPTION;
END INPUT;
```

Figure 205. Input File Example

Results of a BLAST Run Using Report Writer

As mentioned in the previous section, Report Writer will create data files for all design days by default. These will be named "dday01.rwd", "dday02.rwd", "dday03.rwd", etc. If the REPORT FILE line is included in the input file, an "annual.rwd" file will be created for the annual data. There is a limit on the number of weather environments that can be simulated in one BLAST run. This limit is 13 total environments (design days plus the annual run). Thus, Report Writer is also limited to a total of 13 environments. However, on certain systems this number may be smaller due to file handling limitations.

The data contained in the Report Writer data files is hourly data for each variable that was requested. The structure of this file is very important since the Report Writer stand-alone code expects the data in a defined format. Thus, users should **not** alter the contents of these files (with the ".rwd" extensions). Modifications to these files can cause problems with the Report Writer stand-alone program.

One more important point to remember is that the names given to the Report Writer data files are generic names. BLAST will always use these names to create the data files. As a result, the files should be renamed after the BLAST run is complete to avoid the fact that these files will be overwritten the next time Report Writer BLAST is executed. The files can be renamed to any legal name on the particular system on which the user is working. For more information on the structure of the Report Writer data file, see Report Writer (Stand-Alone).

Remember that Report Writer BLAST can produce some rather large files, especially for annual runs. This can quickly use up a computers available disk space. Caution should always be used when running Report Writer BLAST. User should also use caution when viewing the Report Writer data files. Some file editor programs have file size limits. This may truncate the file and eventually cause the Report Writer stand-alone program to crash.

Report Writer (Stand-Alone)

The Report Writer stand-alone program is a general-purpose number cruncher. Although designed with BLAST in mind, it can be used to manipulate, reduce, and format any data as a function of time. The principle behind this program is simple: input a series of data points, perform computations on the data, and then output the results. The input format is fixed, but RW can perform a wide variety of computations, such as average, minimum, maximum, frequency, cut, and slice. In addition, RW has the capacity to produce various output formats that can be read directly into spreadsheet programs.

Miscellaneous Report Writer Terms

There are several miscellaneous terms that relate specifically to the Report Writer stand-alone program. Their definitions are used throughout the rest of this section and are given below.

Data Sets

The basic unit of information in Report Writer is a data set. A data set consists of a one-dimensional array of floating point numbers, a start date (the date of the first data point), a period (what frequency was the data sampled), and a count (number of data points).

Date Strings

Date strings are used throughout Report Writer. They specify the starting date for data sets and are used when printing output tables. In Report Writer, dates are interpreted/printed as strings in the form HRhh/dd/mmm, where hh is a two digit number for hour, dd is a two digit number for day, and mmm is a three letter abbreviation for the month. Any one of the three fields may be omitted if it is not needed. The month abbreviations are **not** case-sensitive.

Examples:

HR03/05/Jan means 3am on the 5th of January

HR17/12/May means 5pm on the 12th of May

21/Mar means the 21st of March

Jun means June

Period Strings

Period strings specify a "delta time" value. Their purpose is to indicate the amount of spacing between points in a data set. Period strings are interpreted/printed in one of two forms. The more common form is one word: hourly, daily, monthly, or yearly. The less common form is used for more control over the period: hourly/hh-hh or daily/dd-dd. Period strings are **not** case-sensitive.

Examples:

hourly: Each data point covers an hour

daily:	Each data point covers a day
monthly:	Each data point covers a month
yearly:	There is only one data point, and it covers one year's worth of data.
hourly/08-17:	All data points are hourly with only the hours from 8am to 5pm of each day covered.
daily/01-10:	All data points are daily with only the days from the 1st to the 10th of each month covered.

File Formats

There are three main files that Report Writer will access: the input file, the output file, and the command file. The Report Writer input file is created by BLAST and does not need to be modified. Report Writer will create the output file based upon the user command file. Each of these files will be discussed in the next subsections.

Command File Format

The command file is a **user-defined** file that controls the actions taken by the Report Writer. HBLC users will create this command file when they select "Report Writer" from the "Other Programs" tab on the menu bar. The command file will be based on the options chosen in the ensuing form.

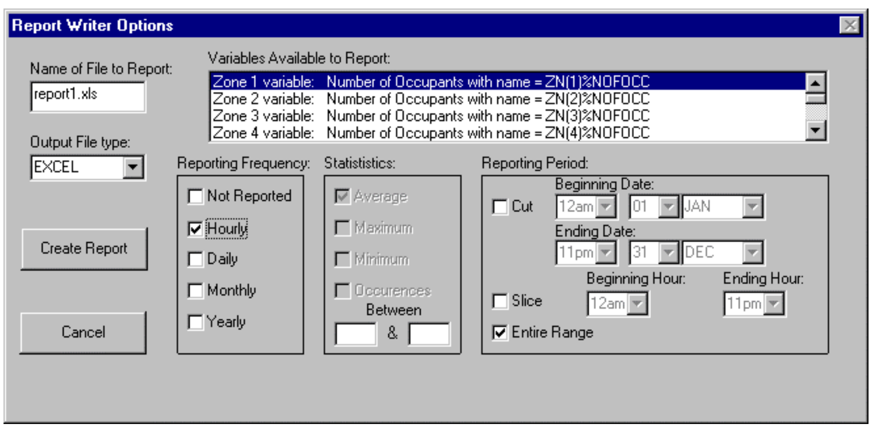

Figure 206. Report Writer Options screen in HBLC

After opening Report Writer, HBLC will prompt the user to select the *.rwd file that has the simulation data that is to be reported. Once a report file has been chosen, the variables that are stored in the input file will appear in a list on the Report Writer Options form. The user may then choose variables and their method of reporting and create a report.

For users without access to HBLC, basic command files can be created using the Report Writer File Generator program. This program accompanies Report Writer and can be executed from the DoBLAST interface on the PC by selecting RWFGEN. The program is menu driven and fairly self-explanatory. It prompts the user for all of the information necessary to create the Report Writer command file (COMINP.DAT) and then creates the file. Report Writer File Generator also searches each input file for variables, eliminating the need to search through the ".rwd" files to find the desired variables and variable names.

The command file is broken up into blocks and sections by the use of keywords. The Report Writer keywords are described in detail below. Basically, each new keyword encounter starts a new section in a particular block. Blocks are separated from each other by the **END** keyword. Each block of the command file describes how to produce one set of output data. Each section in the block specifies information about the output data set. An example of a Report Writer command file is given in subsection Example of a Command File

The format of the command input file is fairly flexible. The basic structure of the file is given below.

```
KEYWORD=data
  data
  data
  ...
  ...
  data
KEYWORD=data
  data
  data
```

There are several rules that govern the structure of the command file. These rules include:

1.) All keywords must begin in the first column, but data may begin in any column. Data resembling keywords may be distinguished from keywords by starting it in any column other than the first.

2.) All data encountered is associated with the last keyword that was detected.

3.) If the keyword is appended with an equals sign, then everything following the equals sign is counted as a line of data. When parsing for the equals sign, spaces are ignored.

4.) Blank lines are ignored.

5.) Anything following an exclamation point is ignored (i.e., the exclamation point is a comment character).

6.) All keywords are case-**in**sensitive.

7.) In general, words in the command file are separated by spaces, tabs, formfeeds, and commas as needed. The absence of a word may be indicated by using extra commas or an empty set of quotes. In places where spaces, tabs, or formfeeds are important to the word being parsed, they may be overridden by enclosing the word in double quotes. The parser will then skip all characters up to the next double quote or the end of the line.

8.) With some exceptions, keywords usually do not need to be specified in any particular order (the END keyword and the KEY keyword are exceptions).

TITLE Keyword

This keyword allows a block to be named. The last line of data encountered in this section is the title of the block. If another **TITLE** keyword is encountered within the same block, it will override the previous one.

INPUT Keyword

This keyword allows the specification of the Report Writer input files discussed in Section 3.2.1. Each line of data following the keyword is a filename. If another **INPUT** keyword is encountered in the same block, the effect will be cumulative. When the Report Writer starts searching for variable data, it will scan all of the files whose names it has accumulated in this block.

OUTPUT Keyword

This keyword allows the specification of the output files to be produced by Report Writer. Each line of data following the keyword is a file type followed by a filename. The file type is a word specifying one of the output file type listed earlier (TABLE, LOTUS, EXCEL, or DATA). If another **OUTPUT** keyword is encountered in the same block, the effect will again be cumulative. When Report Writer begins the output production phase, it will write each file name and file type specified to the screen in succession.

Note: If the same file name is used more than once in the command file or the name of an existing file is used, the information will **not** be appended. Whenever the Report Writer writes an output file, it will overwrite any already existing file.

VARIABLE Keyword

This keyword is probably the most important keyword in any block of the command file. Each instance of the **VARIABLE** keyword defines one set of output data for the current block. The **VARIABLE** keyword may be repeated as many times as necessary to name the output data sets desired.

The data within this section has a very specific format. The first line of data can have up to three fields and **must** be specified. In order, the fields are variable name, alias, and column width. Each of these fields are described below. The remaining data lines define functions (transformations) to be performed on the data set by Report Writer. These functions are optional and may be omitted.

VARIABLE Name Field: The first field in this first data line is required and names the data set from which to start processing. This name is case sensitive and must match one of the variables in the data input files specified for this block. If the name cannot be found, Report Writer will stop and an error message will be printed naming the unresolved data set. Note that the KEY keyword (described below) can be used to shorten this field.

VARIABLE Alias Field: For the purpose of output clarity, it is sometimes convenient to be able to alias the data set to another name. If this field is specified, an alias will be defined for the data set. The exact use of the alias depends on the type of output being generated. If this field is left undefined, the alias defaults to the original data set name.

VARIABLE Column Width Field: In the Table output file format, each column corresponds to one of the VARIABLE sections. The column width field, if specified, is a number that sets the width of the column for the variable defined in this section. If left undefined, the column width defaults to 20.

There are six transformations that may be performed on a data set by Report Writer. These include cut, slice, average, maximum, minimum, and frequency. Each of these functions is described below. *Please note that only one function can be used per VARIABLE keyword.* See Section 3.2.3.8 for an example of requesting more than one function for a specific variable.

Variable Function Descriptions

The **CUT** function allows the data set to be trimmed to a subset of the original data set. The syntax for this transformation is:

CUT <start date string> <end date string>

The two dates in this statement specify where to begin and end extraction of the data. If either date is outside the range of the data set, then they will be rounded. If either is not specified, then the earliest and latest dates are assumed, respectively. Some examples of the use of the **CUT** function are given below.

CUT 01/MAY 31/MAY **-** Extracts all of the data between May 1 and May 31.

CUT HR08/01/MAY HR17/05/MAY **-** Extracts all of the data between 8am on May 1 and 5pm on May 5.

The **SLICE** function works like the **CUT** function, but it extracts a periodic subset instead of a whole subset. For example, the **CUT** function may allow all data from 03/Jan to 07/Mar, whereas the **SLICE** function allows all data from 8am to 5pm for every day of the set to be extracted. The syntax for the **SLICE** transformation is:

SLICE <start integer> <end integer>

The two integers specify the starting and ending hour (or day) to perform the slice. Whether the integers mean hour or day depends on the period of the data set on which the operation is performed. If either integer is out of range or not specified, reasonable assumptions will be made instead (hour=1 for start, hour=24 for end; or day=1 for start, day=31 for end). Some examples of the use of the **SLICE** function are given below.

SLICE 8 17 Extracts data between 8am and 5pm for every day of the data set.

SLICE ,,17 Extracts data between midnight and 5pm for every day of the data set.

SLICE 17 Extracts data between 5pm and midnight for every day of the data set.

Note: Users of Report Writer should implement only one **SLICE** per command file block. The use of more than more **SLICE** in a block can lead to unpredictable results. In addition, while it is possible to use more than one **CUT** function in a particular command file block, users should limit the number of **CUT** functions to one if a **SLICE** command is also present in that block.

The **AVERAGE** function computes averages for every period from a data set. The syntax for this transformation is:

<period string> AVERAGE

The period string specifies the period over which the computation is done (and the period of the resulting data set). Some examples of the use of the **AVERAGE** function are given below.

DAILY AVERAGE Computes averages for every day in the data set.

MONTHLY AVERAGE Computes averages for every month in the data set.

The **MAXIMUM** function computes maximums for every period from a data set. The syntax for this transformation is:

<period string> MAXIMUM

The period string specifies the period over which the computation is done (and the period of the resulting data set). Some examples of the use of this function are shown below.

DAILY MAXIMUM Computes maximums for every day in the data set.

MONTHLY MAXIMUM Computes maximums for every month in the data set.

The **MINIMUM** function computes minimums for every period from a data set. The syntax for this transformation is:

<period string> MINIMUM

The period string specifies the period over which the computation is done (and the period of the resulting data set). Some examples of this syntax are shown below.

DAILY MINIMUM Computes minimums for every day in the data set.

MONTHLY MINIMUM Computes minimums for every month in the data set.

The **FREQUENCY** function calculates the frequency of occurrence between two limits for the data set. In other words, the number of times a data point falls within a certain limit is tabulated for each period specified by the command. The syntax for this transformation is:

<period string> FREQUENCY <minimum> <maximum>

The period string specifies the period over which the computation is done (and the period of the resulting data set). The minimum and maximum fields specify the limits of the window for tabulation. These limits are inclusive, and both fields are floating point numbers. If the minimum field is left out, the frequency is calculated for all data below the maximum. If the maximum field is left out, the frequency is calculated for all data above the minimum. If both fields are left out, this function will tabulate the total number of data points for the period. Some examples of the use of the FREQUENCY function are given below.

DAILY FREQUENCY 1.0,2.0 **-**Counts all the data points that fall between 1.0 and 2.0 for every day of the data set.

MONTHLY FREQUENCY 1.0,2.0 **-**Counts all the data points that fall between 1.0 and 2.0 for every month of the data set.

DAILY FREQUENCY ,,0.0 **-**Counts all the data points that are equal to or below 0.0 for every day in the data set.

DAILY FREQUENCY 0.0 **-**Counts all the data points that are equal to or above 0.0 for every day in the data set.

KEY Keyword

Sometimes, a group of variable names may all have a common prefix. Instead of specifying the whole name in each variable block, this keyword can be used to specify the prefix and then only the rest of the name need be specified. The use of this keyword is best shown by an example.

Suppose there were a series of variable definitions like this:

```
VARIABLE=ZN(1)%NOFOCC
VARIABLE=ZN(1)%MRT
VARIABLE=ZN(1)%MAT
```

By using the **KEY** keyword, this can be changed to:

```
KEY=ZN(1)%
VARIABLE=NOFOCC
VARIABLE=MRT
VARIABLE=MAT
```

The "ZN(1)%" declaration in the **KEY** field means that further variable declarations must begin with "ZN(1)%". This prefix will remain in effect until either the **END** or another **KEY** keyword is encountered. To clear the current declaration, just use KEY="".

END Keyword

The END keyword marks the end of a particular block in the command file. It causes Report Writer to begin processing the current block of information.

Example of a Command File

The preceding sections detailed the use of keywords that make up the command file that the user must produce in order to execute Report Writer. At this point, the reader may still be slightly confused as to how each of these statements work together in the command file. A fully documented example of a typical command file that uses results from a BLAST run is shown below. Below the example, each line of the sample file is noted and described.

```
TITLE
  Report Writer Example:  Zone Data
INPUT
  dday01.rwd
OUTPUT
  EXCEL myrun.exc
```

```
7    TABLE myrun.tab
8  VARIABLE
9    ZN(14)%NOFOCC
10   CUT HR08/21/JAN HR17/21/JAN
11 VARIABLE
12   ZN(14)%QLTCON
13   SLICE 8 17
14 VARIABLE
15   TEMP%SURFACE(2)  T2MIN  5
16   DAILY MINIMUM
17 VARIABLE
18   TEMP%SURFACE(2)  T2MAX  5
19   DAILY MAXIMUM
20 END
21 TITLE=RW System and Plant Data
22 INPUT=annual.rwd
23 OUTPUT=DATA sandp.dat
24 OUTPUT=LOTUS sandp.wk1
25 KEY=FS(1)%
26 VARIABLE=MXAIRT
27 VARIABLE=FRACOA
28 KEY=""
29 VARIABLE=ZF(1.14)%ZNFNLW
30 VARIABLE=CP(5)%EELECF
31 END
```

Lines 1 - 2: These two lines define the title for the first block of the command file. This title will be printed on the first line of each of the output files.

Lines 3 - 4: These lines determine the file that Report Writer will use as the input file or raw data. This file is created by BLAST during a simulation.

Lines 5 - 7: These three lines together tell Report Writer which output file formats to use and the names of the files to create. Remember that if these files already exist in the current directory, they will be overwritten.

Lines 8 - 10: The next three lines name the first variable of the block. Line 8 is the keyword that tells Report Writer to expect a variable name. Line 9 gives Report Writer the name of the variable, i.e. ZN(14)%NOFOCC. Line 10 denotes that Report Writer is to send only the data between 8am on January 21 and 5pm on January 21 to the output files. Since the input file is from a design day, this CUT statement is essentially the same as the SLICE statement in line 13.

Lines 11 - 13: These lines are similar to lines 8 - 10 except the difference in variable name and the use of the SLICE function.

Lines 14 - 16: These lines define the variable TEMP%SURFACE(2) which is the surface temperature of heat transfer surface number two. Note that line 15 assigns this variable the alias "T2MIN" and sets the column width to 5. A daily minimum is tabulated.

Lines 17 - 19: These lines define the variable TEMP%SURFACE(2) which is the surface temperature of heat transfer surface number two. Note that line 18 assigns this variable the alias "T2MAX" and sets the column width to 5. A daily maximum is tabulated.

Line 20: This line marks the end of the first block.

Line 21: This line defines the title of the second block. Notice that this block uses a more compact structure by including the equal signs. Either structure may be used in Report Writer. This line is similar to lines 1 and 2 in the first block.

Line 22: This line determines the input file. The file "annual.rwd" is created by a BLAST annual simulation. This line is similar to lines 3 and 4 in the first block.

Lines 23 - 24: These two lines relay information on the desired output formats and files to Report Writer. These lines are similar to lines 5 - 7 in the first block.

Line 25: This line demonstrates the use of the **KEY** keyword. The string after the equal sign will be prepended to all of the variables that follow until another **KEY** keyword is encountered.

Lines 26 - 27: These lines define two variables for this block. The full variable names are "FS(1)%MXAIRT" and "FS(1)%FRACOA".

Line 28: This line clears the **KEY** keyword. Until another **KEY** keyword is encountered, nothing will be prepended to the variable names.

Lines 29 - 30: These lines define two more variables for this block. Note that the zone in system variable, "ZF(1.14)%ZNFNLW", is the final humidity ratio for zone 14 served by fan system 1.

Line 31: This marks the end of the second block. Since this particular **END** keyword is at the end of the file, it may be left out. However, for stylistic reasons and simplicity, it has been included in this example.

Input File Format

The input file is created by BLAST and generally does not require user modification. The format of the input file is highly defined, making it simple to parse. A highly defined input file speeds the reading in of the data. The input file is broken up into blocks, each block containing a header section and a pure data section. An input file can contain one or more blocks, which are implicitly delineated within a data file and may be repeated as many times as needed.

Header Section

The header section of a typical Report Writer input file is structured like the following:

line #	line format
1	**BLAST-FORMAT 3.0**
2	**<integer n>**
3	**<integer t>**
4	**<date string>**
5	**<period string>**
6	**<key string>**
7	**<variable name 1>**
8	**<variable description 1>**
9	**<variable name 2>**
10	**<variable description 2>**
	...
	...
2n+7	**<variable name n>**
2n+8	**<variable description n>**

The input file structure displayed above has the following features:

1.) Line 1 must contain the keyword "BLAST-FORMAT x.0" where x is either 1, 2, or 3. This is an indicator of the file's format and does **not** relate to the BLAST version number. The file that is created by a BLAST run will be in "format 2.0". Use of format 2.0 does not allow the key string of line 6 to be defined. Format 3.0 requires the key string. See point 6 below for more information.

2.) Line 2 must be an integer specifying how many variables are to be defined within this block.

3.) Line 3 must be an integer specifying the total number of data points for each variable in the current block.

4.) Line 4 must have a date string defining the start time for all the variables in the block.

5.) Line 5 must have a period string defining the spacing between data points (hourly, daily, etc.).

6.) Line 6 may have a "key string". When the data block is read in, the "key string" will be prepended onto all of the variable names which follow it. This field may be left as a blank line in format 3.0. It must be omitted in format 1.0 or 2.0.

7.) Each of the next pairs of lines contains information on variables whose data is recorded in the data section described below. The first line of each pair must have a **case-sensitive** identifier that will be used by Report Writer when storing the variable. Each variable is identified by BLAST in the following fashion:

Zone Variables	ZN(zone number)%variable name
Surface Temperatures	TEMP%SURFACE(heat transfer surface number + 1000)
System Variable	FS(system number)%variable name
Zone in System Variable	ZF(system number . zone number)%variable name
Plant Variable	CP(plant number)%variable name

where the "variable name" for each variable is the name listed in Appendix A. Examples of these identifiers are shown in Section 3.6. The second line of each pair is for documentation purposes only and describes in a phrase the purpose or function of the variable. There must be n pairs of lines of these lines in the header section.

Data Section

The data section of the input file is very straightforward. It consists of a series of integers or floating point numbers. There is no set field width for each number. The only requirement is that the numbers be separated by at least one space, a comma, or a carriage return. The actual number of data points on each line is totally variable and can change on a line-by-line basis, if necessary.

The total number of data points is the product of the number of variables in this block, n, and the total number of data points for each variable, t. The data points are ordered in such a way that the first n data points are the first values for all of the variables in the order described in the header at the first time interval. The next n data points are for the variables at the second time interval, etc., until all data points have been read. The result can be visualized as a two-dimensional array where the columns are the variables, the rows are the time intervals, and the array elements are the data points.

Output Files

Report Writer currently has the ability to print out four different output file formats. Each format has a specific application for which it was designed. The next four subsections describe the Table, Lotus, Excel, and Data formats in detail. All four options can be chosen from a pull down menu in the “Report

TABLE Format

The Table format produces exactly what its name implies. The data is converted into a table where the variables are printed as columns with the time steps making up the rows. Each Table format file contains two sections: a header section and a table section. The header summarizes the contents of the file and displays the following information:

1.) The names of the variables that were processed.
2.) Any alias that was assigned to the variables.
3.) A summary of the transformations that were performed on each data set.

4.) The start date, the period, and the number of data points in all of the data sets.

The table section has the following characteristics:

1.) The leftmost column contains a series of date strings corresponding to the date for each row of data points.

2.) The top row of each column displays a variable name or its alias, if one has been defined.

3.) The remaining rows hold the data for each variable named in the first row of the column in a decimal-point centered format. If there is no data point for that particular row, the column is padded with spaces. If the data point is too large, the decimal point centered format will be overridden and right-shifted to allow the number to fit. If the data point becomes so large that it can not be displayed in the allowable column width, then the leftmost digits will be displayed followed by an asterisk.

LOTUS Format

The Lotus format creates a file that is similar in nature to the Table format. The difference is that the Lotus format is a file that can be imported directly into the Lotus 1-2-3 spreadsheet program without modifications. Thus, after running the Report Writer program, a file exists that can be manipulated in a spreadsheet environment. This allows the user to take advantage of various functions that are offered by the spreadsheet program, such as graphing capabilities, improved output formatting options, etc. To effectively use the Lotus format, take the following steps:

1.) Create a Lotus format file using the Report Writer stand-alone program.

2.) Enter Lotus 1-2-3 and **import** the output file as **values**.

3.) Format column 2 as a date and column 3 as a time.

4.) Expand the column widths to a proper size for the data.

EXCEL Format

The Excel format is identical to the Lotus format except that the file that is created can be read directly into the Excel spreadsheet program. The procedure for using the Excel format is also very similar:

1.) Create an Excel format file using the Report Writer stand-alone program.

2.) Enter Excel and **open** the output file as a **tab-delimited** file.

3.) Expand the column widths to a proper size for the data.

DATA Format

The Data format is nearly identical to the format of the input file. For a description of this format, see the section 3.2.1. The creation of this file allows two substitutions to be performed. First, the name field of the Data file is assigned the value of the data set's alias. This allows the renaming of variables. Second, the description field is expanded to include a description of any transformations that were performed on the original data. This creates a trail showing how the data was created.

Report Writer Execution

The following subsections describe both how to run Report Writer and how Report Writer operates. While the descriptions given on how to run Report Writer will be specific to the current release, the internal procedures of Report Writer are the same for all versions of the program.

Running Report Writer

On an IBM compatible computer, the following steps should be taken:

1.) After performing a BLAST simulation, note the Report Writer files which were produced (files with an "rwd" extension). Rename these files, if necessary, to avoid them being overwritten the next time BLAST is executed.

2.) Access Report Writer through HBLC, entering the report parameters by checking the appropriate boxes, entering values in data boxes, and selecting the variables and formats from their menus. Non-HBLC users should use the File Generator Program (from the DoBLAST interface) or a text editor to create the command file. This file can be called COMINP.DAT; however, it can be named any legal file name if the user executes Report Writer from the DoBLAST interface which will prompt the user for the file where the Report Writer commands are stored. Make sure that any name changes made to the input files in step one are reflected in the command file.

3.) Create the reports. Non-HBLC users will run Report Writer by selecting it from the DoBLAST interface.

Note that the Apollo version is slightly different. The command file can be named anything, and Report Writer can be executed by typing "**runrepwrt** *filename*" in the current directory. Also, the location of the Report Writer executable can be located anywhere as long as the runrepwrt script is properly defined.

Report Writer Internal Procedures

Report Writer has a specific order of actions that it follows when it executes. These steps are listed in order of execution below.

1.) The command file is opened.

2.) The first block of the command file is read and parsed. If there was no command input block left to be read, then the command file is closed and execution stops .

3.) All data files named in the current block are scanned for the variables declared in the current block. These variables are read into memory.

4.) All variables that were named in the current block are mapped to the variables that were found. If a variable could not be located anywhere in the data files, execution stops with an error indicating the missing variable.

5.) All the transformations are performed.

6.) The output files are created, one at a time, in the order declared in the current block.

7.) Execution continues at step 2 with the reading and parsing of the next block of the command file.

Report Writer Limitations

Theoretically, Report Writer should be unlimited in the size and quantity of the objects on which it operates. Unfortunately, memory size presents a severe limit on just how many or how large these objects can be. Because of this, several principles were adhered to when the program was written:

1.) Objects that require large amounts of memory (data points for example) share the memory space as one unit. For example, if the data point limit was 200 and there were two data sets, the total size of both data sets cannot exceed 200 points. Set 1 could be 25 points, while set 2 could be 175 points.

2.) Wherever there was a choice between increasing execution speed or conserving memory, execution speed was sacrificed. It is far better to be able to process large sets slowly than to not be able to process them at all.

Below is a summary of the current limits of Report Writer.

Command Input Blocks

There is no limit on the number of blocks in a command file. The reason for this is because the "slate is wiped clean" every time a new block gets parsed. This also means that all of the limits listed below only have effect within a block and not across blocks.

Variables

The total number of variables that may be read in plus the number of output data sets produced during the execution of any command block is 40. The total number of variables plus transformations that may be stored during the execution of any command input block is 30.

String Names

There are several types of strings in Report Writer. All of them have an outside length limit. If any string entered is too large for its corresponding size limit, the string will be truncated to the maximum size.

1.) The title string (**TITLE** keyword) is limited to 80 characters in length.

2.) All variable names and aliases are limited to 20 characters in length.

3.) All variable descriptions are limited to 80 characters in length.

4.) All file name strings are limited to 80 characters in length.

Data Points

Report Writer maintains one large floating-point array for the storage of all of the data points in all of the data sets. Each variable that is read in uses a piece of that array. In addition, any variable section (**VARIABLE** keyword) that performs a transformation uses a piece of that array. This array has an upper limit of 878400 data points, meaning that the sum of the data points in all of the data sets cannot exceed 878400.

Functions and Arguments

Report Writer also maintains an internal array that stores all the functions that are programmed within one block. Every time a transformation is declared within a variable section in a command block, space in this array gets used. The relationship between array usage and transformation declaration is:

1.) AVERAGE, MINIMUM, and MAXIMUM use 2 locations each.

2.) FREQUENCY uses 4 locations.

3.) CUT and SLICE use 3 location each.

4.) The act of declaring a variable section in a command block uses one location.

This array is limited to 100 locations.

In addition, an array is maintained for storage of the function arguments for FREQUENCY, CUT, and SLICE. Each of these functions use two locations. The total limit for this array is 50.

File Size

There is no limit on either the total size of the input file or the total size of the command file. In addition, any number of variables may be declared in an input file. The reason this is possible is because the Report Writer only reads in the variables it needs and ignores any others that happen to be declared.

File Handling

There is a maximum of 16 open input and 16 open output files at any given time. This means that for any given block in the command file, no more than 16 input and 16 output files may be declared.

HBLC File Creation

The HBLC generated command file will only create one output file at a time. If variables need to be reported into separate files or formats, Report Writer must be run separately for each new report. The increase in number of runs is offset by the ease with which a new report can be specified using the HBLC graphical interface.

Report Writer Summary

This section will give a quick summary of the steps necessary to use Report Writer in BLAST and the Report Writer program. Each step will refer the reader to other sections of this document and other documents for more information on certain topics.

Step 1. Create a BLAST Input File

Create a BLAST input file using HBLC or BTEXT, or use an existing input file with Report Writer syntax. For more information on BTEXT or BLAST, see the *BTEXT User Guide* or the *BLAST Overview*. For more information on the Report Writer syntax, see the *Report Writer in BLAST* section of this document. For a list of variables currently available for use with Report Writer, see the *Report Writer Variable List* following this summary.

Step 2. Run the BLAST Program

Run BLAST as normal. Specify the correct input file and a weather file, if necessary. This will create one file with an ".rwd" extension for every weather environment (design days, annual runs) in the input file. Remember that these files should be copied or renamed so that they are not overwritten the next time BLAST is executed. See the *Report Writer in BLAST* section of this document for more information on the results of a BLAST run. See the *BLAST Installation Guide* for more information on running BLAST.

Step 3. Create the Report Writer Command File

The Report Writer command file (COMINP.DAT) tells the Report Writer program what functions are to be performed and how the data is to be manipulated. Remember that this file can be created using either HBLC, the Report Writer File Generator program, or a text editor. Use the correct names for the input data files. These are the output data files created by the BLAST run with the ".rwd" extensions For more information on creating a command file for Report Writer, see the *Report Writer (Stand-Alone)* section of this document.

Step 4. Run Report Writer New Version

HBLC users simply click on "Create Report". For non-HBLC users, executing the Report Writer is also very simple. On an IBM compatible machine, choose **REPWRT** from the DoBLAST interface. This will create the output files that were specified in the command file. See the *Report Writer (Stand-Alone)* section of this document for more information on the Report Writer program.

Step 5. Read the Data into a Spreadsheet

This final step should be fairly simple. Load up the desired spreadsheet program and use its procedures to read in the data file that was created by Report Writer. Consult the particular spreadsheet documentation for more information on reading in data files. HBLC will ask the user whether or not to launch the spreadsheet program and open the report.

Fan System Variable Applicability Chart

Applicability Chart (fan system types listed below)

VARIABLE/TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CCEADB	*	*	*		*	*		*	*	*			*	*	*
CCEAW	*	*	*		*	*		*	*	*			*	*	*
CCLADB	*	*	*		*	*		*	*	*			*	*	*
CCLAW	*	*	*		*	*		*	*	*			*	*	*
CCMFR	*	*	*		*	*		*	*	*			*	*	*
QCC	*	*	*		*	*		*	*	*			*	*	*
HCEADB	*	*	*	*	*	*	*	*	*	*			*	*	*
HCLADB	*					*	*	*	*	*					*
HCLAW	*					*	*	*	*	*					*
HCMFR	*					*	*	*	*	*					*
QHC	*					*	*	*	*	*					*
MXAIRT	*	*	*	*	*	*		*	*	*			*	*	*
MXAIRW	*	*	*	*	*	*		*	*	*			*	*	*
DMXAT	*	*	*	*	*	*		*	*	*			*	*	*
FRACOA	*	*	*	*	*	*		*	*	*	*	*	*	*	*
HUMLW	*	*	*	*	*			*	*	*			*	*	
HUMEGY	*	*	*	*	*			*	*	*			*	*	
WATER	*	*	*	*	*			*	*	*			*	*	
DXPWR						*									
HTRCPQ	*	*	*	*	*			*	*	*			*	*	*
QHTREC	*	*	*	*	*			*	*	*			*	*	*
QPRHT	*	*	*	*	*			*	*	*			*	*	
SFNPWR	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
RFNPWR	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
EFNPWR	*	*	*	*	*			*	*	*	*	*	*	*	*
SMASS	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SMASR	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SMASE	*	*	*	*	*			*	*	*	*	*	*	*	*
SRAW	*	*	*	*	*	*	*	*	*	*			*	*	*
SRAT	*	*	*	*	*	*	*	*	*	*			*	*	*
AHSLD(IHOUR,1)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AHSLD(IHOUR,2)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AHSLD(IHOUR,3)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
AHSLD(IHOUR,4)	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
TLMIN															*
TLMAX															*
TNMIN															*
TNMAX															*
TTMIN															*
TTMAX															*
NTWKT															*
LPELEC															*
SUPHLD															*
SUPCLD															*
TOWLOD															*

• Indicates parameter is valid for the system

TYPE 1: MULTIZONE
TYPE2: TERMINAL REHEAT
TYPE3: VARIABLE VOLUME
TYPE4: UNIT VENTILATOR
TYPE5: SUBZONE REHEAT
TYPE6: DX PACKAGE UNIT
TYPE7: UNIT HEATER
TYPE8: THREE DECK MULTIZONE
TYPE9: DUAL DUCT VAV
TYPE10: SINGLE ZONE DRAW
TYPE11: TWO PIPE FAN COIL
TYPE12: FOUR PIPE FAN COIL
TYPE13: TWO PIPE INDUCTION
TYPE14: FOUR PIPE INDUCTION
TYPE 15: WATER LOOP HEAT PUMP

Adding Report Writer Variables to BLAST

Editor's Note: It is not possible to add Report Writer variables to BLAST without recompiling the BLAST code. BLAST source code is included on the BLAST CD-ROM.

A great deal of care has been taken in order to make the Report Writer capabilities of BLAST as easy as possible to use. Most of the Report Writer code that was added to BLAST is listed in rwrite.ftn. In the case of new subroutines, a good number of comments have been included in the code so that it is easier to read. In the same vein, the addition of new variables to Report Writer BLAST should also be fairly simple. The code has been written so that the post-programmer will need to know almost nothing of how Report Writer works internally to add variables to the current list that is already available. In fact, one does not even need to have a great knowledge of FORTRAN to add variables to BLAST. However, careless users who do not follow the directions outlined in this section can cause the program to lose its functionality very quickly. Backup copies of files should be made before modifying the BLAST code. The BLAST Support Office does not accept the responsibility for users who do not follow the procedures outlined in this section.

Addition of Variables

There are two main sections of the Report Writer code addition that must be modified in order to add Report Writer variables to BLAST. The modifications that deal with Report Writer have been coded with a "MOD148" or "MOD183" label. The two sections of the code that must be changed to add variables will be discussed below.

Increasing the Array Sizes

The arrays used by Report Writer have been sized so that no extra or blank elements are present. Thus, every time a new variable is added, the relevant arrays must be increased in size. Each of the four main types of variables (surface temperatures not included) has three main arrays and one variable counter associated with them. For example, the zone variables have the following arrays and counter variable: RWZNVA, RWZNVN, RWZNVD, and RWNZNV. All of these are described in bld5.ftn. To add **one** zone variable, the following changes would have to be made to the zone arrays:

1.) Increase the second dimension of the logical array, RWZNVA, from "31" to "32" in line 15 of rwvctl.inc.

2.) Increase the dimension of both RWZNVN and RWZNVD in lines 23 and 24 of rwvctl.inc from "31" to "32".

3.) Add one to RWNZNV in the data statement shown on line 839 of bld5.ftn. In other words, change the "31" on this line to "32".

4.) Increase the number in line 840 of bld5.ftn from "3100" to "3200". This is the number of elements in this two-dimensional array (number of zones possible, 100, multiplied by the number of zone variables, now 32).

5.) Add the name of the variable in BLAST to the list of zone variable names (RWZNVN) that starts on line 852 of bld5.ftn. To do this, follow the structure of that statement and add the new variable's name to the end of the list before the "/" on line 858 of bld5.ftn. The name must be 6 letters long (pad the name with spaces if it is shorter), be enclosed in single quotes, and be preceded by a new comma to set it off from the previous name.

6.) Add the variable's description to the RWZNVD array data statement. The data for RWZNVD starts on line 877 of bld5.ftn. Follow the pattern established by the previous lines. The new line should be added after line 909 of bld5.ftn. Note that the counter in line 898 will have to be incremented from "31" to "32". Also note that FORTRAN only allows up to 19 continuation lines. Thus, the variable description arrays must be broken down into blocks of 20.

Please note that any references to line numbers in the preceding section are approximations. The changes that are necessary to add other types of variables (fan system, zone in fan system, or central plant) are essentially the same except that the other arrays would be modified. If there is any doubt as to how this would work, contact the BLAST Support Office.

Modifying the Printing Routines

In the previous section, all of the necessary changes to the Report Writer arrays were accomplished. The only other change that must be made is adding a printing line in one of the three printing routines (subroutines RWPZNV, RWPFSV, and RWPCPV). These three routines are called for each hour of a (load, system, or plant) simulation that Report Writer data is needed. Only three routines are necessary because the zone routine will also print out the surface temperatures and the system routine will print out the zone in fan system variables. These three subroutines can be found in rwrite.ftn. The structures of these subroutines are all similar and fairly straightforward. In the previous section, the addition of a zone variable was discussed. This discussion will continue in this section.

To allow the new zone variable to print, another line that is similar to the one shown in line 388 of rwrite.ftn needs to be added after line 388 but before line 389 which is a CONTINUE statement for a loop. Basically, the new line must have a "32" instead of a "31", and the new variable must replace "QBBRAD". The "CNVE" is a conversion function (for energy) that is used to convert the output into the correct units. This must also be replaced by the proper conversion subroutine. Consult the general section of the BLAST code (rout3.ftn) for other conversions. The addition of a plant variable is essentially similar to the addition of a zone variable.

The printing of fan system and zone in fan system variables is slightly different. Due to the fact that certain variables are undefined when the system is "OFF", an extra condition must be placed on those variables during printing. If the system is "OFF", variables that are undefined are "given" the value of -9999 (i.e., a value of -9999 is printed out for the variable). Otherwise, if the system is "ON", the variable is defined and is printed out normally. Thus, when adding a system variable, check on whether or not the variable is defined when the system is "OFF". If it is undefined, follow the expanded printing structure as shown for fan system variable number 1 (CCEADB). If it is defined, use the same structure as for a zone variable. A brief study of the printing subroutines should make these paragraphs clearer.

Creating a New Version of BLAST

After the changes outlined above have been implemented, the user is ready to compile a new version of BLAST. Compile BLAST as you normally would after other changes have been made to the BLAST code. If you have never compiled BLAST on your own before, consult your compiler and system manual.

Testing BLAST Changes

Additions to the Report Writer BLAST code should always be thoroughly tested. This means that not only does the variable print out but the values being printed out are reasonable for that variable. Variables in BLAST are not always clear-cut. Thus, caution should be used when adding variables. This, however, is one advantage of having the Report Writer capabilities in BLAST. Variables that previously were not fully understood can now be deciphered using Report Writer. In addition to testing the BLAST code after variables have been added, the programmer should also complete the final step of running the data files through the Report Writer New Version program. This can sometimes reveal subtle errors that were not noticed when viewing the data files.

WIFE and Weather Tape Manual

Introduction to the WIFE program

The Weather Information File Encoder (WIFE) program processes weather data tapes to produce files containing surface and solar data in the form used by the BLAST program. Original raw data tapes come from the National Climatic Center of National Oceanic and Atmospheric Agency (NOAA), and other sources. WIFE has the ability to read the following raw (or unprocessed) weather file formats:

BLAST ASCII

1440, T1440

DATSAV

280, T280 solar radiation tapes

TRY(Test Reference Year)

TMY(Test Meteorological Year)

SOLMET

OTHER

The processed weather files which BLAST uses are not user readable, however, there are several reporting options in WIFE which can be used so that WIFE will report statistics on dry bulb temperature, wet bulb temperature, beam solar radiation, etc. on an hourly, daily, or monthly basis.

WIFE Functions

The WIFE program has three basic functions: to create processed weather files for running BLAST, to modify existing weather files, and to report the status of the data contained on the raw weather file. HBLC will prompt the user to select a mode when accessing WIFE through the "Other Programs" tab of the menu bar.

Create **-** This is used to process a raw weather data file into a format that BLAST can read.

Modify - This is used to modify an existing processed weather file. Modifications include replacing the existing holidays, special, or daylight savings time period with new values.

Report - A **REPORT** command is available for producing output reports which give weather information such as dry bulb temperature, wet bulb temperature, barometric pressure, wind speed, sky temperature, and solar radiation, on an hourly, daily, or monthly basis; as well as calendar information which shows special days and holidays.

General Syntax Rules

In order to use WIFE, the user must create a WIFE input file. The syntax rules for generating a WIFE input file are very simple. The following sections explain syntax for various commands. Commands are combined within an input file with two very simple rules:

1). order is not important for WIFE input file commands, but the user should structure the input file to be easily read, and always use the same type of structure. This will make it easier in the future if something in the input file needs to be changed.

2). between each command statement the user must place either a comma or a semicolon. This is how the program separates each command.

Section 2 explains in detail how input files should be constructed in order to create and modify BLAST readable weather files. The table below may be used as a reference for specific usage questions.

Command Syntax	**Allowable Abbreviations**	**See Section**
TITLE = *"title for output WTHRFL"*		Creating Processed Weather for BLAST
*DATE REQUEST TYPE *= single date THRU single date*		Creating Processed Weather for BLAST, Reports, Holiday and Daylight Savings Time
YEAR = *year*	YR = *year*	Creating Processed Weather for BLAST
LATITUDE = *number*	LAT =*number*	Creating Processed Weather for BLAST
LONGITUDE = *number*	LONG = *number*	Creating Processed Weather for BLAST
TIME ZONE = *number*	TIME = *number*, TIME ZONES = *number*,	Creating Processed Weather for BLAST
TAPE = *(tape type, station #)*	TAP = *(tape type, station #)*	Creating Processed Weather for BLAST, Tape Types Used with WIFE
UNITS	UNIT	Reports
ENGLISH	ENG	Reports
METRIC	MET	Reports

REPORT	REP, SUMMARY	Creating Processed Weather for BLAST, Modifying Processed Weather for BLAST
DAILY HOURLY	DAY, DETAILS FROM, THRU	Reports
CALENDAR = *single date THRU single date*		Reports
MODIFY	MOD	Modifying Processed Weather for BLAST
DEFAULTS	DEF, DFLTS	Defaults for Holidays and Daylight Savings Time

**Date Request Type can be RUN, SPECIAL (1-4), HOURLY, DAILY, DAYLIGHT, HOLIDAY, or CALENDAR*

Table 90. WIFE syntax simplifications

WIFE Program Files

Each of the above functions requires that different files be available. The user should be familiar with the usage of the following files:

***PROJ*.WIN -** This is the WIFE input file, and must be all capital letters. It contains instructions for WIFE, and it must be present.

The WIFE input file (written by the user) consists of a set of commands that tells WIFE how to process the raw data file. The commands can appear in any order, but must be separated by commas or semicolons. White space is ignored (spaces, tabs, carriage returns, etc.).

Commands fall into two categories: report commands and generation or modification commands. Report commands control what is written to the output file (**wot**). Generation/modification commands direct the translation of the raw weather data file (**dat**) into the processed weather file (**wea**).

Certain information is required during the creation process (e.g., tape type, station number, requested run period, latitude, and longitude). Additionally, the user may input calendar-type data (such as holidays) and request reports. During modification, only calendar data are changed on the existing **wea**; thus, commands specifying tape type, latitude, etc. are ignored. If only reports are being made from an existing **wea**, then input calendar data are ignored.

***PROJ*.WOT -** WIFE will always create a report output file. This text file is the only user-readable output that WIFE produces. It contains all of the pertinent information relating to the processing of the **dat** file, such as which days on the weather file contain insufficient data**,** etc.

***PROJ*.DAT -** This is the raw weather data file. It may be in one of several standard formats obtained from several sources such as NOAA (the National Oceanic and Atmospheric Agency). This file must exist if the user is creating a new processed weather file from raw data.

***PROJ*.S280 -** This file contains "solar 280" raw weather data. This data is optional and is used to supplement some of the raw data files. The use of this file must be consistent with the instructions in the WIFE input file.

NOTE: 280 tapes may not be used with TMY and SOLMET tapes.

OLWTHR - This file is an existing processed weather file, which has been created by WIFE during a previous run. This file must exist if the user is producing summary reports of an existing processed weather file or if the user is creating a new weather file by modifying an existing one. Either **olwthr** or **dat** must exist, but never both.

WTHRFL - This is the processed weather file that is used by BLAST. This file is created by WIFE, and should never exist at the beginning of execution.

Step by Step Procedures for Running WIFE

Creating Processed Weather for BLAST

When creating a processed weather file, two input files are required; and two output files are created by WIFE.

Input Files

***proj*.win** (user written input file, all capital letters)

***proj*.dat** (raw weather data)

Output Files

***proj*.wot** (user readable output file)

***proj*.wea** (processed weather file to be read by BLAST)

The following steps should be followed to create a BLAST readable weather file.

Step 1: Create a WIFE Input File

The first step in creating a processed weather file for BLAST is creating an input file for WIFE. The following sample ***proj*.win** file contains the minimum amount of information necessary (exception is TMY2 type), with exception of the ***REPORT*** command:

```
TITLE = "Name of weather file site(Place,State/Country), and raw
data format type(TMY,TRY,DATSAV...)",
LAT = latitude, LONG = longitude, TIME = timezone,
TAPE = (tapetype,station #), YEAR = year of tape,
RUN = rundates, REPORT,
```

The commands above (except Report) are usually necessary (depending on "tapetype") for an input file made for creating a processed weather file where:

"Name of weather file site(Place,State/Country), and raw data format type(TMY,TRY,DATSAV...)" briefly describes the contents of the weather file. There is a 40 character limit for this title which must be in capital letters only (no lowercase letters). When a processed weather file is run with BLAST, the title is printed throughout the BLAST output reports to indicate the environment that was used. This is only for the user's convenience, any title will do. When processing TMY2 data, WIFE will automatically use the information contained on the TMY2 data file and overwrite anything entered here.

latitude **-** Is a real or integer number which indicates the latitude of the weather data (-90 _ lat _ 90). Latitudes in the Northern hemisphere are positive and latitudes in the Southern hemisphere are negative. When processing TMY2 data, Wife will use the latitude from the TMY2 data file and overwrite anything entered here.

longitude **-** Is a real or integer number which indicates the longitude of the weather data (-360 _ long _ 360). Longitude is numbered positively moving west from the Greenwich Meridian. When processing TMY2 data, Wife will use the longitude from the TMY2 data file and overwrite anything entered here.

timezone - Is an integer number which indicates the time zone of the weather data (1 to 24). Time zones are numbered moving west from the Greenwich Meridian. When processing TMY2 data, Wife will use the timezone from the TMY2 data file and overwrite anything entered here.

tape type - Specifies the tape type. Valid tape types are: BLAST ASCII, T1440, 1440, DATSAV, S280, T28, TRY, TMY,OTHER, SOLMET, See sections 4.1, 4.2, and 4.4 for a description of what these tape types signify. Note that one tape type signifies a tape format and may encompass more than one actual tape type.

station # - Specifies the 5 digit WBAN number supplied on a particular tape. If the number on the tape is longer than 5 digits, use on only the first five. When processing TMY2 data, Wife will use the station # data from the TMY2 data file and overwrite anything entered here.

year - Is the year the tape was made; to be selected from raw data. Neither TMY or TMY2 data processing require this field.

*rundate*s - Specifies run period. Default = 01JAN THRU 31DEC. However, this can be set to any length by the user, using the format shown above. Weather files do not always start on 01JAN, and the year set in the input file must correspond with the year of the starting date for the run period.

REPORT - (Optional) **REPORT** is one of several reporting options which specify the information sent to WIFE's output file, ***proj*.wot**. See section 3.1 for a further discussion of report options and the information they provide. If no report is specified **REPORT** is the default .

An example ***proj*.win** file follows:

```
TITLE = "ZURICH, SWITZERLAND   RYD",
LAT = 47.48, LONG = 8.53, TIME =23,
TAPE = (DATSAV, 06670), YEAR = 1980,
RUN = FROM 01NOV THRU 31OCT,
REPORT,
```

Required data for TMY2 files:

```
TAPE = (TMY2, 12345),
RUN = FROM 01NOV THRU 31OCT,
```

Step 2: Run WIFE

To run Wife you must have the **.win** and **.dat** files available then follow the instructions given in the 'Running WIFE' section of your BLAST installation guide. WIFE can easily be run from HBLC.

Modifying Processed Weather for BLAST

If a processed (BLAST readable) weather file needs to be modified the user may change the parameters of the WIFE input file to get the desired results. In order to inform WIFE that you are using a processed file you must use the **MODIFY** command. A processed weather file can be modified to make changes to the parameters listed below. Additional information on all available options for these parameters and the correct command syntax is given in sections on Reports and Holiday and Daylight Savings Time.

holidays

daylight savings time

special days

reports

The **MODIFY** command cannot be used to change the six main parameters of the ***proj*.win** that define a processed weather file. In order to change these parameters (listed below), the processed weather file would have to be recreated from raw data as in section 2.1.

TITLE

LAT

LONG

TIME, **TAPE**

YEAR

RUN

The following steps should be followed to create a BLAST readable weather file.

Step 1: Create a WIFE Input File

The following type of input file is used to modify a processed weather file.

```
MODIFY,report options,
daytype options,
```

The **MODIFY** command is followed by a list options the user wishes to use, here:

report options **-** is a combination of the options used to specify the weather file information (reports), or calendar information the user is interested in. See section 3.1 for more information on reports.

daytype options **-** is a combination of options which is used to specify time periods for holidays, daylight savings time, and special days. See section 3.2 for more information on these options.

An example ***proj*.win** file follows:

```
MODIFY,
SPECIAL1 = FROM 1 APR THRU 15 APR,
SPECIAL2 = 13 MAR, CALENDAR, DEFAULTS,
REPORT, DAILY, UNITS (ENGLISH),
HOURLY = FROM 1 JAN THRU 5 JAN,
```

For more explanation concerning the commands used above, see sections 3.1 and 3.2.

Step 2: Run WIFE

To run WIFE you will need the previously processed weather file (***proj*.wea**), and your WIFE input file (***proj*.win**). Then run WIFE following the instructions in your BLAST installation manual.

Using WIFE for Reporting Weather Statistics

Reports are used to find out selected characteristics of the weather file being used. Several reports can be generated by WIFE when processing raw weather data, or when using the modify command on a processed weather file, as in the previous examples. See section 3.1 for more information on report capabilities in WIFE.

WIFE Features

Reports

Report commands can be used when creating or modifying a processed weather file, and determine what will be present in the output file (***proj*.wot**). Report commands are used to:

1. Specify units. Units are either metric or English
2. Determine the frequency of the information recorded in the ***proj*.wot** file. Reports are produced as one line per hour, per day, or per month. They can be broken out so that a block of one line per hour/day is printed, and then the program reverts back so that one line per day/month is printed (see example below). The user can specify all of the reports at once, or none at all depending on need.
3. To make a calendar of Special Days, Holidays and daylight savings time in the ***proj*.wot** file.

The following commands will produce output as described:

UNITS *(METRIC|ENGLISH),* **-** Metric **-** Output units are expressed in SI units. English **-** Default output units are expressed in English units. [default]

REPORT, - A one line per month report is produced. This is the default if no report is specified.

DAILY = *date request* **-** A daily report is requested (1 line per day), (implies REPORT). **DAILY** = *date request,* An hourly report (1 line per hour) is produced for a specified date. The following is an example, DAILY= 19MAR. See section 3.3 for *date request* syntax.

HOURLY = *date request,* **-** An hourly report (1 line per hour) is produced for a specified date or block of dates.

Examples, **HOURLY = FROM 12JUL THRU 19JUL. HOURLY = 19MAR.**

See Section "Specifying Dates in WIFE" for *date request* syntax.

CALENDAR - A calendar is produced showing months, days, Holidays, special days, and daylight savings time period.

The commands are used in a WIFE input file as illustrated below. This example instructs WIFE to report one line per day, and one line per month for the whole year. WIFE would report one line per hour from Jan 1st through Jan 5th, and produce a calender for the year showing daylight savings time, holidays and special days. The **DEFAULTS** command selects the default holiday list and specifies the daylight savings time date as shown in the next section “Holiday and Daylight Savings Time”. These commands can be added to your ***proj*.win** file when you are creating a processes weather file, or when you are running a modify run.

```
REPORT, UNITS(ENGLISH),DEFAULTS,
CALENDAR, DAILY,
HOURLY=FROM 1JAN THRU 5JAN,
```

If no report commands are given the following defaults are used by WIFE:

```
UNITS(ENGLISH)
REPORT
```

Holiday and Daylight Savings Time

Day Types

Day types in a processed weather file are used by BLAST to trigger various schedule profiles for indicated dates. Scheduled profiles are defined in the BLAST input deck, and assigned to specified dates in WIFE. For example, suppose the user has defined Monday through Friday to have the same profiles, and Saturday and Sunday to have another profile. If you want to specify a special day, such as New Years day, to have the same profile as Saturday and Sunday, you would use the following syntax in your WIFE input file: SUNDAY**=01JAN**. If this is a bit confusing, you can assign Sunday's profile to a **SPECIAL1** variable (in your BLAST input deck), and use the following WIFE input statement: SPECIAL1**=01JAN**. In short, WIFE allows a BLAST user to define which days of the year are special, and in the BLAST input deck the user defines his special day profile. **SPECIAL** day types can also be used to allow for special events that require certain schedules.

The valid day types, and their abbreviations, are:

HOLIDAY	(HOL)
SPECIAL1	(SP1)
SPECIAL2	(SP2)
SPECIAL3	(SP3)
SPECIAL4	(SP4)
DAYLIGHT	(DST): daylight savings time period.

For example:

```
HOLIDAY = 3RD MONDAY IN FEBRUARY,
SPECIAL1 = FROM 1AUG THRU 15AUG,
DST = FROM LAST SUN IN APR THRU LAST SUN IN OCT,
HOURLY = FROM LAST SUN IN APR THRU 5MAY,
```

Here **HOLIDAY** and **SPECIAL1** have profiles previously assigned in the BLAST input deck. See section “Specifying Dates in WIFE” for Syntax rules applying to these commands.

Defaults for Holidays and Daylight Savings Time

Specifying **DEFAULTS** results in the following holidays and daylight savings time period:

Holidays

January 1 (or Friday preceding or Monday succeeding)

November 11 (or Friday preceding or Monday succeeding)

December 25 (or Friday preceding or Monday succeeding)

July 4 (or Friday preceding or Monday succeeding)

Third Monday in February

Last Monday in May

First Monday in September

Second Monday in October

Fourth Thursday in November

Daylight Savings Time

Last Sunday in April through last Saturday in October.

Note: If the user wants these holidays he should place DEFAULTS in the input file. However, if the user does not want these holidays and Daylight Savings Time, then the DEFAULTS statement should not be used in the input. This allows the user to define his own holidays, special days, and Daylight Savings Time without having the original holidays interfere.

Specifying Dates in WIFE

Date forms are used to specify run periods, holidays, special day types, daylight savings time period, and hourly report dates. Names of months and days of the week can be spelled out, or abbreviated using the conventional 3 letter abbreviations associated with them. Dates can be specified in four different ways, depending on the commands you are using:

1). Using a specific day and month, e.g. **1JAN** or **1JANUARY**. There can not be a space between the day of the month, and the month.

2). Using only numbers, e.g. **1/2** (February 1st).

3). Specifying a certain day in a time period, e.g., **2ND TUES IN APR or 2ND TUESDAY IN APRIL**, meaning the second Tuesday in April.

4). Specifying by position, e.g., **LAST SUN IN APR** or **FINAL** S**UNDAY OF APRIL**, meaning the last Sunday in April.

Holidays, Special Day Types, and Hourly Reports:

The user enters holiday, special day types, or hourly report requests as:

REQUEST = single date

or

REQUEST = **FROM** single date **THRU** single date

Where *single date* is in any of the formats described above, and *REQUEST* is any of the following **SPECIAL[1-4] (SP[1-4])**, **HOLIDAY (HOL)**, **HOURLY (HR)**, **DAYLIGHT (DST), DAILY, CALENDAR**, **CAL**, **CALNDR.**

Run Periods

For the run period (used in creating a new processed weather file), only simple dates of the same format as points 1 and 2 in the previous section are allowed. For example

```
RUN=FROM 1JAN THRU 31DEC
RUN=1JAN
DST=FROM 31OCT THRU 31APR
```

Weather Tapes

Tape Types Used with WIFE

Weather tapes come from various different sources, have different formats, different information, and are made using different methods of data acquisitions. Sometimes a particular tape type has better information for the type of simulation you are doing. The list under 'Acceptable WIFE Tape Type' column in the chart below defines the tapetype syntax for the **TAPE =** command in WIFE. The 'Description of Tape Type' column describes the type of tapes which use the particular syntax.

Acceptable WIFE Tape Type	Description of Tape Type
1440, T1440	NOAA TDF-1440.
TRY	NOAA Test Reference Year (TRY).
TRY (WYEC)	ASHRAE WYEC weather tapes have the same format as TRY tapes.
TMY	NOAA Typical Meteorological Year (TMY).
SOLMET	NOAA Solar Radiation (SOLMET).
280, T28	Solar Radiation 280 tapes. (must be used in conjunction with TMY and SOLMET tapes)
DATSAV	U.S. Air Force ETAC old BEAPS format
BEAPS	U.S. Air Force ETAC new BEAPS format with solar data.
OTHER	User-defined tape.
ASCII	ASCII weather files are made using previously processed WIFE files converted to ASCII format
TMY2	TMY2 Typical Meteorological Year data published from NREL

Table 91. Descriptions of compatible weather file formats

Data Acquisition Methods for Weather Files

The types of the files above (with exception of **OTHER**, **ASCII**, and **DATSAV**) also refer to how the weather data on the tapes was gathered and compiled. The following definitions are designed to provide the reader with a better understanding of how their specific data has been gathered or derived. Reference for the following information (with exception of **OTHER** and **ASCII,** and **BEAPS**) is the ASHRAE Fundamentals 1989, p. F24.3 **-** F24.4.

1440 - U.S. Weather Service 1440 weather data tapes. These tapes are compiled by taking one year of actual weather data.

TRY - Test Reference Year taxes were prepared by National Climatic Data Center. They consist of 8760 hours of data from 27 years of 1440 series data tapes. One year is determined by eliminating extreme months in order of importance until only one year remains. This format does not necessarily represent the long-term mean.

TMY - Test Meteorological Year tapes were prepared using the 1440 tapes from the years between 1954, and 1972. One years worth of data is weighted using nine key indices: total horizontal radiation, maximum, minimum, and mean of dry bulb and dew point, and the maximum and mean of the wind speed. These indices were weighted as follows, 50% of importance is based on solar data, one-sixth dry bulb, one-sixth dewpoint, and one-sixth wind velocity. Twelve typical months were then chosen based on their closeness to the long-term cumulative distribution functions. Discontinuities between months were machine smoothed.

SOLMET - Solmet tapes are the weather tapes from which the TMY format is created. SOLMET tapes are the actual weather tapes from the years 1954 through 1972 for 26 U.S. stations, containing both climate and solar data.

280, **T28 -** Solar Radiation tapes.

DATSAV(RYD) - DATSAV files are produced using RYD (Reference Year Data) and formatted with old BEAPS format. Reference Year Data is obtained by using a computer program called CEARY (Computerized Energy Analysis Reference Year). This program searches through the available weather data and finds the 12 consecutive months that are most representative of the long-term mean of the dry bulb temperature, based upon the lowest root-mean-square error (RSME). This method was designed to replace the TRY format. (ref. correspondence with USAFETAC/ECE). This format does not include solar data.

BEAPS - (New) BEAPS files are the same as DATSAV (old BEAPS above) except that BEAPS files include solar data.

TRY (WYEC) **-** ASHRAE WYEC weather tapes have the same format as TRY tapes, and therefore can be read in by WIFE using the same routines. However these tapes are created differently from TRY tapes. WYEC tapes consist of composite weather data from several years. To process using WIFE, the dates must be modified so that all dates have the same year.

OTHER - WIFE may be used to process any user-defined tape. These 'non-standard' weather data files may be processed by specifying tape type "OTHER" and modifying subroutine RDOTH as needed. The RDOTH routine contains instructions on modifications necessary to read customized weather data formats. Additional help may be obtained by looking at subroutines RDTRY, RDTMY, RD1440, RD280, RDSOLM, and RDDATS. These routines provide good examples of how a WIFE "RD" routine should look. Since the processed weather file is a binary file, the same compiler that was used for the BLAST code needs to be used for the WIFE code, or a converter must be used. If you do not have source code, and would like to process a 'non-standard' tape please contact the BLAST Support Office for information on WIFE source code and compilers currently used by the BSO..

ASCII - ASCII data files are previously processed weather files (for BLAST) which have been reconverted into a an ASCII format which is readable by WIFE. The original weather data from which BLAST ASCII weather files originate can be any of the other tape types mentioned above. Only information needed by BLAST remains in this file (any information in the above files that is not necessary for BLAST is discarded).

TMY2 - WIFE can process the TMY2 data published from the National Renewable Energy Laboratory (NREL) in 1995. TMY2 data is derived from the 1961-1990 National Solar Radiation Data Base. TMY2 data are based on more recent and accurate data than the TMY data. "Their intended use is for computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different system types, configurations, and locations in the United States and its territories. Because they represent typical rather than extreme conditions, they are not suited for designing systems to meet the worst-case conditions occuring at a location." (User's Manual for TMY2s, NREL, June 1995). Because of the format of the TMY2 files, WIFE can accept less input than for other types. (Specifically, LAT, LONG, TIME, TITLE are not required. Nor is a specific Station number – all of this is supplied on the TMY2 file).

BSO Weather Tape Library

The BLAST Support Office has an extensive library of WIFE processed and BLAST ASCII weather files which it distributes to the public. The library is mostly composed of weather files from the United States, but weather files from other countries are also available. Please check the BLAST Catalogue for a listing of available files. The library is constantly growing, so if the file you need is not on our list it would be worthwhile to call or write to see if it has been recently acquired.

The WIFE processed weather files are created with default holidays (See section Holiday and Daylight Savings Time for a listing of default holidays), and English units. An input file is sent out with the processed file to allow you to modify your processed weather file.

BLAST ASCII Format Information

Following is a description of the BLAST ASCII format:

Header Information describing file attributes come first:

Format	Description
FORMAT(A40,1X,2F11.3)	Weather title, latitude, longitude
FORMAT(F6.0,2X,I6,2X,I4,2X,I4)	Time Zone, Weather Station Number, Number of Days, Version Number Where: 1. Time Zone - 0 is GMT, 6 is Central, etc. 2. Version Number - not really used for this application

Table 92. Header information for BLAST ASCII format

Following the header information, twenty-four (24) lines of weather information are shown for each day of the year. The format of each day's data is shown below.

Format	Description
FORMAT(I4,2I2,1X,48I1)	Year, Month, Day of Month, Rain (for each hour), Snow (for each hour) Where: 1. Year - 4 digit year 2. Month - (1=Jan,...,12=Dec) 3. Day of Month - (1,...,31, must be valid for Month) 4. Rain,Snow (0 is none, 1 is yes)
FORMAT(2(8F10.6,/),8F10.6)	Dry Bulb Temperatures for each hour (degrees C)
FORMAT(2(8F10.6,/)8F10.6)	Wet Bulb Temperatures for each hour (degrees C)
FORMAT(3(6F12.5,/)8F10.6)	Barometric Pressure for each hour (Newton/Meters2)
FORMAT(12F6.4,/12F6.4)	Humidity Ratio for each hour
FORMAT(2(8F10.5,/),8F10.5)	Wind Speed for each hour (Meters/Second)

FORMAT(12F6.2,/,12F6.2)	Wind Direction for each hour (Degrees, 0=North, 90=East, 180=South, 270=West)
FORMAT(2(8F10.5,/),8F10.5)	Beam for each hour (Watts/Meters²) (normal to rays)
FORMAT(2(8F10.5,/),8F10.5)	Diffuse for each hour (Watts/Meters²) (global)

Table 93. Weather information for BLAST ASCII format

Examples

WIN Examples:

1. Creation run with special day period, hourly reports, using a SOLMET raw data tape:

```
TITLE = "** SOLMET ** FORT WORTH, TEXAS",
LAT = 32.75, LONG = 97.33, TIME = 6,
TAPE = (SOLMET, 03927), YEAR = 1970,
RUN = FROM 1 JAN THRU 31 DEC, REPORT,
DAILY, UNITS (ENGLISH), DEFAULTS,
SPECIAL1 = FROM 1ST SUNDAY IN AUGUST THRU 3RD SUNDAY IN AUGUST,
CALENDAR, HOURLY = FROM 1 JAN THRU 5 JAN,
HOURLY = FROM LAST SUNDAY IN JUNE THRU 1ST SUNDAY IN JULY,
```

2. Typical creation run with hourly reports, using a DATSAV tape generated using RYD method:

```
    TITLE = " ZURICH, SWITZERLAND    RYD",
    TAPE = (DATSAV, 06670),
    TIME=23,LAT=47.48,LONG=8.53,
    YEAR = 1980,
    RUN = FROM 01NOV THRU 310CT,
    HOURLY = FROM 18JUN THRU 23JUN,
    UNITS(METRIC),
    REPORT,DEFAULTS,
```

3. A typical weather file modification run with some reporting:

```
REPORT, DAILY, UNITS (ENGLISH), DEFAULTS,
MODIFY, SPECIAL1 = FROM 1 APR THRU 15 APR,
SPECIAL2 = 13 MAR, CALENDAR,
HOURLY = FROM 1 JAN THRU 5 JAN,
```

4. A typical weather file report generation run:

```
REPORT, DAILY, UNITS (ENGLISH),
HOURLY = FROM 1ST TUESDAY IN SEP THRU 14 SEP,
```

NOTE: *.WIN files must be written in capital letters.

WIFE Output

At beginning of all output files is a copy of the user created input file, which is reprinted verbatim. The information which follows, station number, latitude, longitude, time zone, year, and the run period, is obtained by the user from the raw weather file and put on the input file.

```
TITLE=" DES MOINES/MUNICIPAL, IA ",
TAPE=(ASCII,14933),
TIME= 6,LAT=41.53,LONG= 93.65,
RUN=FROM  1JAN THRU  31DEC,
HOLIDAY=2ND MONDAY IN JULY,
SPECIAL2=04JUL,
UNITS(METRIC),
SPECIAL1=FROM 18JUN THRU 22JUN,
DST=FROM LAST SUN IN APR THRU LAST SUN IN OCT,
YEAR=1979,
DAILY,
HOURLY=FROM 25JUN THRU 29JUN,
CALENDAR,
 STATION 14933 AT LOCATION, LAT=  41.53 LONG=   93.65 TIME ZONE=
6.
 STARTING YEAR= 1979  RUN PERIOD=  1 JAN  THRU  31 DEC
```

Using this reprint of the input file allows the user to determine what will be present in the output file that follows.

Calendar

A calendar is produced if specified in the user input file. This calendar shows the days that are set as special, as well as holidays and daylight savings time. Special days are used in conjunction BLAST and have no bearing on the WIFE ***proj*.wea** file. Below is an example of one month of the calendar output. When calendar is specified, WIFE will print the calendar for the entire year.

In this example, S2 located next to the fourth of July implies that the day is the second special day(s) that the user specified in the input file. The HL located next to the ninth shows that the day has been specified as a holiday. The reader will note that this is normally not a holiday but was specified by the user.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SAT
			July			
1	2	3	4 S2	5	6	
8	9 HL	10	11	12	13	
15	16	17	18	19	20	
22	23	24	25	26	27	
29	30	31				

Table 94. Example calendar

Control of holidays and special days is controlled by using the SPECIAL or HOLIDAY command in the input file.

Hourly Report

An hourly report is specified in the user input for one day, or a set of consecutive days using the hourly command. The following is an example of one day of hourly reporting.

DATE 1/ 1/1986 DAY OF WEEK 4 DST 0 HOL 1 DECLINATION SINE= -.3914 COSINE= 0.9202 EQTIME= -0.0542

0HOUR	RAIN	SNOW	TDB	TWB	BP	OHR	WSPD	WDIR	TSKY	BEAM	DIFF	SRAD
			DEG. F	DEG. F	IN H2O		FT/MIN		DEG. F	BTUH/FT**2	BTUH/FT**2	BTUH/FT**2
1	0	0	39.02	35.78	401.47	0.0038	1771.65	240.0	12.31	0.00	0.00	0.00
2	0	0	39.02	35.78	401.47	0.0038	1555.12	250.0	12.31	0.00	0.00	0.00
3	0	0	39.02	35.78	401.47	0.0038	1771.65	240.0	12.31	0.00	0.00	0.00
4	0	0	37.94	37.23	401.47	0.0047	1771.65	230.0	12.76	0.00	0.00	0.00
5	0	0	37.94	36.77	401.47	0.0045	2204.72	270.0	12.46	0.00	0.00	0.00
6	0	0	35.96	35.28	401.47	0.0043	1988.19	260.0	10.26	0.00	0.00	0.00
7	0	0	37.04	35.08	401.47	0.0040	3110.24	290.0	10.79	0.00	0.00	0.00
8	0	0	35.06	33.14	401.47	0.0037	1771.65	280.0	8.41	0.00	0.01	0.00
9	0	0	37.04	33.13	401.47	0.0032	2204.72	310.0	9.39	33.63	18.17	4.80
10	0	0	39.02	33.57	401.47	0.0029	3326.77	320.0	10.67	142.58	29.84	14.58
11	0	0	39.92	33.72	401.47	0.0028	4035.43	320.0	11.31	167.61	35.83	20.31
12	0	0	41.00	32.61	401.47	0.0021	3326.77	340.0	10.60	177.01	38.73	23.25
13	0	0	42.08	32.75	401.47	0.0019	3818.90	320.0	11.01	176.77	38.65	23.17
14	0	0	42.08	32.30	401.47	0.0017	3110.24	320.0	10.35	166.75	35.59	20.06
15	0	0	42.08	32.07	401.47	0.0016	2677.17	320.0	10.00	140.48	29.41	14.20
16	0	0	41.00	31.87	401.47	0.0018	2204.72	320.0	9.68	119.25	17.39	7.44
17	0	0	39.02	29.25	401.47	0.0012	2893.70	320.0	5.46	0.00	0.00	0.00
18	0	0	37.04	28.21	401.47	0.0013	2677.17	310.0	4.07	0.00	0.00	0.00
19	0	0	35.96	27.56	401.47	0.0013	2204.72	320.0	3.07	0.00	0.00	0.00
20	0	0	35.06	27.01	401.47	0.0013	1771.65	290.0	2.23	0.00	0.00	0.00
21	0	0	34.07	26.40	401.47	0.0013	1771.65	290.0	1.30	0.00	0.00	0.00
22	0	0	33.08	27.22	401.47	0.0018	1988.19	280.0	2.26	0.00	0.00	0.00
23	0	0	33.08	27.22	401.47	0.0018	1771.65	270.0	2.26	0.00	0.00	0.00
24	0	0	29.12	25.26	401.47	0.0020	1122.05	260.0	-0.84	0.00	0.00	0.00

Table 95. One day of hourly weather data

Going across the columns, the report provides

- hour of the day
- rain or snow, 0 means no rain or snow, 1 means rain or snow
- dry bulb and wet bulb temperatures
- barometric temperature
- outside humidity ratio
- wind speed and direction (in degrees)

- temperature of the sky
- beam and diffused radiation

Daily Report

This report is generated by placing the DAILY command in the wife input file. The report provides a daily summary of temperature, heating and cooling degree days, and total radiation. The following is an example of one month of daily reporting.

```
WTHRFL STATISTICS FOR JFK AIRPORT, NEW YORK, NY: RYT,CEARY E     YEAR 1986

MONTH/DAY        TEMPERATURES         DEGREE DAYS        TOTAL
              LOW    HIGH    MEAN    HEATING   COOLING    RADIATION
              DEGREES  FAHRENHEIT                         BTUH/FT**2

    3   1     25.2    41.0    33.1      31.9       0.0      1065.
    3   2     27.1    39.9    33.5      31.5       0.0      1123.
    3   3     28.2    43.0    35.6      29.4       0.0      1001.
    3   4     30.2    43.0    36.6      28.4       0.0       779.
    3   5     35.1    50.0    42.5      22.5       0.0      1363.

    3   6     32.0    45.0    38.5      26.5       0.0       886.
    3   7     17.2    39.0    28.1      36.9       0.0      1197.
    3   8     14.2    30.2    22.2      42.8       0.0      1608.
    3   9     27.1    44.1    35.6      29.4       0.0       796.
    3  10     37.9    51.1    44.5      20.5       0.0      1017.

    3  11     39.0    62.1    50.5      14.5       0.0      1318.
    3  12     30.2    46.0    38.1      26.9       0.0      1185.
    3  13     37.0    42.1    39.6      25.4       0.0       950.
    3  14     39.0    50.0    44.5      20.5       0.0       959.
    3  15     44.1    64.9    54.5      10.5       0.0      1350.

    3  16     45.0    57.9    51.4      13.6       0.0      1157.
    3  17     37.9    48.9    43.4      21.6       0.0      1320.
    3  18     37.9    51.1    44.5      20.5       0.0      1624.
    3  19     43.0    52.0    47.5      17.5       0.0      1004.
    3  20     25.2    59.0    42.1      22.9       0.0      1162.

    3  21     17.2    33.1    25.2      39.8       0.0      1829.
    3  22     25.2    42.1    33.6      31.4       0.0      1844.
    3  23     31.1    44.1    37.6      27.4       0.0      1787.
    3  24     36.0    53.1    44.5      20.5       0.0      1806.
    3  25     31.1    52.0    41.5      23.5       0.0      1892.

    3  26     42.1    59.0    50.5      14.5       0.0      1629.
    3  27     46.0    64.0    55.0      10.0       0.0      1235.
    3  28     42.1    59.0    50.5      14.5       0.0      1882.
    3  29     43.0    61.0    52.0      13.0       0.0      1863.
    3  30     44.1    59.0    51.5      13.5       0.0      1872.

    3  31     48.9    73.0    61.0       4.0       0.0      1875.

MONTH SUMMARY
                                            TOTAL          DAILY AVE

    3  **     14.2    73.0    42.2     705.6       0.0      1367.
```

Table 96. One month of daily weather data

Monthly Report

This report is generated by default. It provides a breakdown of high, low, and average temperature, heating and cooling degree days, and daily radiation average for the month. If daily is turned on this report will be one line at the end of each month, otherwise it will be a table containing all months.

MONTH/DAY	TEMPERATURES LOW	HIGH	MEAN	DEGREE DAYS HEATING	COOLING	TOTAL RADIATION
	DEGREES FAHRENHEIT					BTUH/FT**2
1**	-16.1	46.9	17.4	1474.3	0.0	579.
2**	-6.0	50.0	23.9	1150.2	0.0	883.
3**	12.9	70.0	36.2	891.4	0.0	1205.
4**	21.0	86.7	50.7	428.4	0.5	1558.
5**	34.0	82.0	60.7	162.4	28.5	1867.
6**	48.0	91.0	70.2	19.9	176.9	2141.
7**	54.0	91.9	74.2	2.0	286.0	2095.
8**	51.1	98.1	72.0	19.1	237.2	1799.
9**	37.9	90.0	63.0	121.6	61.0	1443.
10**	21.0	84.9	54.1	348.3	10.0	1035.
11**	18.0	66.0	39.6	762.4	0.0	605.
12**	-4.0	57.0	29.0	1114.8	0.0	461.

Table 97. One year of monthly data

Yearly Report

This report is generated by default. It provides a breakdown of high, low, and average temperature, heating and cooling degree days, and daily radiation average for the year.

MONTH/DAY	TEMPERATURES LOW	HIGH	MEAN	DEGREE DAYS HEATING	COOLING	TOTAL RADIATION
	DEGREES CENTIGRADE					W.HR/M**2
****	-16.1	98.1	49.4	6494.7	800.1	1308.
	30 JAN	13 AUG				

Table 98. One year of summarized weather data

Troubleshooting

Bad Data

Thirty consecutive days of bad data will cause the WIFE program to abort. A day of bad data can be caused by the following:

1. end of file markers in the weather data record.
2. less than 4 good dry bulb readings in a day (24 hours).

*The WIFE program will also abort due to a discrepancy between the start and end dates in the WIFE input deck and the dates on the raw weather tape.

When data is missing from the weather tape, or if the data is faulty, WIFE automatically replaces the data by using a trigonometric fit. Solar data contained on the tapes are converted into beam and diffuse radiation components for use by BLAST. If the solar data are bad or not available, WIFE will replace the data by using cloud cover information and default values to determine the solar radiation that is present.

Weather Report

Introduction to Weather Report

The weather checking program, WTHRPT, is a stand-alone utility designed to provide summary statistics for processed BLAST weather files. WTHRPT does not require any previous knowledge of the weather file's contents. It enables users to create winter and summer design days and helps identify erroneous weather files.

Weather Report Input

WTHRPT allows the user to specify reporting units (metric or English), summer months, winter months, peak summer month, and peak winter month. The following transcript shows WTHRPT queries and sample user responses.

```
  Units = English (Y/n)?
n
 This program can report approximate "design day"
 temperatures by viewing the hottest and coldest
 spans.  In the Northern Hemisphere, this can
 be accomplished by looking at Jul - Sep for the
 Summer conditions and Dec - Feb for the Winter.
 In the Southern Hemisphere, this is reversed to
 Dec - Mar for Summer, Jun - Aug for Winter.

 In the following, put in the start Summer month
 and the end Summer month.  Likewise for Winter.
 If you enter zero for the month values, this
 program will use the default values.
 Enter beginning month (Jun = 6) for Summer
6
 Enter ending month for Summer
9
 Enter beginning month for Winter
12
 Enter ending month for Winter
2
 In addition to the span, this program will do
 some special calculations based on which month
 is the design month for Summer and for Winter.
 If you enter zero for the next values, the
 program will use the next month following your
 beginning months entered earlier.
 Enter Summer design month
8
 Enter Winter design month
```

Weather Report Output

The following is a listing of the WTHRPT output file NYCJFK.ROT:

```
1 ** Weather File: JFK AIRPORT, NEW YORK, NY: RYT,CEARY E
    Latitude:  40.65 Longitude:   73.78 Time Zone:  5.0
 ** Year 1985   2677.2  Heating Degree Days    542.4 Cooling Degree Days
  Maximum Temperature Day Occurred on  4 Sep  High values, Drybulb=   33.30  Coincident Wetbulb=  23.91
   Low Drybulb=  22.80  Wind Speed (Avg)=     12.3 Wind Direction= 252.9
   Barometric Pressure= 100000.00  Total Horizontal=    5371.86  Clearness (Avg)=    0.695
  Minimum Temperature Day Occurred on 15 Jan  High values, Drybulb=   -4.90  Coincident Wetbulb=  -8.23
   Low Drybulb= -13.80  Wind Speed (Avg)=     16.6 Wind Direction= 305.4
   Barometric Pressure= 100000.00  Total Horizontal=    2351.96  Clearness (Avg)=    0.846
                                 Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
                                ----   ----   ----   ----   ----   ----   ----   ----   ----   ----   ----   ----
  Avg. Temp. (C) (Drybulb)       0.8   -0.1    5.7   11.0   17.2   21.1   23.6   23.3   20.6   14.7   10.1    1.1
  Avg. Temp. (C) (Wetbulb)      -1.6   -2.1    2.7    7.5   12.9   16.0   19.7   19.4   16.7   11.2    7.7   -1.2

  Avg. Daily Max Temp.           4.7    2.6   10.2   14.9   22.0   25.3   27.4   26.8   24.8   19.0   13.2    4.4
  Avg. Daily Min Temp.          -3.1   -2.9    1.2    7.0   12.4   16.9   19.9   19.8   16.3   10.5    7.0   -2.1
  Avg. Daily Range               7.8    5.5    9.0    7.9    9.6    8.5    7.5    7.0    8.5    8.5    6.2    6.5

  Maximum Temperature (C)       12.8    9.4   22.8   23.3   32.2   33.3   32.8   31.7   33.3   24.4   22.8   12.8
  Minimum Temperature (C)      -13.8   -7.7   -9.9    1.1    6.1    9.4   15.0   16.1    9.4    2.2    1.1   -9.9

  # Days Max  32. and Above                                         2      1             3
  # Days Max   0. and Below      7      6      1                                                              5
  # Days Min   0. and Below     25     21     14                                                             23
  # Days Min -18. and Below

  Avg. Wind Speed (M**3/Sec)    12.7   10.6   12.0   11.3   10.7   11.8    9.0    8.5    8.9    9.5    9.8   12.1
  Avg. Wind Speed (Day)         13.1   10.7   12.8   12.6   12.2   12.8    9.9    9.5    9.7   10.3   10.1   12.6
  Avg. Wind Speed (Night)       12.2   10.5   11.2   10.0    9.2   10.8    8.2    7.5    8.1    8.7    9.6   11.5
  Avg. Wind Direction          236.1  189.3  212.5  182.6  184.0  211.2  181.3  170.2  181.2  177.9  164.3  230.9

  Avg. Temp. (Day)               1.7    0.2    6.9   11.6   18.2   21.8   24.6   24.1   21.9   16.0   10.5    1.9
  Avg. Temp. (Night)             0.3   -0.5    4.2    9.3   14.7   19.6   21.9   22.1   19.2   13.9    9.3    1.1

  Avg. Radiation              1877.0 2519.8 4309.4 5307.4 6704.4 6786.5 6622.5 5773.5 4768.5 3024.7 1886.4 1680.9
  Avg. Clearness                0.68   0.63   0.76   0.72   0.80   0.76   0.78   0.76   0.77   0.68   0.60   0.68
  Avg. Pressure (000)          100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0  100.0

  Avg. Rel. Hum. at  4am        87.7   88.2   89.8   88.4   88.5   82.2   89.2   88.0   89.5   87.8   88.4   86.3
                    10am        83.4   86.2   79.4   77.1   71.4   69.7   73.9   74.5   74.3   76.5   84.2   82.1
```

```
                  4pm        79.1   82.7   77.7   77.4   74.6   67.8   73.7   72.4   72.3   72.7   83.4   78.8
                 10pm        84.2   87.3   86.5   85.8   85.1   76.4   87.1   81.9   84.9   83.5   88.5   82.6
1 ** Weather File: JFK AIRPORT, NEW YORK, NY: RYT,CEARY E
    Latitude:  40.65 Longitude:   73.78 Time Zone:  5.0

 Monthly Average Temperatures as a Function of Hour of the Day
                                Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct    Nov    Dec
             Hour               ----   ----   ----   ----   ----   ----   ----   ----   ----   ----   ----   ----
               0                 0.1   -0.7    3.9    8.9   14.3   19.1   21.6   22.2   18.9   13.7    9.3    0.9
               1                -0.2   -0.9    3.4    8.6   13.9   18.6   21.6   21.7   18.4   13.3    9.1    0.7
               2                -0.3   -1.2    3.3    8.6   13.9   18.2   20.9   21.3   18.0   12.8    9.0    0.6
               3                -0.9   -1.3    3.2    8.4   13.6   18.1   20.7   21.0   17.8   12.3    8.8    0.5
               4                -1.1   -1.4    2.9    8.2   13.2   17.9   20.5   20.7   17.4   11.9    8.7    0.4
               5                -1.4   -1.6    2.8    8.0   13.4   17.7   20.2   20.4   17.2   11.9    8.4    0.4
               6                -1.2   -1.8    2.6    7.9   14.1   18.4   20.9   20.6   17.0   11.8    8.2    0.2
               7                -1.1   -2.1    3.3    8.9   15.6   19.4   22.0   21.8   18.4   12.3    8.2    0.0
               8                -0.9   -1.7    4.5   10.1   17.0   20.4   23.5   23.1   19.8   13.9    8.7    0.3
               9                 0.2   -1.1    5.7   11.0   18.3   21.4   24.8   24.0   21.2   15.3    9.6    1.0
              10                 1.1   -0.4    6.8   12.0   19.5   22.2   25.5   24.7   22.4   16.3   10.4    1.8
              11                 2.1    0.3    8.1   12.5   20.1   23.1   25.9   25.0   23.2   17.1   10.9    2.2
              12                 2.6    0.9    8.6   13.0   20.7   23.7   26.2   25.9   23.9   17.7   11.3    2.7
              13                 3.1    1.3    8.6   13.2   20.9   23.8   26.5   26.2   24.0   18.2   11.5    3.2
              14                 3.3    1.4    8.8   13.5   20.5   24.0   26.7   26.0   23.9   18.2   11.7    3.1
              15                 3.3    1.7    8.8   13.4   20.1   23.9   26.1   25.7   23.8   17.9   11.4    2.9
              16                 2.9    1.4    8.2   12.9   19.0   23.7   25.9   25.4   23.3   17.5   11.0    2.5
              17                 2.1    1.1    7.5   12.7   18.3   23.1   25.7   24.8   22.5   16.7   10.5    2.0
              18                 1.8    0.8    6.5   11.8   17.5   22.5   24.8   24.3   21.5   16.0   10.2    1.8
              19                 1.7    0.8    5.8   11.0   16.4   21.7   24.0   23.5   21.0   15.6   10.0    1.7
              20                 1.5    0.6    5.6   10.5   15.9   20.9   23.0   23.1   20.6   15.1   10.0    1.4
              21                 0.8    0.2    5.3   10.0   15.6   20.7   22.7   22.8   20.2   14.3    9.6    1.3
              22                 0.5   -0.1    4.7    9.6   14.9   20.2   22.3   22.5   19.6   14.0    9.5    1.3
              23                 0.2   -0.3    4.4    9.4   14.8   19.8   21.9   22.1   19.3   13.7    9.4    1.1
1 ** Weather File: JFK AIRPORT, NEW YORK, NY: RYT,CEARY E
    Latitude:  40.65 Longitude:   73.78 Time Zone:  5.0

 Following Design Temperatures based on Normal Spans
 Jun-Sep for Summer,  Dec-Feb for Winter
 Design Temperatures --------------------------------------- Summer ---------- Winter ----------
                                                                Coinc                  Coinc
                             Per Cent                   T(Dry)  T(Wet)         T(Dry)  T(Wet)
                                1.0                        33.     23.           -10.    -13.
                                2.5                        32.     23.            -9.    -11.
                                5.0                        30.     22.

 Following Design Temperatures based on Single Months
 Aug for Summer,  Feb  for Winter
 Design Temperatures --------------------------------------- Summer ---------- Winter ----------
                                                                Coinc                  Coinc
                             Per Cent                   T(Dry)  T(Wet)         T(Dry)  T(Wet)
                                1.0                        31.     25.            -7.     -9.
                                2.5                        31.     25.            -6.     -9.
                                5.0                        30.     23.

 Winter (Lowest) Temperatures                 Summer (Highest) Temperatures
               Dec-Feb    Feb                                     Jun-Sep     Aug
         Temp   Hours     Hours                             Temp   Hours     Hours
          -13       2         0                               33      15         0
          -12       3         0                               32      17         1
          -11       2         0                               31      33        11
          -10       6         0                               30      14         5
           -9       9         0                               29      49        13
           -8      32         0                               28      97        29
           -7      36         6                               27     150        56
           -6      92        26                               26     193        76
           -5      92        30                               25     123        38
           -4      39        17                               24     317       106
```

Using the Weather Report Program

Verification of Weather Tape Design Temperatures

One use for WTHRPT is to check the validity of weather files. If the output is significantly different from known conditions for the location, something might be wrong with the weather file. A comparison between design temperatures based on the information in the weather file and data taken from the *1989 ASHRAE Handbook of Fundamentals* (IP version) is shown below. Values in parentheses are from Chapter 24 of the handbook.

```
 FOLLOWING DESIGN TEMPERATURES BASED ON NORMAL SPANS
 JUL-SEP FOR SUMMER,  DEC-FEB FOR WINTER
 DESIGN TEMPERATURES
                     --------- SUMMER -------------------- WINTER -
---
                                      COINC
COINC
       PER CENT           T(DRY)     T(WET)        T(DRY)
T(WET)
         1.0              93.(94)    74.(75)       -6.(-3)     -
7.
         2.5              91.(92)    73.(74)       -2.( 2)     -
3.
         5.0              90.(89)    72.(74)
```

The 1%, 2.5% and 5% design temperatures reported by WTHRPT are based on a single year of weather data. Since ASHRAE design temperatures are usually based on approximately 15 years of weather data, the Weather File Reporting Program design temperatures should be used for comparison only. In this example, the values from WTHRPT are in good agreement with the ASHRAE design temperatures.

Using Weather Report to Create Temporary Design Days

Output from WTHRPT is useful in generating summer and winter design days for BLAST runs. 2.5% winter and summer design days will be created from the output. An ASHRAE winter design day has a constant low temperature with no solar radiation. For this weather file, this becomes a dry-bulb temperature of -2° F and a wet-bulb of -3° F. No solar radiation mandates that the clearness be 0. A winter design day is usually January 21. For proper scheduling, be sure the type of day (weekday, weekend, holiday, etc.) is correct for the intended use of the design day. The wind speed and direction and the barometric pressure can be obtained from the monthly average. The resultant BLAST design day for a Springfield winter becomes:

```
SPRINGFIELD WINTER
 = (HIGH=-2.00,LOW=-2.00,WB=-3.00,DATE=21JAN,PRES=399.8,
      WS=1158.10,DIR=204.80,CLEARNESS=0.000,WEEKDAY);
```

Creation of a summer design day is similar, except the day has high and low temperatures and a clearness value. The high dry-bulb and mean coincident wet-bulb can be obtained the design temperature section. The wind speed, wind direction, clearness and barometric pressure can be obtained from the monthly averages. The low temperature can be approximated by subtracting the average daily range from the high temperature. In this case, an average range of 20° yields a low of 71° F. The resultant design day is shown below.

```
SPRINGFIELD SUMMER
 = (HIGH=91.00,LOW=71.00,WB=73.00,DATE=21JUL,PRES=399.70,
      WS=756.30,DIR=192.60,CLEARNESS=0.780,WEEKDAY);
```

Additional Comments on WTHRPT Output

The units for average pressure and average radiation are not shown on the output. They are inches of water for average pressure and Btu/hr•ft^2 for average radiation.

The values for wind speed and wind direction have significant digits that imply a degree of accuracy that is not available on all weather tapes. If the weather tape from which the data is taken did not have this degree of accuracy, then insignificant digits should be ignored.

Summary

WTHRPT is an easy-to-use, stand-alone utility that provides summary statistics for processed BLAST weather files. WTHRPT compliments the BLAST family of programs, and is a useful tool for creating design days.

APPENDICES

APPENDIX A--ABSORBTIVITY OF MATERIALS TO SOLAR RADIATION

Reprinted by permission from Thermal Radiation Properties Survey (Honeywell Research Center, Minneapolis, Minnesota, 1966), pp. 245-248.

Table 99. Solar Absorptivity of Selected Building Materials

Material	Solar Absorptivity
BRICKS	
Clay, cream, glazed	0.36
Clay, Felton, dark portion	0.63
Clay, Felton, light portion	0.4
Lime clay, French	0.46
Gault, cream	0.36
Light buff	0.516
Light buff but darker than above	0.6
Mottled purple	0.77
Red	0.699
Red, common and tiles	0.68
Red, wire-cut	0.52
Stafford blue	0.89
Stock, light fawn	0.57
White glazed	0.26
White glazed (2 specimens)	0.25-0.27
TILES	
Clay, purple (dark)	0.82
Clay, dark purple, machine-made	0.81
Red	0.67
Red, hand-made	0.6
Red, light, Dutch	0.43
Red, light, machine-made	0.66
Red, light, machine-made	0.62
Concrete, uncolored	0.65
Concrete, black	0.91
Concrete, dark	0.91
Concrete, brown	0.85
Concrete, brown, very rough	0.88
ASPHALT	
New, 3 specimens	0.91
New, 3 specimens	0.91
New, another specimen	0.93
Pavement	0.852
Pavement, free from dust	0.928
Pavement, weathered, 3 specimens	0.82, 0.83, 0.89

Material	Solar Absorptivity
ROOFING	
Bituminous felt, aluminized	0.4
Bituminous felt	0.88
Bituminous felt	0.89
Bitumin-covered, brown	0.87
Sheet, green	0.86
Sheet, black matte surface	0.97
Sheet, black matte surface	0.97
ASBESTOS CEMENT	
Aged	0.75
Aged 6 months	0.61
Aged 12 months	0.71
Aged 6 years, very dirty	0.83
Red	0.69
Red	0.74
Washed with soap and water	0.4
White	0.61
White (2 samples)	0.49-0.42
LIMESTONE	
Anston	0.6
Bath	0.53
Clipsham	0.46
Indiana	0.571
Ketton	0.42
Portland	0.36
Steetley	0.33
SAND-LIME	
Light-red	0.55
Red	0.68
White, fine sand	0.41
White, coarse sand	0.5
MARBLE	
White	0.44
Ground, unpolished	0.465
Cleavage	0.592
GRANITE	
Reddish	0.55
FELDSPAR	
K2OA12O36SIO2	0.606
MORTAR SCREENED	0.73

Material	Solar Absorptivity
SANDSTONE	
Grey, Bristol pennant	0.76
Polmaise, light fawn	0.54
Stancliffe, light grey	0.62
Woolton, red	0.73
WHITEWASH	
On galvanized iron	0.22
On galvanized iron	0.22
On galvanized iron	0.26
On galvanized iron, a very thick layer	0.22
OTHER MATERIALS	
Thickly tinned surface	0.05
Wood, smoothly planed	0.78
Basalt	0.72
Red sandstone	0.6
Marble (white)	0.58
Granite	0.45
Dolomite lime	0.41
Clay shale	0.69
Paris plaster	0.78
White plastered wall	0.92
Gravel	0.29
Sand	0.76
Glass	0.93
Sawdust	0.75
Clay	0.39
Red brick wall	0.93

Table 100. Solar Absorptivity, Reflectivity, and Transmissivity of Parachute Cloth

Material	Absorptivity	Reflectivity	Transmissivity
Dacron, 100 lb	0.05	0.35	0.60
Dacron, 300 lb	0.11	0.54	0.35
Dacron, 600 lb	0.12	0.61	0.27
Dacron, 800 lb	0.19	0.62	0.19
Nylon rip-stop (orange) 1.1 oz per sq yd, MIL-C-7020B Type I	0.13	0.23	0.64
Nylon rip-stop, 1.1 oz per sq yd (white) MIL-C-7020	0.08	0.27	0.65
Nylon rip-stop, 1.6 oz per sq yd (white) MIL-C-7020B Type III	0.06	0.22	0.72
Nylon cloth 2.25 oz per sq yd, MIL-C-7350B Type I	0.05	0.36	0.59
Nylon cloth 4.30 oz per sq yd, MIL-C-8021 Type I	0.08	0.44	0.48
Nylon cloth 7.0 oz per sq yd, MIL-C-8021 Type II	0.13	0.46	0.41
Nylon cloth 14.0 oz per sq yd, MIL-C-8021 Type III	0.11	0.62	0.27

Table 101. Solar Reflectivity of Selected Types of Cloth

Material	Solar Reflectivity
QM1, cotton sheeting bleached, 4 oz per yd	0.62-0.66
QM2, cotton sateen prepared for dyeing, 9 oz per yd	0.68-0.72
QM4, cotton sateen undyed, 9 oz per yd	0.69-0.72
QM6, cotton sateen, medium gray, 9 oz per yd	0.53
QM7, cotton sateen, dark gray, 9 oz per yd	0.24
50 percent wood, 50 percent cotton knit, undyed, 10.5 oz per yd	0.62

Cotton knit, undyed, 3 oz per yd	0.60

APPENDIX B--LOCATION DATA

Below time zone boundaries in North America and the zone numbers are indicated. The table shows latitude and longitude for 50 major U.S. cities with each state represented.

Time Zone 5 Eastern Standard Time

Time Zone 6 Central Standard Time

Time Zone 7 Mountain Standard Time

Time Zone 8 Pacific Standard Time

Table 102. Latitude and Longitude of Some Major U.S. Cities

State, City	Latitude (Deg N)	Longitude (Deg W)
Alabama, Mobile	30.7	88.03
Alaska, Fairbanks	64.82	147.87
Arizona, Phoenix	33.43	112.02
Arkansas, Little Rock	34.73	92.23
California, San Francisco	37.62	122.38
Colorado, Denver	39.75	104.87
Connecticut, Hartford	41.73	72.65
Delaware, Wilmington	39.67	75.6
Florida, Miami	25.8	80.27
Georgia, Atlanta	33.65	84.43
Hawaii, Helemano	21.53	158.03
Idaho, Boise	43.57	116.22
Illinois, Chicago	41.98	87.9
Indiana, Indianapolis	39.73	86.28
Iowa, Des Moines	41.53	93.65
Kansas, Topeka	39.05	95.68
Kentucky, Louisville	38.18	85.73
Louisiana, New Orleans	29.98	90.25
Maine, Portland	43.65	70.32
Maryland, Baltimore	39.18	76.77
Massachusetts, Cambridge	42.38	71.08
Michigan, Detroit	42.5	83.03
Minnesota, Minneapolis	44.88	93.22
Mississippi, Biloxi	30.4	88.9
Missouri, Columbia	38.82	92.22
Montana, Billings	45.8	108.53
Nebraska, Omaha	41.3	95.9
Nevada, Las Vegas	36.25	115.03
New Hampshire, Concord	43.2	71.5
New Jersey, Trenton	40.27	74.82
New Mexico, Albuquerque	35.05	106.62
New York, New York	40.77	73.9
North Carolina, Charlotte	35.23	80.93
North Dakota, Bismarck	46.77	100.75
Ohio, Dayton	39.9	84.2
Oklahoma, Oklahoma City	35.4	97.6
Oregon, Portland	45.6	122.6
Pennsylvania, Pittsburgh	40.5	80.22
Rhode Island, Providence	41.73	71.43
South Carolina, Charleston	32.9	80.03
South Dakota, Sioux Falls	43.57	96.73
Tennessee, Memphis	35.08	90
Texas, Fort Worth	32.83	97.05
Utah, Salt Lake City	40.77	112.97
Vermont, Burlington	44.47	73.15
Virginia, Norfolk	36.88	76.2
Washington, Seattle	47.45	122.3
West Virginia, Wheeling	40.18	80.65
Wisconsin, Madison	43.13	89.33
Wyoming, Cheyenne	41.15	104.82

APPENDIX C--EARTH TEMPERATURE TABLES FOR UNDERGROUND HEAT DISTRIBUTION SYSTEM DESIGN

The tables in this appendix are from T. Kusuda, *NBSD Computer Program for Heating and Cooling Loads in Buildings*, NBSIR 74-574 (National Bureau of Standards, November 1974). They were developed by applying monthly average temperatures prepared by the U.S. Weather Bureau for many localities in the United States to a technique described in the *Earth Temperature and Thermal Diffusivity at Selected Stations in the United States* by T. Kusuda and P.R. Achenbach (ASHRAE, 1965). These temperature data are, however, for the undisturbed earth. The earth temperature immediately under the building may be estimated by taking an arithmetic average of the building temperature and the design earth temperature found in the appropriate table.

For example, the ground temperature for a building in Washington, D. C. should be estimated as follows:

Select the soil condition (e.g., average soil), season (e.g., summer), and the nearest site (e.g., Upper Marlboro, MD) from the following tables. These give a summer average earth temperature of 66°F (18°C).

Select a building temperature (e.g., 72°F [22°C]) and use it to compute the required summer ground temperature for BLAST. In this case: 0.5(66+72) = 60°F (18°C).

Compute temperature for other seasons similarly and interpolate to determine all twelve monthly temperatures.

Table 103. Dry Soil, AVERAGE EARTH TEMPERATURE IN DEG. F., TG

STATION	STATE	WINTER	SPRING	SUMMER	FALL	YEAR
AUBURN	AL	60	61	71	70	65
DECATUR	AL	52	54	65	65	59
PALMER AAES	AK	31	31	42	41	36
TEMPE	AZ	62	64	73	74	68
TUCSON	AZ	68	69	77	79	73
BRAWLEY	CA	70	73	83	84	77
DAVIS	CA	61	61	72	72	67
FT. COLLINS	CO	44	45	58	56	51
STORRS	CT	46	45	58	58	52
GAINESVILLE	FL	65	70	77	77	73
ATHENS	GA	59	61	72	72	66
MOSCOW	ID	43	42	52	52	47
LEMONT	IL	46	45	59	59	52
URBANA	IL	46	47	61	60	53
WEST LAFAYETTE	IN	47	47	62	61	54
AMES	IA	44	45	62	60	52
BURLINGTON	IA	47	49	66	65	56
CASTANA	IA	42	42	61	59	51
COUNCIL BLUFFS	IA	47	47	62	62	55
SARATOGA	IA	41	40	59	57	49
SPENCER	IA	42	42	58	57	50
GARDEN CITY	KS	48	51	66	66	58
MANHATTAN	KS	48	50	64	64	56
MOUND VALLEY	KS	52	54	68	68	60
LEXINGTON	KY	51	52	65	64	58
UPPER MARLBORO	MD	48	59	63	63	56
EAST LANSING	MI	45	43	57	57	50
FAIRMONT	MN	42	43	58	57	50
FARIBAULT	MN	40	40	55	53	47
ST. PAUL	MN	42	40	57	56	49
WASECA	MN	41	46	59	54	50
STATE UNIV.	MS	60	62	73	73	67
FAUCETT	MO	47	47	61	61	54
KANSAS CITY	MO	48	49	62	61	55
SIKESTON	MO	52	54	67	67	60
SPICKARD	MO	50	49	60	62	55
BOZEMAN	MT	39	37	50	48	43
HUNTLEY	MT	44	44	58	57	50
LINCOLN	NE	45	45	60	60	53
NEW BRUNSWICK	NJ	48	48	60	60	54
ITHACA	NY	44	43	54	54	49
COLUMBUS	OH	47	47	59	60	53
COSHOCTON	OH	46	46	58	58	52
WOOSTER	OH	46	46	58	58	52

STATION	STATE	WINTER	SPRING	SUMMER	FALL	YEAR
BARNSDALL	OK	56	57	69	69	63
LAKE HEFNER	OK	56	57	70	71	64
PAWHUSKA	OK	54	55	68	68	61
OTTAWA	ONTARIO	42	39	54	52	47
CORVALLIS	OR	50	51	61	60	55
HOOD RIVER	OR	46	48	57	57	52
MEDFORD	OR	51	52	61	61	56
PENDLETON	OR	46	49	61	60	54
STATE COLLEGE	PA	46	45	59	58	52
KINGSTON	RI	45	43	55	56	50
CALHOUN	SC	56	58	70	69	63
MADISON	SD	40	40	54	54	47
JACKSON	TN	53	55	66	64	59
TEMPLE	TX	64	65	77	77	71
SALT LAKE CITY	UT	44	45	56	55	50
BURLINGTON	VT	42	40	54	53	48
PULLMAN	WA	43	46	55	52	50
SEATTLE	WA	48	50	56	56	53
AFTON	WY	43	43	53	53	48

Table 104. Average Soil, Average Earth Temperature

AVERAGE EARTH TEMPERATURE IN DEG. F., TG, THERMAL DIFFUSIVITY IN FT²/HR   ALPHA = .025

STATION	STATE	WINTER	SPRING	SUMMER	FALL	YEAR
BARNSDALL	OK	53	56	73	70	63
LAKE HEFNER	OK	52	56	74	72	64
PAWHUSKA	OK	50	54	72	68	61
OTTAWA	ONTARIO	39	37	58	52	47
CORVALLIS	OR	47	50	64	60	55
HOOD RIVER	OR	43	48	59	57	52
MEDFORD	OR	48	52	64	61	56
PENDLETON	OR	41	49	65	61	54
STATE COLLEGE	PA	42	44	63	59	52
KINGSTON	RI	41	41	58	57	50
CALHOUN	SC	52	57	73	70	63
MADISON	SD	36	38	59	55	47
JACKSON	TN	50	55	69	64	59
TEMPLE	TX	61	65	81	77	71
SALT LAKE CITY	UT	40	45	60	56	50
BURLINGTON	VT	39	38	59	54	48
COLEMAN	WA	40	45	58	52	50
SEATTLE	WA	46	50	59	56	53
AFTON	WY	41	42	56	53	48

Table 105. Wet Soil, Average Earth Temperatures

AVERAGE EARTH TEMPERATURE IN DEG. F., TG, THERMAL DIFFUSIVITY IN FT²/HR ALPHA = .050

STATION	STATE	WINTER	SPRING	SUMMER	FALL	YEAR
AUBURN	AL	54	61	76	70	65
DECATUR	AL	46	53	71	65	59
PALMER AAES	AK	27	30	48	41	36
TEMPE	AZ	56	64	79	74	68
TUCSON	AZ	62	69	82	81	73
BRAWLEY	CA	63	73	90	84	77
DAVIS	CA	55	60	78	73	67
FT. COLLINS	CO	37	45	65	56	71
STORRS	CT	40	44	65	59	52
GAINESVILLE	FL	58	72	81	79	73
ATHENS	GA	52	61	78	73	66
MOSCOW	ID	38	42	57	53	47
LEMONT	IL	39	44	67	60	52
URBANA	IL	39	47	68	60	53
WEST LAFAYETTE	IN	40	47	69	62	54
AMES	IA	35	44	70	61	52
BURLINGTON	IA	38	48	74	66	56
CASTANA	IA	32	42	70	61	51
COUNCIL BLUFFS	IA	39	47	70	63	55
SARATOGA	IA	33	39	68	58	49
SPENCER	IA	33	42	66	58	50
GARDEN CITY	KS	38	52	74	67	58
MANHATTAN	KS	40	49	72	65	56
MOUND VALLEY	KS	44	55	75	69	60
LEXINGTON	KY	44	51	72	65	58
UPPER MARLBORO	MD	41	49	69	64	56
EAST LANSING	MI	39	41	64	57	50
FAIRMONT	MN	35	43	67	57	50
FARIBAULT	MN	34	38	62	54	47
ST. PAUL	MN	35	38	65	57	49
WASECA	MN	31	49	67	53	50
STATE UNIV.	MS	53	62	78	74	67
FAUCETT	MO	41	45	68	61	54
KANSAS CITY	MO	41	48	68	61	55
SIKESTON	MO	45	54	75	68	60
SPICKARD	MO	44	48	65	64	55
BOZEMAN	MT	34	35	57	48	43
HUNTLEY	MT	37	43	66	57	50
LINCOLN	NE	36	44	68	62	53
NEW BRUNSWICK	NJ	41	47	66	62	54
ITHACA	NY	39	41	61	54	49
COLUMBUS	OH	40	47	65	61	53
COSHOCTON	OH	40	45	64	60	52
WOOSTER	OH	40	45	65	59	52

STATION	STATE	WINTER	SPRING	SUMMER	FALL	YEAR
BARNSDALL	OK	50	56	75	70	63
LAKE HEFNER	OK	49	57	77	73	64
PAWHUSKA	OK	48	54	75	68	61
OTTAWA	ONTARIO	37	37	61	51	47
CORVALLIS	OR	45	51	67	60	55
HOOD RIVER	OR	41	49	61	57	52
MEDFORD	OR	46	52	66	61	56
PENDLETON	OR	38	50	68	60	54
STATE COLLEGE	PA	40	44	66	59	52
KINGSTON	RI	39	41	61	57	50
CALHOUN	SC	49	58	76	69	63
MADISON	SD	33	38	62	55	47
JACKSON	TN	48	55	72	64	59
TEMPLE	TX	58	65	84	77	71
SALT LAKE CITY	UT	37	45	62	55	50
BURLINGTON	VT	37	38	62	54	48
PULLMAN	WA	37	45	60	50	50
SEATTLE	WA	44	50	60	56	53
AFTON	WY	39	42	59	53	48

Glossary of Terms

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