NECAP 4.1 - NASA'S ENERGY-COST ANALYSIS PROGRAM
ENGINEERING FLOW CHARTS

May 1982

Ronald N. Jensen

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26 25 1982

LANGLEY RESEARCH CENTER
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HAMPTON, VIRGINIA

National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665
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Section 1

INTRODUCTION

This manual is one in a set of NECAP manuals referenced below that describes the computer program NECAP - NASA's Energy Cost Analysis Program. The program is a versatile building design and energy analysis tool which has embodied within it, state-of-the-art techniques for performing thermal load calculations and energy use predictions. With the program, comparisons of building designs and operational alternatives for new or existing buildings can be made.

The major feature of the program is the "response factor" technique for calculating the heat transfer through the building surfaces which accounts for the building's mass. The program expands the response factor technique into a "space response factor" to account for internal building temperature swings; this is extremely important in determining true building loads and energy consumption when internal temperatures are allowed to swing.

The algorithms for the thermal loads portion of NECAP comes from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE) manual, Procedure for Determining Heating and Cooling Loads for Computerized Energy Calculation. The original NECAP was published in 1975 and was supported by two manuals entitled NECAP - NASA's Energy Cost Analysis Program, NASA CR-2590 Part I User's Manual and NASA CR-2590 Part II Engineering Manual. Since that time, NASA has used NECAP for building heating and cooling design loads and energy analysis. The program has been used as a reference for the development of several other computerized programs.

This version of NECAP, called NECAP-4.1, contains the following modifications and improvements:

- A NECAP input data processor (NIPP) module was developed which greatly simplifies and reduces the user input task. The original fixed format data field suitable for punching onto computer cards has been eliminated in favor of a free format data field suitable for use with computer terminals.

- Provide built-in default values for most input data.

- The Response Factor module was made an integral part of the Thermal Load Analysis and System modules.

- The Variable Temperature module and System and Equipment Simulation module were brought together into one module to allow dynamic simulation and interaction (feedback) between the space, its distribution system, and the heating and cooling plant equipment. In the previous version of NECAP, the hourly space temperatures and system heating/cooling loads were calculated using given heating/cooling capacities. Because of varying plant equipment capacity due to ambient conditions, scheduling, distribution system control options, etc., "loads-not-met" resulted in the old program. "Loads-not-met" were not accounted for in space temperature drift above or below the allowed temperature range.
Modify the thermostat and ventilation schedule input.
- Improve fan on/off code.
- Addition of process loads.
- Modify the weather tape system.
- Use system component part load performance curves.
- Default CFM, chiller size, and boiler size data.
- Provide an executive summary for energy.
- Print out a temperature frequency chart.
- Add more flexibility to print out.
- Change the glass shade coefficient.
- Correct air infiltration coefficients, fan efficiencies, and floor panel heating algorithms.

The new program is documented in the following manuals:

**TM 83238, Users Manual** - Describes examples and output forms.

**TM 83239, Input Manual** - Details the input requirements.

**TM 83240, Engineering Manual** - Provides the algorithms for the program.


**CR-165802, Operations Manual** - Gives the specific operating instruction for Langley Research Center's computer system operation.

Program modifications were directed specifically at program improvements and not at a complete rework of the program structure. We wish to acknowledge the contributions made by the project's contractor, GARD, Inc. of Niles, IL, for the various changes and documentation in the program performed under contract NASW-3307. The program's maintenance contractor, Computer Science Corporation, of Hampton, Virginia also assisted in program updates and documentation.

The program is run on NASA, Langley Research Center's large computer system. Users should be cautioned that program implementation can be time consuming and costly. Although computer run costs are much lower than the original response factor programs, they are still a magnitude greater that the simple "bin method" type energy calculation. With this in mind, judgment should be exercised to assure that needs are compatible with the investment. Operational assistance in running the program cannot be provided by NASA.
There are limited means to update the material. Comments on the program are welcomed, although the Government accepts no obligation even if the suggestions are used. Send comments to:

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Mail Stop 443
NASA, Langley Research Center
Hampton, VA 23665

NECAP-4.1 is made up of the following program modules:

NECAP Input Processor (NIPP)
Thermal Load Analysis (TLAP)
Systems Energy Simulation (SESP)
Owning and Operating Cost (ESCON)
Section 2

NECAP INPUT PROCESSOR PROGRAM
BEGIN NIPP

CALL OVERLAY (1,0)
PROGRAM PRECAP
INPUT DATA DECODER

CALL OVERLAY (2,0)
PROGRAM DATVER
VERIFY INPUT DATA

CALL OVERLAY (3,0)
PROGRAM WEATHER
PROCESS WEATHER DATA FROM TAPE

END
BEGIN PRECAP

IF PRINTING OF COMMON BLOCK DESIRED?
YES: WRITE OUTPUT
NO:

IF DEFAULT LIST DESIRED?
YES: WRITE DEFAULT LIST
NO:

VARIABLE INITIALIZATIONS TO ZERO

IF PRINTING DESIRED?
YES: WRITE NUMBER OF CARDS
NO:

SET CONTINUATION FLAG TO ZERO

READ NEW INPUT RECORD

IF END OF FILE ENCOUNTERED?
NO:
YES:
CALL LABEL
DECODE CARD LABEL

IS PRINTING DESIRED?

WRITE CARD STATISTICS

IS IRET < 2?

PAGE 2

PAGE 1

IS IRET > 2?

IS PRINTING DESIRED?

WRITE POSITION OF POINTER IN RECORD

IS POINTER TO END OF RECORD?

SET CONTINUATION FLAG TO UNITY

PAGE 1

Page 3
BEGIN DATVER

CALL OVERLAY (2,1)
PROGRAM DATAV
DATA VERIFICATION OF INPUT FOR TLAP PROGRAM

CALL OVERLAY (2,2)
PROGRAM SYSCHK
DATA VERIFICATION OF INPUT FOR SESP PROGRAM

IF ERRORS

YES
PRINT OUT ERRORS

NO

END
BEGIN READ

READ CARD

WRITE CARD

IS DATA WITHIN LIMIT VALUES?

YES

PRINT ERROR MESSAGE

INCREMENT ERROR COUNTER

NO

HAVE ALL CARDS BEEN READ?

YES

HAS NUMBER ERRORS BEEN EXCEEDED?

NO

END

YES

ABORT PROGRAM
PROGRAM WEATHER

READ ALTITUDE OF BUILDING AND PRINTING FLAG

READ SUMMER WEATHER DATA

READ WINTER WEATHER DATA

READ STATION DATA

READ GROUND TEMPERATURE

WRITE INPUT DATA TO UNFORMATTED FILE

IS PRINTING DESIRE ?

YES

ECHO INPUT DATA

NO

IS 1440 TAPE TO BE USED ?

YES

CALL NO1440

PROCESS WEATHER TAPE AND WRITE DATA TO FILE

NO

CALL MSF

PROCESS WEATHER TAPE AND WRITE DATA TO FILE

RETURN

2-9
Section 3

THERMAL LOADS ANALYSIS PROGRAM
PROGRAM TLAP

CALL INITIAL
READ IN AND INITIALIZE DATA

CALL HLA
PERFORM HOURLY LOAD CALCULATIONS AND PRINT OUT SPACES' LOAD REPORTS

END
ENTER CENTER

DETERMINE NUMBER OF BLANKS AT RIGHT HAND

REALLOCATE IDEN IN FIELD

WRITE IDEN ON OUTPUT DEVICE KAGIT

IF WANTED, WRITE IDEN ON OUTPUT DEVICE 2

RETURN
```
ENTER DAYMO

IFACT=0
MONTH=1

I=3,12

II=12
NDOYS=IDOY-NUMDAY(II)-LEAP

NDOYS > 0

MONTH=II

MONTH > 2

IFACT=LEAP

I=I.MO

RETURN

3-5
```
ENTER FILM

EXTERIOR SURFACE INDEX IS

IS=1  IS=2  IS=3  IS=4  IS=5  IS=6

CALCULATE FILM COEFFICIENT  CALCULATE FILM COEFFICIENT  CALCULATE FILM COEFFICIENT  CALCULATE FILM COEFFICIENT  CALCULATE FILM COEFFICIENT  CALCULATE FILM COEFFICIENT

RETURN
I calculate heat gain/loss for delayed heat transfer surfaces.
ENTER HL

CALCULATE WEIGHTED WINDOW SOLAR LOAD

CALCULATE WEIGHTED SPACE SENSIBLE LOAD

CALCULATE WEIGHTED SPACE LIGHTING LOAD

SUM COMPONENTS OF WEIGHTED SENSIBLE LOAD

CALCULATE TOTAL SPACE SENSIBLE LOAD

CALCULATE TOTAL PLENUM SENSIBLE LOAD

RETURN

3-10
ENTER HLA

INITIALIZE GENERAL VARIABLES

START HOUR DO LOOP

TIME > 1

CALL SUN I CALL DAYMO

KODE ≥ 2

CALL DST CALL HOLIDAY

KODE ≥ 2

SET WEATHER VARIABLES USING WINTER DESIGN DAY DATA

SET WEATHER VARIABLES USING SUMMER DESIGN DAY DATA

PAGE 2
START DELAYED SURFACE DO LOOP

J=1,JLIM

GO

PAGE 6

ICALD(JJ)=1

YES

PAGE 6

NO

ABS(HANG)≤ ABS(SUNRAS)

YES

CALL SUN 3

NO

J

PAGE 5

3 DAY=1

N TIME < IRISEL

I TIME ≥ ISETI

YES

ETA 70 > 0

NO

SHADD(I TIME, JJ)=1.0

YES

NO

NSP > NDD(JJ)

YES

NLOOKD=0

2 DAY >1

YES

NO

SHADD(I TIME, JJ)=0.0

CALL SEARCH

CALL SEARCH

PAGE 5

PAGE 5

3-14
COMPUTE NEW SCHEDULE ALGORITHM

CALL HL

IF IPick(i) < 0
    YES
ELSE
    NO

IF Codinf(i) = 0.0
    YES
ELSE
    NO

CALL INF

IF CODE < 3
    YES
    PAGE 12
ELSE
    NO

IF HOUR % JSTART I < 1
    YES
    PAGE 12
ELSE
    NO

CALL REPT3

PAGE 12
IF CODE = 3

IF I HOUR < J START + 96

IF I < 1

IF CODE < 3

WRITE HOURLY WEATHER TO "A" TAPE

SUM HOURLY BUILDING POWER

PAGE 13

3-22
KODE ≤ 2

IGNOR = 1
IDAY = 1

CALL QMAX
CALL REPRTE6

KODE = 3

CALL REPRTE5
CALL REPRTE6

< CODE = 1

KODE = 3

CALL REPRTI

MONTH = 11

KODE = 2

CALL DESCY

CALL DESCY

PAGE 1
ENTER HOLIDAY

SET HOLIDAY FLAG TO ZERO

IS IT NEW YEAR'S DAY?

NO

IS IT GEORGE'S BIRTHDAY?

NO

IS IT MEMORIAL DAY?

NO

IS IT FOURTH OF JULY?

NO

IS IT LABOR DAY?

NO

A

YES

RESET JOL TO UNITY

RETURN

A

IS IT COLUMBUS DAY?

NO

IS IT VETERANS DAY?

NO

IS IT THANKSGIVING DAY?

NO

IS IT CHRISTMAS DAY?

NO

RETURN

YES

RETURN
ENTER HQ

CALCULATE OUTSIDE TEMPERATURE

CALCULATE HEAT GAIN/LOSS FOR QUICK TRANSFER SURFACES

RETURN
ENTER INF

IF DRY BULB LESS THAN 50°

YES

HEATING COIL MAY BE ON
SET SPACE HUMIDITY RATIO TO OUTSIDE AIR HUMIDITY RATIO

NO

COOLING COIL MAY BE ON.
SET SPACE HUMIDITY RATIO PROPORTIONAL TO DEW POINT OF AIR LEAVING COIL

COMPUTE SENSIBLE INFILTRATION LOAD

COMPUTE LATENT INFILTRATION LOAD

RETURN

3-27
ENTER INITIAL

READ BUILDING IDENTIFICATION AND LOCATION DATA

IS TYPE OF RUN DESIGN DAY AND/OR REGULAR

YES

CALL DESDY TO COMPUTE DESIGN DAY WEATHER

NO

READ IN WEATHER DATA

IS TYPE JUST DESIGN DAY

NO

READ IN HOURLY PRINT CODE, NUMBER OF SCHEDULES AND PROCESSING FLAG

CALL REPORT TO PRINT SUMMARY OF BUILDING DATA

CALL REPORT TO ECHO DATA READ IN SO FAR

CALL SCHEDUL TO READ IN PEOPLE, LIGHTING, AND EQUIPMENT OPERATING DATA

CALL DAYMO TO DETERMINE DAY OF MONTH AND MONTH OF YEAR

READ IN NUMBER OF SHADING SURFACES AND CALL INPUT TO READ IN EACH SHADING SURFACE'S DATA
READ IN NUMBER OF TYPES OF DELAYED SURFACES, NUMBER OF STANDARD SURFACES, AND STANDARD SURFACE CODES

CALL STNORD TO GENERATE RESPONSE FACTOR DATA FOR EACH STANDARD DELAYED SURFACE

CALL RESFAC TO CALCULATE RESPONSE FACTOR DATA FOR EACH NON-STANDARD DELAYED SURFACE

READ IN NUMBER OF DELAYED SURFACES AND EACH DELAYED SURFACE'S THERMAL CHARACTERISTICS

CALL INPUT2 TO READ IN EACH DELAYED SURFACE'S GEOMETRIC DATA

READ IN INDICES OF SHADING SURFACES DELETED FROM EACH DELAYED SURFACE

READ IN SHADOW PICTORIAL DATA FOR EACH DELAYED SURFACE REQUESTED

READ IN NUMBER OF QUICK SURFACES AND EACH QUICK SURFACE'S THERMAL CHARACTERISTICS

CALL INPUT2 TO READ IN EACH QUICK SURFACE'S GEOMETRIC DATA

READ IN INDICES OF SHADING SURFACES DELETED FROM EACH QUICK SURFACE

READ IN SHADOW PICTORIAL DATA FOR EACH QUICK SURFACE REQUESTED
READ IN NUMBER OF WINDOWS AND EACH WINDOW'S THERMAL CHARACTERISTICS

CALL INPUT2 TO READ IN EACH WINDOW'S GEOMETRIC DATA

READ IN INDICES OF SHADING SURFACES DELETED FROM EACH WINDOW

CALL SETBAC TO CALCULATE THREE SETBACK SHADINGS FOR EACH WINDOW REQUESTING THEM

READ IN SHADOW PICTORIAL DATA FOR EACH WINDOW REQUESTED

READ IN NUMBER OF INTERNAL SURFACES AND EACH INTERNAL'S DATA

READ IN NUMBER OF UNDERGROUND SURFACES AND EACH UNDERGROUND'S DATA

READ IN MONTHLY GROUND TEMPERATURES

READ IN NUMBER OF SPACES

READ IN SPACE DATA FOR EACH SPACE

CALL REPT2 TO PRINT OUT EACH SPACE'S DATA

CALL DESDY TO CALCULATE DESIGN HOURLY DRY AND WET BULB TEMPERATURES

END
ENTER INPUT

LONG FORM?

NO

READ GEOMETRIC DATA

CONVERT AZIMUTH ANGLE AND TILT ANGLE TO RADIANS

CALL RECTAN
CALCULATE COORDINATES OF VERTICES

CALL RECAP2 TO ECHO DATA

RESET NUMBER OF VERTICES

RETURN

J=1, NV

READ COORDINATES OF VERTICES

CALL RECAP2 ECHO DATA

RETURN

3-31
ENTER INPUT2

READ SURFACE FACTORS

CONVERT FACTORS TO INTEGER

LONG FORM?

YES

READ GEOMETRIC DESCRIPTION

CONVERT AZIMUTH ANGLE AND TILT ANGLE TO RADIANS

CALCULATE SURFACE AREA

CALL RECTAN

CALL RECAP2

ECHO DATA

RESET NUMBER OF VERTICES

RETURN

J = 1, NV

READ COORDINATES OF VERTICES

CALL APOL

CALCULATE AREA

CALL RECAP2

ECHO DATA

CALL RECAP2

ECHO DATA
ENTER LEEP

LEEP ← 0

IS IT LEEP YEAR?

YES → LEEP ← 1

NO → RETURN
ENTER LOKIN

SET SHADOW PICTORIAL DISPLAY PARAMETERS FOR DELAYED, QUICK, AND WINDOW SURFACES

RETURN
ENTER PPWVMS

CONVERT TEMPERATURE TO CENTIGRADE

IS T < 273.16

YES

$z = 273.16 / T$

ASSIGN VALUES TO P1, P2, P3, P4

CALCULATE VAPOR PRESSURE

RETURN

NO

$z = 373.16 / T$

ASSIGN VALUES TO P1, P2, P3, P4
ENTER PSY

IS DEW POINT TEMPERATURE < 32

NO

CALL PPWVMS
CALCULATE VAPOR PRESSURE

CALL PPWVMS
CALCULATE VAPOR PRESSURE

CALCULATE HUMIDITY RATIO

CALCULATE ENTHALPY

CALCULATE DENSITY

RETURN
ENTER RECAPI

WRITE HEADING

WRITE INPUT DATA CARDS LI-LIO

RETURN
ENTER RECAP2

IS NUMBER OF VERTICES = 1?

YES

WRITE COLUMN LABEL

CONVERT AZIMUTH AND TILT ANGLES TO DEGREES

WRITE GEOMETRIC PROPERTIES

NO

I ← I, NV

RETURN

WRITE COORDINATES
ENTER
RECTAN

CALCULATE
COSINES AND SINES
OF AZIMUTH AND
TILT ANGLES

CALCULATE
COORDINATES OF
VERTICES

RETURN
ENTER REPORT2

WRITE UPPER BORDER

WRITE WEATHER TAPE USED

WRITE BEGINNING DATE OF STUDY

WRITE LENGTH OF STUDY

WRITE INITIAL OUTSIDE WEATHER

WRITE LOWER BORDER

RETURN
ENTER REPRT3

WRITE UPPER BORDER

WRITE TITLE

WRITE THE INFORMATION WHICH THE FIRST LINE OF PRINTED BLOCK GIVES

WRITE INFORMATION WHICH FOLLOWING LINES OF EACH PRINTED BLOCK CONTAINS

WRITE LOWER BORDER

RETURN
ENTER REPRT5

WRITE TOP OF REPORT SUMMARIZING USER INPUT DATA

CALCULATE MINIMUM DRY-BULB TEMPERATURE FOR SUMMER DESIGN DAY

MONTH ← 3, 11

CALL DESDY
CALCULATE MAXIMUM DRY-BULB TEMPERATURE FOR WINTER DESIGN DAY

CALL DESDY
CALCULATE DESIGN DRY-BULB AND WET-BULB TEMPERATURES FOR DECEMBER

WRITE THESE TWO TEMPERATURES

WRITE THESE TWO TEMPERATURES

RETURN

CALL DESDY
CALCULATE HOURLY DESIGN DRY-BULB AND WET-BULB TEMPERATURES

WRITE THESE TWO TEMPERATURES

RETURN
ENTER REPT6

I ← 1, N

B

CALCULATE TOTAL FLOOR AREA

CALCULATE TOTAL VOLUME

CALCULATE WEIGHTED SPACE TEMPERATURE

CALCULATE TOTAL COOLING CFM

CALCULATE TOTAL HEATING CFM

WRITE IDENTIFICATIONS

WRITE CONDITIONS FOR SUMMER PEAK LOAD

WRITE CONDITIONS FOR WINTER PEAK LOAD

WRITE COMPONENTS OF SUMMER AND WINTER PEAK LOAD

WRITE SUBTOTALS FOR SUMMER SENSIBLE, SUMMER LATENT AND WINTER SENSIBLE LOADS

WRITE RETURN AIR LOAD CREATED BY LIGHT HEAT

WRITE FAN HEAT LOAD

A

WRITE IDENTIFICATION

WRITE TIME AND CONDITIONS FOR SUMMER PEAK LOAD

WRITE CONDITIONS FOR WINTER PEAK LOAD

WRITE COMPONENTS OF SUMMER AND WINTER PEAK LOAD

WRITE TOTAL SUMMER SENSIBLE, SUMMER LATENT AND WINTER SENSIBLE LOAD

WRITE TOTAL SPACE COOLING

WRITE TOTAL SPACE HEATING

WRITE SUPPLY AIR CFM REQUIRED TO MEET TOTAL SPACE COOLING

C

3-47
WRITE SUPPLY AIR CFM REQUIRED TO MEET TOTAL SPACE SENSIBLE HEATING LOAD

WRITE SUPPLY CFM REQUIRED PER SQUARE FOOT OF FLOOR AREA

WRITE VENTILATION AIR LOAD FOR SUMMER PEAK COOLING HOUR

WRITE VENTILATION AIR LOAD FOR WINTER PEAK HEATING HOUR

WRITE TOTAL LOADS FOR SUMMER SENSIBLE, SUMMER LATENT AND WINTER SENSIBLE LOADS

WRITE TOTAL COOLING LOAD

WRITE TOTAL HEATING LOAD

WRITE SUPPLY AIR CFM AND CFM PER SQUARE FOOT REQUIRED TO MEET HEATING AND COOLING LOADS, VARIABLE VOLUME

WRITE SUPPLY AIR CFM AND CFM PER SQUARE FOOT REQUIRED FOR CONSTANT VOLUME SYSTEM, TO MEET HEATING AND COOLING LOADS

RETURN
RESFAC
(TLAP AND SESP)

ENTER RESFAC

CALL ZERO

CALL FALSE

1 CALL MATRIX
2 CALL DER

CALL SLOPE

CALCULATE RESPONSE FACTORS AND COMMON RATIO

END

3-49
ENTER RMRSS

SET TYPE OF CONSTRUCTION ON BASIS OF WEIGHT OF FLOOR

SET VALUE OF WEIGHTING FACTORS FOR HANDLING SOLAR HEAT GAIN THROUGH GLASS

SET VALUE OF WEIGHTING FACTORS FOR HANDLING WALL AND SURFACE HEAT GAIN

SET VALUE OF WEIGHTING FACTORS REQUIRED FOR HANDLING SPACE HEAT GAIN FROM LIGHTS

SET WEIGHTING FACTORS FOR REMAINDER OF LIGHT HEAT WHICH IS ASSUMED ADDED TO PLENUM SPACE ABOVE

RETURN
ENTER SCHEDUL

I = I, NUMT

READ CODED SCHEDULE MATRIX

FILL IN MATRIX FOR STANDARD AND NON-STANDARD SCHEDULE

ECHO SCHEDULES

RETURN
ENTER SCHED

IS IT A HOLIDAY?

SET TYPE OF DAY TO DAY OF WEEK

IS IT CHRISTMAS PERIOD?

SET TYPE OF DAY TO 9

IS IT DAYLIGHT SAVING TIME?

SET CORRECTED TIME TO HOUR OF DAY

IS IT FIRST HOUR OF DAY?

SET CORRECTED TIME TO 24

RETURN
ENTER SEARCH

\[ I \leftarrow I, N \]

RETURN

IS PICTORIAL OUTPUT DESIRED FOR SPACE NO. AT HOUR AND MONTH?

\[ J \leftarrow 0 \]

\[ J \leftarrow 1 \]
ENTER
SETBAK

CALCULATE X, Y, AND Z COORDINATE OF 1ST VERTEX OF SHADING NO.1

CALCULATE X COORDINATES FOR:
2ND, 3RD, AND 4TH VERTICES OF
SHADING NO.1, VERTICES 1 THROUGH 4 OF SHADING NO.2,
AND VERTICES 1 THROUGH 4 OF
SHADING NO.3

CALCULATE Y COORDINATES FOR:
2ND, 3RD, AND 4TH VERTICES OF
SHADING NO.1, VERTICES 1 THROUGH 4 OF SHADING NO.2,
AND VERTICES 1 THROUGH 4 OF
SHADING NO.3

CALCULATE Z COORDINATES FOR:
2ND, 3RD, AND 4TH VERTICES OF
SHADING NO.1, VERTICES 1 THROUGH 4 OF SHADING NO.2,
AND VERTICES 1 THROUGH 4 OF
SHADING NO.3

END
RETURN
PROBLYSTIC SHADING
TEST FOR ENCLOSURE BY SP VERTICES
PROJECT SP VERTICES INTO RP PLANE
CLIP SP POLYGONS
TRANSFORM SP VERTICES INTO X'Y'Z COORDINATES
DELETE POLYGONS NOT IN RP PLANE
TRANSFORM RP VERTICES INTO X'Y'Z COORDINATES
TEST FOR ENCLOSURE BY RP PLANE
TRANSFORM RP VERTICES INTO X'Y'Z COORDINATES
CALCULATE ROTATION MATRIX
TRANSFORM SP VERTICES INTO X'Y'Z COORDINATES
TEST FOR ENCLOSURE BY SP ELEMENTS IN RP PLANE
REPLACE SP ELEMENTS IN RP PLANE
MAKE CORRELATE TRANSFORMATIONS
ENTER SHADOW
ENTER SHG

CALCULATE INWARD FLOWING FRACTION OF THE RADIATION ABSORBED BY THE INNER AND OUTER PANE

CALCULATE DIRECT SOLAR LOAD

CALCULATE DIFFUSE SOLAR LOAD

CALCULATE TRANSMITTED SOLAR LOAD

CALCULATE ABSORBED SOLAR LOAD

CALCULATE SOLAR HEAT GAIN THROUGH GLASS

CALCULATE HEAT CONDUCTION THROUGH GLASS

RETURN
ENTER STNDRD

ESTABLISH SPACE FOR WHICH RESPONSE FACTOR DATA IS BEING GENERATED

IS STNDRD SURFACE № = 1?

YES

NO

SUM NUMBER OF RESPONSE FACTOR TERMS UP TO SURFACE NUMBER MINUS ONE

INCREMENT LOC FOR EACH RESPONSE FACTOR TERMS

CALCULATE X-, Y-, AND X- RESPONSE FACTOR TERMS

RETURN
ENTER SUN I

CALCULATE TANGENT OF DECLINATION ANGLE

CALCULATE EQUATION OF TIME

CALCULATE APPARENT SOLAR CONSTANT

CALCULATE ATMOSPHERIC EXTINCTION COEFFICIENT

CALCULATE SKY DIFFUSE FACTOR

CALCULATE SUN RISE ANGLE

RETURN
CALCULATE DIRECTION COSINE OF SUN IN X, Y, AND Z DIRECTION

IS DIRECTION COSINE OF SUN UPWARD ≤ 0.001?

CALCULATE INTENSITY AND BRIGHTNESS

RETURN
ENTER SUN3

CALCULATE BRIGHTNESS OF GROUND

CALCULATE DIRECTION COSINES OF NORMAL TO SURFACE SUBJECT TO PRELIMINARY CHECKS

CALCULATE COSINE OF INCIDENT RADIATION ON SURFACE

CALCULATE INTENSITY OF DIRECT NORMAL SOLAR RADIATION

CALCULATE INTENSITY OF DIFFUSE RADIATION

CALCULATE TOTAL RADIATION INCIDENT UPON SURFACE

RETURN
ENTER TAR

CALCULATE TRANSMISSION FACTORS FOR DIRECT SOLAR AND DIFFUSE RADIATION

CALCULATE ABSORPTION FACTORS FOR DIRECT AND DIFFUSE RADIATION

RETURN
ENTER WBF

IS BAROMETRIC PRESSURE = 29.92 ?

YES

ITERATE WBF UNTIL Y1 OR Y2 \leq 0

CALCULATE WBF

RETURN

NO

LET Y \leftarrow \log(H)

IS ENTHALPY \leq 11.758 ?

YES

CALCULATE WET-BULB TEMPERATURE

NO

CALCULATE WET-BULB TEMPERATURE
Section 4
SYSTEMS ENERGY SIMULATION PROGRAM
PROGRAM SESP

CALL SESIN
READ IN AND INITIALIZE DATA

CALL SMEXEC
EXECUTE SIMULATION

CALL SCLOSE
PRINT OUT FINAL REPORT

END
Enter Absor

Determine Capacity Adjustment Factor for Non-Standard Conditions

Determine Capacity Adjustment Factor for Chilled Water at Other Than 10 °F

Calculate Total Capacity Adjustment Factor

Calculate Full Load Steam Rate

Calculate Total Full Load Steam Consumption

Calculate Part Load Factor

Calculate Total Partial Load Steam Consumption for Given Load

Return
ENTER AHU

$m = \text{AHU}$

$m = 1$  $m = 2$

**AHU type 1**  **AHU type 2**

- Calculate Required Leaving Coil Air Temperature
- Check Mixed Air Temp (TMA) vs Leaving Coil Temp (TLC)
  - TMA < TLC
    - No Load Condition
    - CALL CCORIL
    - Calculate Cooling Coil Load And Humidity Ratio
  - TMA = TLC
    - Calculate Heating Load And Humidity Ratio
  - TMA > TLC
    - No Load Condition
    - CALL CCORIL
    - Calculate Cooling Coil Load And Humidity Ratio
- TMA = TLC
- CALL CCORIL
- Calculate Cooling Load And Humidity Ratio

CALL DENS
- Calculate Density Of Air Leaving Fan.

Is There a Cooling Coil Load?
- YES
  - NO Humidifier Load
  - CALL HUM
    - Calculate Supply Air Humidity Ratio And Steam Humidifier Water Requirement
    - RETURN
- NO
  - RETURN

RETURN
CALCULATE LOGARITHM OF GIVEN NUMBER TO BASE 10.
ENTER BRAD

Is Ambient temp. Greater Than Ambient High Limit?

YES

Baseboard Heat=0

NO

RETURN

Is Baseboard Heating to be Simulated?

YES

Calculate entering Air Temperature.

Calculate Hot Water Temperature

Call TRSET

Calculate Baseboard Heat

Adjust Base Sensible Thermal Load

RETURN

NO

RETURN
ENTER CCØIL

Calculate Leaving Wet Bulb Temperature

Calculate Dry Bulb Temperature Difference

DT ≤ 0.

No Cooling Coil Load

RETURN

DT > 0.

Temperature Difference (DT)?

CALL PSY1

Calculate Sensible Heat Extracted

CALL PSY1

Calculate Latent Heat Extracted And Total Heat Extracted

RETURN
ENTER CENT

Calculate Leaving Condenser Water Temperature At Full Load

Calculate Full Load Power Per Ton

Calculate Error Correction To Adjust Full Load Power Per Ton To Correspond To Catalog Data

Calculate Corrected Full Load Power Per Ton

Calculate Full Load Power Consumption

Calculate Partial Load Factor

Calculate Part Load Power Consumption For Given Load

Return
ENTER CHLADJ

DETERMINE CHILLER SIMULATION CODE

CHECK CHILLER FOR BUILT-IN PERFORMANCE

DETERMINE CAPACITY FACTOR WHICH ADJUSTS FOR OPERATION AT CONDITIONS OTHER THAN STANDARD

DETERMINE ADJUSTED CAPACITY

IS USER-DEFINED CHILLER?

YES

CALL CHLUSR

DETERMINE CHILLER CAPACITY

NO

RETURN
CALL IUNIT
DETERMINE PEAK CAPACITY

CALL IUNIT
DETERMINE PEAK POWER

CALCULATE ACTUAL CHILLER CAPACITY

CALL IUNIT
DETERMINE CHILLER PERCENT PEAK POWER AT FRACTION OF FULL LOAD

CALCULATE ACTUAL CHILLER POWER

RETURN

ENTER CHLUSR

J ← 1.5

OBTAIN PROPER USER-DEFINED INPUT DATA

SESP CHLUSR
Is built in curves?

Yes

Calculate percentage power

Is power % < 5%?

Yes

Calculate cooling tower power

No

Set power to zero

No

Determine fraction of full load power at tecon and ctfll conditions

Call IUNI

No

RETURN

RETURN
READ NUMBER OF YEARLY SPACE THERMOSTAT SCHEDULES

READ YEARLY THERMOSTAT SCHEDULES

READ NUMBER OF RESET SCHEDULES

READ RESET SCHEDULES

READ NUMBER OF USER DEFINED SURFACES

READ RESPONSE FACTOR DATA

READ NUMBER OF FAN SYSTEMS

READ DISTRIBUTION PARAMETERS 1-5

READ NUMBER OF SPACES

READ PLENUM INDICATOR

READ REGULAR SPACE DATA 1-4

READ PLENUM SPACE DATA 1-2

ANY LOADS NOT BEING USED?

DEFAULT VARIOUS INPUT PARAMETERS

A

B

4-13
READ NUMBER OF COND WTR/AMB WGT POINTS

READ LVG WAT TEMP/AMB WGT

READ NUMBER OF PCT LOAD/COND WTR TEMP POINTS

READ CHANGE CT LVG WTR TEMP/PCT PEAKLOAD

READ NUMBER OF PCT PEAK POWER/COND WTR TEMPS POINTS

READ PCT PEAK POWER/CT LVG WTR TEMP

READ NUMBER OF PCT PEAK POWER/PCT LOAD POINTS

READ PCT PEAK POWER/PCT PEAK LOAD

READ NUMBER OF DX/HEAT PUMPS

READ DX/HEAT PUMP DATA 1

READ NUMBER OF COOLING DATA POINTS

READ COOLING DATA POINTS

READ DX/HEAT PUMP DATA 2

READ NUMBER OF HEATING DATA POINTS

READ HEATING POINTS
READ PUMP PARAMETERS

READ NUMBER OF
PROCESS LOADS

READ PROCESS
LOAD DATA

READ STEAM
PARAMETERS

READ MISCELLANEOUS
PARAMETERS

CHANGE PERCENTAGES
TO FRACTIONS

WILL ANY DATA
CAUSE ERROR?

YES

WRITE MESSAGE

NO

RETURN
ENTER DENSY

Calculate Density Of Moist Air At Desired Conditions

Return
DUMMYIO

SHOULD NEVER BE CALLED

IF RETURN CALLED

MAKE DUMMY I/O CALLS TO FORCE FORTRAN LIBRARY ROUTINES TO BE GLOBAL

YES

RETURN

NO

END
ENTER DXHP

SET UP ARRAYS ACCORDING TO MODE

CALL IUNI

USE PERCENT DESIGN CAPACITY TO CALCULATE CAPACITY AVAILABLE

CALL IUNI

USE PERCENT DESIGN POWER TO CALCULATE POWER REQUIRED

IS IT HEATING MODE?

YES

IS HEATING LOAD MET?

YES

CALCULATE ACTUAL POWER

RETURN

NO

CALCULATE SUPPLEMENTARY HEAT

NO

IS COOLING LOAD MET?

YES

CALCULATE COOLING LOAD NOT MET

NO
\[ \text{ALFA} = \frac{\text{DRA} \times (\text{RA} - \text{LVG})}{(\text{RA} \times \text{DRA} - \text{OA} \times \text{DOA} + \text{LVG} \times (\text{DOA} - \text{DRA}))} \]

- **OUTSIDE AIR - RETURN AIR < 0**
  - **YES**
  - **LEAVING AIR - OUTSIDE AIR ≤ 0**
    - **YES**
      - \[ \text{ALFA} = 1.0 \]
      - RETURN
    - **NO**
      - **OUTSIDE AIR = RETURN AIR**
        - **YES**
          - \[ \text{ALFA} = 1.0 \]
          - RETURN
        - **NO**
          - **LEAVING AIR - RETURN AIR ≤ 0**
            - **YES**
              - \[ \text{ALFA} = \text{ALFAM} \]
              - RETURN
            - **NO**
              - \[ \text{ALFA} < \text{ALFAM} \]
                - **YES**
                  - \[ \text{ALFA} = 1.0 \]
                  - RETURN
                - **NO**
                  - \[ \text{ALFA} = \text{ALFAM} \]
          - **NO**
        - **NO**
          - **LEAVING AIR - OUTSIDE AIR < 0**
            - **YES**
              - \[ \text{ALFA} < 1.0 \]
                - **YES**
                  - \[ \text{ALFA} = 1.0 \]
                  - RETURN
                - **NO**
                  - \[ \text{ALFA} = \text{ALFAM} \]
    - **NO**
      - **LEAVING AIR - RETURN AIR < 0**
        - **YES**
          - \[ \text{ALFA} = 1.0 \]
          - RETURN
        - **NO**
          - **OUTSIDE AIR = RETURN AIR**
            - **YES**
              - \[ \text{ALFA} = 1.0 \]
              - RETURN
            - **NO**
              - **LEAVING AIR - RETURN AIR ≤ 0**
                - **YES**
                  - \[ \text{ALFA} = \text{ALFAM} \]
                  - RETURN
                - **NO**
                  - \[ \text{ALFA} < \text{ALFAM} \]
                    - **YES**
                      - \[ \text{ALFA} = 1.0 \]
                      - RETURN
                    - **NO**
                      - \[ \text{ALFA} = \text{ALFAM} \]

**END**
ENTER ENGY

III <- 1,2

WRITE TOTAL HEATING AND COOLING LOADS

WRITE ELECTRICAL LOADS

WRITE HEADERS

WRITE LOADS OIL

WRITE DIESEL FUEL LOADS

WRITE STEAM LOADS

WRITE GAS LOADS

WRITE HEADERS

RETURN

4-21
CONVENTIONAL COOLING SEGMENT

Type Of Chiller (M1)

M1=1
CALL RECIPI
Determine Chiller Power Required

M1=2
CALL CENT
Determine Chiller Power Required

M1=3
CALL CENT
Determine Chiller Power Required

M1=4
CALL ABSOR
Determine Chiller Steam Required

M1=5
CALL CENT
Determine Chiller Power Required

Adjust Power For Open Machine

Convert Steam Required To Heat Required

Adjust Power For Open Machine

CALL STTUR
Determine Steam Required

Convert Steam Required To Heat Required

Type Of Cooling Energy (M2)

M2=1
Calculate Gas Cooling Required

M2=2
Calculate Oil Cooling Required

M2=3
Calculate Electric Cooling Required

M2=4

M2=5

C
To p. 4
ENTER ESIZE

CALCULATE TOTAL HEATING PLANT CAPACITY

I ← I,NCHIL

DETERMINE COOLING TOWER FAN HORSEPOWER REQUIREMENT

DETERMINE CHILLED WATER FLOW RATE

DETERMINE BOILER WATER FLOW RATE

SIZE PUMP MOTORS

SIZE BOILER AUXILIARY HORSEPOWER

SUM HEATING AND COOLING EQUIPMENT BRAKE HORSEPOWER DEMAND

SIZE ON-SITE GENERATION PLANTS

ENGINE/GENERATION SIZING

RETURN

DETERMINE COOLING CAPACITY

IS M#4 ?

YES

SIZE CONDENSER WATER FLOW RATE AND COOLING TOWER AIR FLOW

IS M#5 ?

YES

SIZE CONDENSER FLOW RATE AND COOLING TOWER AIR FLOW

NO

DETERMINE SIZE OF STEAM TURBINES
ENTER EXSUM

ESTABLISH CONVERSION MATRIX

CALCULATE BUILDING CAPACITIES

WRITE HEADER

INITIALIZE REPORT MATRIX

CALCULATE CONSUMPTION OF VARIOUS ENERGY TYPES

USE CONVERSION MATRIX TO FILL REPORT MATRIX

CALCULATE TOTALS FOR ENERGY TYPES

DIVIDE BY FLOOR AREA

CALCULATE GRAND TOTALS

CONVERT TOTALS TO KTBU

WRITE ENERGY MATRIX AND GRAND TOTALS

RETURN
Inter FANOF

Sum ABS value, zone sensible loads, system k

Is sum of zone loads = 0.0 ?

NO

RETURN

YES

Initialize general variables.

j = 1

j = j + 1

Is j > JMAX_k ?

YES

Sum base power requirements.

Call BRAD

Sum zone sensible loads not met including effect of baseboard heat.

Distribute sensible loads not met.

Adjust total fan brake horsepower.

RETURN

4-30
2. Call TEMP
   Calculate process water mode (hot water, chilled water, or changeover).
   Are boiler and chiller on?
   YES
   NO
   Is chiller on?
   YES
   NO
   Process mode set to chilled water
   NO
   Process mode set to hot water

   j = j + 1

   Is j > JMAX ?
   YES
   NO

From p. 2
Calculate base electrical power
Calculate sensible thermal load
Is boiler on?
YES
NO
Call HEAT
Calculate mixed air conditions.
Calculate zone supply air temperature.
Calculate fan heat and mixed air conditions downstream of blower.
Call H2B2H
Calculate zone moisture changes.

To p. 2

Call FAN
Determine if fan is shut off. If off, distribute electrical and thermal loads.

Is fan shut-off?
YES
RETURN
NO
Is this a 2-pipe fan coil system?
YES
NO

To p. 2

4-31
ENTER FHTG

Initialize General Variables

\( j = 1 \)

\[ j \neq \text{MAX} \]

YES

NO

Calculate Base Power Requirements

Calculate System Heating Load

Is Heating Load Present?

YES

Calculate Panel Temperature

Calculate Surface Temperature Of Floor

Calculate Downward And Edgewise Heat Loss Coefficient

Calculate Downward And Edgewise Heat Loss

Calculate Heating Requirement Of System

Distribute Unmet Heating And Cooling Loads

RETURN

SESP

FHTG

4-33
ENTER FILM

EXTERIOR SURFACE INDEX IS

IS = 1 IS = 2 IS = 3 IS = 4 IS = 5 IS = 6

CALCULATE FILM COEFFICIENT CALCULATE FILM COEFFICIENT CALCULATE FILM COEFFICIENT CALCULATE FILM COEFFICIENT CALCULATE FILM COEFFICIENT CALCULATE FILM COEFFICIENT

RETURN
SEGMENT TWO

From p. 1

k + 1

Is k Greater Than NMIZ?

NO

j = 1

Is j Greater Than NMAX?

NO

Calculate Heating And Cooling Airside Design Temperature Differences

Calculate Zone Supply Air Quantities

Calculate Zone Return Air Quantities

Sum System Supply And Exhaust Air Quantities

Calculate Average Zone Set Point Temperature System k

Calculate Minimum Outside Air Fraction

CALL MIN

Calculate System Humidity Ratio Setpoint

Initialize System Return Air Humidity Ratio And Density

Calculate Supply Return And Exhaust Fan Power

Sum Building Fan Power

Calculate Supply & Return Fan Temperature Rises Due To Fan Heat (At Design Conditions)

Calculate Zone And System Air Mass Flow Rates, Supply, Return & Exhaust

To p. 3

4-36
SEGMENT THREE

From p. 2

Write System & Equipment Simulation Title Page

Write Distribution Systems Characteristics Page

Write Zone Air Flow Summary Page

Rewind Load Tape

RETURN
ENTER H2OZN

Calculate Amount Of Water Entering Zone Air Due To People

Calculate Amount Of Water Entering Zone Air Due To Infiltration

Calculate Amount Of Water Required To Maintain Zone Humidity Ratio Set Point

Calculate Total Water Added To Zone Air And Net Water Required To Maintain Setpoint

RETURN
ENTER HUM

CALL PSY2

Calculate Humidity Ratio of Air at Saturated Conditions.

Calculate Humidity Ratio of Moist Air at Desired Conditions.

Return
Calculate Temperature And Humidity Ratio Of Air Leaving Induction Unit

CALL WZNEW

Calculate Zone Humidity Ratio

Calculate Return Air Humidity Ratio And Density

2-Pipe Or 4-Pipe System?

4-Pipe

RETURN

2-Pipe

Is Process Water In Changeover Mode?

NO

RETURN

YES

Calculate Changeover Energy & Add To AHU Heating Or Cooling Load

RETURN
ENTER IUNI

NMI = N - 1
j = 1
DLEX = X(2) - X(I)

IORDER = 0

YES

IERR = -1

NO

FOR NT = 1, NTAB: SET 40(NT) = Y(I, NT)

RETURN

N < 2

YES

IERR = -2

RETURN

NO

DELX = 0

YES

IERR = J + 1

RETURN

NO

YES

N = 2

IPT = 1

NO

IS INDEPENDENT ARRAY STRICTLY MONOTONIC

YES

NO

IPT = IPT + NMI

IN = SIGN(I.O, DLEX * (XO - X[IPT]))
Enter MAX

\[ |x| > |A| \]

\[ A = x \]
\[ IB = IY \]

Return

Return
CALL PSYCH

Calculate Enthalpy of Return Air

\[ m = \text{MXAIR} \]

\[ m = 1 \]

\[ m = 2 \]

\[ m = 3 \]

\[ \text{H2A} > \text{HRA} \]

\[ \text{NO} \]

Calculate Fraction of Outside Air Required

\[ \text{CALL ECON\text{\textregistered}} \]

Calculate Fraction of Outside Air Required

\[ \text{YES} \]

Calculate Fraction of Outside Air Required

\[ \text{CALL ECON\text{\textregistered}} \]

Calculate Fraction of Outside Air Required

\[ \text{RETURN} \]

Calculate Mixed Air Dry-Bulb Temperature

Calculate Mixed Air Humidity Ratio

Calculate Mixed Air Density

RETURN
Enter KFM

Is Fan Shut Off Option Used?

Initialize Variables

Is J = MAXJ?

Identify Zone Sensible Thermal Load

Is Boiler On?

Sum Zone Base Power Requirement

Sum Zone Supply & Return Air Mass Flows

Calculate System Return Air Temperature

Calculate Zone Supply Air Temperature

CALL HZRM Calculate Zone Humidification Requirements

CALL TEMP Calculate HOT and Cold Deck Air Temperatures

CALL TAMB Determine If Fan is Shut Off, If Off Distribute Electrical and Thermal Loads

RETURN

CALL BOARD Calculate Baseboard Heating Load

ZONE DO LOOP

j = J + 1

A To p. 2
From p. 1

Calculate Design Economizer Approach Temperature

CALL MAIN
Calculate Mixed Air Conditions

Calculate Premise Cool Load

Calculate Mixed Air Temperature After Supply Fan

Check if Chiller And Boiler Are Operating and Reset Reset Deck Temperature If Required

J = 1

IS
J = MAX
YES

Calculate Fraction Of Zone Mass Flow Thru Hot And Cold Deck

NO

J = J + 1

Check If There Is A Zone Heating Load Not Met

YES

Update Summation Of Zone Heating Loads Not Met And Number Of Hours Loads Not Met

CALL MAIN
Keep Track Of Zone Peak Heating Load Not Met

NO

Check If There Is A Zone Cooling Load Not Met

YES

Update Summation Of Zone Cooling Loads Not Met And Number Of Hours Loads Not Met

CALL MAIN
Keep Track Of Zone Peak Cooling Load Not Met

NO

Sum Zone Hot And Cold Deck Mass Flow Rates

Calculate Heating Cool Load

To p. 3
CALL CC_BIL
Calculate Cooling Load

Calculate Hot Deck Humidity Ratio Required To Satisfy Control Zone Humidity Set Point

CALL HUM
Calculate Hot Deck Humidity Ratio Corresponding To The High Limit Of BOSHR

Is Required Hot Deck Humidity Ratio < Maximum And > Humidity Ratio Of Mixed Air

YES

Calculate Amount Of Humidification Water Required

J = J + 1

NO

Reset The Hot Deck Humidity Ratio Required

Is J > MAX_J

J = J + 1

Calculate Zone End-Of-Hour Humidity Ratio

Calculate System End-Of-Hour Return Air Humidity Ratio And Density

Return
ENTER NUMDEV

SET LOAD POSITIVE

INITIALIZE FRACTION OF FULL LOAD FOR EACH UNIT

M ← 1, NTYPE

CHECK FOR LOAD CONDITIONS ON LAST DEVICE

RETURN

DEFINE LOW, NORMAL, AND HIGH LOADS

N ← 1, NUMM

CAN LOAD BE MET?

YES

NO

RESET X AND SET FFL TO NORMAL OPERATING POINT

A

IS LOAD < MINIMUM LOAD?

NO

YES

RETURN

LAST UNIT IS LESS THAN MINIMUM LOAD

LAST UNIT IS WITHIN OPERATED RANGE
Define A & B Sets of Constants

Convert Air Temperature to Absolute Centigrade Degrees (T)

Is T < 273.16 ?

YES

Define P Set of Constants

Calculate Partial Pressure of Water Vapor in Moisture Saturated Air.

Return

NO

Define P Set of Constants
ENTER PROCES

FOR N=1, NO. PROCES LOADS:

IF ENERGY SOURCE OF PROCESS LOADS

IS INDIRECT: CALCULATE LOAD TO BE ADDED TO BOILER

IS GAS: CALCULATE LOAD FOR PROCESS GAS

IS OIL: CALCULATE LOAD FOR PROCESS OIL

IS ELECTRIC: CALCULATE LOAD FOR PROCESS ELECTRIC

IS STEAM: CALCULATE:

1. ENTHALPY DIFFERENCE BETWEEN ENTERING AND LEAVING STEAM

2. LOAD FOR PROCESS STEAM

END
ENTER PSY1

CALL PPWVM

CALCULATE PARTIAL PRESSURE OF WATER VAPOR IN AIR FOR GIVEN CONDITIONS

CALCULATE HUMIDITY RATIO OF AIR FOR GIVEN CONDITIONS

CALCULATE ENTHALPY OF AIR FOR GIVEN CONDITIONS

CALCULATE DENSITY OF AIR FOR GIVEN CONDITIONS

RETURN
CALL PPWVM

CALCULATE PARTIAL PRESSURE OF WATER VAPOR IN AIR FOR GIVEN CONDITIONS

CALCULATE HUMIDITY RATIO OF AIR FOR GIVEN CONDITIONS

RETURN
ENTER PSYCH

CALCULATE ENTHALPY OF MOIST AIR FOR GIVEN CONDITIONS

CALCULATE SPECIFIC VOLUME OF MOIST AIR FOR GIVEN CONDITIONS

CALCULATE SPECIFIC DENSITY OF MOIST AIR FOR GIVEN CONDITIONS

RETURN
ENTER PTLD

IS FAN FULLY LOADED?

SET UP INTERMEDIATE VARIABLE PCT = PC

IS PCT < 0.20?

IS PCT > 1.1?

m = NC

m=1

CALCULATE FRACTION OF POWER REQUIRED FOR VAR. SPEED MOTOR CONTROL

m=2

CALCULATE FRACTION OF POWER REQUIRED FOR INLET VANE DAMPER CONTROL

m=3

CALCULATE FRACTION OF POWER REQUIRED FOR DISCHARGE DAMPER CONTROL

RETURN

CALCULATE FRACTION OF POWER REQUIRED FOR 100% LOADING

RESET PCT = 0.20

RESET PCT = 1.1

SESP PTLD
Calculate Power Per Ton Of Refrigeration Required

Calculate Total Hourly Power Consumption

Return
CALL FIXAIR
Calculate Mixed Air Conditions

CALL AHU
Calculate Heating, Cooling & Humidification Loads

\( j = 1 \)

Is \( j > J_{\text{MAX}} \)?

\( j = j + 1 \)

Fan System Type (\( F_{\text{AN}} \))

\( F_{\text{AN}} = 1 \)

Calculate Reheat Coil Load

Heating

Zone Thermal Load

Cooling

Is Reheat Coil On?

\( \text{No Load} \)

\( \text{Yes} \)

CALL ZAR.

Calculate Zone Heating Load

\( F_{\text{AN}} = 13 \)

Calculate Reheat Coil Load

Heating

Zone Thermal Load

Cooling

CALL CCBIL

Calculate And Distribute Heating Load Not Met

\( F_{\text{AN}} = 5 \)

Calculate And Distribute Cooling Load Not Met

\( F_{\text{AN}} = 6 \)

Calculate And Distribute Heating Load Not Met

CALL ZCEN

Calculate Zone Humidity Ratio

Calculate Return Air Humidity Ratio And Density

RETURN

4-59
BEGIN
WRITE SUMMARY OF EQUIPMENT SIZES
WRITE TEMPERATURE DISTRIBUTION PROFILE
CALL ENGY
WRITE ANNUAL SUMMARY OF BUILDING MONTHLY ENERGY AND RESOURCE CONSUMPTION AND DEMANDS
CALL EXSUM
WRITE EXECUTIVE SUMMARY
CALL ECON
WRITE ECONOMIC SUMMARY
END
BEGIN SESIN

INITIALIZE UNIT VARIABLES AND SWITCHES

CALL VTIN
READ IN BUILDING DESCRIPTION TAPE

CALL CSIN
READ IN INPUT DECK

CALL VTINITT
CALL VTCSRF
INITIALIZE SPACE RESPONSE FACTOR VARIABLES

CALL FSIZE
INITIALIZE FAN SYSTEM DATA

CALL ESIZE
INITIALIZE HEATING AND COOLING PLANT DATA

END
READ ZONE LOAD DATA FROM INPUT LOAD TAPE

IS MxMSTRT?  YES / NO

IS INHOUR < INSRT?  YES / NO

IS INHOUR < HSTP?  YES / NO

ARE EXTERIOR LIGHTS OFF?  YES / NO

CALL CLGTWR
CALCULATE ENTERING AND LEAVING CONDENSER WATER TEMP. AND TOWER FAN SWITCH STATUS

CALL CHLADJ
FIND CHILLER'S PERFORMANCE

SUM CHILLER PLANT CAPACITY

SUM BOILER PLANT CAPACITY
IS THERE ANY DX/HEAT PUMP UNITS?

CALL VTHOUR
CALCULATES HOURLY INTERPRODUCTS OF SPACE TEMP AND RESPONSE FACTORS

IS FIRST PASS?

IS MAIN PLANT RET?

ARE THERE DIVERGING RHO'S?

ARE THERE DIVERGING RHO'S?

RHOCHP(KADJ, IDX) ← 1.0

RHOCHP(KADJ, IDX) ← 1.0

RHOH(KADJ) ← 1.0

RHOH(KADJ) ← 1.0

RHOH(KADJ) ← 1.0

RHOH(KADJ) ← 1.0

CALL DXHP
DETERMINE HEATING CAPACITY

CALL DXHP
DETERMINE COOLING CAPACITY

IS UNIT DX ONLY?

YES

NO

CALL DXHP
DETERMINE COOLING CAPACITY

CALL DXHP
DETERMINE HEATING CAPACITY

IS FIRST TIME THROUGH LOOP?

YES

IS NUMBER TRIPS > 5?

NO

YES

IF KADJ = 1

Determine if it is diverging

ARE THERE HEAT PUMPS?

NO

YES

INITIALIZE ADJUSTMENT FLAGS AND COUNTER

IS THERE ANY DX/HEAT PUMP UNITS?

NO

YES

IS FIRST TIME THROUGH LOOP?

YES

NO

IS NUMBER TRIPS > 5?

NO

YES

IF KADJ = 1

Determine if it is diverging

ARE THERE HEAT PUMPS?

NO

YES

INITIALIZE VT CALCULATIONS

DONE

F E
ARE THERE DIVERGING RHO'S?

CALL VTLOAD
CALCULATES SPACE TEMPERATURE AND HEATING/COOLING EXTRACTION RATES

IS IDXHP(IDX) = 2?

YES

ZERO OUT PLENUM LIGHTING LOADS FOR SPACES WITH ATTACHED PLENUMS

INITIALIZE HEATING AND COOLING PLANT LOADS

K ← 1, KMAX

PROCESS LOADS FOR HEATING PLANT

COMPARE PLANT AVAILABILITY TO REQUIREMENTS

HAVE LOOPED 5 TIMES?

YES

SUM PLANT ENERGY REQUIREMENTS

NO

SUM RESOURCE REQUIREMENTS

CALL RHFS
CALL SZHRT
CALL M2DD
CALL FHTG
CALL VARVL

CALL COIL
CALL INDUC
SESP
SMEXEC
Page 5

[Diagram flowchart with steps:
1. Is there DX or heat pump simulation? (YES or NO)
2. If YES, calculate cooling load.
3. Calculate heating load.
4. Calculate net load to central equipment.
5. Set up terms for output tape.
6. Cooling tower simulation.
7. Set up temperature distribution profile.
8. Call equipment.
10. Add DX/HP tower requirements.
11. Sort resource requirements for output table.]

4-66
ENTER STEAM

CALCULATE ENTHALPY OF LOW PRESSURE STEAM

RETURN
ENTER

Determine Power Output Required For Each Turbine

Determine Enthalpy Of Entering Steam

Determine Entropy Of Entering Steam

Determine Leaving Steam Temperature After Isentropic Expansion And Exhausting At 2 psig

Calculate Enthalpy Of Leaving Steam

Calculate Theoretical Steam Rate

Calculate Base Steam Rate

Calculate Horsepower Loss

Calculate Superheat Correction Factor

Determine Full Load Steam Rate

Determine Part Load Steam Rate

Determine Total Steam Consumption

Return

4-68
SET BUILDING OCCUPIED FLAG = 2

IS BUILDING OCCUPIED?

IF YES, FLAG = 1

IF NO, I ← I, 15

IS TEMPERATURE < RANGE?

IF YES, INCREMENT I TM

RETURN

RETURN
ENTER TOT

SUM MONTHLY ENERGY CONSUMPTION

RETURN
Is T0A at or below lower limit?

Is T0A at or above upper limit?

Calculate TRSET as an inverse function of outdoor temperature

Set TRSET equal to upper media temperature limit

Set TRSET equal to lower media temperature limit

Return
To p. 1


2. CALL MAIN
   Calculate Mixed Air Conditions

   Redefine Leaving Air Temperature
   Are Boiler or Chiller Off?

   CALL MIL
   Calculate Heating, Cooling, & Humidification Loads

   Adjust Total Fan Brake Horsepower

   j = j + 1

   IN j = 1

3. SUR ZONE Base Power Requirements

   Calc. Terminal Unit Sensible Thermal Requirements

   Are Terminal Reheat Cells Used?

   Re-Heat Req'd
   Is Re-heat on?

   CALL ZONE
   Calc. Terminal Unit Load

   Re-Cooling Req'd

   Update Cooling Load Non-Net Variables

   Update Cooling Load Net Variables

   Zone Load Net Met

4. ZONE LOAD

5.(Return)

6. Calc. Btu/hr Air Density and Humidity Ratio

Page 2
ENTER VTCSRF

I ← 1, NS

RETURN

A

Determine the highest number of response factor terms that a delayed surface may have

Limit number response factors to 10

Initialize space response factors

Calculate correction factor for underground surfaces

Calculate correction factor for delayed surfaces

Calculate correction factor for non-underground floors for furnishings

Default values for floor and ceilings

Default values for underground surfaces

Perform relative end test

Set index j ← 1

Set number terms defined for space

Default values for ceilings

Default values for non-underground floor

Default values for furnishings

Store space response factor into matrix

Yesspacefast responding?

Have all space factors been calculated?

Is space fast responding?

Increment J

A
ENTER VTHOUR

I ← 1, NS

RETURN

INITIALIZE SPACE PARAMETERS

FOR EACH QUICK SURFACE CALCULATE INDEX, U-FACTOR, ROUGHNESS FACTOR INDEX

FOR EACH WINDOW CALCULATE INDEX, U-FACTOR

FOR EACH INTERNAL SURFACE CALCULATE INDEX, ADJACENT SPACE NUMBER

CALCULATE FINAL SPACE RESPONSE FACTORS

INITIALIZE PLENUM VARIABLES

IS A CEILING PLENUM?

YES

IS FAN OPERATING?

NO

EVALUATE PLENUM VARIABLES

NO

CALCULATE TEMPERATURE DIFFERENCE

DEFINE TERMS
ENTER VTIN

READ JOB DESCRIPTION VARIABLES

READ BUILDING SURFACE DESCRIPTION DATA

READ ZONE DESCRIPTION DATA

READ RUN DESCRIPTION DATA

CALCULATE RESISTANCE AND U-FACTORS FOR SINGLE AND MULTI-PANE WINDOWS

RETURN
ENTER VTINIT

CALCULATE SUM U*A FOR ALL INTERNAL HEAT TRANSFER SURFACES IN EACH SPACE

INITIALIZE RUN PARAMETERS FOR EACH SPACE

RETURN
SET PROPER WEEKLY THERMOSTAT SCHEDULE INDEX

SET SPACE THERMOSTAT TYPE AND CHECK FOR FLOATING SPACE TEMP

SET HIGH AND LOW THERMOSTAT LIMITS DEVIATIONS AND SPACE HEATING AND COOLING CAPACITY

IF FLOATING SPACE TEMP?

SET LIMIT VALUES AT QUANTITIES THAT WILL NEVER BE EXCEEDED

ZERO OUT SPACE HEATING AND COOLING CAPACITIES

CALCULATE SLOPE OF THERMOSTAT FUNCTION LINE

CALCULATE INTERCEPT OF THERMOSTAT FUNCTION LINE

CALCULATE SPACE TEMP DEVIATION AT END OF HOUR

CALCULATE HEAT EXTRACTED FROM OR SUPPLIED TO SPACE DURING HOUR

DOES NEEDED HEAT EXCEED AVAILABLE HEAT?

MAKE CORRECTIONS OF HEAT EXTRACTION AND SPACE TEMPERATURE DEVIATION

DOES NEEDED COOLING EXCEED AVAILABLE COOLING?

MAKE CORRECTIONS OF HEAT EXTRACTION AND SPACE TEMPERATURE DEVIATION
SESP
VTLOAD
PAGE 2

A

B

C

NO

YES

TYPE & THERMOSTAT?

STORE SPACE END-OF-HOUR TEMPERATURE DEVIATION FOR NEXT HOUR

CALCULATE SPACE TEMPERATURE DEVIATION

CALCULATE END-OF-HOUR SPACE TEMPERATURE

SET UP VARIABLES FOR FAN SYSTEM SIMULATION

RETURN

INITIALIZE HEAT EXTRACTION RATE

IS LOWER LIMIT EXCEEDED?

YES

NO

RESET HEAT EXTRACTION AND SPACE TEMPERATURE DEVIATION

IS SPACE HEATING CAPACITY EXCEEDED?

YES

NO

RESET HEAT EXTRACTION AND SPACE TEMPERATURE DEVIATION

RETURN
ENTER VTPOHD

INITIALIZE PRINT FLAGS

ARE THERE ANY PRINT-OUTS?

YES  RETURN

NO  

I ← 1, IPO

ANY PRINT-OUTS THIS DAY?

YES  SET PRINT FLAGS TO UNITY

NO  RETURN

RETURN
Enter ZL0

HEATING COIL
IQ = 1
Is leaving temp > high limit?
YES
Reset leaving temp = high limit. Calculate and distribute heating load and load not met.
RETURN
NO
Calculate and distribute heating load.
RETURN

COOLING COIL
IQ = 2
Is leaving temp < low limit?
YES
Reset leaving temp = low limit. Calculate and distribute cooling load and load not met.
RETURN
NO
Calculate and distribute cooling load.
RETURN
Section 5
OWNING AND OPERATING COST PROGRAM
BEGIN ECON

READ IDENTIFICATION DATA - FAC, CITY, ENGR, PROJ, DATE

READ BUILDING LIFE

READ ESCALATION FACTORS

READ ENERGY UNIT COST DATA

READ NUMBER OF CASES TO BE ANALYZED

\[ NR < 1, NRUN \]

RETURN

READ SYSTEM DESCRIPTION LABEL

READ NUMBER OF ENERGY CATEGORIES

ARE THERE ANY ENERGY CATEGORIES?

YES

NO

B PAGE 4

A PAGE 2
ECON
PAGE 3

WRITE SYSTEMS DESCRIPTION LABEL

J=1,6

INITIALIZE TOTAL COST AND CONSUMPTION OF ENERGY TYPE J

I=1,NCATE

SUM GRAND TOTAL COST FOR ALL ENERGY

SUM PRESENT VALUE OF ENERGY FOR EACH TYPE

SUM ANNUITY FOR EACH ENERGY TYPE

WRITE REPORTS

IS ENERGY TYPE = J ?

INCREMENT FLAG COUNTER; SUM TOTAL COST OF ENERGY

SUM TOTAL CONSUMPTION OF ENERGY TYPE J AND ITS TOTAL COST

HAS HEADER BEEN WRITTEN ?

WRITE HEADER

WRITE COST AND CONSUMPTION INFORMATION
MAKE INITIALIZATIONS FOR EQUIPMENT CATEGORY COSTS

IS INSTALLATION OF EQUIPMENT COST < 0 ?
YES — PAGE 1
NO

IS EXPECTED LIFE OF EQUIPMENT < 0 ?
NO — PAGE 1
YES

IS BUILDING LIFE = EQUIPMENT LIFE ?
NO — SET BUILDING LIFE RATIO AND EQUIPMENT LIFE RATIO
YES — SET BUILDING AND EQUIPMENT LIFE RATIOS TO 1

IS RESELL VALUE TO BE CONSIDERED AT END OF BUILDING LIFE ?
NO — RECALCULATE PRESENT VALUE
YES — CALCUATE PRESENT VALUE OF FLOOR SPACE COST FOR EACH YEAR OF LIFE

IS FLOOR COST < 0 ?
NO
YES — PAGE 5
WRITE HEADINGS

I ← 1, NCATQ

WRITE OUT FINAL RESULTS

G PAGE 1

10 TOTAL SALVAGE <0

IS TOTAL ANNUITY >0

IS OVERHAUL PERIOD >0 <0

IS SALVAGE FLAG >0 <0

WRITE REPORT

WRITE MESSAGE

IS SALVAGE FLAG >0 <0

WRITE REPORTS

WRITE REPORTS

=0

=0

5-6
NASA's Energy-Cost Analysis Program (NECAP) is a powerful computerized method to determine and to minimize building energy consumption. The program calculates hourly heat gain or losses taking into account the building thermal resistance and mass, using hourly weather and a "response factor" method. Internal temperatures are allowed to vary in accordance with thermostat setting and equipment capacity.


This manual supports the "Engineering Manual" (TM 832340) by providing flow charts for the program.