

DOE-2 USER NEWS

: A COMPUTER PROGRAM FOR BUILDING ENERGY USE ANALYSIS

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BULLETIN BOARD

Item: Beginning with the DOE-2.1B version of the program, purchasers of the documentation will be able to order individual volumes, not perforce the entire set as in the past. NTIS will accept orders for individual copies of the BDL Summary, Users Guide, Reference Manual, Parts 1 and 2, (as one unit), and the Sample Run Book. When the Engineers Manual is released as Volume IV, it also will be offered as a separate title.

It is envisioned that a typical office of four DOE-2 users would find it useful to have on hand one each of the following: the Users Guide, Sample Run Book, and Engineers Manual. Two copies of the Reference Manuals and four BDL Summaries, for quick desk reference, would complete the set.

Item: The DOE-2.1B Update Package will be published as a "stand-alone" document for use with the new features in the program. There will be no replacement sheets for the basic volumes, only references under affected commands to this Supplement. The BDL Summary will again be republished; it will contain the only integrated listing of all of the 2.1B commands and keywords until the release of the 2.1C version of the code when a complete new set of documentation will be published.

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FUNCTIONAL VALUES

Development is well underway to add a mechanism for introducing functional values into the LOADS and SYSTEMS subprograms. This feature, described below, will be implemented in the developmental version of the program and should be available in DOE-2.1C (LOADS) and DOE-2.1E (SYSTEMS).

The functional values capability will enable simulation of innovative design techniques by allowing users to write specific calculation algorithms to be incorporated into simulation calculations. For each component simulation block, after the standard calculation is done, the user input functional values are evaluated. Functions will have access to all global variables, such as drybulb temperature, solar altitude, etc., as well as intermediate and final calculated values such as solar gain through windows, wall area, schedules, etc. Each value will be accessed in a manner similar to the hourly report variables. From a user interface point of view, there are two steps in using the functions:

First: The values inside the simulation program are equivalenced to local variables that are used in expressions. This will be done by a new command, ASSIGN-VARIABLES. This part creates the interface between the user function variables and the simulation program variables. Also, any table declarations for PWL (piece wise linear) functions are entered here. Variable names must be 8 characters or less. All variables are type real. If they contain an integer value inside simulation programs, the value is converted to the real format.

Second: This is the function calculation part in which the expressions and logic flow are defined. Algebraic expressions are used for calculations and conditional commands for decisions. Here, the algebraic expressions are allowed in a similar way as with FORTRAN statements. The GOTO and IF statements (as well as FORTRAN library functions ABS, AMOD, INT, SORT, SIN, ASIN, COS, ACOS, EXP and ALOG) are available. The PWL function takes a table of x and y as one of its arguments and returns the interpolated value of y for any given x value.

MULTIPLYING PROBLEMS

Modeling buildings on a computer, as with DOE-2, is an art and not a science. This truism is often unappreciated by users and by critics of DOE-2, who mistakenly think that the model is the same as reality or should be. Knowing what amount of detail to include and how much to ignore not only depends upon one's purpose for making the model, but also upon one's engineering judgement. A compromise is often made between accuracy and simplicity, between the level of detail described and the cost of computation.

This situation is most poignant in preparing the input for DOE-2 when a building's configuration and equipment suggest that use might be made of the MULTIPLIER keywords, particularly in the SPACE (and ZONE) commands. Strictly speaking, no two spaces are exactly equivalent in a physical sense; so the justification for causing the model to treat them as equivalent by using MULTIPLIER in the SPACE command depends upon the user's judgement that, thermodynamically, the spaces being treated together will behave quite similarly and will effectively be at the same temperature. Spaces on middle floors of high-rise office buildings are the usual candidates for MULTIPLIER; so also are a series of similar offices on the same floor along one exposure of a building. Obviously, the motivation for using MULTIPLIER is two-fold: to reduce the amount of input and to reduce the cost of the computer run.

When a user breaks away from a strict description of the physical building and attempts to create an equivalent model, particular care has to be taken. It is possible to set up paradoxes that are unresolvable, not only by DOE-2, but by the user. As an example consider the following input:

```
SPACE-1 = SPACE ... MULTIPLIER = 3 ..
IW-1    = INTERIOR-WALL ...
        AREA = 600 NEXT-TO SPACE-2 ..
SPACE-2 = SPACE ... MULTIPLIER = 4 ..
```

How should the heat transfer through IW-1 be calculated? What is the configuration of the seven spaces indicated by the input? What does the wall area represent? We have here a "legitimate" input to DOE-2.1A and one that neither causes an error message to be issued nor gives meaningful results. This input was not anticipated when the program was written and the program merrily proceeds by virtue of a bug!

Now, what is the bug? There are really several, but they all have the same result. The bug in DOE-2.1A is that the MULTIPLIER keyword is not handled properly in regard to INTERIOR-WALLS. If an INTERIOR-WALL is defined in one space, when DOE-2.1A is working on the NEXT-TO space, it does not look across the wall to discover what the MULTIPLIER is on the other side. In the example above, DOE-2.1A will compute the thermal transfer from SPACE-1 to SPACE-2 by multiplying the area of the wall by 3, but will calculate the thermal transfer in the opposite direction by multiplying the wall

area by 4.

In the paradoxical input above, the situation is not well defined in the first place, so the result matters little. The problem really arises in non-paradoxical input as below:

```
SPACE-1 = SPACE ... MULTIPLIER = 3 ..
IW-1    = INTERIOR-WALL ...
        AREA = 600 NEXT-TO SPACE-2 ..
SPACE-2 = SPACE ... MULTIPLIER = 1 ..
```

Here we have set MULTIPLIER = 1 (the default, provided here only for clarity) in SPACE-2 and what is being described is three identical spaces, each with a 600 square foot wall in common with SPACE-2. From the perspective of SPACE-2, the INTERIOR-WALL has an area of 1800 square feet (3 x 600). DOE-2.1A will, however, provide SPACE-2 with an INTERIOR-WALL with only a 600 square foot area. During the simulation, this generally introduces a minimal error if both SPACE-1 and SPACE-2 are being held to the same temperature, since one expects little thermal transfer to take place. More severe is the error introduced when calculating Custom Weighting Factors. In that case, the mass of the INTERIOR-WALL in SPACE-2 will be underestimated by a factor of 3.

The general solution to these problems in DOE-2.1A is to calculate and store the Custom Weighting Factors for each space separately and to eliminate INTERIOR-WALLS during the simulation. Another alternative is to define INTERIOR-WALLS in each space as being NEXT-TO the same space. None of these solutions is very satisfactory and in DOE-2.1B an effort has been made to resolve the problems.

It can be seen that the problem with MULTIPLIER in the SPACE command is the INTERIOR-WALL and the solution to the problem must be to come to grips with these walls. Eliminating INTERIOR-WALLS between conditioned zones, with the argument that the heat transmission across such walls is small, is an argument that fails when the user wants to include daylighting effects or to compute Custom Weighting Factors for the spaces. On the other hand, how does one model the wall between two spaces being described together through the MULTIPLIER keyword? Which space is NEXT-TO the described space?

The solution in DOE-2.1B will be to introduce a new interior wall-type keyword and to allow several types of INTERIOR-WALLS. Also, a new keyword, FLOOR-MULTIPLIER, will be introduced into the SPACE command to account simultaneously in high rise commercial buildings for multiple "identical" floors and multiple peripheral spaces in thermal contact with a core space. No transmission across INTERIOR-WALLS is computed for FLOOR-MULTIPLIER, whereas there is for MULTIPLIER. Thus one will use FLOOR-MULTIPLIER to account for the number of identical floors and MULTIPLIER to account for the identical spaces on the same floor.

BUGS DISCOVERED IN DOE-2.1A AND INTERIM SOLUTIONS

As we close the books on the 2.1A version of the program and move onto the next version, which has just been frozen and shipped to the National Energy Software Center for processing, we have collected the separate listings of bugs that have appeared in the last three issues of the newsletter. Herewith is a complete list of bugs found in DOE-2.1A.

This index is intended to cross-reference bugs by 1) abort routine, 2) system-type affected (except those which affect all systems), 3) report affected, and 4) subject matter, command, and/or keyword.

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- [1] The END command should be a legal command in PARAMETRIC-INPUT ECONOMICS, but EDL does not recognize it. An error message, ILLEGAL COMMAND IN PARAMETRIC RUN, is issued. Since it cannot find an END command, the program may keep reading end-of-files until it hits the job's time limit.
Interim solution: Do not use PARAMETRIC-INPUT ECONOMICS. Rather, enter a separate ECONOMICS input for each set of parametric values.
- [2] Weighting factors depend on LIGHTING-TYPE. However, if ASHRAE weighting factors are being used in two SPACES (through the use the keyword FLOOR-WEIGHT), and the second SPACE is LIKE'd to the first, with the exception of a different LIGHTING-TYPE, the program incorrectly uses the same set of weighting factors for both SPACES.
Interim solution: Do not use LIKE for SPACES for which you want different weighting factors.
- [3] When a user LIKE's a command to another command which is not of the same type, (an EXTERIOR-WALL LIKE'd to an INTERIOR-WALL, for example), the correct error message is printed out, followed by the extraneous message:
ERROR *** CANNOT LIKE SOMETHING TO ITSELF
Interim solution: Ignore the extra error message; correct the input and it will disappear.
- [4] When one SPACE is LIKE'd to another, and the first SPACE uses SHAPE=BOX, two erroneous caution messages are printed for the second SPACE:
CAUTION --- IF SHAPE=BOX IS INPUT, VOLUME IS NOT USED CAUTION --- IF SHAPE=BOX IS INPUT, AREA IS NOT USED
Interim solution: Ignore the two caution messages.

- [5] Whenever SHAPE=BOX is input in the SPACE command, the keyword VOLUME is not used. However, the program always issues the following erroneous caution message:
CAUTION --- IF SHAPE=BOX IS INPUT, VOLUME IS NOT USED
Interim solution: Ignore the caution message.
- [6] 1) In the LV-C Report, the TASK LIGHTING KW and the W/SQFT are switched in position.
2) When the zone OA specified is less than exhaust, the program increases the outside air rate for the zone to be equal to the exhaust rate. The SV-A report, however, still lists the specified OA at the zone level.
3) In PV-D, the last eight characters of the utility name are incorrect.
Interim solution: None.
- [7] If, in SPACE-CONDITIONS, the TEMPERATURE is set outside the range of 70 to 80°F, and if PEOPLE-HEAT-GAIN is specified, then the value calculated by the program for the latent load due to people will be negative.
Interim solution: Do not use PEOPLE-HEAT-GAIN under these conditions. Instead, specify both PEOPLE-HG-LAT and PEOPLE-HG-SENS.
- [8] When SKY-FORM-FACTOR is specified, but GND-FORM-FACTOR is not, or vice versa, for quick walls, the unset form factor does not get reset. It remains at its flag value of -66666, resulting in strange loads.
Interim solution: For quick walls, input both SKY-FORM-FACTOR and GND-FORM-FACTOR or neither, as the documentation indicates.
- [9] If INTERIOR-WALLS are used in a SPACE NEXT-TO a SPACE with a MULTIPLIER, the heat exchange across that wall is not calculated correctly. The program will incorrectly place only one wall between the spaces rather than the MULTIPLIER number of walls.
Interim solution: None; define all spaces separately if INTERIOR-WALLS are important.
- [10] When DESIGN-DAYS are input, the solar calculations are based on the keywords CLOUD-TYPE, CLOUD-AMOUNT, and CLEARNESS. However, if the job is run with a packed weather file containing solar data (e.g., a TMY tape), the program ignores these keywords and their values and the DESIGN-DAYS receive zero solar data. The regular RUN-PERIOD reports are unaffected by this bug.
Interim solution: Run the DESIGN-DAY input deck with any packed weather file with no solar information on it (a TRY file, for instance). Then run the regular RUN-PERIOD input deck with the desired solar file.
- [11] When a zone for which SIZING-OPTION=ADJUST-LOADS is specified and multiple internal walls exist attached to this zone, the program will sometimes terminate without performing the simulation or issuing any message.
Interim solution: None; remove the SIZING-OPTION keyword from the ZONE command.
- [12] The program will abort in routine PTAC if, in a PTAC system, the following conditions occur simultaneously: MAX-ELEC-T is greater than the outside air drybulb temperature and the heatpump is running.
Interim solution: Use the default (40) or a sufficiently low value for MAX-ELEC-T.
- [13] There is a typographical error in the code that always causes an incorrect calculation of the design cooling mixed air temperature. This is a minor or possibly severe bug, depending on compiler type. Depending upon the machine, the program may abort in routine DESIGN.
Interim solution: None.
- [14] When SUPPLY-CFM has been specified and is being distributed in a variable air volume system, the heating and cooling flow rates are not always correct relative to the THERMOSTAT-TYPE and MIN-CFM-RATIOS.
Interim solution: Specify the zonal ASSIGNED-CFMs and let the program sum them into SUPPLY-CFM.
- [15] 1) In a zonal unit with HEAT-SOURCE=HEAT-PUMP, (RESYS or PTAC), the design calculations for the zone max heating addition rate do not correctly use MIN-HP-T and MAX-ELEC-T. 2) When HEATING-CAPACITY is specified in a central system with reheat coils, the sign of the reheat coil capacity is wrong.
Interim solutions: For 1), ignore the SV-A report's max heat addition. For 2), reverse the sign on the value given for the zonal heating capacity in SV-A.

- [16] When a user specifies exhaust air for a zone in a system not allowing exhaust air, the program converts the exhaust air to an outside airflow. When this conversion is done, however, there is no check to see whether outside air has already been specified. Thus, the exhaust overrides the outside air even if the former is smaller. This will be changed in DOE-2.1B to take the larger of the two.
Interim solution: Input outside air rather than exhaust.
- [17] The SS-J report is accurate only for the systems in the first PLANT-ASSIGNMENT.
Interim solution: None.
- [18] In the design calculations for zonal heating capacities, the fan heat is incorrectly subtracted rather than added. This causes slight oversizing equal to twice the fan heat.
Interim solution: None; reduce fan heat to minimum.
- [19] If a system is sized based upon the cooling peak load or upon MAX-COOL-RATE, the heat addition rate reported in the SV-A report should be calculated based upon the fan size. At present, the SV-A reports instead the peak heating load or MAX-HEAT-RATE. A similar problem exists when the sizing is based upon the peak heating load.
Interim solution: None; insignificant bug, ignore this figure.
- [20] When using DUCT-DELTA-T in a RESYS system, the value is added to the MAX-SUPPLY-T rather than subtracted from it, so the answer moves in the wrong direction.
Interim solution: None; do not use DUCT-DELTA-T in a RESYS system.
- [21] In the zonal systems, HP and PTAC, the electrical input to heating and cooling (DX heating and cooling only) is calculated incorrectly when the heating and/or cooling capacity is specified but the CFM is not. This usually results in a small error, but can result in a very large error: the error is proportional to the ratio of specified capacity and the capacity that the program would use if automatic sizing were allowed. In the case of the larger error, this can result in negative electrical input to heating and/or cooling.
Interim solution: Specify the CFM when specifying the capacity.
- [22] These are two interrelated bugs in the RESYS system: 1) If VENT-TEMP-SCH is not specified, it should default to the top of the heating throttling range. Thus, ventilation should occur, if the outside temperature is below the cooling set-point, until the temperature drops into the heating throttling range. The bug does not permit ventilation unless the zone temperature would rise into the cooling throttling range without the ventilation. 2) If VENT-TEMP-SCH is set equal to the COOL-TEMP-SCH, an ambiguous temperature band is created between the VENT-TEMP-SCH and the bottom of the cooling throttling range. Natural ventilation will not occur until the zone temperature reaches the cooling set-point, while mechanical cooling will begin at one-half the throttling range below this temperature. In the simulation this anomaly shows up as a small but erroneous heating effect.
Interim solutions: For 1), specify VENT-TEMP-SCH. For 2), set VENT-TEMP-SCH to be less than COOL-TEMP-SCH minus one-half the throttling range.
- [23] When the load on a PTAC or HP system is low and no outside air has been specified, sometimes a negative fan electrical will be reported. This will cause the peak fan electrical to be significantly off in most cases. Other numbers are not usually significantly affected.
Interim solution: None.
- [24] When the HEAT-SOURCE=HEAT-PUMP option is used in the PTAC system, the auxiliary electric heat capacity (ELEC-HEAT-CAP) is not automatically sized. Thus, the total electric input to heating can be drastically underestimated and the zones will have many hours overheated.
Interim solution: Specify ELEC-HEAT-CAP.
- [25] In the ENERGY-COST command, the keywords BLOCK and MULTIPLIER are alternate ways of specifying load blocks in which energy will be priced differently. The bug is that BLOCK is treated like MULTIPLIER and MULTIPLIER is treated like BLOCK.
Interim solution: Use BLOCK when you want MULTIPLIER and vice versa.
- [26] When the THERMO-CYCLE option is used with the DIRECT-COOL-MODE keyword, but no centrifugal chiller is specified as required, multiple error messages reading, misleadingly,
ERROR *** THERMOCYCLE REQUIRES AT LEAST ONE COMPRESSION CHILLER
are printed, but the program does not stop in BDL as it should. In addition, the error message should read ... ONE CENTRIFUGAL CHILLER.
Interim solution: Correct input.

- [27] If, for a ZONE-TYPE=PLENUM, the keyword MULTIPLIER is specified, the program will give incorrect results, the severity of which increases in proportion to the value specified for MULTIPLIER.
Interim solution: None; do not use MULTIPLIER for ZONE-TYPE=PLENUM. Specify each zone separately.
- [28] The values for the system-level HOURLY-REPORT variables 78, 79, and 80 are not reported out.
Interim solution: None.
- [29] Some underheating and undercooling may be incorrectly reported in SS-F when COOL-CONTROL=WARMEST or HEAT-CONTROL=COLDEST. This is due to the use by the program of an incorrect value for the zone thermostat throttling range in the calculation of supply temperature. The value used is one-half the actual value. This bug affects only the calculation of the supply temperature; other calculations use the correct value for the throttling range.
Interim solution: There is no way to avoid this bug entirely when using the COLDEST/WARMEST options, but specifying a THROTTLING-RANGE that is 2 to 3 times the normal range will minimize the underheating/undercooling problem. This may, however, require adjusting the setpoints to ensure that average zone temperatures are maintained as desired.
- [30] If the value input for DESIGN-HEAT-T for a zone is equal to the value input for MAX-SUPPLY-T, or if it is equal to the sum of MIN-SUPPLY-T and REHEAT-DELTA-T, and MIN-CFM-RATIO has not been specified, the program will abort in routine DESIGN.
Interim solution: Change either the DESIGN-HEAT-T or MAX-SUPPLY-T/MIN-SUPPLY-T such that they are not equal.
- [31] If SYSTEMS and/or PLANT are run with DESIGN-DAY RUN-PERIODS only, and SUMMARY reports are requested, they will be produced, but with incorrect or all zero values. Note, however, that no SYSTEMS or PLANT SUMMARY reports are intended to be produced for DESIGN-DAY RUN-PERIODS; DESIGN-DAY runs are intended only for PLANT sizing.
Interim solution: None; ignore the SYSTEMS and PLANT SUMMARY reports.
- [32] The program may abort in routine HTPUMP if cooling is scheduled on in a HP system, but heating is scheduled off. This should be a rare occurrence in this system since it defeats the normal purpose.
Interim solution: Schedule both heating and cooling on.
- [33] The program will give erroneous results if LIGHTING-TYPE = REC-FLUOR-NV has been specified in a space for which custom weighting factors are desired.
Interim solution: Use LIGHTING-TYPE = SUS-FLUOR.
- [34] In a CBVAV system, when the following four conditions are met simultaneously, then the supply temperature may be incorrectly calculated (on the high side): 1) the presence of a fixed economizer, 2) the fans were off the previous hour, 3) outside air is relatively cold, and 4) mixed air is being passed to spaces.
Interim solution: None.
- [35] If custom weighting factors are requested for a zone with INTERIOR-WALLS NEXT-TO an UNCONDITIONED or PLENUM zone, then a bug in BDL will result in energy disappearing from the building. The amount of energy lost depends upon the fraction of wall surface contiguous with the unconditioned zone.
Interim solution: In LOADS, define all zones as CONDITIONED. In SYSTEMS, define plenums and unconditioned zones appropriately. Do not allow SYSTEMS to size variable air volume systems from peak loads, if there is a single system for the entire building.
- [36] A bug in the estimation of mixed air temperatures for TPIU and FPIU systems causes the central heating to be overestimated in a large number of situations. This is usually only problematic when the minimum fraction of outside air is large (close to 100%) or when the outside air dampers are not moveable (OA-CONTROL = FIXED).
Interim solution: None.

Weather

Tape: There is an anomaly on the packed TRY weather tape for Medford, OR, which shows up as a maximum temperature of 156°F in the month of August. The problem originates on the raw TRY tape where, on August 15 at hour 18, the drybulb temperature reads 100°F and the wetbulb 34°F. This error led to an algorithm breakdown in the packer.
Interim solution: Correct the wetbulb temperature on the raw TRY tape through interpolation, and repack.

THE HEAT EXCHANGER

This section is devoted to questions from users and responses from the Building Energy Simulation Group and its consultants. Your questions and comments are most welcome.

* * * * *

Question: I have perimeter zones that are served by two systems, a two-pipe induction unit and a constant volume reheat fan system. How does DOE-2 handle such a dual-system arrangement?

Answer: Unfortunately, the program is not presently capable of simulating such a situation. Only one thermostat is allowed per zone and without multiple thermostats and other monitors, there is no way the program can calculate how much conditioning is being provided by the first system, and therefore, when to kick in the second system. One way to get around this restriction with DOE-2 is to split each zone into two. The skin zone might be 1 or 2 feet deep, with no equipment, people, etc. in it, and the second zone would describe the real working area.

Incidentally, another user has pointed out that there is no WARNING or ERROR message issued when the same zone name, either accidentally or deliberately (under the false assumption that one can model a dual-system zone), is entered under two different systems. Although the program is designed to catch many input errors, the burden of checking for these kinds of errors (especially the more complex modeling technique errors) must be shared by the user.

* * * * *

Question: I would like to see a control capability that would initiate system start-up in the morning based on the simulated indoor and outdoor conditions at the time. On very cold Monday mornings, after a week-end setback, the system may have to turn on two or three hours earlier than on a mid-week winter morning which is not so cold. This type of control is virtually impossible to schedule.

Answer: It is true that you cannot schedule system start-up based on a combination of outdoor temperature and the magnitude of the zone deviation from the start-up setpoint (a measure of the required warm-up period). This type of capability will be available when functional values are added to the SYSTEMS subprogram (see front page article). Meanwhile, you can do so based simply on zone temperature, with the use of NIGHT-CYCLE-CTRL in conjunction with the FAN-SCHEDULE. The following input would turn the fans on at 3:00 AM on Mondays if the temperature at that hour, in any zone, was found to be below the heating throttling range. Prior to 3:00 AM, they would not be allowed to cycle on for any reason by virtue of the -1 value in the schedule.

```
STARTUP = SCHEDULE THRU DEC 31 (MON) (1,3) (-1) (4,6) (0) (7,17) (1)
          (18,24) (0)
          (TUE,FRI) (1,5) (-1) (6) (0) (7,17) (1)
          (18,24) (0)
          (WEH) (1,24) (-1) ..
```

```
SFANS-1 = SYSTEM-FANS FAN-SCHEDULE = STARTUP
```

```
NIGHT-CYCLE-CTRL = CYCLE-ON-ANY ..
```

* * * * *

