DOE-2 USER NEWS
: A COMPUTER PROGRAM FOR BUILDING ENERGY USE ANALYSIS

DOE-2 User Coordination Office
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Table of Contents

BULLETIN BOARD

Item: The DOE-2.1 Reference Manual makes frequent reference to a forthcoming DOE-2.1 Program Manual. In fact, the major effort this year has gone into a DOE-2.1 Engineering Manual, which should be available next spring. We apologize for the misleading references in the documentation and for the dashed hopes of an early release of a Program Manual.

Item: Potential buyers of the IBM version of the tape should be aware that there are no weather tapes provided with the IBM package. The cost of purchasing them separately from NOAA must be assumed by the purchaser.

DOE-2 ON A MICRO-COMPUTER?

Now that micro-computers are becoming affordable by even the smallest engineering or architectural firm, the issue has arisen whether DOE-2 will run on a micro-computer. The answer is clearly in the negative for the program in its present form, but would it be possible to make changes so that the program would run? The answer to that question is affirmative in principle (given enough patience, anything of that sort is possible), but impractical with current technology. Because this question continues to arise, the following list of problems that must be solved might be of use to the user community.

We have assisted two groups attempting to implement DOE-2 on small machines. The first was a mini-computer in the $40,000 range (256Kbyte memory, 10Mbyte disk). The second was a desk-top computer/calculator in the $10,000 range (256Kbyte memory, 5Mbyte hard disk). Both these efforts were unsuccessful and abandoned after a few months of work. The main problems were:

i) Program Size — combined data and code storage requires at least 300,000 to 350,000 bytes of main memory. Breaking it into smaller pieces will require huge increases in overhead computational time.

ii) Machine Speed — the above mentioned machines were projected to take a minimum of 18 to 72 hours computation time for a year simulation for a 10 to 15 zone problem, if all the code and the data are core resident.

The speed problem arises both with the CPU execution speed and with the machine's input/output speed. Typical small computers are 100 to 1000 times slower in CPU execution than the large CDC machines. This alone would not be too bad, since the small machine would be dedicated to a single user. When the program generates a lot of output, however, the size and speed of the disk and CPU combination becomes very important. If the system is so small that I/O is necessary both to store intermediate program results and to move pieces of the program itself in and out of memory, the overall machine speed comparison degrades to at least 1000 to 10,000 times slower.

iii) Large Amount of Output Required — The typical DOE-2 run generates a huge amount of output, both as intermediate results (as between LOADS and SYSTEMS) and as reports for the user. It is unusual or impractical to have enough disk space or a fast printer on these small machines (typically, these devices are as costly as the computer itself). Again, the speed of the storage device will have a critical effect upon the simulation time.

iv) Coding Time — Since the size of most small computers will require that the code be broken up into much smaller pieces, a significant amount of re-programming time will be required. This task is compounded (or made impossible for micro-processors) by the operating systems available for these computers. Many of these operating systems have no automatic feature that allows programs to be segmented and thus require that the user write a file containing information to be transmitted between the segments. The execution time required for this type of segmentation has not been included in the estimates above.

v) Restart Problems - With long execution times one begins to have problems with the execution time exceeding the mean interval between machine/environment interruptions or errors. This means that an error recover-restart system must be developed or else the simulation accomplished up to the point of interruption is lost.

vi) Portability - Small mini-computers and microprocessors do not usually have a FORTRAN compiler. If they do, it is usually very limited and non-standard. This means that a substantial effort must be made to convert from FORTRAN to another language (BASIC or PASCAL) or to find ways around the limitations of the FORTRAN compiler (space limits, variable limits, routine limits, I/O limits, etc.).

vii) Word Size - Most common micro-processors use 8 bit (one byte) words and some use 16 bit (two byte) words. The DOE-2 code depends upon the capability of equivalencing real and integer arrays and upon being able to store in a single variable address either one real number, one integer, or four characters. Using an 8 bit word would require a quadruple precision integer (unheard of except on larger IBM systems); double precision with a 16 bit word (are there any 16 bit mini-computer FORTRAN compilers that allow this?); or single precision on a 32 bit word system. Thus implementation on a less than 32 bit (or four byte word) machine can become quite complicated, unless the system has the precision capabilities mentioned above.

The outcome of these earlier efforts to convert DOE-2 to a small machine has been the evaluation that, although it is possible to complete the project, it is not worth the expense. A more reasonable effort would be to investigate what subset of DOE-2 capabilities constitute a minimum useful set. Once this is known, efforts can be expended to compile algorithms to satisfy this need. These algorithms can, for the most part, come from DOE-2; but many may have to be produced by simplifying DOE-2 algorithms for both space and time considerations. There are lots of possibilities for reduced-time algorithms; a feasibility study would be required to explore these ideas.

Another possibility that is being pursued by private concerns is the recoding of BDL for the micro-computer, so that a clean input deck could be prepared in-house and then sent as a batch job to a main-frame computer. There is no news at present on how successful these efforts are proving.

NEW SIZING OPTION IN SYSTEMS

This new feature in the DOE-2.1A version of the code was introduced too late to appear in the documentation update package. Users are advised to retain this issue, or a photocopy of the article, in their Reference Manual.

In DOE-2.1 the sizing of systems (if not specified by the user) is a function of the peak heating and cooling loads, calculated at the temperature set in LOADS. If the LOADS temperature is between the DESIGN-HEAT-T and DESIGN-COOL-T for a zone, the peak loads will be over-estimated for heating and for cooling and consequently the air-flow rate for the zone will not, in fact, exactly correspond to the heat addition or heat extraction actually required at the peaks.

Another problem with the sizing strategy in DOE-2.1 is that plenums and unconditioned zones are also treated at constant temperature in LOADS, and usually at the same temperature as the conditioned zones. As a result, there is no contribution to the peak loads of conditioned zones from inter-zone heat transfer between the conditioned and adjacent unconditioned zones. Since an unconditioned zone is likely to be colder than the conditioned zones in winter and hotter in summer, both the peak heating load and the peak cooling load for an adjacent conditioned zone will be under-estimated. These two effects will cancel each other only accidently.

In an attempt to give the user the opportunity to correct for both of these defects, a new keyword has been introduced into the ZONE command in SYSTEMS. This keyword, SIZING-OPTION, has the values FROM-LOADS (the default)

and ADJUST-LOADS. The default option will result in the sizing for that zone being done as in DOE-2.1 and described above (upward compatibility). The option ADJUST-LOADS tells SYSTEMS to adjust the heating and cooling peak loads to account for difference between the value of the TEMPERATURE keyword in the SPACE command in LOADS and the value of DESIGN-HEAT-T and DESIGN-COOL-T in the ZONE command in SYSTEMS. A steady state adjustment is made for the external and internal wall conductances as well as for the infiltration loads.

In order to account for the difference in mean temperature for unconditioned and plenum zones at the heating and cooling peak conditions, the keywords DESIGN-HEAT-T and DESIGN-COOL-T are now allowed for ZONE-TYPE = UNCONDITIONED or PLENUM. They should be set equal to the user's predicted value of the zone temperature at the time of peak heating and cooling, respectively, in surrounding zones to which they are connected by an internal wall. If no value is specified for DESIGN-HEAT-T or DESIGN-COOL-T for ZONE-TYPE = UNCONDITIONED or PLENUM, that value will default to the LOADS calculation temperature.

Note: This keyword should usually be specified for all zones (explicitly or through a LIKE) to get more accurate sizing of air-flow rates. Optionally, it could be specified only in the conditioned zones, where one wants to know the air-flow rates and allowed to default in the unconditioned and plenum zones. In this case, however, one should still specify the DESIGN-HEAT-T and DESIGN-COOL-T for the unconditioned and plenum zones, so that the surrounding zone loads are appropriately modified.

STUD WALL CONSTRUCTION

Typically, residential exterior walls are not uniform layers of materials as seems to be required by DOE-2. Rather there are, say, 2 by 4's placed 18 inches apart with either air or insulation in between. The question is how to model such construction in DOE-2. At present the technique is rather awkward; in later versions of the program we intend to make the task easier.

To illustrate the technique to be used in DOE-2.1 or 2.1A, consider a wall with a horizontal cross-section as shown in the figure.
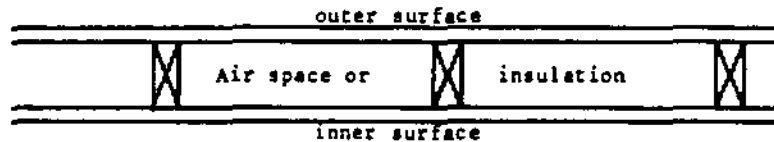
Assume the outer layer is plywood sheathing and the inner layer is gypsum plaster and consider the case of insulation in the air-gap. The procedure is to model two different uniform walls: the first is solid wood between the inner and outer layer and the other has insulation between these layers. Using the code-words from the Reference Manual, the LAYERS commands are:

```
WOOD        =LAYERS          MATERIALS=(PW06,WD05,GP05)
                            INSIDE-FILM-RES=.68  ..
INSUL       =LAYERS          MATERIALS=(PW06,IN11,GP05)
                            INSIDE-FILM-RES=.68  ..
```

The CONSTRUCTION commands might be:

```
WOOD-WL     =CONSTRUCTION     LAYERS=WOOD
                            ABSORPTANCE=.8
                            ROUGHNESS=3  ..
INSUL-WL    =CONSTRUCTION     LAYERS=INSUL
                            ABSORPTANCE=.8
                            ROUGHNESS=3  ..
```

For each actual stud-type exterior wall it is necessary to input two exterior walls with exactly the same position and orientation and the same attached windows and doors. One of these artificial walls will have CONSTRUCTION=WOOD-WL, while the other will have CONSTRUCTION=INSUL-WL. The effect of a stud wall will be derived by setting the keyword MULTIPLIER equal to .1 for the WOOD-WL wall and to .9 for the INSUL-WL wall:

```
WALL-1      =EXTERIOR-WALL    HEIGHT=8  WIDTH=40  CONSTRUCTION=WOOD-WL
                            X=15  Y=25  AZIMUTH=180  MULTIPLIER=.1  ..
                                 .
                                 .
                                 .

WALL-2      =EXTERIOR-WALL    HEIGHT=8  WIDTH=40  CONSTRUCTION=INSUL-WL
                            X=15  Y=25  AZIMUTH=180  MULTIPLIER=.9  ..
                                 .
                                 .
                                 .
```

The program will now calculate the transmission through each of these walls, multiply that through the first by .1, through the second by .9, and sum the result. This is the same result for linear heat flow that would occur for two inches of wood in every 20 inch section of the wall.

NEW BUGS DISCOVERED IN DOE-2.1 AND FIXED IN DOE-2.1A

The following is a list of new bugs discovered in the DOE-2.1 version of the code since the last issue of the DOE-2 USER NEWS, dated May, 1981. They have been fixed in DOE-2.1A, which will soon be available through NTIS. An update package to the documentation to accompany DOE-2.1A will also be published at that time.

CLASSIFIED INDEX

This index is intended to cross-reference bugs by 1) abort routine, 2) system-type affected (except those affecting all systems), and 3) command.

ABORT ROUTINE	SYSTEM-TYPE	COMMAND
CFO: 135	RESYS: 137	CURVE-FIT: 135
WDTSUN: 136		DIAGNOSTIC: 134
		MIN- and MAX-SUPPLY-T: 138
		PARAMETER: 139

BDL

[134] The command DIAGNOSTIC cannot be used outside of the INPUT ... END sequence, i.e., as a zero level command. The abbreviation, LIST, is not affected by this bug.

Interim solution: Use LIST when it is desired to place the command at the zero level.

[135] The program loses track of SCM in routine CFO in SDL when it is writing out a curve fit block. The program will abort with the message "SCM beyond FLS".

Interim solution: Try adding some dummy CURVE-FITs in SDL.

LOADS

[136] The program will abort in routine WDTSUN if a LATITUDE north of the Arctic Circle or south of the Antarctic Circle, (plus or minus 66.5 degrees) is input.

Interim solution: None.

SYSTEMS

[137] In the RESYS system, the cooling part load ratio can be calculated during the winter months as being >> 1.0. This then results in a very large cooling load and a negative electric input to cooling. This can occur when the default curves are replaced by ones that produce a small sensible heat ratio at low winter wetbulbs instead of a sensible heat ratio equal to 1.0.

Interim solution: Turn cooling off during the winter or replace the curves if they seem to be the source of the trouble. Check curves to ensure that when the wetbulb temperature is low, the sensible heat ratio goes to 1.0.

[138] The MIN-SUPPLY-T and MAX-SUPPLY-T are intended to be limits to the temperature of supply air entering the zone after active heating or cooling. If the mixed air temperature calculated for the hour is below MIN-SUPPLY-T or above MAX-SUPPLY-T and if no coil is active to treat the air (mixed air passes into the space), the program incorrectly changes the temperature of air entering the space to keep within these limits. This will have a significant effect if either of these two values is significantly different from the range of expected mixed air temperatures.

Interim solution: If the mixed air temperature can be expected to fall occasionally outside of the range MIN-SUPPLY-T to MAX-SUPPLY-T, lower and raise the MIN- and MAX-SUPPLY-T, respectively. The coil can be manually sized, if a different size is required from that calculated using these new design temperatures.

PLANT

[139] The SOLAR-EQUIPMENT command cannot be used in a PARAMETRIC-INPUT PLANT. Thus, PARAMETERs cannot be changed. This is so because of a bug that, when defining PARAMETERs in a solar PLANT run, the PARAMETER to be used by the solar simulation must be defined after the SOLAR-EQUIPMENT command but before they are referenced as keyword values.

Interim solution: None; Use INPUT-PLANT with entire changed definitions.

THE HEAT EXCHANGER

This section is devoted to common, and uncommon, questions from users and responses from the DOE-2 User Coordination Office. Your questions and comments are most welcome.

* * * * *

Question: I have a building with overhangs described with BUILDING-SHADE. I notice that increasing the size of the overhang reduces the amount of direct solar radiation falling on the windows, as I would expect. However, no matter how large I make the overhangs, the diffuse radiation stays the same. What's happening?

Answer: In DOE-2, BUILDING-SHADE affects only the direct component of solar radiation. To take into account the reduction in diffuse solar gain due to the overhangs on your building, you should enter values for SKY-FORM-FACTOR and GND-FORM-FACTOR in your WINDOW commands. The value for GND-FORM-FACTOR is simply the fraction of the hemisphere facing the window which is covered by ground, adjacent buildings, trees, hills, etc. The SKY-FORM-FACTOR is the fraction of the hemisphere subtended by the sky.

For a vertical window, the default value for both these keywords is 0.5, i. e., an unobstructed vertical window receives diffuse radiation from 50% of the sky hemisphere and from 50% of the ground plane. If a window with an overhang received radiation from only 25% of the sky, then you would enter SKY-FORM-FACTOR=0.25 and GND-FORM-FACTOR=0.5.

Before going to the trouble of estimating form factors for all of the windows, it is advisable to make a run with default form factors. If it turns out that hourly reports show diffuse solar gain to be much less then direct, it probably isn't worth the effort to assign window form factors. Even more information on solar gain through windows will be available in DOE-2.1A, where a new report, LS-E, will provide you with load components, on a month-by-month basis, for each space.

* * * * *

Question: The exterior wall of the building I want to model consists of a series of identical panels with a recessed window in the center of each panel. If it were not for shading from a nearby building, I know that I could describe one panel and use the MULTIPLIER keyword in the EXTERIOR-WALL command to account properly for the conduction and solar gain through the wall. Because I want to determine the effect of the shading from the nearby building, I thought of describing the wall as one surface and then describing the windows using the multiplier. What I want to know is whether DOE-2 will properly account for the solar gain through the windows.

Answer: Generally speaking, it is not appropriate to use the MULTIPLIER keyword for a surface or for the fenestration or doors on that surface, if there is shading from other buildings or surfaces that will move across the surface in question. The MULTIPLIER keyword only acts after the heat gain through the surface has been calculated based on the position of the representative surface element. In other words it cannot take into account that some of the windows will be wholly in the sunlight, others wholly in the shade, and some only partially shaded. As DOE-2.1 is currently constructed — and probably for some indefinite time into the future — there are few short-cuts that will work when shading is important. In that case it is necessary to describe the geometry exactly.

* * * * *

Question: I thought to make comparisons among various simple residential buildings by describing them as separate, uncoupled spaces in LOADS. In SYSTEMS, I defined a separate system for each zone (space) and a separate PLANT-ASSIGNMENT for each system. Finally, I made a series of PLANT inputs corresponding to each PLANT-ASSIGNMENT. When I ran this single input, I found a problem with the value of MISC EQUIP in the BEPS report. I got the same value for MISC EQUIP for each residence, even though I had input different values for SOURCE-BTU/HR for each residence. What happened?

Answer: DOE-2.1 was written under the assumption that only one building was being described at a time. The loads due to equipment or processes in a space are identified with the space in which they occured, but the energy consumed by such equipment or processes is summed and sent to PLANT to be satisfied by a utility or plant equipment. The values reported in the BEPS report for MISC EQUIP are the sum of the energies consumed in each of the zones.

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The DOE-2 User Coordination Office encourages user response to this section. Please send questions and comments to:

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