

DOE-2 USER NEWS

: A COMPUTER PROGRAM FOR BUILDING ENERGY USE ANALYSIS

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Building Energy Simulation Group

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BULLETIN BOARD

Item: The DEC10 and VAX conversions of the program have been completed and the DOE-2.1A tapes for these machines are now available from both NTIS and NESC. See the next column for more information. There is also an NTIS order form on the last page containing purchasing information for the DOE-2 package.

Item: As you may have noticed in the reprinting of the complete Bug Report for DOE-2.1A in the last newsletter, we have "closed the books" on that version and will no longer be reporting bugs peculiar to DOE-2.1A. This is in keeping with our past policy in regard to DOE-2.0A, DOE-2.1, etc. While not wishing to abandon users of older versions of the program, it is simply not possible for us to provide support for all predecessors of the most current one, soon to be 2.1B. Because the code is so massive, our ability to recall the intricacies of earlier code diminishes as a function of time.

We therefore encourage users to work with the latest, most improved version of DOE-2. We realize that people become comfortable with a given version, but every effort is made to make the program upwardly-compatible, i.e., your old input decks will not require changes to run on the new version. (To date, we have been 98% successful in this effort.) Of course, you won't have the old bugs to get around, and unless you modify your basic decks, you will not be taking advantage of the new features.

GOOD NEWS AND BAD

Recent inquiries to the NTIS Order Desk have revealed that the price of the DOE-2 tapes have risen by approximately \$1000. Further investigation uncovered the party responsible for this action. The U.S. Department of Energy has directed the National Energy Software Center, which creates the tapes and distributes them through NTIS, to adopt a cost recovery program that has led to an increase in all of their software prices. There is some good news to go with the bad.

As part of this new program, NESC now has a new operating structure. They offer a package of any two software packages in their collection, per year, plus the documentation that goes with them, on the following basis:

Class 1: DOE, prime contractors to DOE, and NRC, for an annual registration fee of \$1500.

Class 2: Educational institutions, non-profit organizations, other Federal agencies, local state and foreign governmental bodies, for an annual fee of \$1620.

Class 3: Commercial organizations, for \$1984 annually.

The fee is reduced by approximately \$200 in subsequent years. One can also purchase additional programs at the "regular" rates. For instance, registrants can purchase, in addition to the two programs covered by their annual fee, the DEC10 version of DOE2.1A at \$1378, \$1488, and \$1832 for Classes 1 through 3, respectively. The VAX11 tape is available for one dollar more. Participants are also given timely notices of all updates to their programs.

With the current NTIS costs hovering around \$1450, not including the documentation, plus the edge NESC has on turn-around time, this new package may represent an attractive alternative to many organizations.

For more information, please contact:

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POWERED INDUCTION UNITS

In keeping with our policy of sharing with our readers some of the long-term development work being done by our staff on the program, we have prepared the following article describing a new feature of the program that we plan to introduce into the 2.1C version.

We are currently working on the implementation of a new central system model, the powered induction unit (PIU), in SYSTEMS. Our interest in doing so is motivated by the increasing popularity of this system type. Historically, VAV systems were developed in order to conserve some of the energy wasted in reheat and fan energy by constant-volume systems. But because present designs have very low lighting levels and better treatment of glazing, both of which result in low design air flows, PIUs have been receiving increasing interest. The reason for this is that these systems hold the room air-flow rates at more tolerable levels, maintain reasonable humidity and eliminate overcooling, while still providing the savings in fan and reheat energy of conventional VAV systems. PIUs are being manufactured by a number of companies and are being installed in many new buildings. At present, DOE-2 cannot model PIUs. Thus, designers are unable to use the program to examine how much energy PIUs require in their particular application.

A typical situation in which PIUs would be employed would be one in which the central or core zones of the building require cooling year-round, while the exterior zones need cooling in the summer and heating in the winter. The PIU attempts to use the excess heat produced in the core to heat the exterior zones as well as providing sufficient air movement. Each exterior zone typically has a PIU terminal unit. One type (called series or constant volume) has a VAV terminal unit valving primary air into a mixing box containing a blower. The blower blows a constant volume of air into the zone by mixing primary air from the VAV supply system with secondary air from the plenum or a duct. The secondary air originates in the building core. The amount of air supplied to the zone is constant, but the proportion of primary and secondary air varies, depending on whether cooling or heating is needed. A second type of PIU unit (denoted parallel or variable volume) has the blower in parallel with the VAV unit. That is, the blower is only in the secondary air stream. Thus, the heating mode is constant volume but the cooling mode (when the blower is off) is variable volume. However, a minimum recirculation rate in the space

can always be maintained by turning the blower back on. Both types of PIU units can be run when the central fans are off; the parallel unit blower can also be turned off when the central fan is running. Both units optionally contain heating coils.

Implementation of the system will take the following form: A new SYSTEM-TYPE (PIU) and its associated defaults will be added to the SYSTEM command. Keywords, tentatively named ZONE-FAN-CFM, ZONE-FAN-KW, ZONE-FAN-SCH, TERMINAL-TYPE, REHEAT-DELTA-T, and INDUCED-AIR-ZONE, will be added to the ZONE command to describe the terminal unit and blower. Changes will be made to the DESIGN routine to size the zone PIU blowers.

The order of the zones will be changed so that interior zones are simulated before exterior zones. Then the calculation of the supply air temperature for the exterior zones will be corrected to account for the fact that the air supplied to the exterior zones is a mixture of primary and secondary air. Code will be added to allow the zone fans to run when the central fans are off. Finally, for parallel PIUs, the extraction rate vs. zone temperature equation will be altered to model the situation in which, as the zone temperature falls, the blower turns on before the zone heating coil is activated.

As designers and manufacturers have become more conscious of some of the negative aspects of energy conserving systems with regard to comfort, so have we at LBL. As an example, in the 2.1B version of the program, new scatter plot reports have been added that indicate the number of hours that both space temperatures and humidity ratios fall within predefined bins during occupied hours. We are also experimenting with adding a thermal comfort scatter plot to the SYSTEMS reports based on the ASHRAE Comfort Index. It is obvious that a program like DOE-2 has the potential of analyzing the comfort performance of systems as well as the energy performance, since all of the calculations are made and it is simply a matter of reporting them. The next step might be that of reporting the number of hours various air circulation rates occur within the space. We have also considered using the inside surface temperatures of window glass and exterior walls as part of the comfort report. If you have any ideas or suggestions, please feel free to write to us and express them.

We see a lot of DOE-2 inputs created by users and we cannot help noticing how few have a good feeling for "nesting" schedules and other handy short-cuts. Since schedules can be such a pain, it behooves the user to learn the easiest methods of preparing them. Unfortunately, the Reference Manual barely touches on most of these concepts.

First, let's reiterate the functions of the three basic schedule commands: DAY-SCHEDULE defines the hours of the day, WEEK-SCHEDULE defines the days of the week, and SCHEDULE refers to the calendar period. What we mean by the "nesting" of schedules can be simply put: it is the combining of DAY-SCHEDULEs and WEEK-SCHEDULEs and their values into a single SCHEDULE. It also therefore applies to combining DAY-SCHEDULE(s) into a single WEEK-SCHEDULE.

The easiest way to demonstrate the various methods of nesting, and other short-cuts, is to give examples. The first in each example below is the standard Reference Manual approach, followed directly by our easy-does-it alternative.

Example 1 - Abbreviations

```
LTG1 = DAY-SCHEDULE  HOURS = (1,7)
                   VALUES = (0)
                   HOURS = (8)
                   VALUES = (.4)
                   HOURS = (9)
                   VALUES = (.6)
                   HOURS = (10)
                   VALUES = (.8)
                   HOURS = (11,18)
                   VALUES = (1.0)
                   HOURS = (19,24)
                   VALUES = (0) ..
```

or, as condensed and abbreviated:

```
LTG1 = D-SCH (1,7) (0) (8,10) (.4,.6,.8)
          (11,18) (1.0) (19,24) (0) ..
```

Example 2 - Eliminating WEEK-SCHEDULE

The standard method:

```
LTG1 = (same input as above)
LTG2 = D-SCH (1,7) (0)
          (8,12) (.4,.6,.8,1,1)
          (13,24) (0) ..
LTG3 = D-SCH (1,24) (0) ..
WORKDAY = WEEK-SCHEDULE (MON,FRI) LTG1
                   (SAT) LTG2
                   (SUN,HOL) LTG3 ..
```

```
VACATION = WEEK-SCHEDULE (MON,HOL) LTG3 ..
PLANT-SCH = SCHEDULE THRU JUN 15 WORKDAY
            THRU JUL 5 VACATION
            THRU DEC 31 WORKDAY ..
```

or the short-cut, nesting the W-SCH keywords, and only referencing the D-SCHs:

```
PLANT-SCH = SCH THRU JUN 15 (WD) LGT1
            (SAT) LGT2
            (SUN,HOL) LGT3
            THRU JUL 5 (ALL) LGT3
            THRU DEC 31 (WD) LGT1
            (SAT) LGT2
            (SUN,HOL) LGT3 ..
```

Example 3 - Nesting

```
OC1 = DAY-SCHEDULE  HOURS = (1,7)
                   VALUES = (0)
                   HOURS = (8,17)
                   VALUES = (1)
                   HOURS = (18,24)
                   VALUES = (0) ..
OC2 = DAY-SCHEDULE  HOURS = (1,24)
                   VALUES = (0) ..
WORKDAYS = WEEK-SCHEDULE (WD) OC1 (WEH) OC2 ..
PAYROLL = SCHEDULE THRU DEC 31 WORKDAYS ..

or all of the above nested:

PAYROLL = SCH THRU DEC 31 (WD) (1,7) (0)
                        (8,17) (1)
                        (18,24) (0)
                        (WEH) (1,24) (0) ..
```

Example 4 - Re-using DAY-SCHEDULES

We won't describe the standard example, but you can surely imagine it.

```
LTG1 = D-SCH (1,7) (.05) (8,18) (1)
            (19,24) (.05) ..
OC1 = D-SCH (1,7) (.0) (8,12) (1)
            (13) (.5) (14,17) (1)
            (18,19) (.1) (20,24) (0) ..
NONE = D-SCH (1,24) (0) ..
RETOOL = D-SCH (1,7) (0) (8,17) (.2)
            (18,24) (0) ..
LIGHTS = SCH THRU JUN 15 (WD) LGT1 (WEH) NONE
            THRU JUL 3 (ALL) RETOOL
            THRU DEC 31 (WD) LGT1 (WEH) NONE ..
PEOPLE = SCH THRU JUN 15 (WD) OC1 (WEH) NONE
            THRU JUL 3 (ALL) RETOOL
            THRU DEC 31 (WD) OC1 (WEH) NONE ..
```

DOCUMENTATION UPDATES

The following corrections to the Reference Manual apply to the DOE-2.1A version, dated May 1981. If your manuals have not yet been updated, the page numbers will be incorrect. See the NTIS Order Form on the back page for information on the DOE-2 Documentation Update package.

- On page III.145, in Note 5, replace the word "Automatic" with "ASHRAE".
- On page IV.102, under the SYSTEM-FANS command, the decimal point in the default value for SUPPLY-DELTA-T is incorrectly placed. It should read 0.218°F.
- On page IV.181, there are two corrections to be made. In the first paragraph, in the expression of the bi-quadratic equation, the fifth term is incorrect. It should read:

$$z = a + bx + cx^2 + dy + ey^2 + fxy$$

In the footnote, change the last two sentences beginning:

However, only three coefficients need

to read:

However, four coefficients must must be entered to avoid an ERROR message.

- On page IV.184, the last line in the first paragraph should be changed to read:

If fewer are specified than required, an ERROR will occur.
- On page IV.214, under the discussion of MIN-AIR-SCH, it should be made clear that the value entered in the schedule is a fraction specifying the ratio of minimum outside air flowrate to the total design flowrate calculated by the program or input using SUPPLY-CFM.
- Also on page IV.214, under OA-CONTROL, it should be stated that, for a system that doesn't allow outside air economizers, the effective default is FIXED.
- On page V.43, Table V.6, there is a misprint. Under the first keyword listed, ABSOR1-CAP-FT, the second coefficient should be negative, i.e., -0.079006. The value stored in the program is correct.
- On page VIII.40, in the discussion of the EDIT function of the DOE-2 Weather Processor, Cards 4 and 5 have been reversed. The description of Card 4 in fact belongs to Card 5, and Card 5, Card 4. Please re-label and reverse the order of the two cards. Also, the footnote to these two descriptions should be removed.

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 want to compare DOE-2 results with some measured data. In going through the descriptions of the hourly report variables, I have come across a number of ambiguous points that need clarification. For instance, in LOADS, VARIABLE-TYPE = BUILDING, VARIABLE-LIST Numbers 37 and 40, can you tell me what these two variables include?

Answer: #37 is QBELEC, which includes all the building electrical load input at the LOADS level - lights, equipment, elevators, etc. #40 is QBEQEL, which includes all electrical load input through the EQUIPMENT-KW and EQUIPMENT-W/SQFT keywords in LOADS, plus any from SOURCE-BTU/HR with SOURCE-TYPE=ELECTRIC. Nothing comes from the BUILDING-RESOURCE command.

Question: In SYSTEMS, VARIABLE-TYPE = U-name of PLANT-ASSIGNMENT, are Nos. 1 and 2, the same as VARIABLE-TYPE = GLOBAL, Nos. 8 and 9 in PLANT? Do they include pipe losses and gains?

Answer: No, they aren't, and don't. They are the total cooling and heating loads from SYSTEMS, summed over all the systems in the PLANT-ASSIGNMENT. They are hourly outputs from SYSTEMS and hourly inputs to PLANT. They are the same as GLOBAL variables 1 and 2 in PLANT.

PLANT GLOBAL #8 is the same as #1 plus pipe heat loss and load not met from the previous hour, plus any other PLANT heat demand, such as boiler make-up water, stored heat, heat required to run equipment (e.g., absorption chillers) that is not met by heat recovery. PLANT GLOBAL #9 is PLANT GLOBAL #2 plus pipe heat gain and any load carried over, plus cold storage.

Question: And No. 3, is it the same as PLANT, VARIABLE-TYPE = GLOBAL, No. 10?

Answer: No, it is the same as PLANT GLOBAL #3. #3 is output from SYSTEMS and input to PLANT, while PLANT GLOBAL #10 is #3 plus electricity for pumps and electricity for any plant equipment (electric boilers, compression chillers, etc.)

Question: How about Nos. 5 and 6. Do they include electricity for pumps, domestic hot and chilled water?

Answer: No, they don't. Number 5 includes all electricity used for heating at the SYSTEMS level. Possibilities include electricity for preheat coils, heating coils, zone coils, and baseboards. No domestic hot water is included; this is passed from LOADS directly to PLANT. Electricity for pumps is added in PLANT. #6 includes electricity for compressors in DX units and electricity for crankcase heat. Electricity for condenser fans is not included.

Question: Also in SYSTEMS, VARIABLE-TYPE = U-name of ZONE, No. 36, what does "total and zone" mean?

Answer: That's a good question. #36 is used only for system types TPFC, FPFC, HP, and PTAC. For HP and PTAC, it is the same as #33, the zone coil cooling. For TPFC and FPFC, it is a partial sum of the zone coil cooling. That is, if there are four zones in a TPFC and you have input VARIABLE-TYPE = u-name of the third zone, then #36 is the sum of the zone coil cooling for zones 1, 2, and 3.

Question: In PLANT, VARIABLE-TYPE = COOLING-TWR, No. 3, is this the sum of 20 and 21?

Answer: Yes, this is the electric energy consumed by the tower and is the sum of EFAN + EPUMP, #20 and #21.

Question: And COOLING-TWR, Nos. 6 and 18, are these two the same?

Answer: Again, yes. #6 and #18 are the same for the cooling tower. #6 is normally ISIZE, the numbers (in decimal digits) of each size of one type of equipment running during the current hour. If there are four chillers of the same type, one of 300 tons, 2 of 200 tons, and one of 100 tons, and all are running, then ISIZE = 121, indicating 1 chiller of the largest size is running, two of the intermediate size are running, and one of the smallest size is running. If only the 300 ton chiller is running, then ISIZE = 100. In the case of the cooling tower, ISIZE is set to NCELL, the number of the cells operating during the current hour. And so, for cooling towers, #6 equals #18.

Question: Is No. 11 the same as outside wet-bulb temperature?

Answer: Not quite. #11 is APP, the approach to wet-bulb temperature, i.e., $T_{out} - T_{wet}$.

Question: Nos. 13 through 16, what is the rating factor? What is a TU?

Answer: A TU (tower unit) is a method for sizing towers. A tower with 100 TU can cool 100 gpm of 90°F water to 80°F at 70°F outside wet-bulb. The rating factor (F_r) is the relative area (A_r) in TU divided by gpm at the design air flow-rate. If the gpm is the design gpm, then $F_r = 1$. Otherwise,

$$F_r = \left[\frac{\dot{M}_{air}}{M_{air\ design}} \right]^p * \frac{A_r}{gpm}$$

where p is in the range of 0.6 to 1.1.

Question: And lastly, No. 19 for COOLING-TWR, is this the "pan" or "basin" temperature? Is it the same as No. 12 for the chillers' VARIABLE-TYPE?

Answer: TTOWER is the exiting tower water temperature (T_{out}). It is equal to the entering condenser temperature, and therefore is the same as #12 for any of the other chillers.

* * * * *

Please direct your questions and comments to:

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