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DOE-2 USER NEWS

A COMPUTER PROGRAM FOR BUILDING ENERGY USE ANALYSIS

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BULLETIN BOARD

Item: DOE-2.1B is now the official, and most current, version of the program. The CDC version is available for purchase from NTIS and, to their registrants, from the National Energy Software Center, Argonne National Laboratory, Argonne, IL (312) 972-7250. The VAX and IBM versions will follow shortly. Purchasers of the new tape will automatically receive one complete set of DOE-2 user documentation, including the 2.1B updates, with their order. Additional copies of the documentation may be obtained from NTIS. Please note that it is now possible to order individual volumes from the basic set of documentation. The back page of this newsletter is a tear-out sheet containing an order form for tapes and documentation.

Item: As announced in the last issue, the DOE-2 Engineers Manual, Version 2.1A, has now been published. This volume will be updated sometime next year, to incorporate both DOE-2.1B and DOE-2.1C material. In anticipation, however, of an immediate interest in the new daylighting routines, we have produced a separate interim report, entitled Daylighting Calculation in DOE-2, LBL-11353 (III.2.9 only). A limited number of copies are available from this office. Please submit your request in writing to the address above.

THE NEW METRIC OPTION

Canadian and overseas users of DOE-2 will especially benefit from the metric option which has been introduced into the new version of the program. American users with foreign clients can also make use of the feature. Due to the flexibility of the code, output units are independent of input. Therefore, input decks employing the English unit system can be used to produce metric output, and vice versa. Additionally, input and output units can be switched back and forth at all levels of the program. Thus one could have, for example, LOADS in English units and SYSTEMS in metric units. Please refer to the DOE-2 Supplement, Version 2.1B, for a full discussion of the metric option.

There are several important guidelines to follow when preparing a metric input/output deck.

- The new keywords that invoke the metric option, INPUT- and OUTPUT-UNITS = METRIC, must be entered under the INPUT command at the beginning of each subprogram. Otherwise, the downstream programs will default back to ENGLISH.
- The use of libraries is subject to certain restrictions. 1) The DOE-2 Preassembled Library of materials and layers cannot be accessed if the LOADS subprogram is input in metric units. 2) User-created libraries may contain only one type of units. And 3) a library created in one unit-system cannot be used, of course, in a production run employing the other system.
- Many experienced users of the scheduling commands may have all but forgotten the existence of the keywords HOURS and VALUES in the DAY-SCHEDULE command. But their presence becomes significant when preparing a schedule that defines a temperature in a metric input deck. Specifically, the VALUES keyword must be replaced by the metric keyword TEMPERATURES (abbreviated, TEMP) to alert BDL to the fact that the value entered is expressed in ° Celsius. For example:

```
DAY1 = D-SCH  HOURS = (1,24) TEMP = (21) ..
```

The reporting of temperature-related data will be meaningless if this keyword is neglected. Obviously, this requirement

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ELEVATED SUPPLY AIR TEMPERATURES FOR VAV SYSTEMS

Over the past few months, we have had a number of inquiries from DOE-2 users concerning the best approach for modelling elevated Supply Air Temperatures (SAT) of 60 to 65°F on VAV systems. The engineers indicate to us that HVAC designers face new problems because of increased air flow-rates and the associated increased fan energy. If we look at the problem closely, we can see that we really need to bring our air flow-rates back up to the levels that we used to consider normal prior to our high efficiency lighting systems, better glazing methods, and high room temperature setpoints. These combined energy-saving methods can result in reduced indoor air quality with design air flow-rates of less than .5 CFM/sqft at 55°F supply air temperatures.

Since such low peak flow-rates fall below minimum acceptable levels, the first move is to elevate the supply air temperature. Higher SATs increase the air flow-rate, assuming the room temperature (RMT) remains constant at 78°F, as shown in the following relationship:

$$\text{AIRFLOW} = \frac{\text{SENSIBLE HEAT GAIN}}{1.08 * (\text{RMT} - \text{SAT})}$$

Most VAV supply fans are located downstream of the cooling coils (i.e., FAN-PLACEMENT = DRAW-THROUGH), so that SAT = Coil Leaving Air Temperature + Fan Heat. Therefore, if the user's SAT is not elevated above, say, 60°F and fan heat is ~4°F, then the cooling coil leaving air temperature is ≈56°F DB and 54°F WB. This gives us a Humidity Ratio (W) of ≈.0086 lb moisture/lb dry air which is sufficient to hold an acceptable space relative humidity of 50% RH at peak design loads, even though they may rise to 60% RH under conditions less than peak.

Now, however, if we elevate the SAT to 65°F (and fan heat is 4°F), we have a coil leaving air temperature ≈61° DB and 59°F WB. This results in a W ≈ .0104 lb moisture/lb dry air and a space RH of 58% at peak design loads, but exceeds 60% RH under conditions less than peak. Since ASHRAE STD 90 allows humidity control to prevent space relative humidities above 60%, the question is: "What are the DOE-2 options for modelling humidity control when we have elevated supply air temperatures to maintain acceptable air flow-rates?"

For our base case, let's take a VAVS system with just the following inputs:

DESIGN-COOL-T = 78 → from ZONE-CONTROL

COOL-CONTROL = CONSTANT
COOL-SET-T = 65
MIN-SUPPLY-T = 60
MAX-HUMIDITY = 60
} from SYSTEM-CONTROL

Let's also assume that the building sensible cooling load is 100,000 Btu/hr: therefore DOE-2 will calculate a supply air flow-rate as follows:

$$\text{SCFM} = \frac{100000}{1.08*(\langle\text{DESIGN-COOL-T}\rangle - \langle\text{MIN-SUPPLY-T}\rangle)}$$

$$\text{SCFM} = \frac{100000}{1.08 * (78 - 60)} = 5144\text{CFM}$$

Whereas what we really want is a supply air flow-rate based on COOL-SET-T, so that if the MAX-HUMIDITY exceeds 60%, the supply air temperature will be depressed to MIN-SUPPLY-T for additional moisture removal. To accomplish this, we must force the system supply air flow-rate to the value we desire by first calculating the correct amount by hand and then entering this value using the keyword SUPPLY-CFM.

$$\text{SCFM}' = \frac{100000}{1.08 * (78 - 65)} = 7123\text{CFM}$$

SUPPLY-CFM = 7123

The next consideration is whether we desire reheat to maintain the COOL-SET-T = 65 when the SAT is depressed by the MAX-HUMIDITY = 60 limit. If so, we also need to input HEAT-SET-T = 65 which allows the simulation of reheat by the air handling unit reheat coil.

If a Packaged VAV Unit was selected, with SYSTEM-TYPE = PVAVS, we can energize condenser recovery for reheat by entering under SYSTEM-EQUIPMENT the keyword MAX-COND-RCVRY = .8. Two other keywords, MIN-UNLOAD-RATIO with a value of .5, and MIN-HGB-RATIO with a value of .1, are optional but advisable, since Hot Gas Bypass is the normal set-up whenever condenser heat is recovered.

Two other options for elevated SATs are available to the DOE-2 user. The first is to reset the supply air as a function of outside air temperature. The necessary keywords are as follows:

```
DESIGN-COOL-T = 78
COOL-CONTROL = RESET
MIN-SUPPLY-T = 60
MAX-HUMIDITY = 60
SUPPLY-CFM = 7123
COOL-RESET-SCH = R-SET
```

A schedule that would be appropriate for R-SET might be:

```
R1 = DAY-RESET-SCH
     SUPPLY-HI = 70   SUPPLY-LO = 65
     OUTSIDE-LO = 70  OUTSIDE-HI = 90  ..

R-SET = SCHEDULE  THRU DEC 31 (ALL) R1 ..
```

Given this input, if MAX-HUMIDITY exceeds 60% RH, the reset schedule would be overridden and the cooling coil leaving air temperature depressed to MIN-SUPPLY-T = 60. However, if HEAT-SET-T = 65 is input, the SAT, as reset by the schedule R-SET, will again be maintained using reheat and the coil leaving air temperature will be ≈56°F.

The second option is to use a "discriminator" control to set the supply air temperature to satisfy the cooling requirements of the "warmest" zone, which by definition would more than satisfy all other zone cooling loads. The correct input in this case is:

```
DESIGN-COOL-T = 78
COOL-CONTROL = WARMEST
MIN-SUPPLY-T = 60
MAX-HUMIDITY = 60
SUPPLY-CFM = 7123
```

Given this input, if MAX-HUMIDITY exceeds 60% RH, the discriminator would be overridden and the cooling coil leaving air temperature depressed to MIN-SUPPLY-T = 60. However, if HEAT-SET-T = 65 is input, the SAT as reset by the discriminator would be maintained using reheat. Notice that in all cases if reheat is locked out either by a HEATING-SCHEDULE or by failure to input the HEAT-SET-T keyword, DOE-2 will simulate subcooling in the space once the VAV box has reached its minimum stop, as input by the keyword MIN-CFM-RATIO.

In the near future, we will be adding, at the DOE-2.1C level, yet another system type, the PIU (for Powered Induction Unit) which the user can employ to increase zone air flow-rates. With this system the SAT to the space is elevated by inducing 1979 CFM from the ceiling plenum, mixing it with 5144 CFM of supply air from the air handler, and thus producing the desired total flow-rate of 7123 CFM used in the previous discussions. However, in this case, the cooling coil leaving air temperature can remain at 56°F and, thus, remove the required moisture so that the space humidity never exceeds the 60% RH limit. In effect, the reheat comes from the ceiling plenum free of charge.

To sophisticated designers, these discussions may appear simplistic. We wish to assure them that we too are cognizant of the many changes in the relationships between temperatures and flow-rates in actual VAV systems operations; DOE-2 simulation of VAV systems and their response to sensible space loads takes into account such real-world complexities. For example,

1) The cooling coil leaving air temperature is depressed by the controller as it approaches the bottom of its throttling range which naturally results in increased moisture removal. Just the reverse is true as sensible loads increase.

2) As the flow-rate at the cooling coil decreases, the leaving humidity ratio is further depressed since there is better contact of the air with the coil fin surface. DOE-2 simulates this with a linear curve labelled COIL-BF-FCFM.

3) Fan heat ΔT decreases as the fan flow-rate decreases; therefore the cooling coil leaving air temperature increases because the controller location is simulated as being downstream of the supply fan.

4) As the flow-rate to the space decreases, the space humidity ratio increases if the moisture gain in the space is a constant. Except for auditoriums, etc., most of the latent load on a system comes from the outside air rather than from within the building. Therefore a VAV system often can do a reasonable job of holding the relative humidity without reheat.

5) Since the peak latent loads normally coincide with the peak sensible loads, a VAV system often operates quite well without reheat; what little space subcooling that does occur, especially when the SAT is elevated, is not objectionable. Granted, the ASHRAE STD 90 cooling setpoint of 78°F is ignored by many building occupants.

6) The other SYSTEM-TYPEs besides VAVS and PVAVS to which this entire discussion applies are the Ceiling Bypass-VAV (CBVAV) and the Ceiling Induction (SZCI) systems. CBVAV has a characteristic that should not go unmentioned. The flow-rate at the fan and coil is constant, and if the leaving air temperature is also constant, the leaving humidity ratio is constant. So even though the space temperature is controlled by varying the flow-rate to the space, the plenum air has a moisture level that does not vary. The moisture in the controlled space can easily migrate to the dryer ceiling space and therefore is seldom the problem it is with the straight VAV system. However, this does not remove the requirement to design using higher air flow-rates when the space sensible gains are low.

7) The user has the option in DOE-2.1B of setting a minimum zone air flow-rate using the ZONE-AIR keywords CFM/SQFT and AIR-CHANGES. This would eliminate the step outlined above of precalculating SUPPLY-CFM and entering its value as input. Notice that COOLING-CAPACITY will be recalculated by the program and may differ from the procedure followed above.

8) With the PIU system, in DOE-2.1C, if the plenum temperature is not higher than the space temperature, there is no free reheat available and the space will be simulated as being subcooled.

See also "Sizing Fans for VAV Systems" in our May 1981 issue.

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