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LBL–35520

DOE–2 BASICS

Version 2.1E

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May 1994

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What Is DOE-2?

DOE-2 is an up-to-date, unbiased, well-documented public-domain computer program for building energy analysis. DOE-2 predicts the hourly energy use and energy cost of a building given hourly weather information and a description of the building and its HVAC equipment and utility rate structure. DOE-2 is a portable FORTRAN program that can be used on a large variety of computers, including PC's. Using DOE-2, designers can determine the choice of building parameters that improve energy efficiency while maintaining thermal comfort. The purpose of DOE-2 is to *aid* in the analysis of energy usage in buildings; it is *not* intended to be the sole source of information relied upon for the design of buildings. The judgment and experience of the architect/engineer still remain the most important elements of building design.

About This Manual

During the 15 years that DOE-2 has been in existence, it has grown to three times its original size due to the addition of new capabilities. As a result, using the program can be difficult not only for the novice but also for the experienced user.

The enormous number of input and output variables from which you can choose is only part of the problem. Up until now there has been no attempt to give you guidance as to what is considered "basic" and what might be termed "finesse". Learning to use DOE-2 is analogous to learning a card game: first you learn how to bid, then to follow suit, then to trump. It is only after the "basic" rules have been mastered that the idea of a "finesse" can enter the game. This manual is aimed at introducing you to the basic rules of DOE-2.

DOE-2 Basics covers approximately 80% of normal simulation applications, yet requires you to be familiar with only 25% of the input variables available in the program. These variables have been chosen from our long experience of assisting the most experienced users prepare their inputs.

There is a real danger in preparing a manual with a limited set of variables because so many useful features of the program are left out. To compensate for this, we have provided, in Appendix A, a directory of the more complex features of DOE-2.

Other Documentation

In addition to this *DOE-2 Basics*, there are six other pieces of documentation:

- *Reference Manual (2.1A)*
  - detailed instructions on how to use all features of Version 2.1A of the program
- *Supplement (2.1E)*
  - a companion volume to the *Reference Manual (2.1A)*, it contains detailed discussions and instructions for using the enhancements introduced into subsequent versions of the program
- *BDL Summary (2.1E)*
  - summarizes all input commands and keywords
  - lists defaults, limits, abbreviations
- *Sample Run Book (2.1E)*
  - shows input and output for simple and complex buildings and systems
  - illustrates most program features
  - a complete set of sample inputs and outputs is available on the mainframe DOE-2 tape for you to examine, run, and/or edit; a reduced set of samples is distributed on diskette with the PC versions of DOE-2.
- *Engineers Manual (2.1A)*
  - describes engineering and mathematical basis of program calculations
  - lists sources of algorithms
- *User News*
  - published quarterly
  - distributed free of charge
  - features articles on the effective use of DOE-2
  - lists program problems and bug fixes
  - provides a directory of DOE-2 related software products

Any program user may receive the *User News* free of charge. To be put on the distribution list, please write the Simulation Research Group, Bldg. 90 - Room 3147, Lawrence Berkeley Laboratory, Berkeley, CA 94720.

DOE-2 manuals are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; tel. (703) 487-4650, Fax (703) 321-8547. Contact NTIS for price and delivery information.

Title of Document (version of DOE-2)	NTIS Order Number
Reference Manual (2.1A)	LBL-8706, Rev.2
Supplement (2.1E)	*
DOE-2 Basics (2.1E)	*
BDL Summary (2.1E)	*
Sample Run Book (2.1E)	*
Engineers Manual (2.1A)	DE-830-04575

* At the time this manual went to press, NTIS reference numbers had not yet been assigned. Please call Kathy Ellington at (510) 486-5711, or fax to (510) 486-4089, for reference numbers.

What does a DOE-2 run look like?

Following are the input (complete with a system, plant, and energy rate) and selected output reports for the single zone building shown below. (A more detailed version of this building, with five zones and a plenum, is shown in Appendix B.)

BM034

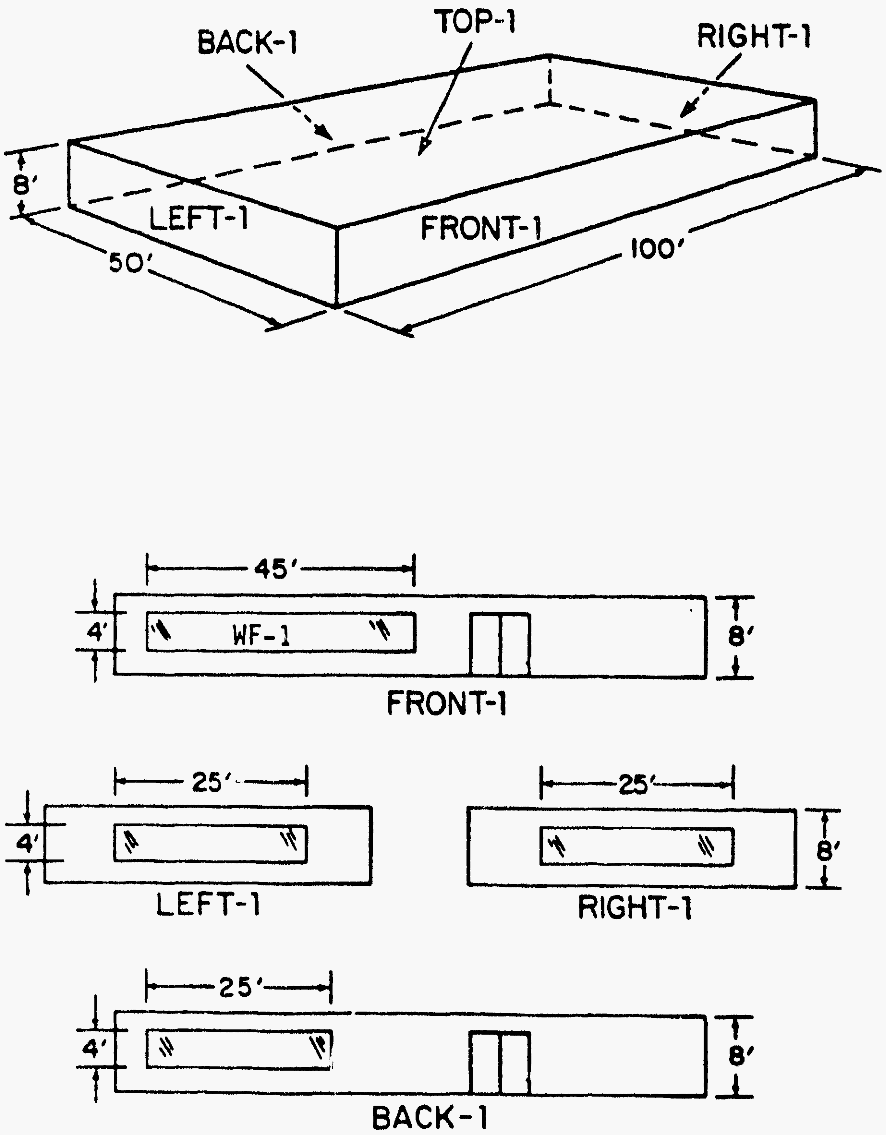


Figure 1.1: Simple Structure — Single Zone Building. LEFT-1, FRONT-1, etc. are user-defined names.

Sample Input

```
INPUT LOADS  ..

TITLE    LINE-1 *SIMPLE EXAMPLE FOR DOE-2 BASICS* ..

RUN-PERIOD         JAN 1 1974  THRU  DEC 31 1974    ..

ABORT              ERRORS   ..
DIAGNOSTIC         WARNINGS  ..
LOADS-REPORT       SUMMARY = (LS-C) ..

                   $ CHICAGO LOCATION

BUILDING-LOCATION  LATITUDE = 42.0  LONGITUDE = 88.0
                   ALTITUDE = 610   TIME-ZONE = 6
                   AZIMUTH = 0 ..

                   $ CONSTRUCTIONS AND GLASS TYPES

WA-1-2         =LAYERS  MATERIAL = (WD01,PW03,IN02,GP01)  ..
RB-1-1         =LAYERS  MATERIAL = (RG01,BR01,IN22,WD01)
                        INSIDE-FILM-RES = .76  ..

ROOF-1         =CONSTRUCTION       LAYERS   = RB-1-1 ..
WALL-1         =CONSTRUCTION       LAYERS   = WA-1-2 ..
FLOOR-1        =CONSTRUCTION       U-VALUE  = .05 ..
D1             =CONSTRUCTION       U-VALUE  = .5 ..

WINDOW-1       =GLASS-TYPE         SHADING-COEF = .9  PANES = 2 ..
G-DOOR         =GLASS-TYPE         SHADING-COEF = .8  PANES = 1 ..


                   $ OCCUPANCY SCHEDULE

OCCUPY-1       =SCHEDULE   THRU DEC 31
                           (MON,FRI) (1,8)(0)
                                     (9,11)(1)
                                     (12,14)(.8,.4,.8)
                                     (15,18)(1)
                                     (19,21)(.5,.1,.1)
                                     (22,24)(0)
                           (WEH)     (1,24)(0) ..

                   $ LIGHTING SCHEDULE

LIGHTS-1       =SCHEDULE   THRU DEC 31
                           (MON,FRI) (1,8)  (0.05)
                                     (9,14)  (.9,.95,1,.95,.8,.9)
                                     (15,18)  (1)
                                     (19,21)  (.6,.2,.2)
                                     (22,24)  (0.05)
                           (WEH)     (1,24)  (.05) ..
```

```
                    $ OFFICE EQUIPMENT SCHEDULE

EQUIP-1        =SCHEDULE   THRU DEC 31
                           (MON,FRI) (1,8) (.02)
                                     (9,14) (.8)
                                     (15,20) (.8,.7,.5,.5,.3,.3)
                                     (21,24) (.02)
                           (WEH)     (1,24) (.02) ..

                    $ INFILTRATION SCHEDULE

INFIL-1        =SCHEDULE   THRU MAR 31 (ALL) (1,24) (1)
                           THRU OCT 31 (ALL) (1,24) (0)
                           THRU DEC 31 (ALL) (1,24) (1) ..


                    $ SPACE DEFINITION

OFFICE-ENV     =SPACE-CONDITIONS   PEOPLE-SCHEDULE   = OCCUPY-1
                                   LIGHTING-SCHEDULE = LIGHTS-1
                                   EQUIP-SCHEDULE    = EQUIP-1
                                   LIGHTING-TYPE     = REC-FLUOR-RV
                                   LIGHTING-W/SQFT   = 1.5
                                   EQUIPMENT-W/SQFT  = 1
                                   AREA/PERSON       = 110
                                   PEOPLE-HEAT-GAIN  = 450
                                   FLOOR-WEIGHT      = 70
                                   INF-METHOD        = AIR-CHANGE
                                   INF-SCHEDULE      = INFIL-1
                                   AIR-CHANGES/HR    = .6 ..


OFFICE         =SPACE              SPACE-CONDITIONS = OFFICE-ENV
                                   AREA = 5000         VOLUME = 40000 ..

                    $ WALLS, WINDOWS, AND DOORS

    FRONT-1    =EXTERIOR-WALL      HEIGHT = 8          WIDTH = 100
                                   AZIMUTH=180         CONSTRUCTION = WALL-1 ..

      WF-1     =WINDOW             WIDTH = 45          HEIGHT = 4
                                   GLASS-TYPE = WINDOW-1 ..

      DF-1     =WINDOW             WIDTH = 8           HEIGHT = 7
                                   GLASS-TYPE = G-DOOR .. $ GLASS DOOR

    RIGHT-1    =EXTERIOR-WALL      HEIGHT = 8          WIDTH =  50
                                   AZIMUTH = 90        CONSTRUCTION = WALL-1 ..

      WR-1     =WINDOW             LIKE WF-1           WIDTH = 25 ..

    BACK-1     =EXTERIOR-WALL      HEIGHT = 8          WIDTH = 100
                                   AZIMUTH = 0         CONSTRUCTION = WALL-1 ..
```

```
      WB-1      =WINDOW              LIKE WF-1          WIDTH = 45 ..
      DB-1      =DOOR                WIDTH = 8          HEIGHT = 7
                                     CONSTRUCTION = D1 ..   $ WOOD DOOR

    LEFT-1      =EXTERIOR-WALL       HEIGHT = 8         WIDTH =  50
                                     AZIMUTH = 270      CONSTRUCTION = WALL-1 ..

      WL-1      =WINDOW              LIKE WF-1          WIDTH =25 ..

    TOP-1       =ROOF                HEIGHT = 50        WIDTH = 100
                                     AZIMUTH = 180      CONSTRUCTION = ROOF-1 ..

    BOTTOM-1    =UNDERGROUND-FLOOR   AREA = 5000
                                     CONSTRUCTION = FLOOR-1  ..

END ..
COMPUTE LOADS ..


INPUT SYSTEMS ..


FANS-ON        =SCHEDULE    THRU DEC 31
                            (MON,FRI)  (1,7)(0)  (8,18)(1)  (19,24)(0)
                            (WEH)  (1,24)(0)  ..

COOLSETPT      =SCHEDULE    THRU DEC 31
                            (MON,FRI)  (1,7)(99)  (8,18)(76)  (19,24)(99)
                            (WEH)  (1,24)(99)  ..

HEATSETPT      =SCHEDULE    THRU DEC 31
                            (MON,FRI)  (1,7)(55)  (8,18)(72)  (19,24)(55)
                            (WEH)  (1,24)(55)  ..

DHW            =SCHEDULE    THRU DEC 31
                            (MON,FRI)  (1,7)(0)  (8,18)(1)  (19,24)(0)
                            (WEH)  (1,24)(0)  ..

OFFICE         =ZONE        DESIGN-HEAT-T      = 72
                            DESIGN-COOL-T      = 74
                            HEAT-TEMP-SCH      = HEATSETPT
                            COOL-TEMP-SCH      = COOLSETPT
                            OA-CFM/PER         = 20 ..

AC-SYST        =SYSTEM      SYSTEM-TYPE        = SZRH
                            MAX-SUPPLY-T       = 110
                            MIN-SUPPLY-T       = 55
                            NIGHT-CYCLE-CTRL = CYCLE-ON-FIRST
                            FAN-SCHEDULE       = FANS-ON
                            DRYBULB-LIMIT      = 68
                            OA-CONTROL         = TEMP
                            ZONE-NAMES         = (OFFICE) ..
```

```
SYSTEMS-REPORT  SUMMARY = (SS-A) ..

P1              =PLANT-ASSIGNMENT  SYSTEM-NAMES = (AC-SYST)
                                   DHW-GAL/MIN  = .222
                                   DHW-SCH      = DHW ..

END ..
COMPUTE SYSTEMS ..



INPUT PLANT ..

P1              =PLANT-ASSIGNMENT ..

SHW             =PLANT-EQUIPMENT   TYPE = DHW-HEATER
                                   SIZE = -999 .. $ AUTO SIZED

HWG             =PLANT-EQUIPMENT   TYPE = HW-BOILER
                                   SIZE = -999 ..

CHLR            =PLANT-EQUIPMENT   TYPE = HERM-REC-CHLR
                                   SIZE = -999 ..

PLANT-PARAMETERS  HERM-REC-COND-TYPE = AIR .. $ AIR COOLED CONDENSER

PLANT-REPORT      SUMMARY = (BEPS) ..

END ..
COMPUTE PLANT ..



INPUT ECONOMICS ..

BLC             =BLOCK-CHARGE      BLOCK1-TYPE = ENERGY
                                   BLOCK1-DATA = (800,.075,
                                                  1200,.095,
                                                     1,.10) ..

ELECT-RATE      =UTILITY-RATE      RESOURCE = ELECTRICITY
                                   BLOCK-CHARGES = (BLC) ..

GAS-RATE        =UTILITY-RATE      RESOURCE = NATURAL-GAS
                                   ENERGY-CHG = .62 ..

ECONOMICS-REPORT  SUMMARY = (ES-D) ..

END ..
COMPUTE ECONOMICS ..
STOP ..
```

Sample Output

The following pages show the output reports generated by the sample input for Chicago weather.

SIMPLE EXAMPLE FOR DOE-2 BASICS — DOE-2.1E-005 Tue Mar 29 13:02:28 1994LDL RUN 1

REPORT- LS-C BUILDING PEAK LOAD COMPONENTS — WEATHER FILE- TRY CHICAGO

*** BUILDING ***

FLOOR AREA	5000	SQFT	465	SQMT
VOLUME	40000	CUFT	1133	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 4 PM		JAN 12 8AM	
DRY-BULB TEMP	94F	34C	-7F	-22C
WET-BULB TEMP	74F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	SENSIBLE (KBTU/H)	SENSIBLE (KW)
WALL CONDUCTION	4.361	1.278	0.000	0.000	-8.498	-2.490
ROOF CONDUCTION	56.769	16.633	0.000	0.000	-65.669	-19.241
WINDOW GLASS-FRM COND	6.007	1.760	0.000	0.000	-22.272	-6.526
WINDOW GLASS SOLAR	29.406	6.614	0.000	0.000	2.582	0.757
DOOR CONDUCTION	0.766	0.224	0.000	0.000	-1.755	-0.514
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-1.500	-0.440	0.000	0.000	-7.500	-2.197
OCCUPANTS TO SPACE	10.479	3.070	8.056	2.360	0.525	0.154
LIGHT TO SPACE	21.836	6.398	0.000	0.000	2.744	0.804
EQUIPMENT TO SPACE	11.061	3.241	0.000	0.000	0.889	0.261
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-19.196	-5.624
TOTAL	139.181	40.780	8.056	2.360	-118.149	-34.618

	COOLING				HEATING			
TOTAL LOAD	147.238	KBTU/H	43.141	KW	-118.149	KBTU/H	-34.618	KW
TOTAL LOAD / AREA	29.45	BTU/H.SQFT	92.873	W /SQMT	23.630	BTU/H.SQFT	74.524	W /SQMT

```
***************************************************************
*                                                             *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR    *
*  ----    LOADS                                              *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION      *
*          IN CONSIDERATION                                   *
*                                                             *
***************************************************************
```

SIMPLE EXAMPLE FOR DOE-2 BASICS DOE-2.1E-005 Tue Mar 29 13:02:28 1994SDL RUN 1

REPORT- SV-A SYSTEM DESIGN PARAMETERS AC-SYST WEATHER FILE- TRY CHICAGO

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
AC-SYST	SZRH	1.020	5000.0	45.

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
6918.	5.311	2.4	0.	0.000	0.0	0.134	256.389	0.699	-342.822	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
OFFICE	6918.	0.	0.000	1.000	927.	0.00	0.00	141.97	0.00	-283.93	1.0

SIMPLE EXAMPLE FOR DOE-2 BASICS DOE-2.1E-005 Tue Mar 29 13:02:28 1994SDL RUN 1

REPORT- SS-A SYSTEM MONTHLY LOADS SUMMARY FOR AC-SYST WEATHER FILE- TRY CHICAGO

	- - - C O O L I N G - - -						- - - H E A T I N G - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-35.811	7	8	-1.F	-1.F	-312.633	4632.	16.811
FEB	0.00000					0.000	-28.390	11	8	5.F	4.F	-293.867	4001.	16.811
MAR	0.00000					0.000	-17.126	25	8	14.F	12.F	-262.729	4111.	16.811
APR	[illegible]	29	16	68.F	62.F	106.217	-3.525	8	8	30.F	27.F	-189.422	4095.	16.811
MAY	[illegible]	21	14	85.F	75.F	166.823	-0.806	13	8	43.F	40.F	-78.441	4106.	16.811
JUN	[illegible]	21	16	91.F	77.F	197.350	0.000	17	8	54.F	48.F	-0.084	3754.	16.811
JUL	[illegible]	6	16	92.F	74.F	216.134	0.000					0.000	4106.	16.811
AUG	[illegible]	19	15	91.F	71.F	199.028	0.000					0.000	4106.	16.811
SEP	[illegible]	11	15	87.F	71.F	165.944	-0.435	23	8	36.F	34.F	-116.905	3754.	16.811
OCT	[illegible]	3	15	74.F	66.F	87.558	-2.720	21	8	30.F	29.F	-208.883	4106.	16.811
NOV	[illegible]	1	15	71.F	59.F	83.303	-15.157	25	8	27.F	25.F	-231.982	3705.	16.811
DEC	[illegible]					0.000	-29.037	26	8	15.F	15.F	-279.563	4419.	16.811
TOTAL	[illegible]						-133.006						48901.	
MAX						216.134						-312.633		16.811

SIMPLE EXAMPLE FOR DOE-2 BASICS DOE-2.1E-005 Tue Mar 29 13:02:28 1994PDL RUN 1

REPORT- BEPS BUILDING ENERGY PERFORMANCE SUMMARY WEATHER FILE- TRY CHICAGO

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
AREA LIGHTS	74.7	0.0
MISC EQUIPMT	35.9	0.0
SPACE HEAT	8.5	204.3
SPACE COOL	30.4	0.0
HEAT REJECT	5.1	0.0
PUMPS & MISC	3.9	0.0
VENT FANS	56.2	0.0
DOMHOT WATER	0.0	51.7
TOTAL	214.8	256.0

```
TOTAL SITE ENERGY      470.82 MBTU     94.2 KBTU/SQFT-YR GROSS-AREA     94.2 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY    900.50 MBTU    180.1 KBTU/SQFT-YR GROSS-AREA    180.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  0.5
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.0

NOTE:  ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.
```

SIMPLE EXAMPLE FOR DOE-2 BASICS DOE-2.1E-005 Tue Mar 29 13:02:29 1994EDL RUN 1

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELECT-RATE	ELECTRICITY	1 2 3 4 5	62939. KWH	5982.	0.0950	YES
GAS-RATE	NATURAL-GAS	1 2 3 4 5	2560. THERM	1587.	0.6200	YES
				==========		
				7569.		

ENERGY COST/GROSS BLDG AREA: 1.51
ENERGY COST/NET BLDG AREA: 1.51

Structure of DOE-2

DOE-2 has five parts, as shown in Fig. 1.2: one program for translation of the input, and four simulation subprograms. The four simulation subprograms are executed in sequence, with the output of one becoming the input to the next. Each of the four simulation subprograms also produces printed reports of the results of its calculations. The subprograms are summarized below:

1) **BDL - The Building Description Language processor**
reads the flexibly formatted data supplied by you and translates it into computer recognizable form. It also calculates response factors for the transient heat flow in walls and weighting factors for the thermal response of building spaces.

2) **LOADS - the loads simulation subprogram**
calculates the sensible and latent components of the hourly heating or cooling load for each user-designated space in the building, assuming that each space is kept at a constant temperature selected by you. LOADS is responsive to weather and solar conditions, to schedules of people, lighting and equipment, to infiltration, to the time delay of heat transfer through walls and roofs and to the effect of building shades on solar radiation.

3) **SYSTEMS - the secondary* HVAC system simulation subprogram**
LOADS produces a first approximation of the energy demands of a building. SYSTEMS corrects this approximation by taking into account outside air requirements, hours of equipment operation, HVAC equipment control strategies, and the transient response of the building when neither heating nor cooling is required to maintain the temperature and humidity setpoints. The output of SYSTEMS is a list of the actual heating and cooling coil loads at the zone and system levels.

4) **PLANT - the primary* HVAC system simulation subprogram**
simulates the behavior of boilers, turbines, chillers, cooling towers, storage tanks, etc., in satisfying the secondary systems heating and cooling coil loads. PLANT takes into account the part-load characteristics of the primary equipment in order to calculate the fuel and electrical demands of the building.

5) **ECONOMICS - the economic analysis subprogram**
calculates the cost of energy. It can be used to compare the costs of different building designs or to calculate savings for retrofits to an existing building.

---

* The words *secondary* and *primary* are historical terminology in the U.S. building industry. The "air side" equipment (fans, ducts and coils) is referred to as the "secondary" system; whereas the boilers, chillers and other energy conversion equipment are called "primary".

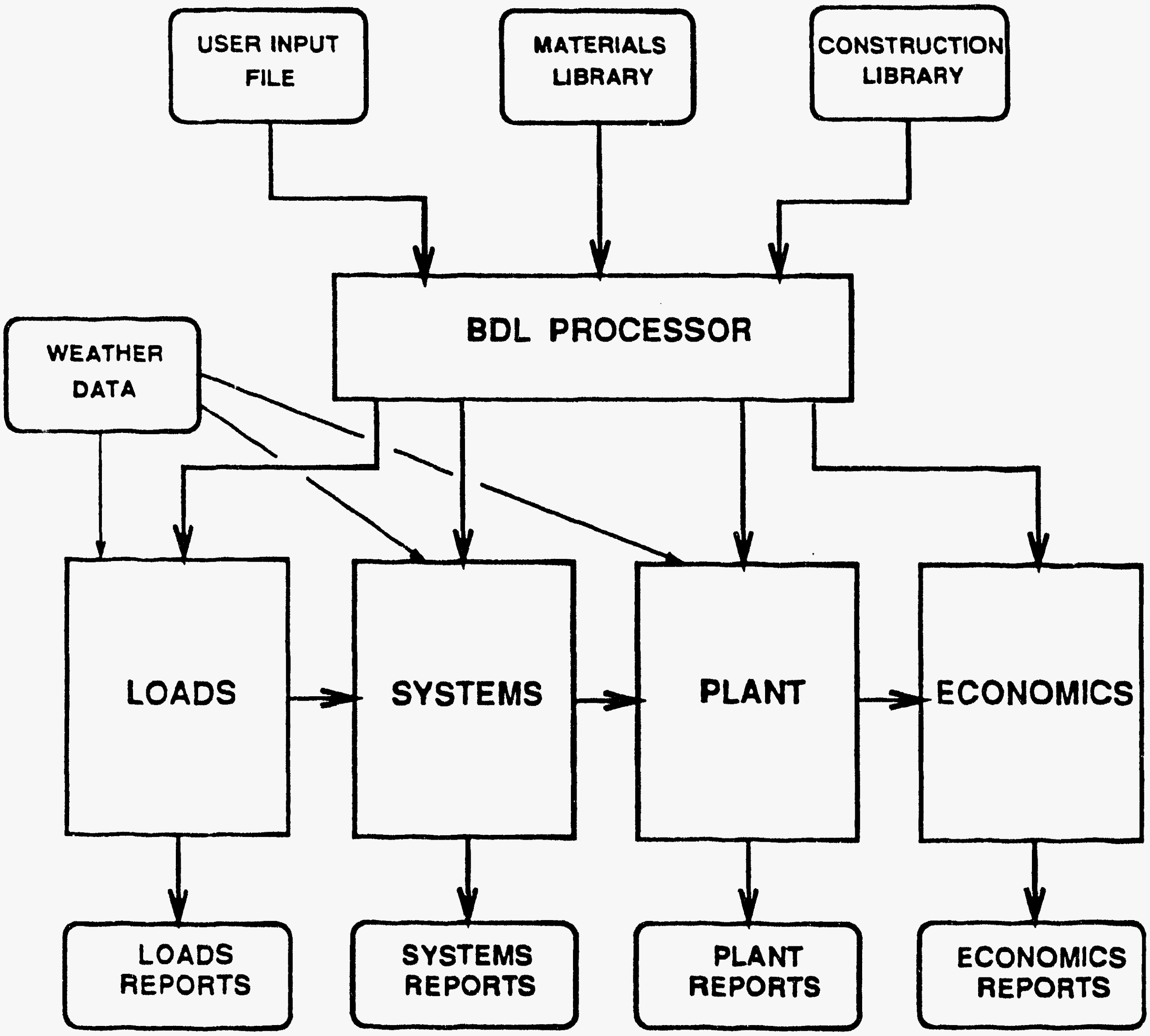


Figure 1.2: DOE-2 Program Flow

Uses for DOE-2

Because of the scope and flexibility of its input, DOE-2 can be used in many applications, especially those involving design of building envelope and systems, and selection of energy conserving or peak demand reduction alternatives. For example:

Energy Conservation Studies

a) Effect of the thickness, order, type of materials, and orientation of exterior walls and roofs;

b) Effect of thermal storage in walls and floors, and in energy storage tanks coupled to HVAC systems;

c) Effect of occupant, lighting, and equipment schedules;

d) Effect of intermittent operation, such as the shutdown of HVAC systems during the night, on weekends, holidays, or for any hour;

e) Effect of reduction in minimum outside air requirements and the scheduled use of outside air for cooling;

f) Effect of internal and external shading, tinted and reflective glass, use of daylighting.

Building Design Studies

a) Initial design selection of the basic elements of the building, primary and secondary HVAC systems, and energy source;

b) During the design stage, evaluating specific design concepts such as system zoning, control strategies, and systems selection;

c) During construction, evaluating contractor proposals for deviations from the construction plans and specifications;

d) A base of comparison for monitoring the operation and maintenance of the finished building and systems;

e) Analysis of existing buildings for cost-effective retrofits.

How Has DOE-2 Been Validated?

DOE-2 has been verified against manual calculations and against field measurements on existing buildings in a DOE-sponsored project conducted by Los Alamos National Laboratory. For more information on program validation, please refer to the following:

- *DOE-2 Verification Project, Phase 1, Interim Report,* Los Alamos National Laboratory, Report No. LA-8295-MS, 1981

- *DOE-2 Verification Project, Phase 1, Final Report,* Los Alamos National Laboratory, Report No. LA-10649-MS, 1986.

These reports are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

Weather Files

The DOE-2 mainframe tape comes with Chicago weather; it also comes with a weather processor program for converting weather tapes into DOE-2 compatible weather files. Users of the PC versions of DOE-2 should contact their vendor for information on weather files. Weather files can be obtained from the following organizations:

TMY or TRY weather tapes	National Climatic Data Center Federal Building Asheville, North Carolina 28801 (704) 259-0871 Climate Data (704) 259-0682 Main Number
CTZ weather tapes	California Energy Commission Attn: Bruce Maeda, MS-25 1516-9th Street Sacramento, CA 95814-5512 1-800-772-3300 Energy Hotline
WYEC weather tapes	ASHRAE 1791 Tullie Circle N.E. Atlanta, GA 30329 (404) 636-8400

Program-Related Software and Services

Each issue of the *User News* contains a directory of software and services pertaining to DOE-2. This listing includes names and addresses of consultants, information on training, where to purchase the PC versions of DOE-2, how to obtain pre- and post-processor software, etc. Because the information is subject to constant change, we decided not to include it in *DOE-2 Basics.*

To get current information, please contact the

Simulation Research Group
Bldg. 90 - Room 3147
Lawrence Berkeley Laboratory
One Cyclotron Road
Berkeley, CA 94720

BUILDING DESCRIPTION LANGUAGE (BDL)

BDL Instructions

In this manual, the acronym BDL is used both as the name of the DOE-2 input language and as the name of the DOE-2 subprogram that translates DOE-2 input instructions into a machine readable format. For a list of *basic* BDL input commands and keywords, see Appendix F of this manual. A complete list of commands and keywords can be found in the *BDL Summary (2.1E)*.

To aid in understanding the following sections, we recommend that you refer to the "Sample Input", starting on p.7.

The primary element of BDL is the *instruction*. An instruction corresponds roughly to an English sentence and always includes a *command* that specifies the subject matter, and a *terminator* that ends the command. An example is the BDL instruction that defines the run period for the simulation (see "Sample Input"):

```
RUN-PERIOD  JAN 1 1974  THRU  DEC 31 1974 ..
```

Each instruction is assumed by BDL to stay in effect until it sees a terminator. If there is more data, it assumes a new instruction is coming and seeks out the controlling command word of that instruction. This process continues until BDL reads the STOP command. Note that no reference is made here to coming to the end of a line. An instruction may stretch over many lines without your needing to indicate that the second and following lines are continuations of the first. BDL assumes that they are continuations as long as it has not discovered a terminator, and thus allows you to arrange the input any way you wish.

Terminator

The symbol for the *terminator* is .. (two periods with no space between them and one or more blank spaces preceding them. ***Don't forget to end each instruction with a terminator***; otherwise, pages of error messages may result.

Comments

Any line of input may contain a comment; comment lines start and end with a dollar sign ($). Be sure to put at least one space between the terminator and the start of the comment line (.. $comment).

INPUT Command

Before inputting data for a subprogram, you have to use the INPUT command to tell BDL which program data are being presented next; for example:

```
INPUT LOADS ..
```

END Command

END tells BDL that the program data started by INPUT command is complete. The lines between INPUT and END must contain all data needed to perform the simulation for the subprogram indicated.

COMPUTE Command
COMPUTE requests that a simulation be performed using input data between the previous INPUT and END commands. In the sample, COMPUTE LOADS requests a LOADS simulation and that the LOADS data between INPUT LOADS and END be used. The sequence continues by telling BDL to accept SYSTEMS data input (INPUT SYSTEMS).

Keywords*
The description of a building is entered between INPUT and END with a series of commands, each of which accepts additional pieces of information that describe the content of the command. The identification of the specific content is through *keywords*.

Keywords always appear in the form keyword=value, or keyword=(a list of values), where you specify a "value" or "list of values". As an example, the BUILDING-LOCATION command tells BDL that the data to follow give the building's location and time zone.

```
BUILDING-LOCATION   LATITUDE=42     LONGITUDE=88
                    ALTITUDE=610    TIME-ZONE=6
                    AZIMUTH=0       HOLIDAY=NO ..
```

In this example there are six keyword=value pairs (LATITUDE=42, LONGITUDE=88, ALTITUDE=610, TIME-ZONE=6, AZIMUTH=0, and HOLIDAY=NO).

Spacing between lines, commands, keywords, etc., is arbitrary except that a blank indicates the end of a keyword=value pair. For this reason blank spaces may not be embedded within a single keyword. For example, the keyword TIME-ZONE is recognized as one word; if the dash is omitted (TIME ZONE), then two words are produced and BDL won't recognize either one as a keyword. Because spaces, commas, and equal signs may be used interchangeably as separators, BDL interprets

LATITUDE 42
LATITUDE,42
LATITUDE=42

all in the same way. However, equal signs between keywords and their values do make the input more readable. Note that for the keyword, HOLIDAY, the value assigned (NO) is a code-word rather than a number.

U-Names and Referenced Commands
Some keywords take values that are user-defined names, called "u-names". With u-names, previously-defined commands can be referenced, allowing data from one instruction to be used in one or more subsequent instructions.

To illustrate the use of referenced commands and u-names, we specify the construction of a wall. The first step is to indicate the different layers of the wall starting from the outside surface. This is given by an instruction whose command is LAYERS, which must be given a u-name, in this case WA-1-2.

```
WA-1-2 =LAYERS    MATERIAL=(WD01,PW03,IH02,GP01) ..
```

* Please refer to Appendix E for a list of "*basic*" commands, keywords, and abbreviations.

Note that, in general, a command must be the first word in an instruction unless it is preceded by a u-name (preferably with an intervening equal sign).* There are two other points to note in this example. First: when a list of values is assigned to a keyword, the list must be enclosed in parentheses ( ). Second: the values of some keywords are code-words; in this example they were taken from the list of materials described in Appendix D, the Materials Library.

Since the LAYERS command has a u-name, it can be referenced in a subsequent instruction that describes the unique construction of a wall. Its value is the u-name you have given to the set of materials above. Thus

```
WALL-1 =CONSTRUCTION   LAYERS=WA-1-2 ..
```

Here, the CONSTRUCTION command has been given the u-name WALL-1 to remind you that it describes the construction type of the exterior wall, and so that it can be referenced later.

To complete the chain of referenced commands, the south-facing wall of the building has an exterior wall with construction WALL-1:

```
FRONT-1 =EXTERIOR-WALL   HEIGHT=8
                         WIDTH=100
                         AZIMUTH=180
                         CONSTRUCTION=WALL-1 ..
```

Choosing u-names

In the example above, the command EXTERIOR-WALL has also been given a u-name, FRONT-1. This is optional and is *not* required. However, there are reasons for u-naming specific walls, windows and the like. The first is that several of the optional reports in the LOADS subprogram are verifications of input organized in an informative manner. Unless the various components are u-named, it is difficult to tell which wall, for example, is being described. Another reason is to make use of the labor-saving keyword LIKE, which is described below. The rule for choosing u-names is this: a u-name is any alpha-numeric string of 16 or fewer symbols which have no embedded spaces and that are different from all commands, keywords and code-words or their corresponding abbreviations or reserved words. "Reserved" means that the word is recognized by the program as a command or keyword or value.

LIKE Keyword

Many commands allow the LIKE keyword. When used, LIKE must be the first keyword following the command and its symbolic value must be the u-name of a previously defined command of the same type. This keyword instructs BDL to assign to this command the same values of all the keywords in the referenced command. For example,

```
WF-1=WINDOW   HEIGHT=4
              WIDTH=45
              GLASS-TYPE=WINDOW-1 ..
```

allows us to reference this window and change its width, creating a new window, WR-1:

```
WR-1=WINDOW  LIKE=WF-1  WIDTH=25 ..
```

* There are some commands, like BUILDING-LOCATION, which cannot have u-names. The complete list of commands, keywords, their abbreviations, and summary rules is given in the *BDL Summary (2.1E)*.

Subcommands

A *subcommand* is similar to a command except that it can be referred to by a subsequent command through the use of a u-name. Unlike a command, however, the keywords of a subcommand can be included within its associated command. In the example, SPACE-CONDITIONS keywords are referenced in the SPACE command by specifying SPACE-CONDITIONS=OFFICE-ENV. In a multi-space building, this would allow the same SPACE-CONDITIONS to be assigned to several spaces, thus saving input effort.

Building Description

One of the first steps in energy analysis is to obtain the architectural and mechanical drawings for the building to be simulated. Keep in mind that the goal is to create a model of the building in order to analyze thermal energy flows and not to describe in minute detail what the building looks like architecturally. You can save input time and computer time by describing the building from an energy perspective rather than from an architectural perspective.

To understand this more fully, it is necessary to know how DOE-2 treats the boundaries of spaces. DOE-2 does *not* attempt to reconstruct the space geometrically from the your description of the bounding surfaces. Rather, the program calculates the flow of energy *only through the surfaces you describe*. It does not test whether walls meet or even whether the surfaces describe an enclosed three-dimensional space. It is possible, for example, to define a space with a floor area and a volume and then to describe only one exterior south-facing wall. DOE-2 accepts your word that all you wanted is to examine the energy flow in the space through that one surface. Or you may have decided that the energy flow through the other surfaces (perhaps interior walls) was negligible.

Internal Zoning

The first decision to make is how to divide the inside of the building into discrete spaces or zones. In LOADS these regions are referred to as "spaces" and in SYSTEMS these identical regions are called "zones". When considering the structure and use of a building the word "space" seems appropriate; however, when designing an HVAC system the central concern relates to spaces that are under the same thermostatic control, i.e., zones.

In practical terms this means that you need not be constrained by the details of the architectural plan. Contiguous rooms, that can be expected to behave similarly from a thermodynamic perspective, can be described as a single SPACE in the LOADS input and as a single ZONE (with the same u-name) in the SYSTEMS input. The objective from the perspective of reducing input preparation time and computer run time is to have as few zones as possible consistent with making an adequate model of the thermodynamic behavior of the building.

It is not even necessary to have zones separated by real partitions or interior walls. However, it is common in building energy analysis to create one internal zone and four external zones (one for each exposure — see Appendix B).

In the Example, we have chosen to input the building as one SPACE in LOADS and one ZONE in SYSTEMS. Note that if the dynamics of a building system require transfer of heat from one zone to another, such as a water source heat pump system, it is imperative to input multiple zones so that the transfer can be simulated.

Use of Comments

BDL allows you to introduce comments into the body of the input without affecting the translation of the data. Comments help when you return to DOE-2 input after an absence and may have difficulty reconstructing the original intent. Comments are also helpful if someone else wants to use the input.

BDL recognizes the dollar sign, $, as the beginning and end of a comment. Any string of characters between dollar signs is ignored by BDL in translation but is echoed back in the output. For example, $BUILT-UP ROOF$ is a comment in the following instruction:

```
ROOF-1 =CONSTRUCTION   LAYERS=RB-1-1   $BUILT-UP ROOF$ ..
```

Note that a comment that spans several lines must have $ at the beginning of each line of comment.

Alternative Runs

DOE-2 allows you to make a series of alternative runs in a single input file.* Any number or series of alternative runs is allowed in DOE-2 and in any combination. For example, the input of a base LOADS run with two SYSTEMS alternatives, followed by a single PLANT, is as follows:

```
INPUT LOADS   ..
   .
   .
   .
END           ..
COMPUTE LOADS ..
INPUT SYSTEMS ..      $ FIRST SYSTEM $
   .
   .
   .
END           ..
COMPUTE SYSTEMS ..
INPUT PLANT     ..
   .
   .
   .
END           ..
COMPUTE PLANT   ..
INPUT SYSTEMS   ..    $ SECOND SYSTEM $
   .
   .
   .
END           ..
COMPUTE SYSTEMS ..
COMPUTE PLANT   ..
STOP          ..
```

It is not necessary to re-input the LOADS input after the first SYSTEM, nor is it necessary to re-input the PLANT input after the last SYSTEM; the command, COMPUTE PLANT, is sufficient to re-call the previous PLANT input and thus recompute the effect of the second SYSTEM on it.

---

* DOE-2 also allows you to make parametric runs, i.e., those that involve changing one parameter (or a number of related parameters) to analyze the effect on energy use. You are referred to the *Reference Manual (2.1A)* for a description of how to prepare the input for parametric runs.

Schedules

Hourly profiles of such quantities as lighting power, occupancy, and thermostat setpoint are known as "schedules" in DOE-2. There are three basic types of schedules used in BDL for the entire program.

1) **DAY-SCHEDULE**
   Defines the day's hourly profile; therefore, a separate DAY-SCHEDULE is required for each type of day that needs to be defined.

2) **WEEK-SCHEDULE**
   Defines each type of day in the week [week-day, holidays, half-workdays, etc.].

3) **SCHEDULE**
   Defines the type of week in the year, thereby allowing for the definition of calendar periods, such as summer vacations, etc.

DAY-SCHEDULE

In its simplest form, the input for DAY-SCHEDULEs is:

```
U-NAME = DAY-SCHEDULE (all 24 hours covered) (values for each hour) ..
```

For example:

```
LTG-1 = DAY-SCHEDULE (1,24) (0,0,0,0,0,0,0,0,0.3,0.6,0.8,1,1,1,1,1,1,1,0,0,0,0,0,0) ..
```

Optionally, this can be shortened by writing

```
LTG-1 = DAY-SCHEDULE (1,8)(0) (9,11) (0.3,0.6,0.8) (12,18) (1) (19,24) (0) ..
```

which is representative of a week-day daily profile. Note that hour 1 is midnight to 1am, hour 2 is 1am to 2am, etc. For example, (12,18)(1)(19,24) (0), above, means that the lights are fully on from 11am to 6pm and fully off from 6pm to midnight.

For week-ends and holidays, let's assume that:

```
LTG-2 = DAY-SCHEDULE (1,24)(0) ..
```

WEEK-SCHEDULE

The purpose of the WEEK-SCHEDULE should now be apparent;
we have two day types — LTG-1 represents week-days, and LTG-2 represents week-ends and holidays. The form of the WEEK-SCHEDULE is:

```
U-NAME = WEEK-SCHEDULE (†) (U-NAME of DAY-SCHEDULE referenced) ..
```

† days of week covered

Using the previously defined DAY-SCHEDULEs, the example can be carried forward with:

```
NORMAL = WEEK-SCHEDULE       (MON,FRI) LTG-1
                             (SAT,HOL) LTG-2 ..
```

where (MON,FRI) includes MON,TUE,WED,THU,FRI and (SAT,HOL) includes SAT,SUN,HOL.

Optionally, this can be shortened to:

```
NORMAL = WEEK-SCHEDULE (WD) LTG-1 (WEH) LTG-2 ..
```

where (WD) stands for week-days and (WEH) for week-ends and holidays. If Saturday is considered part of the normal week, you have to write (MON,SAT) LTG-1 and (SUN,HOL) LTG-2.

SCHEDULE

To illustrate the purpose of SCHEDULE, assume we have a school that is closed in the summer and on week-ends and holidays. Therefore, we need another week type:

```
VACATION = WEEK-SCHEDULE (ALL) LTG-2 ..
```

where (ALL) stands for all days of the week, including holidays, and LTG-2 was the DAY-SCHEDULE representing lights as being "off" for 24 hours.

In its simplest form, SCHEDULE takes the form of:

```
U-NAME =SCHEDULE(THRU †)(U-NAME of WEEK-SCHEDULE referenced) ..
```

† calendar period covered

To finalize the example:

```
LIGHTS = SCHEDULE                 THRU JUN 10 NORMAL
                                  THRU SEP 5  VACATION
                                  THRU DEC 31 NORMAL ..
```

Another option, "nesting of schedules", can be very useful in lessening the chore of preparing schedules. In the above example we could have bypassed the WEEK-SCHEDULEs by "nesting" the DAY-SCHEDULEs in the SCHEDULE itself. For example:

```
LIGHTS = SCHEDULE      THRU JUN 10      (WD) LTG-1 (WEH) LTG-2
                       THRU SEP  5      (ALL) LTG-2
                       THRU DEC 31      (WD) LTG-1 (WEH) LTG-2 ..
```

Further, if there had been no vacation period, the DAY-SCHEDULE as well as the WEEK-SCHEDULE could have been bypassed by "nesting" as follows:

```
LIGHTS = SCHEDULE THRU DEC 31         (WD) (1,8)(0) (9,11)(0.3,0.8,0.8)
                                      (12,18)(1) (19,24)(0)
                                      (WEH) (1,24)(0) ..
```

In the BDL for SYSTEMS, there are special requirements for DAY-RESET schedules, in PLANT there are DAY-ASSIGN schedules, but they all follow the same pattern described above.

Flexibility of Input Format
Most users develop a format that suits them and after a few inputs have been prepared they will use their editor to patch sections of old inputs into new ones, and thus reduce time of preparation. For example, starting on p.1.9, the entire sample input down to the first SPACE is probably worth saving as representative of office buildings. And as you will see in the SYSTEMS section of this manual, we have prepared alternative system inputs, any one of which could be merged into the file to replace the one in this sample.

The following input lines are identical to the PLANT and ECONOMICS input starting on p.1.12. The purpose of the example is to display the freestyle formatting available to you and to display the use of abbreviations and lower case lettering. This also shows how confusing a jumble of input styles can be and the importance of annotating your inputs as you go along.

If you organize the input so that the most important items appear in the left column and indent the less pertinent information, your original intent will be more understandable if you have to review the input in the future. To prove the point, compare the input in the sample run to the input below, which was prepared with no recognizable format.

```
          INPUT PLANT ..

SHW = P-E         TYPE = DHW-HEATER  size =-999 ..
HWG = PLANT-EQUIPMENT  TYPE = HW-BOILER
SIZE =-999 ..
CHR = PLANT-EQUIPMENT  TYPE = HERM-REC-CHLR  SIZE =-999 ..
P-P  BOILER-FUEL = NATURAL-GAS   HERM-REC-COND-TYPE = AIR ..
PLANT-REPORT  S = (BEPU) .. END .. COMPUTE PLANT ..
    INPUT ECONOMICS ..

             ELECT-RATE = UTILITY-RATE
           R = ELECTRICITY  B-C = BLC ..
           BLC = B-C   BLOCK-TYPE = ENERGY
                   BLOCK-DATA = (800,0.75,1200,.090,1,.10) ..

           GAS-RATE = UTILITY-RATE   R = NATURAL-GAS
           ENERGY-CHGS = (.62) ..
      ECONOMICS-REPORT   S = (ES-D) ..
END ..
COMPUTE ECONOMICS ..
STOP ..
```

LOADS

Introduction

The LOADS section of DOE-2 calculates the heating and cooling loads of a building, assuming a fixed indoor air temperature.* The loads components can be divided into two classes, external and internal.

External components are the loads due to heat conduction through walls, heat conduction through windows, infiltration through windows and walls, and solar gain through windows.

Internal components are the loads due to people, lights, and equipment inside the building.

The program first calculates the external load components for all the windows and doors on a wall, then for all the walls in a space. The wall loads are then combined into the total external load for the space. Next, the program calculates the internal load components for the space and combines them, giving the total internal load for the space. The external and internal loads are combined to give the total load for the space. Finally, the space loads are summed, giving the total building load for the hour.

LOADS calculates the heating and cooling loads using ASHRAE algorithms. For the load calculations it is assumed that no HVAC equipment is operating and that each space remains at a user-specified constant temperature. Therefore, the hourly load calculated by LOADS is the energy required to maintain a constant space temperature without the effects of ventilation air.

The building hourly loads are a function of many parameters, including

building latitude
building longitude
building altitude
building location--time-zone
building orientation
hourly ambient dry-bulb temperature
hourly ambient wet-bulb temperature
hourly atmospheric pressure
hourly windspeed
hourly wind direction
hourly insolation
schedules for occupants
schedules for lighting
schedules for equipment
hourly infiltration rate
size of exterior, interior, and underground surfaces
construction of exterior, interior, and underground surfaces
position of exterior, interior, and underground surfaces.

---

* In this Section it is assumed that precalculated weighting factors will be used. For a discussion of alternatives see p.III.143 of the DOE-2 *Reference Manual (2.1A)*.

LOADS Input Instructions

Limitation on Number of Commands

The maximum number of Loads Description Language (LDL) commands that the program can accept in a single run is as follows:

Command	Maximum Number
BUILDING-LOCATION	1
CONSTRUCTION	64
DAY-SCHEDULE	300
DOOR	64
EXTERIOR-WALL/ROOF	300
GLASS-TYPE	32
INTERIOR-WALL	512
LAYERS	64
LOADS-REPORT	1
RUN-PERIOD	1 *
SCHEDULE	100
SPACE	128
SPACE-CONDITIONS	50
TITLE	5 **
u-names	352 ***
UNDERGROUND-FLOOR	64
UNDERGROUND-WALL	64
WEEK-SCHEDULE	200
WINDOW	200

Description of LOADS Input Instructions

The following section describes all LDL input instructions that are required to run the LOADS program.

INPUT

The input data for the LOADS program begins with the instruction:

INPUT LOADS ..

* 1 command specifying up to 15 periods

** This maximum number refers to the number of keyword values, not the number of instructions.

*** The use of the nested scheduling technique, described in the BDL section of this manual, will result in the use of at least three of these u-names for each SCHEDULE specified. You specify one u-name for the SCHEDULE and the balance of the u-names are internally specified by the LDL program. Also, specifying a code-word for a MATERIAL, a LAYERS, or a CONSTRUCTION in the DOE-2 Preassembled Library results in the use of one u-name, internally specified by the LDL program. The same is true when specifying output reports by code-word (LV-A, LS-A, etc.).

RUN-PERIOD

The RUN-PERIOD command is used to specify the initial and final dates of the desired simulation period. The initial date is the first date of the simulation, given in the form: month day year. The LDL code-words that specify the names of the months are given below. The day and year are specified as numbers with a separator (blank or comma) on each side. The final date is the last simulation date, specified in the same manner as the initial date.

The code-words for the months are:

JAN	FEB	MAR	APR	MAY	JUN
JUL	AUG	SEP	OCT	NOV	DEC

u-name is not allowed

Rules:

1. A RUN-PERIOD instruction must be entered for a LOADS program run.
2. Only one RUN-PERIOD instruction is permitted with up to 15 THRUs.
3. The initial and final dates specified in any one computer run must all be in the same year. The final date must be equal to or later than the initial date.
4. The day number cannot be greater than the number of days in the month associated with that date (in other words, SEP 31 1978 is not valid).

   Note: The year of the RUN-PERIOD should ordinarily be the year of the data on the weather tape being used. The program and the weather tapes assume a 365 day year, even for leap years. For more information on this, see HOURLY-REPORT instruction, pp.II.32-33 of the *Reference Manual (2.1A)*.

Example:

1. This instruction would run the LOADS program for one year:

   RUN-PERIOD   JAN 1 1979 THRU DEC 31 1979 ..

2. To run the LOADS program for January and February to study the winter heating peak, and for June and July to study the summer cooling peak, the LDL input instruction would be:

   RUN-PERIOD   JAN 1 1979 THRU FEB 28 1979
                 JUN 1 1979 THRU JUL 31 1979 ..

BUILDING-LOCATION

The BUILDING-LOCATION command is used to specify the location and orientation of the building and other miscellaneous information about it.

u-name	is not allowed.
LATITUDE	is the angular distance from the plane of the equator to the origin of the building coordinate system. It is specified in positive degrees for the northern hemisphere and negative degrees for the southern hemisphere. The allowable range is −66.5 to 66.5 degrees. If not entered here, the value will be taken from the weather tape.
LONGITUDE	is the angular distance from the prime meridian to the origin of the building coordinate system. It is specified in either positive degrees (west) or negative degrees (east) from −180.0 to +180.0. If not entered here, the value will be taken from the weather tape.
ALTITUDE	is the distance of the origin of the building coordinate system above (positive) or below (negative) mean sea level. The default is 0.0, and the allowable range is −1000.0 to 20000.0 feet. **Note**: if you want to input air flow rates and not have the program adjust them for altitude, ALTITUDE should be set to zero.
TIME-ZONE	for a building location is specified by the number of time zones, each 1 hour from the next, from the prime meridian. The values range from −1 to −12 for zones east of the prime meridian and from 1 to 12 for zones west of the prime meridian. If not entered here, the value will be taken from the weather tape. The following table identifies the TIME-ZONE values within the United States by common time zone names.

Time Zone	TIME-ZONE Value	Time Zone	TIME-ZONE Value
Atlantic	4	Mountain	7
Eastern	5	Pacific	8
Central	6	Yukon	9
Hawaii	10		

DAYLIGHT-SAVINGS	means that one 23-hour day occurs in the spring and one 25-hour day occurs in the fall. The building schedules are adjusted accordingly with respect to solar noon. The entry is a code-word, either YES (the default) or NO, that communicates your desire for daylight saving time.

HOLIDAY

The LOADS program can calculate holiday loads using different schedules than for normal weekdays. The code-word YES (the default) gives the holidays; NO gives no holidays. The following table identifies the holiday list. You can change the holiday list using the ALT-HOLIDAYS command; see Supplement (2.1E).

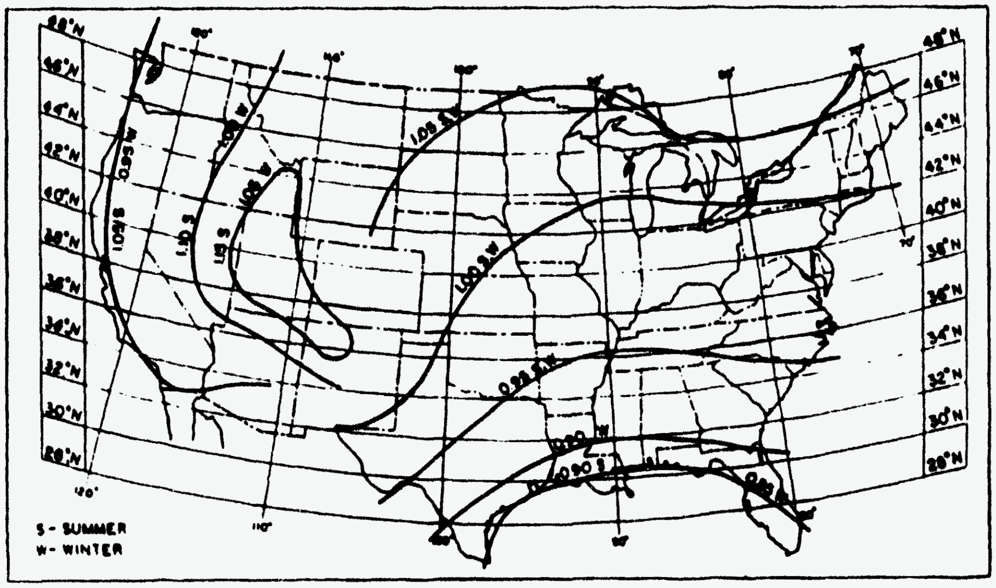
National Holidays of the United States
New Years Day
JAN 1 (unless on Saturday or Sunday)
JAN 2 if a Monday
Martin Luther King's Birthday
Third Monday in JAN
Washington's Birthday
Third Monday in FEB
Memorial Day
Last Monday in MAY
Fourth of July
JUL 3 if a Friday
JUL 4 (unless on Saturday or Sunday)
JUL 5 if a Monday
Labor Day
First Monday in SEP
Columbus Day
Second Monday in OCT
Veterans Day
NOV 10 if a Friday
NOV 11 (unless on Saturday or Sunday)
NOV 12 if a Monday
Thanksgiving
Fourth Thursday in NOV
Christmas
DEC 24 if a Friday
DEC 25 (unless on Saturday or Sunday)
DEC 26 if a Monday
New Years Day (con'd)
DEC 31 if a Friday

AZIMUTH

orients the building relative to the direction of true north. This entry is the angle between true north and the Y-axis of the building. The azimuth is expressed in degrees from 0 to 360° (clockwise as seen from above) or 0 to −360° (counter-clockwise as seen from above). The default is 0.0. Changing this angle has the effect of rotating the building about its z-axis (vertical axis).

GROUND-T — is a list of the local mean ground temperatures for each month. The values should be in degrees Fahrenheit, and in a twelve-element list format. If not entered here, these data will be taken from the weather tape. The range is from -100.0 to 150.0°F.

CLEARNESS-NUMBER — is a list of the local monthly clearness numbers for each month of the year. This is applicable when the clearness numbers on the weather file being used are not appropriate. The allowable range is from 0.5 to 1.2. Table below is reprinted from ASHRAE Trans., Vol. 64, p. 67.



GROSS-AREA — is the gross floor area (outside dimensions) of the conditioned space of the building. The range is from 0.0 to $10^7 ft^2$. Its default is the sum of the floor areas of all conditioned spaces. This keyword is used only for the BEPS (Estimated Building Energy Performance) Report in PLANT, which gives building energy use in KBtu/sqft-gross area/year.

Rules:

1. One and only one BUILDING-LOCATION instruction must be entered for each separate LOADS program run. It should be input before any commands that describe the building or anything associated with it (e.g., SPACE or CONSTRUCTION).
2. If GROUND-T and CLEARNESS-NUMBER are not input, the values will be taken from the weather file.
3. If LONGITUDE, LATITUDE, or TIME-ZONE are not specified, the values will be taken from the weather file.

Example:

```
BUILDING-LOCATION   LATITUDE = 42.0    LONGITUDE = 88.0
                    ALTITUDE = 610     TIME-ZONE = 6
                    AZIMUTH = 0        HOLIDAY = YES ..
```

LAYERS
tells LOADS that the data to follow identify the layers of material that are in a construction, the order of the layers, and the layer thicknesses. It tells the LDL Processor to calculate the response factors for the wall.

u-name — is required for this instruction. It is referenced in a CONSTRUCTION instruction.

INSIDE-FILM-RES — specifies the combined convective and radiative air film resistance for the inside wall surface. The default of .68 hr-ft^2-°F/Btu is an appropriate value for vertical walls. For horizontal surfaces, such as ceilings and floors, the suggested inside-film-resistance can be found in the following table. Because only one value is allowed for each surface, you should decide which is more important, cooling or heating. The allowable range is from 0.0 to 40.0 hr-ft^2-°F/Btu.

	Cooling	Heating
Ceilings	Heat Flowing Downward .92	Heat Flowing Upward .61
Floors	Heat Flowing Upward .61	Heat Flowing Downward .92

If you cannot decide which is more important, cooling or heating, the default value of .68 can be used. For exterior walls and roofs, the outside-film-resistance is calculated by the program depending on windspeed. For interior walls, the air film described in INSIDE-FILM-RES is the film on the side of the wall that is in the SPACE where the wall is specified. For the calculation of the U-Value for an INTERIOR-WALL, the INSIDE-FILM-RES is duplicated on the other surface (opposite side).

MATERIAL — identifies a list of DOE-2 pre-specified material code-words (see Appendix D). The number of elements in the list is the number of layers in the construction. For an *exterior wall*, the sequence of elements in the list is the sequence of the material layers in the exterior wall, starting with the exterior layer and ending with the interior layer. Reversing this sequence can notably affect the thermal performance of a wall.

THICKNESS	identifies a list that gives the thickness, in feet, for each material in the construction and overrides the thickness in the immediately preceding MATERIAL instruction. The allowable range is from 0.0+ (a value greater than 0.0) to 10.0 ft.

Rules:

1. The outside air film coefficient of an exterior wall or roof should not be specified as a layer because it is calculated by the LOADS program as a function of surface roughness and windspeed.

2. The list identified by MATERIAL and THICKNESS must have a one-to-one correspondence. For example, the first material listed in MATERIAL has a thickness equal to the first value listed in THICKNESS.

3. Both lists (MATERIAL and THICKNESS) must have the same number of elements.

4. A list element must be included in THICKNESS for layers specified by a RESISTANCE, but it is a dummy variable, used only to make the list length match with the MATERIAL list length.

5. For an exterior wall or roof, both lists start with the outside layer.

6. Maximum list length for MATERIAL and THICKNESS is 9 elements each.

7. Not all LAYERS can be specified by RESISTANCE (for MATERIAL) only. At least one must be specified as a transient type layer.

Example:

```
WA-1-2=LAYERS    MATERIAL=(WD01,PW03,IN02,GP01) ..

RB-1-1=LAYERS    MATERIAL=(RG01,BR01,IN22,WD01) I-F-R .76 ..
```

CONSTRUCTION

This instruction is used to specify the construction characteristics and properties of an exterior wall, exterior floor, roof, interior wall, interior floor, ceiling, underground wall, underground floor, or non-glass door.

u-name	*must* be specified for this instruction in order to reference this CONSTRUCTION in a subsequent EXTERIOR-WALL, ROOF, INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR, or DOOR instruction.
LIKE	may be used to copy data from a previously u-named CONSTRUCTION instruction.
LAYERS	entry for this keyword is the *u-name* of a previously defined (and entered) LAYERS instruction. This identifies the characteristics of the CONSTRUCTION and specifies heat transfer calculation by the *dynamic*, or delayed technique.
U-VALUE	may be used as a less accurate alternative to LAYERS when the construction has little heat capacitance, and the heat flow is not delayed. A steady-state, or "quick" calculation technique is used. For interior surfaces the U-VALUE should include both film coefficients. For exterior surfaces only the inside film coefficient should be included since the outside film coefficient is calculated hourly as a function of surface roughness and windspeed. The range is from 0.0 to 20.0 Btu/hr-ft^2-°F. Table 2.1 shows typical U-Values for some low-heat capacity walls.

TABLE 2.1 Example U-Values for Constructions With Low Heat Capacity	
Exterior Walls*	U-Value
1/2" Wood sheathing, studs, 1/2" gypsum board	0.35
Metal siding on 1/2" plywood, studs, 1/2" gypsum board	0.38
Stucco on 3/4" pine, studs, 1/2" gypsum board	0.34
Roofs*	
Wood shingles on 1/2" plywood, 2 x 8 studs, 1/2" gypsum board	0.28
Built-up roof on plywood deck, 2 x 8 studs, 1/2" gypsum board w/acoustical tile	0.27
Interior Walls and Floors**	
Gypsum board, 1/2", on either side of metal studs	0.32
Hardwood flooring on 1/2" deck, 2 x 8 floor joists, subfloor, tile (ceiling to space below)	0.20

* Includes inside surface air film.
** Includes inside surface air film on both sides.

Slab doors are also defined as a U-Value CONSTRUCTION. The table below gives some typical U-Values for doors.

TABLE 2.2

Coefficients of Transmission (U-Values) for Slab Doors (Btu/hr-ft^2-°F)

Door Type	Thickness	No Storm Door	Storm Door w/Wood	Storm Door w/Metal
Solid Wood	1 in.	0.64	0.30	0.39
	1.25 in.	0.55	0.28	0.34
	1.5 in.	0.49	0.27	0.33
	2 in.	0.43	0.24	0.29
Steel	1.75 in.			
	A	0.59	—	—
	B	0.19	—	—
	C	0.47	—	—

A = Mineral fiber core (2 lb/ft^3).
B = Solid urethane core with thermal break.
C = Solid polystyrene core with thermal break.

For additional information on U-Values, please see pp.III.80-85 of the *Reference Manual (2.1A)*.

ABSORPTANCE

specifies, as a decimal fraction, the solar radiation absorptance of an exterior surface of an EXTERIOR-WALL or ROOF; this keyword is not appropriate to INTERIOR-WALL, UNDERGROUND-WALL, or UNDERGROUND-FLOOR. The default is 0.70. The following table provides typical values for various exterior surfaces.

TABLE 2.3

Solar ABSORPTANCE for Various Exterior Surfaces (Clean)

Material	ABSORP-TANCE	Paint Paint	ABSORP-TANCE
Aluminum, polished reflector sheet	0.12	Aluminum paint	0.40
Asphalt pavement, weathered	0.82	Black, flat	0.95
Brick, buff, light	0.55	Black, lacquer	0.92
Brick, red	0.88	Black, oil	0.90
Brick, Stafford blue	0.89	Black, optical flat	0.98
Brick, white glazed	0.25	Blue, azure lacquer	0.88
Cement, uncolored asbestos	0.75	Blue, dark	0.91
Cement, white asbestos	0.61	Blue, medium	0.51
Concrete, black	0.91	Blue-gray, dark	0.88
Concrete, brown	0.85	Brown, dark brown	0.88
Concrete, uncolored	0.65	Brown lacquer	0.79
Film, Mylar aluminized	0.10	Brown, medium	0.84
Felt, bituminous	0.88	Brown, medium light	0.80
Felt, bituminous, aluminized	0.40	Gray, dark	0.91
Gravel	0.29	Gray, light oil	0.75
Iron, white-on-galvanized	0.26	Green, lacquer	0.79
Lab vapor deposited coatings	0.02	Green, lacquer, dark	0.88
Marble, white	0.58	Green, light	0.47
Roof, white built-up	0.50	Green, medium dull	0.59
Roofing, green	0.86	Green, medium Kelly	0.51
Slate, blue-gray	0.87	Olive, dark drab	0.89
Tin surface	0.05	Orange, medium	0.58
Wood, smooth	0.78	Red, oil	0.74
		Rust, medium	0.78
		Silver	0.25
		White, gloss	0.25
		White, lacquer	0.21
		White, semi-gloss	0.30
		Yellow	0.57

The table above is a compilation of data from several sources including ***Passive Solar Design Analysis*** by J.D. Balcomb (DOE, Office of the Assistant Secretary for Conservation and Solar Energy, December 1979).

ROUGHNESS is specified as a code-number that indicates the relative roughness of the exterior surface finish of an EXTERIOR-WALL or ROOF. This keyword is **not** appropriate to INTERIOR-WALL, UNDERGROUND-WALL, and UNDERGROUND-FLOOR. The code-numbers are given in the table below; default is 3.

TABLE 2.4

ROUGHNESS Code for Exterior Surface Finish

Surface Finish	Wall	Roof	Code-number
Rough	Stucco	Wood shingles or Built-up roof w/stones	1
	Brick or Plaster		2
	Concrete (poured)	Asphalt shingles	3*
	Clear pine		4
	Smooth plaster	Metal	5
Smooth	Glass Paint on pine		6

* 3 is the default value

Rules:

1. Either LAYERS or U-VALUE should be entered, but entering both, or neither, will generate an error message.
2. If LAYERS is specified, a transient heat transfer calculation is performed. It is recommended for all constructions except very lightweight ones.
3. If U-VALUE is specified, a steady-state heat transfer calculation is performed. It is recommended for very lightweight constructions.
4. The U-VALUE is used to calculate heat transfer through interior walls, floors, underground walls, and underground floors.

Example:

```
ROOF-1=CONSTRUCTION   LAYERS=RB-1-1 ..
WALL-1=CONSTRUCTION   LAYERS=WA-1-2 ..
FLOOR-1=CONSTRUCTION  U = 0.05 ..
```

GLASS-TYPE

This instruction is used to specify the type of glass used in a window.

u-name	is a mandatory entry for this command in order to reference the GLASS-TYPE in a WINDOW instruction.
LIKE	may be used to copy data from a previously u-named GLASS-TYPE instruction.
PANES	Number of panes of glass; the code numbers are 1, 2, or 3 for single-, double-, or triple-pane, respectively. The default is single-pane.
SHADING-COEF	is the ASHRAE shading coefficient of the glass. This keyword value is a number between 0.0 and 1.0, and there is no default. When SHADING-COEF is entered, the program will first calculate the solar heat gain using transmission and absorption coefficients for clear, 1/8" thick, single-pane, double-strength sheet glass. This solar heat gain is then multiplied by the value of SHADING-COEF to determine the resultant solar heat gain. Thus, resultant solar heat gain = SHADING-COEF x (solar heat gain for standard glass). The shading coefficient depends in general not only on the type of glass, but also on whether blinds, shades, draperies, etc., are used with the window. To simulate operable shading devices, you may assign a SHADING-SCHEDULE to a window (see WINDOW command). The resultant solar heat gain each hour will then be multiplied by the schedule value. For shading coefficient values of different glazing types with and without shading devices, see manufacturers' data sheets or the *ASHRAE 1989 Handbook of Fundamentals*, pp.27.26,27.30-33..
GLASS-CONDUCTANCE	is the conductance of the total window except for the outside film coefficient. The conductance given in glass manufacturers' data sheets usually includes the outside air film resistance for a windspeed of 7.5 mph (summer) or 15 mph (winter). The following table can be used to obtain the corresponding value of GLASS-CONDUCTANCE. For example, if U (7.5 mph) = 0.64 Btu/ft^2-hr-°F, then GLASS-CONDUCTANCE = 0.79 (by interpolation).

Note: if GLASS-CONDUCTANCE is not specified, it will default to 1.470 for PANES=1, 0.574 for PANES=2, and 0.304 for PANES=3.

For U-Values of different glazing types, see manufacturers' product data sheets, or the ASHRAE *1989 Handbook of Fundamentals*, pp.27.16-17.

Example:

```
IG-1-1=GLASS-TYPE   PANES=2   SHADING-COEF=.45  ..
```

TABLE 2.5

Correspondence between glass manufacturers U-Value (including outside air film) and DOE-2 GLASS-CONDUCTANCE value (excluding outside air film) All values are in Btu/ft^2-hr-°F.

Summer U-Value (7.5 mph windspeed)	GLASS-CONDUCTANCE	Winter U-Value (15 mph windspeed)	GLASS-CONDUCTANCE
0.1	0.10	0.1	0.10
0.2	0.21	0.2	0.21
0.3	0.33	0.3	0.32
0.4	0.45	0.4	0.43
0.5	0.59	0.5	0.55
0.6	0.73	0.6	0.68
0.7	0.89	0.7	0.81
0.8	1.05	0.8	0.95
0.9	1.23	0.9	1.09
1.0	1.43	1.0	1.24
1.1	1.64	1.1	1.40
1.2	1.87	1.2	1.57
1.3	2.13	1.3	1.74

SPACE-CONDITIONS

The primary use of this subcommand is to define the internal loads in the space. The subcommand, and its associated keywords and code-words, specify the conditions that are appropriate to a space (or to groups of spaces) in the building (any value listed here may be overridden in a SPACE instruction by re-entry of the keyword with a different value). The conditions refer to people, lighting, process equipment, and infiltration. The conditions are primarily specified as a function of their maximum values and their schedules. The conditions can be varied in time and amount via the use of schedules that contain fractional value inputs.

Before specifying the input data for SPACE-CONDITIONS, you should understand some of the logic built into the DOE-2 Program. All of the energy sources associated with a particular space do not necessarily affect the heating and cooling loads of that SPACE. Some energy sources contribute all of their energy to the space and other energy sources contribute from 0 to 100% of their energy to the space.

1. *All* of the energy associated with people, task lighting, and infiltration is assumed to enter the space.

2. Only *part* of the energy associated with the other heat sources in the SPACE (overhead lighting, process equipment, and process utilities) enters the SPACE. The energy that does not enter the space is consumed by a product or process, is added to the return air duct or plenum, or is exhausted from the space. The portion of energy that enters the space, versus the portion that does not enter the space, can be controlled by you through the use of the LIGHT-TO-SPACE keyword and the "sensible and latent" keywords.

   That portion of the energy that does not enter the space has no effect upon the subsequent sizing of HVAC equipment in the SYSTEMS simulator. That energy demand is, however, added to the demands made on the equipment, or purchased utilities, in the PLANT simulator. It is not chargeable to the secondary HVAC system.

   When the program attempts to automatically size equipment in the PLANT simulator, it adds all of the space heating/cooling loads, all of the space process loads, and the building-level utility loads (elevators, exterior lighting, and domestic hot water) and then sizes the equipment accordingly to meet the total. This way, the total utility demands for the building will be correct and the secondary HVAC system will not be charged with energy that rightfully belongs to the process in the building. Only that portion of the process load that enters the spaces as a heating/cooling load will show up in the secondary HVAC system.

   It is important that all of the lighting, equipment, and utilities supplied to a space, for whatever reason, be included in the SPACE-CONDITIONS or SPACE instruction. This includes process equipment and process utilities. If any loads are omitted, the HVAC equipment may be properly sized but the PLANT equipment will probably be undersized. Do not, however, include the HVAC equipment items (fans, coils, etc.) because they are addressed separately by the program. Also, do not include building level loads such as domestic hot water, elevators, etc. because these loads are not associated with any particular space but rather are associated with the entire building.

   You should pay close attention when specifying SCHEDULEs. It cannot be overemphasized how important this is. All the SCHEDULEs associated with SPACE-CONDITIONS, except INF-SCHEDULE, default to the off mode of operation.

This means that even though the maximum output of the equipment, lights, etc. has been specified, the equipment and lights will not be turned on, unless you specify this mode of operation in the SCHEDULEs. Naturally, if you fail to turn the equipment and lights on, the simulation will be faulty.

SPACE-CONDITIONS	To sum up, SPACE-CONDITIONS tells LOADS that the data to follow specify the temperature, floor weight, zone type, infiltration, and internal loads of a space.
u-name	must be specified for this instruction in order for it to be referenced in the SPACE command.
LIKE	may be used to copy data from a previously u-named SPACE-CONDITIONS instruction.
TEMPERATURE	is the space air temperature that will be used in the LOADS simulation. *This is a list with only one value* midway between the heating and cooling setpoints (DESIGN-HEAT-T and DESIGN-COOL-T, respectively) in SYSTEMS. If a zone is unconditioned, TEMPERATURE should be an estimated average temperature for the zone. The default is 70°F, and the range is from 0.0 to 120.0°F. Example: TEMPERATURE = (73) (If the parentheses are omitted, e.g. TEMPERATURE = 73, an error message results.)
PEOPLE-SCHEDULE	is the u-name of the schedule for space occupancy as a function of time. Schedule inputs are fractions of the maximum NUMBER-OF-PEOPLE. If PEOPLE-SCHEDULE is not entered, the schedule value will default to zero, and will therefore simulate the space with *no* people.
AREA/PERSON	is an alternative keyword to NUMBER-OF-PEOPLE; however, AREA/PERSON is the preferred keyword to use. AREA/PERSON defaults to 100 sqft per person.
NUMBER-OF-PEOPLE	is the maximum number of people occupying a space during the simulation. The actual number of people present in the space during any given hour is the value assigned to this keyword multiplied by the fractional value assigned for that hour (see PEOPLE-SCHEDULE). The default is 0 and the range is from 0 to 10000.
PEOPLE-HEAT-GAIN	is the combined maximum latent and sensible heat gain per person to the space. The balance between latent and sensible heat is calculated by the program. The keyword value is varied with respect to time and quantity of people by the PEOPLE-SCHEDULE and NUMBER-OF-PEOPLE or AREA/PERSON. The range is from 350.0 to 2000.0 Btu/hr-

person. The default is zero; therefore, a value must be input or the alternative method of specifying people heat gain, by inputting PEOPLE-HG-LAT and PEOPLE-HG-SENS, should be used. For typical values for different degrees of activity, see the ASHRAE *1989 Handbook of Fundamentals*, Table 3, p.26.7.

PEOPLE-HG-LAT — is the maximum latent heat gain per person to the space by the occupants. The default is 0.0, and the range is from 0.0 to 2000.0 Btu/hr-person.

PEOPLE-HG-SENS — is the maximum sensible heat gain per person to the space by the occupants. The default is 0.0, and the range is from 0.0 to 2000.0 Btu/hr-person.

LIGHTING-SCHEDULE — is the u-name of the schedule for space overhead lighting. Schedule inputs are fractions of maximum lighting energy input (see LIGHTING-KW or LIGHTING-W/SQFT; see also LIGHTING-TYPE and LIGHT-TO-SPACE). If not specified, the LIGHTING-SCHEDULE value will default to zero. This will result in simulation with no lighting, even if lighting is specified by keywords LIGHTING-KW or LIGHTING-W/SQFT, etc.

LIGHTING-TYPE — takes a code-word that specifies the type of overhead lighting used in the space. The following table shows the code-words that can be used. The default is SUS-FLUOR.

Code-word	LIGHTING-TYPE
SUS-FLUOR	Suspended fluorescent
REC-FLUOR-NV	Recessed fluorescent — not vented
REC-FLUOR-RV	Recessed fluorescent vent to return air
REC-FLUOR-RSV	Recessed fluorescent vent to supply and return air
INCAND	Incandescent
SUSPENDED	Incandescent

For mixed types of lighting within the same space, the recommended procedure is to select the dominant type and adjust the percentage of heat produced by the lighting, using the LIGHT-TO-SPACE keyword below.

LIGHTING-KW — is the maximum amount of electrical energy required to operate the main or overhead lights within the space. It is *not necessarily* the sensible heat added by the lights to the space (see LIGHT-TO-SPACE). The actual space lighting energy required by the space during any given hour is the value assigned to this keyword multiplied by the fractional value assigned for that hour (see LIGHTING-SCHEDULE). The default is 0.0, and values can range from 0.0 to 200 kW.

If both LIGHTING-KW and LIGHTING-W/SQFT are specified, the program adds the values.

Note that the values for LIGHTING-KW and LIGHTING-W/SQFT are amounts of electricity consumed by lamps *and* ballasts.

LIGHTING-W/SQFT

is an alternative method (to LIGHTING-KW) for specifying the maximum overhead, or general, lighting energy use. The dimensions are watts of lighting energy use per square foot of space floor area. The default is 0.0, and values can range from 0.0 to 10 W/ft^2. The actual overhead lighting energy required by the SPACE during any given hour is the value assigned to this keyword multiplied by the square feet in the space multiplied by the fractional value assigned for that hour (see LIGHTING-SCHEDULE).

Note that there is a distinction between the amount of illumination produced and the power consumed for incandescent and fluorescent lighting (the keywords describe the power consumed). Thus, if the same values of LIGHTING-KW or LIGHTING-W/SQFT are specified for an incandescent light and for a fluorescent light, the amount of illumination from the fluorescent light will be approximately twice that from the incandescent light. The distribution of the energy for these two is approximately given by the following table.

Type of Energy	Fluorescent percent	Incandescent percent
Visible light	19	10
Infrared	31	72
Convection-conduction	36	18
Ballast	14	0

LIGHT-TO-SPACE

is the fraction, if any, of the lighting energy that is added to the space energy balance as a sensible heat gain. The remaining energy is added (in SYSTEMS) to the ductwork if RETURN-AIR-PATH = DUCT. The default is 1.0 for SUS-FLUOR, REC-FLUOR-NV, and INCAND; 0.8 for REC-FLUOR-RV and REC-FLUOR-RSV. See also *Supplement (2.1E), p.2.81, "Distribution of Heat from Lights"*.

Note: When specifying any zonal system (that is, if SYSTEM-TYPE in SYSTEMS equals UHT, UVT, HP, TPFC, FPFC, TPIU, FPIU, or PTAC) the value of LIGHT-TO-SPACE is automatically set equal to 1.0.

TASK-LIGHT-SCH

is the u-name of the schedule for task lighting in the space. A task light is any small lamp, such as a desk lamp, that would have a different schedule of use than the main space overhead lighting. Schedule inputs are fractions of maximum task lighting energy input (see TASK-LIGHTING-KW or TASK-LT-W/SQFT). If the TASK-LIGHT-SCH is not input, the schedule value will default to zero and no task lights will be simulated.

TASK-LIGHTING-KW — specifies the maximum electrical energy required for task lighting. All of this energy is added to the space. The default is 0.0, and the range is from 0.0 to 200.0 kW. The actual task lighting energy required in the SPACE during any given hour is the value assigned to this keyword multiplied by the fractional value assigned for that hour (see TASK-LIGHT-SCH). If both TASK-LIGHTING-KW and TASK-LT-W/SQFT are specified, the program adds the values. LIGHT-TO-SPACE is not appropriate to this keyword because 100% of task lighting energy goes to the space.

TASK-LT-W/SQFT — is an alternative keyword for TASK-LIGHTING-KW and is based on watts of task lighting per square foot of floor area of the space. The default is 0.0, and ranges from 0.0 to 10.0 W/ft^2. LIGHT-TO-SPACE is not appropriate to this keyword because 100% of task lighting energy goes to the space.

EQUIP-SCHEDULE — is the u-name of the schedule for space equipment operating schedule. Schedule inputs are fractions of maximum equipment energy input (see EQUIPMENT-KW or EQUIPMENT-W/SQFT). If the EQUIP-SCHEDULE is not input, the schedule value will default to zero and no space equipment loads will be simulated.

EQUIPMENT-KW — is the maximum amount of energy required to operate electrical equipment within the space and is *not necessarily* the sensible and/or latent heat added by the equipment to the space (see EQUIP-SENSIBLE and EQUIP-LATENT). The default is 0.0 and the range is from 0.0 to 200.0 kW. The actual equipment energy required by the space during any given hour is the value assigned to this keyword multiplied by the fractional value assigned to that hour (see EQUIP-SCHEDULE). The amount of equipment energy added to the space, if any, may be specified by its components (see EQUIP-LATENT and EQUIP-SENSIBLE). If both EQUIPMENT-KW and EQUIPMENT-W/SQFT are specified, the program adds the values.

EQUIPMENT-W/SQFT — is an alternative keyword for EQUIPMENT-KW and is based on watts of equipment energy per square foot of floor area of the space. The default is 0.0 and the range is from 0.0 to 100.0 W/ft^2.

EQUIP-SENSIBLE — is the fraction of EQUIPMENT-KW, if any, that is added to the space energy balance in the form of sensible heat. The sum of EQUIP-SENSIBLE and EQUIP-LATENT must not exceed 1.0; range is 0.0 to 1.0.

EQUIP-LATENT — is the fraction of EQUIPMENT-KW that is added to the space energy balance in the form of latent heat. The sum of EQUIP-LATENT and EQUIP-SENSIBLE must not exceed 1.00. The default is 0.0. If neither EQUIP-SENSIBLE nor EQUIP-LATENT is specified, all heat from equipment will be considered sensible.

The keywords SOURCE-TYPE, SOURCE-BTU/HR, SOURCE-SCHEDULE, SOURCE-SENSIBLE, and SOURCE-LATENT, described below, must be considered as a group. SOURCE, in this context, implies a utility demand, not equipment. Depending upon how the source is specified, it may or may not result in a space heating/cooling load. Also, a source may or may not result in a utility load on PLANT. It is possible to specify only one source per space.

SOURCE-TYPE — is used when there are internal heating or cooling loads caused by a source other than people, lights, or equipment. The possible code-words for this keyword are:

GAS — The load will contribute to the natural gas use budget in PLANT. Examples include natural gas for ovens, kilns, dryers, etc. GAS is the default.

ELECTRIC — The load will contribute to electricity use budget in PLANT. Examples include electricity for cooking, electroplating, battery charging, etc.

HOT-WATER — The load will contribute to the hot-water budget (natural gas or fuel oil) in PLANT. This load will be reported as a domestic or service hot water load. The HOT-WATER loads will be passed to any *domestic* hot water heater defined in the PLANT-EQUIPMENT command.

PROCESS — Load will *not* contribute a utility load on PLANT (e.g., cooling load caused by a self-contained, portable energy source or other industrial processes). Examples of this type of load are gasoline powered fork trucks, oxyacetylene welders, wood stoves, bottled gas equipment, etc. You should sum up all the PROCESS loads in the zone, be they electrical, gas, hot water, solar, nuclear, etc. and express the total in Btu/hr. This total value should be expressed with the keyword SOURCE-BTU/HR. The portion of the total PROCESS load that enters the zone as a heating or cooling load is then specified by using the SOURCE-LATENT and

Note that the italicized words in the left column are *code-words*, not keywords.

SOURCE-SENSIBLE keywords.

This keyword is not operative unless SOURCE-SCHEDULE is defined.

Note: Do not use the code-word ELECTRIC for specifying electrically heated hot water. Also, do not use the code-word GAS to specify gas heated hot water. In both cases, specify SOURCE-TYPE = HOT-WATER. This will pass a demand for hot water to PLANT, where the hot water heater is specified along with its fuel type. The first approach will pass the wrong type of demand to PLANT.

SOURCE-BTU/HR — is the maximum amount of energy supplied by the source defined by SOURCE-TYPE. This is the maximum amount of energy required to operate devices, other than lighting and equipment, within the space and is *not necessarily* the sensible and/or latent heat added by the source(s) to the load on the space (see SOURCE-SENSIBLE and SOURCE-LATENT). The default is 0.0, and the allowable range is from −10000000.0 to 1000000.0 Btu/hr. A negative value represents heat *removed* from the space.

The actual source energy required by the space, during any given hour, is the value assigned to this keyword multiplied by the fractional value assigned to that hour (see SOURCE-SCHEDULE). This amount of SOURCE-BTU/HR energy added to the load of the space, if any, may be specified by SOURCE-LATENT and SOURCE-SENSIBLE.

SOURCE-SCHEDULE — is the u-name of the schedule for any source of internal energy (such as process equipment *within* a space) other than people, lights, or electrical equipment. Schedule inputs are fractions of SOURCE-BTU/HR. If the SOURCE-SCHEDULE is not entered, the schedule value will default to zero and no SOURCE loads will be simulated.

SOURCE-SENSIBLE — is the fraction of SOURCE-BTU/HR (after being multiplied by the hourly fractional value in SOURCE-SCHEDULE) that is added to the space energy balance in the form of sensible heat. The sum of SOURCE-SENSIBLE and SOURCE-LATENT must not exceed 1.0 and is likely to be less than 1.0 since all such energy is not necessarily added to the space load. The default is 1.0, and it can range from -1.0 to 1.0.

SOURCE-LATENT — is the fraction of SOURCE-BTU/HR (after being multiplied by the hourly fractional values in SOURCE-SCHEDULE), if

---

Note that the italicized words in the left column are *code-words*, not keywords.

any, that is added to the space energy balance in the form of latent heat. The sum of SOURCE-LATENT and SOURCE-SENSIBLE must not exceed 1.0 and is likely to be less than 1.0 since all such energy is not necessarily added to the space load. The default is 0.0.

INF-METHOD — equals a code-word that identifies the method used to calculate infiltration for the space. The possible code-words (italicized) are as follows (the default is NONE).

NONE — No infiltration is calculated.

AIR-CHANGE — The infiltration rate is calculated using the air-change method as described below for keywords AIR-CHANGES/HR and INF-CFM/SQFT. One of these keywords should be specified if INF-METHOD=AIR-CHANGE. AIR-CHANGES/HR will give a windspeed-***dependent*** infiltration rate. INF-CFM/SQFT will give a windspeed-***independent*** infiltration rate.

RESIDENTIAL — The infiltration rate will depend on both windspeed and inside-outside temperature differences as described below for keyword RES-INF-COEF.

RES-INF-COEF — is a list of 3 values which are coefficients in the following formula:

$$\text{Infiltration} = \text{value1} + (\text{value2} \times \text{windspeed}) + (\text{value3} \times \Delta T)$$

where infiltration is measured in air changes/hr, windspeed is in knots (taken from the weather tape) and ΔT (absolute value of outdoor-indoor temperature differential) is in °F. The keyword RES-INF-COEF is appropriate only if INF-METHOD = RESIDENTIAL. The default coefficients are 0.252, 0.0251, and 0.0084. The range is from 0.0 to 20.0 for each coefficient.

AIR-CHANGES/HR* — is the number of infiltration-caused air changes per hour at a windspeed of 10 mph for a space with INF-METHOD=AIR-CHANGE. The default is 0.0 and range is from 0.0 to 30.0. If this keyword is specified, the program will make a windspeed correction each hour to the infiltration rate, so that:

Actual air changes per hour =
(AIR-CHANGES/HR) x (windspeed)/(10 mph)
(This keyword should not to be confused with a keyword of the same name in SYSTEMS.)

---

* One or both of the keywords AIR-CHANGES/HR and INF-CFM/SQFT should be entered. If both are entered their effects are summed.
Choice should be based on whether or not a windspeed correction is desired.

INF-CFM/SQFT*

is the amount of infiltration into a space with INF-METHOD=AIR-CHANGE. It is expressed as the ratio

(infiltration cfm)/(floor area).

There is no correction for windspeed. The default is 0.0 and the range is from 0.0 to 20.0 cfm/ft^2.

INF-SCHEDULE

is the u-name of a schedule that specifies a multiplier on the amount of air infiltration into a space as a function of time. The schedule should contain values that modify the calculated infiltration values. A value of 1.0 would leave the infiltration values unmodified night and day, year round. Any value below 1.0 would represent reduction of infiltration such as that caused by pressurization from a supply fan. Any value above 1.0 would represent an increase in infiltration such as that caused by an exhaust fan, open window, or open door. If INF-SCHEDULE is not input the schedule will default to one for all hours.

Ordinarily, INF-SCHEDULE should not be used with INF-METHOD=RESIDENTIAL method of infiltration because the schedule will distort wind information from the weather tape.

FLOOR-WEIGHT

is used to specify the composite weight of the floor, furnishings, and interior walls of a space divided by the floor area of the space. The value input by you will determine the weighting factors associated with the space. Higher values give a longer time lag between heat gains and resultant cooling loads, and greater damping of peak loads. The default is 70.0, and the range is from 0.0 to 200.0 lb/ft^2.

Example:

```
OFFICE-ENV = SPACE-CONDITIONS
             PEOPLE-SCHEDULE     = OCCUPY-1
             LIGHTING-SCHEDULE   = LIGHTS-1
             EQUIP-SCHEDULE      = EQUIP-1
             LIGHTING-TYPE       = REC-FLUOR-NV
             LIGHTING-W/SQFT     = 1.5
             EQUIPMENT-W/SQFT    = 1
             AREA/PERSON         = 110
             INF-METHOD          = AIR-CHANGE
             INF-SCHEDULE        = INFIL-1
             AIR-CHANGES/HR      = 0.6
             PEOPLE-HEAT-GAIN    = 450  ..
```

* One or both of the keywords AIR-CHANGES/HR and INF-CFM/SQFT should be entered. If both are entered their effects are summed.
Choice should be based on whether or not a windspeed correction is desired.

SPACE

The SPACE instruction is used to specify all the information that is associated with a space. SPACE tells LOADS that the data to follow specify the characteristics of a space.

u-name	must be specified for this instruction as the u-name is referenced in SYSTEMS.
LIKE	may be used to copy data from a previously u-named SPACE instruction. This does *not* include walls and windows belonging to that SPACE.
FLOOR-MULTIPLIER	is used to simplify the input for a multistory building. This keyword equals the number of the floors that are thermodynamically identical and where there is negligible heat transfer from floor-to-floor. The default is 1.0 and the range is from 1.0 to 200.0.
AREA	is the floor area of the space. This keyword is required and its range is from 0.0+ to 100000.0 ft^2.
VOLUME	is the space air volume, used to calculate the infiltration rate by the air-change method. This keyword is required and its range is from 0.0+ to $10^6 ft^3$.
SPACE-CONDITIONS	identifies a previously u-named SPACE-CONDITIONS instruction and associates all of the data in it with the space. Any or all of the keywords associated with a SPACE-CONDITION instruction may also be directly input in a SPACE instruction.

Rules:

1. The SPACE-CONDITIONS default values are assumed if the SPACE-CONDITIONS keyword is not given an entry.
2. The u-name of a SPACE in the LOADS program must be identical to the u-name of a ZONE in the SYSTEMS input.
3. Only SPACE and SPACE-CONDITIONS keywords data are transferred by the LIKE keyword used in SPACE. The keyword data for EXTERIOR-WALL, WINDOW, etc. are not transferred.

Example:

```
OFFICE = SPACE
         SPACE-CONDITIONS = OFFICE-ENV
                     AREA = 5000
                   VOLUME = 40000  ..
```

EXTERIOR-WALL (or ROOF)

This instruction is used to specify the size, construction, and position of an exterior surface of a space such as an exterior wall, roof, or exterior floor (such as above a breezeway or carport). EXTERIOR-WALL and ROOF are synonymous within the program. Each EXTERIOR-WALL instruction is assigned to the SPACE instruction immediately preceding it and describes one of the exterior walls of that space.

u-name — may be used to identify a wall surface.

LIKE — may be used to copy data from a previously u-named EXTERIOR-WALL instruction.

GND-REFLECTANCE — is the solar reflectance of the ground; i.e., the fraction of sunlight incident on the ground that is reflected. The following table provides typical values for various surfaces. The default is 0.2.

Surface	GND-REFLECTANCE
Asphalt, paved	0.18
Concrete, bituminous	0.10
Concrete, light colored	0.32
Concrete, old	0.22
Field, green	0.12-0.25
Field, wheat	0.07
Grass, dry	0.24
Ocean	0.05
Rock, crushed surface	0.20
Soil, dark	0.08

MULTIPLIER — is used to specify the total number of identical (except for position) exterior wall panels located in the same plane. This reduces the amount of data input. It multiplies the net area of the exterior wall (exterior wall area minus window area minus door area). It also multiplies any WINDOW area and DOOR area associated with this exterior wall panel. The range is from 0.0 to 99.0, and default is 1.0.

AZIMUTH — is the azimuth of the exterior wall. The default is 0° (north-facing wall), and the range is from 0° to 360°; east-facing is 90°; south-facing is 180°; west-facing is 270°. Intermediate angles are acceptable.

CONSTRUCTION — identifies the u-name of a previously defined CONSTRUCTION instruction that describes the effective U-Value of this EXTERIOR-WALL (or ROOF). This keyword is mandatory.

HEIGHT	is the dimension of the exterior wall parallel to the Y axis. This is a required keyword, and the range is from 0.0 to 2000.0 feet.
WIDTH	is the dimension of the exterior wall parallel to the X axis. This is a required keyword, and the range is from 0.0 to 2000.0 feet.
TILT	is the inclination of the exterior wall from the horizontal plane. The default is 90.0°, which corresponds to a vertical surface. An upward facing horizontal surface has TILT = 0; a downward facing horizontal surface has TILT = 180. Note that if the command ROOF is used, then TILT will still default to 90° (vertical surface). Thus, for a horizontal ROOF, you would have to explicitly specify TILT = 0. The range of TILT is 0 to 180°.

Rules:

1. A SPACE instruction must precede any EXTERIOR-WALL or ROOF instructions.
2. An EXTERIOR-WALL or ROOF instruction must immediately precede the WINDOW and DOOR instructions that describe the windows and doors in the wall.
3. The area (HEIGHT times WIDTH) of the EXTERIOR-WALL or ROOF must be equal to or greater than the area entered for the WINDOW and DOOR instructions associated with the EXTERIOR-WALL or ROOF.

Example:

```
FRONT-1 = EXTERIOR-WALL
              HEIGHT        = 8
              WIDTH         = 100
              AZIMUTH       = 180
              CONSTRUCTION  = WALL-1   ..
```

Note: If an exterior wall (or roof) is not shaded by obstructions such as neighboring buildings or trees, it is sufficient in DOE-2 to describe the wall geometrically by specifying only HEIGHT, WIDTH, AZIMUTH, and TILT. If shading is involved, the keywords X, Y, and Z (the origin of the wall in the space coordinate system) should also be entered. See *Reference Manual (2.1A)*, p.III.8.

WINDOW

This instruction is used to specify the size, position, and number of windows and the properties of the glass. Each WINDOW command applies to the EXTERIOR-WALL instruction preceding it and describes the windows on that exterior wall. *Note: Glass doors in exterior walls should be treated as windows rather than doors.*

u-name	may be specified.
LIKE	may be used to copy data from a previously entered and u-named WINDOW instruction.
GLASS-TYPE	identifies the u-name of the GLASS-TYPE instruction that describes the glass in this window. This is a required keyword.
HEIGHT	is the height of the glazed part of the window. This keyword is required, and the range is from 0.0+ to 40.0 feet.
WIDTH	is the width of the glazed part of the window. This keyword is required, and the range is from 0.0+ to 1000.0 feet. Note: The window area (HEIGHT times WIDTH) is automatically removed from the associated wall area.
SETBACK	is the distance that the window is recessed into the wall. The range is from 0.0+ to 10 feet. It defaults to 0.0, that is, no setback.
SHADING-SCHEDULE	accepts as input the u-name of a schedule that defines hourly values of a multiplier on the glass shading coefficient (see SHADING-COEF keyword in GLASS-TYPE command). This represents the shading effect of movable devices such as blinds, or drapes. Note that items that change light transmission may also affect conductance. If so, a matching CONDUCT-SCHEDULE should be used. *Note: If the SHADING-SCHEDULE is not input, the schedule will default to 1 for all 24 hours.*
MAX-SOLAR-SCH	is the u-name of a schedule of direct solar gain values in Btu/ft^2-hr. The program will automatically deploy a shading device if the heat gain per ft^2 from direct (beam) solar radiation *transmitted* through the window exceeds the specified value. If MAX-SOLAR-SCH is specified, a corresponding SHADING-SCHEDULE (and CONDUCT-SCHEDULE, if desired) should be assigned to the window. The SHADING-SCHEDULE and CONDUCT-SCHEDULE values will only take effect during hours when the shading device is deployed.

CONDUCT-SCHEDULE — identifies the u-name of the schedule that describes any change in the heat conductance of the window relative to the GLASS-CONDUCTANCE. The factor in the schedule may be less than, equal to, or greater than 1.0. The factor is used as a multiplier against GLASS-CONDUCTANCE. This represents the change of conductance associated with storm windows, insulated shutters, etc.

Any accessories that are added to the window (such as a storm window) that change the conductance may also significantly change the light transmission properties of the window. If so, a matching SHADING-SCHEDULE should be used.

Note: If the CONDUCT-SCHEDULE is not input, the schedule value will default to 1 for all 24 hours.

CONDUCT-TMIN-SCH — is a schedule of values of outside dry-bulb temperature below which movable insulation will be deployed on a window. If this keyword is specified, a corresponding SHADING-SCHEDULE and CONDUCT-SCHEDULE should be assigned to the window.

Window overhangs and fins may be specified with the following keywords:

OVERHANG-A — Units are feet, 0.0 is the default, and there are no limits. See Fig. 2.1.

OVERHANG-B — Units are feet, 0.0 is the default, and there are no limits. See Fig. 2.1.

OVERHANG-W — Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 2.1.

OVERHANG-D — Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 2.1.

OVERHANG-ANGLE — is the angle between the overhang and the window. When set at 90°, the overhang is perpendicular to the window (the default); if $< 90°$, it is tilted down; if $> 90°$, it is tilted up. The range is 0.0 to 180.0°.

Note: For overhang shading calculations to be performed, both OVERHANG-W and OVERHANG-D **must** be specified. If either of them is specified, but not both, a WARNING message is printed and overhang shading is not performed.

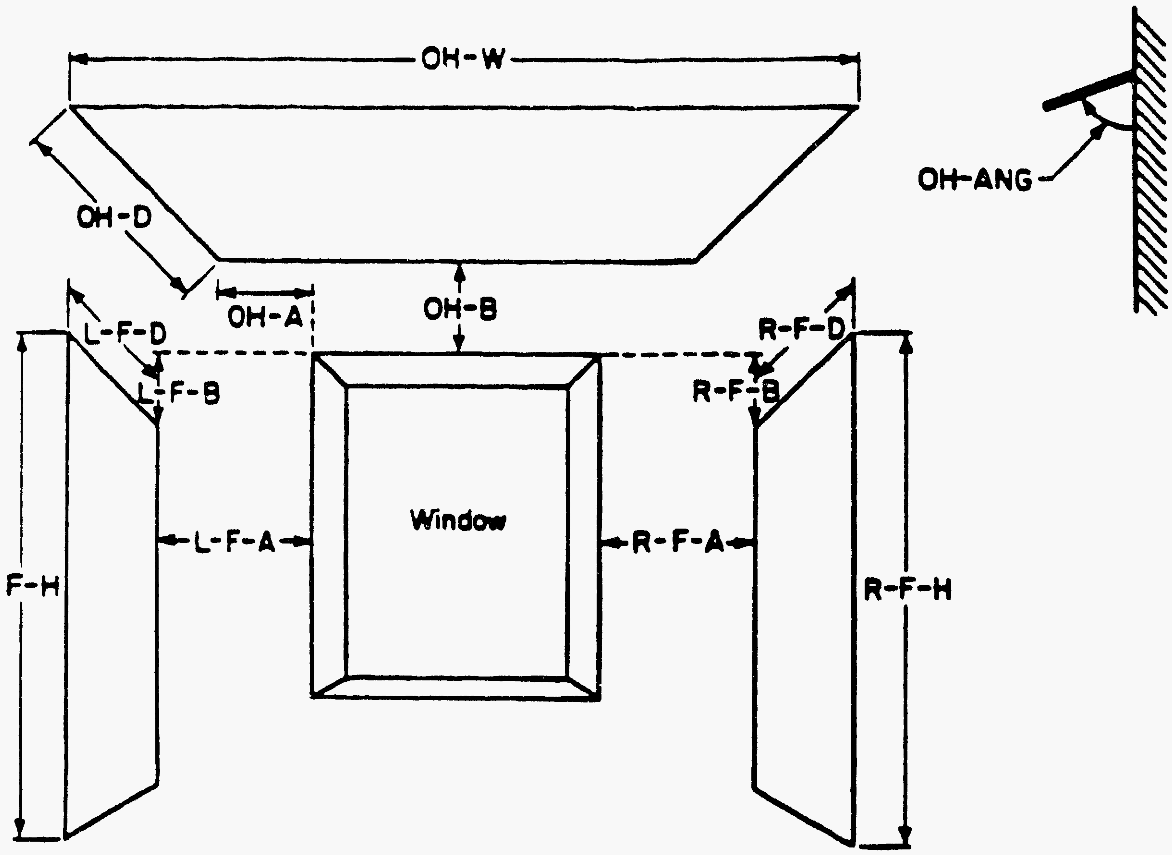


Figure 2.1: Positioning of overhang and fins with respect to a window. The values in this figure are all positive. If the value for L-F-B is input as negative, then the left fin will originate at a point above the top edge of the window, and similarly for R-F-B.

LEFT-FIN-A	Units are feet, 0.0 is the default, and there are no limits. See Fig. 2.1.
LEFT-FIN-B	Units are feet. 0.0 is the default, and there are no limits. See Fig. 2.1.
LEFT-FIN-H	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 2.1.
LEFT-FIN-D	Units are feet. 0.0 is the default, and the range is 0.0 to no limits. See Fig. 2.1.
RIGHT-FIN-A	Units are feet. 0.0 is the default, and there are no limits. See Fig. 2.1.
RIGHT-FIN-B	Units are feet, 0.0 is the default, and there are no limits. See Fig. 2.1.

RIGHT-FIN-H	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 2.1.
RIGHT-FIN-D	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 2.1.

For fin shading calculations to be performed, both of the pair, —FIN-H and —FIN-D, **must** be specified. If either one of the pair is specified, but not both, a warning message is printed and fin shading is not performed.

Note: Even though overhangs and/or fins are specified under the WINDOW command, these shading surfaces are attached to the wall where the window is located and thus shade both the window *and* the wall. Also, if this WINDOW is referred to in another WINDOW command with the LIKE keyword, the attached shades are also copied.

Rules:

1. An EXTERIOR-WALL or ROOF instruction must precede a WINDOW instruction.
2. A GLASS-TYPE instruction must precede a WINDOW instruction.

Example:

```
WF-1 = WINDOW
         WIDTH       = 45
         HEIGHT      = 4
         GLASS-TYPE  = WINDOW-1   ..
```

DOOR

This instruction is used to specify the size, position, and number of doors and their heat-transfer characteristics. Each DOOR instruction applies to the EXTERIOR-WALL instruction preceding it and describes a door on that exterior wall. *Note: Glass doors should be treated as windows rather than doors.*

u-name	may be specified.
LIKE	may be used to copy data from a previously entered and u-named DOOR instruction.
HEIGHT	is the height of the door. This keyword is mandatory. The range is from 0.0+ to 40 feet.
WIDTH	is the width of the door. This keyword is mandatory. The range is from 0.0+ to 1000 feet.
CONSTRUCTION	identifies the u-name of a previously defined CONSTRUCTION instruction that describes the effective U-Value of this door. This keyword is mandatory.
SETBACK	is the distance that the door is recessed into the wall, measured parallel to the Z axis of the surface coordinate system. The range is from 0.0+ to 10 feet, and defaults to 0.0, that is, no setback.

Note. Overhangs and fins can be applied the same as for WINDOW command.

```
Example for a solid wood door:

D1     = CONSTRUCTION
         U-VALUE = .5   ..

DOOR1  = DOOR
         HEIGHT          = 7
         WEIGHT          = 3
         CONSTRUCTION    = D1   ..
```

INTERIOR-WALL

The INTERIOR-WALL instruction is used to specify the size, construction, and adjacent space for an interior wall, ceiling, or interior floor. The INTERIOR-WALL will be considered as a heat transfer surface by the LOADS and SYSTEMS programs. Each INTERIOR-WALL instruction applies to the SPACE instruction preceding it and describes one of the interior walls, ceilings, or interior floors of that space.

u-name	may be specified.
LIKE	may be used to copy data from a previously u-named INTERIOR-WALL instruction.
AREA	is the surface area of the interior wall, ceiling, or interior floor. The range is from 0.0+ to 100000.0 ft^2, and there is no default.
NEXT-TO	is the u-name of the space that shares this interior wall, ceiling, or interior floor as a boundary with the space under consideration. This keyword is required if INT-WALL-TYPE = STANDARD or AIR; otherwise, it is unused.
CONSTRUCTION	is used to identify, by u-name, the previously entered CONSTRUCTION instruction that defines the type of construction used in this wall. This is a mandatory entry.

Example for a case where there is an adjacent space:

```
P1        = CONSTRUCTION
            U-VALUE = .2   ..

PARTITION = INTERIOR-WALL
            AREA          = 320
            CONSTRUCTION  = P1
            NEXT-TO       = SPACE-2   ..
```

UNDERGROUND-WALL or UNDERGROUND-FLOOR

This instruction is used to specify the size and construction of an underground wall, underground floor, or a floor on the ground (slab-on-grade). Each UNDERGROUND-WALL or UNDERGROUND-FLOOR instruction applies to the SPACE instruction preceding it and describes one of the underground walls or underground floors of that SPACE.

Specifying the U-Value and the area of a floor in contact with the soil calls for some engineering judgment. Using the total area of the floor will drastically overestimate the heat loss through the floor, because the floor will tend to raise the temperature of the surrounding soil. Therefore, you should specify an effective (lower) area. For slab-on-grade, the effective area is that of a one-foot-wide band around the perimeter of the surface. For below-grade walls, the effective area is that of a one-foot-high band at the top of the wall.

u-name	may be specified.
LIKE	is analogous to LIKE for INTERIOR-WALL.
AREA	is the effective area of the UNDERGROUND-WALL or UNDERGROUND-FLOOR. The range is from 0.0+ to 100000.0 ft^2, and there is no default.
CONSTRUCTION	is the u-name of a previously defined CONSTRUCTION instruction that describes the LAYERS (response factors) *or* the effective U-Value of this UNDERGROUND-WALL or UNDERGROUND-FLOOR. This keyword is required if UNDERGROUND-WALL (or -FLOOR) is specified.

Rules:

1. The associated SPACE instruction must precede an UNDERGROUND-WALL or UNDERGROUND-FLOOR instruction.
2. Before an UNDERGROUND-WALL or UNDERGROUND-FLOOR instruction is specified, you must specify a CONSTRUCTION instruction having a U-VALUE or LAYERS keyword.

Example:

```
BOTTOM-1 = UNDERGROUND-FLOOR
           AREA         = 5000
           CONSTRUCTION = FLOOR-1  ..
```

LOADS-REPORT

This instruction defines which LOADS reports will be output. Users can select from *verification* reports and *summary* reports. Verification reports echo your input; summary reports show calculation results, usually monthly and annually.

Format:

```
LOADS-REPORT    VERIFICATION = (code-word list)
                SUMMARY = (code-word list) ..
```

Example:

```
LOADS-REPORT    VERIFICATION = (LV-D)
                SUMMARY = (LS-B, LS-D) ..
```

will print verification report LV-D, "Details of Exterior Surfaces in the Project", and summary reports LS-B "Space Peak Load Components", and LS-D "Building Monthly Loads Summary". A description of the basic LOADS reports, with corresponding code-words is given in Appendix C.

SYSTEMS

Introduction

DOE-2 requires a fair amount of understanding of how systems operate. A general description of types of systems is given in this manual. Once you have understood the structure used for the LOADS input, there should be little difficulty in learning the procedure for assembling a SYSTEMS input. The major problem most users have is that DOE-2 offers a high degree of flexibility and a large choice of options for SYSTEMS input. To use this flexibility wisely you are required to know more about HVAC systems than was required by previous energy analysis programs. In the earlier programs, you could simply assign the *name* of the desired system and the program would pull from its file all of the necessary input. To a degree this can be done with DOE-2 by relying on default values and prestored control methods. However, this is not the recommended procedure and is an option to be used only until the you feel comfortable with explicitly specifying the many commands and keywords in DOE-2.

General Discussion of Systems

In this subsection we describe the general properties of HVAC systems for users whose knowledge in this area is limited. *It is important to know what various systems do and not simply know their names.* We will stress the common features and heritage of various systems rather than concentrating on their differences.

Generally, air systems can be split into five distinct categories:

1. Variable Air Temperature Systems (Constant Volume)
2. Reheat Systems (Constant Volume)
3. Air Mixing Systems (Constant Volume)
4. Variable Air Volume Systems (Constant Temperature)
5. Hybrid Systems - A mixture of Systems 1 through 4

Variable Air Temperature Systems (Constant Volume) (SZRH, PSZ)*

Variable air temperature systems are totally responsive to the master control zone's sensible heat gains and losses. As heat gains decrease, the temperature of the supply air increases proportionately, and vice-versa. Usually the heating coil is placed in front of the cooling coil for freeze protection and the two coils are controlled in sequence by the space thermostat. The single zone system is representative of this type of system, with the added feature that subzone reheat coils can be used to adjust for the heating requirements of the subzones that differ from that of the first named zone (in the list of zones assigned to the system).

BM004

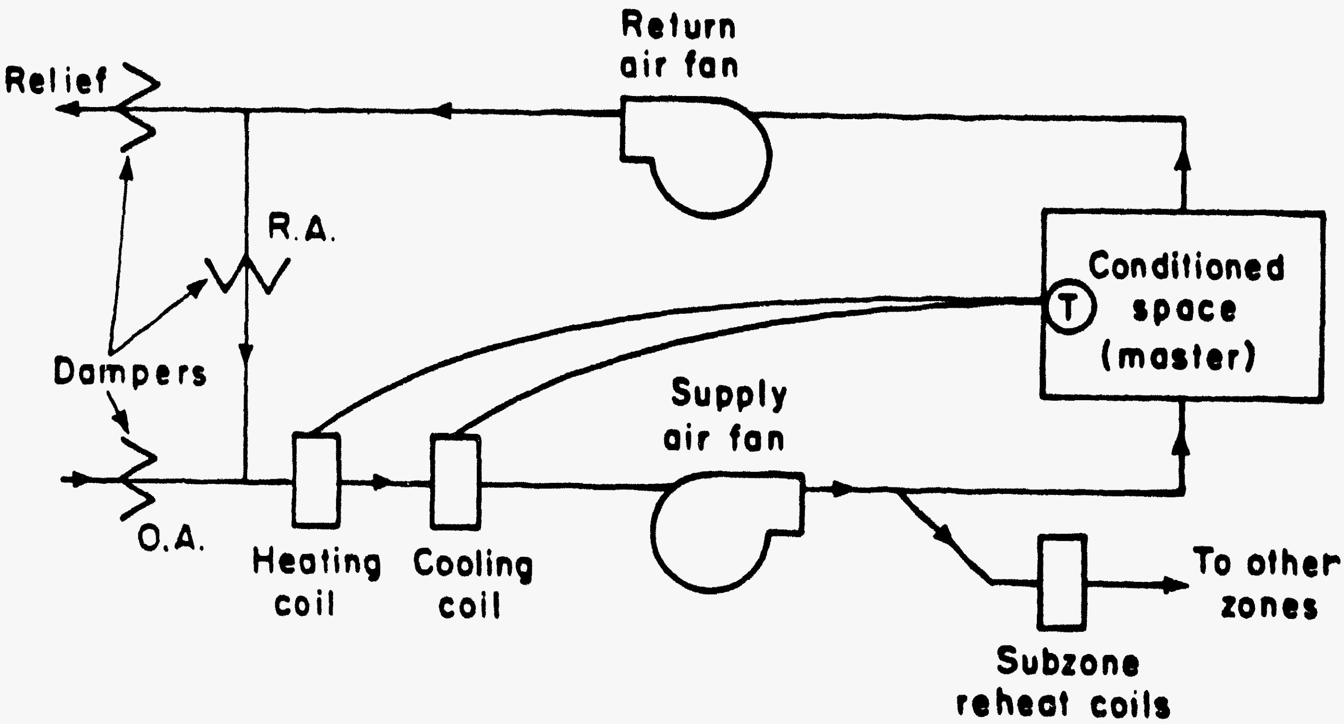


Figure 3.1: Variable Air Temperature System

* The corresponding DOE-2 SYSTEM-TYPE code-words are given in parentheses; for example, PSZ is the DOE-2 "packaged single zone" system. See p.3.8 for a list of system types and code-words.

Reheat Systems (Constant Volume) (RHFS)

Reheat Systems were a natural outgrowth of the single zone variable air temperature system; the reheating coil is located downstream of the cooling coil so that all supply air is cooled as well as dehumidified (the supply air is maintained at a constant temperature). This makes the cooling energy use unresponsive to space loads, whereas the reheat is responsive to space loads, but inversely so. For example, when space heat gains are at their maximum, reheating is not required to hold space temperatures. However, as space heat gains decrease, reheating must increase to compensate for the disappearing space heat gains. Under all conditions the cooling coil cools the air to a constant temperature fixed for the maximum anticipated loading. This is, therefore, an energy intensive system.

BM005

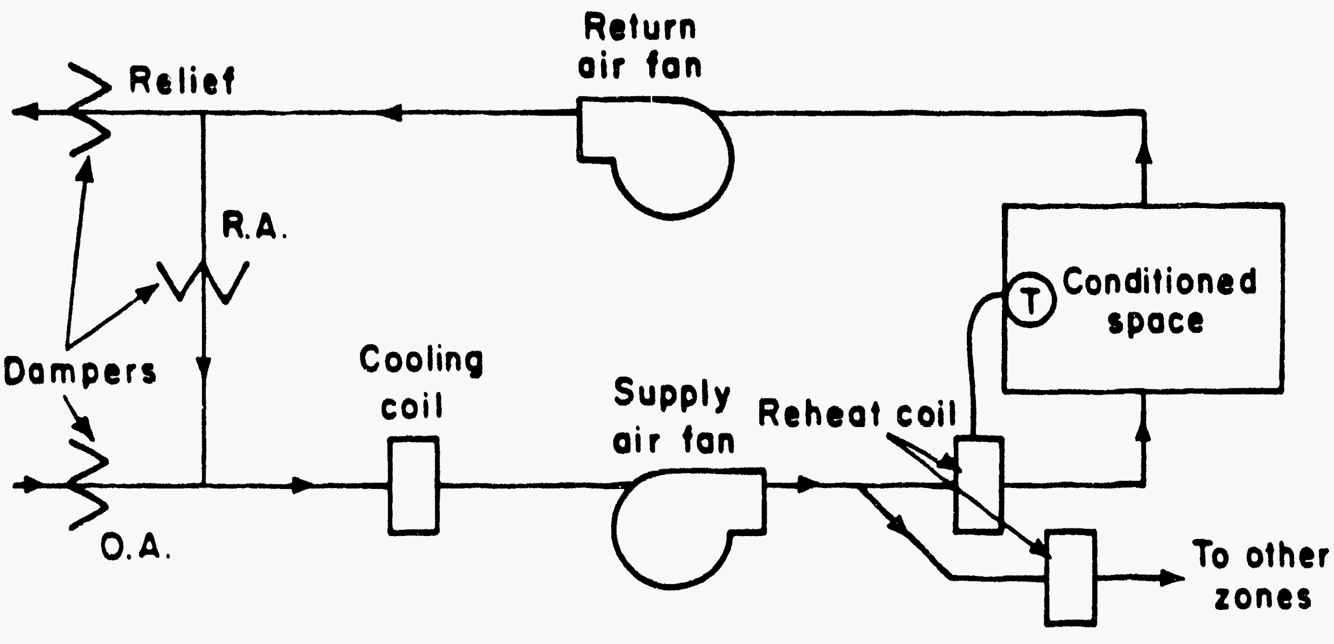


Figure 3.2: Reheat System

Air Mixing Systems (Constant Volume) (DDS, MZS, PMZS)
These systems are commonly referred to as Dual Duct and Multi-Zone Systems. They control space temperatures by the mixing of two air streams, one of which is normally above the space temperature and the other normally below the space temperature. In this constant volume configuration they are also energy intensive.

To understand why air mixing systems can be large energy users, it is necessary to understand the effect the hot deck temperature has on the systems energy consumption during cooling periods. Given a space that requires partial cooling, a given quantity of cold air is needed to satisfy the load; however, the excess air that is not used to satisfy the load must still go to the space because the system is constant volume.

It follows that, of the total supply air that remains in excess of that required to satisfy the space load, the hot stream and the cold stream must mix thermally to cancel each other. If the cold deck is 55°F, the space temperature 75°F, and the hot deck 95°F, the two air streams will mix in equal parts to cancel each other.

However, if the hot deck is 155°F and all other criteria remain unchanged, then the cold deck will pass 4 parts, and the hot deck 1 part, to cancel each other. The cooling and heating energy expended on the excess air for these two hypothetical cases is 1.6 times as much for the second case as for the first. Reset of hot and cold deck temperatures to minimize temperature difference between the hot and cold decks will minimize energy consumption on these systems.

BM006

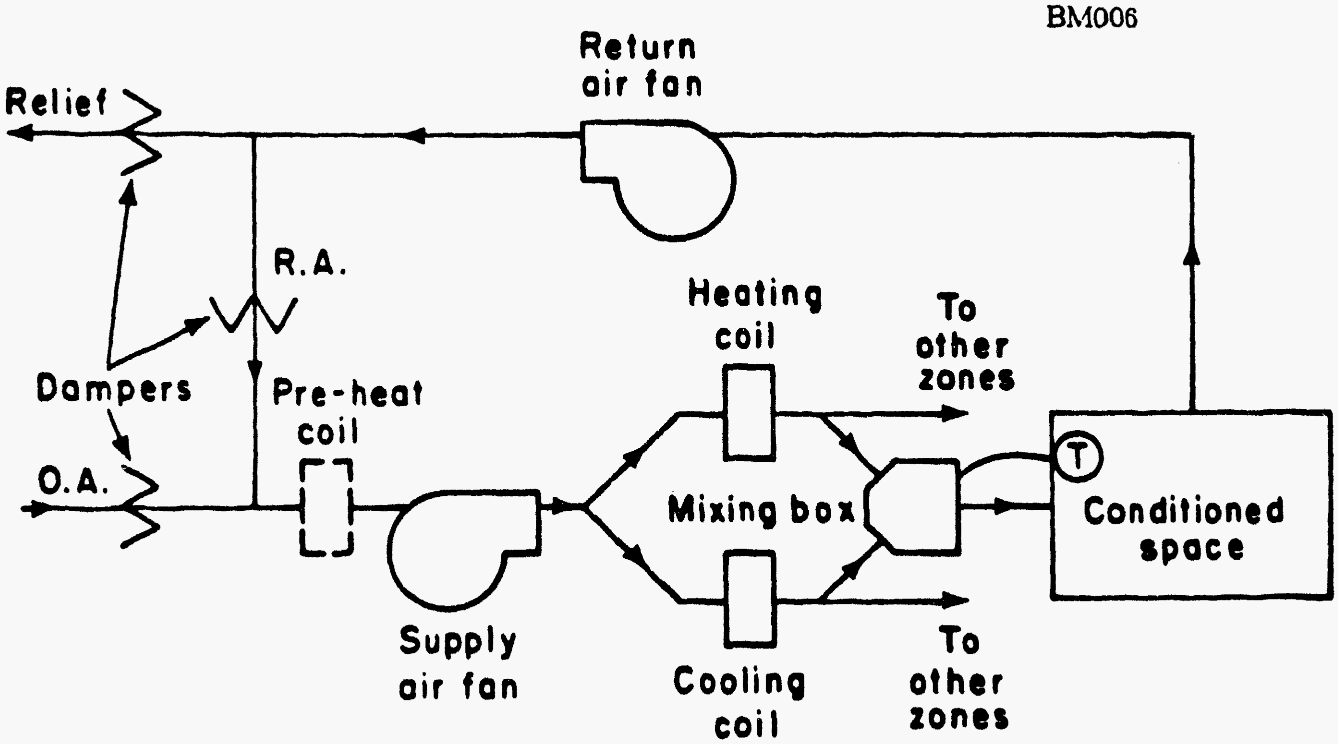


Figure 3.3: Air Mixing (Constant Volume) Systems

Variable Air Volume (Constant Temperature) Systems (VAVS, PVAVS)
Variable Air Volume systems are the easiest to understand. With a decreasing heat gain in the space, the system responds directly with a corresponding decrease in (cold) air supply to the space. Most systems have a minimum stop beyond which the air supply is no longer decreased. The ratio of this minimum air-flow-rate to the design air-flow-rate is referred to as MIN-CFM-RATIO. If an interior space is occupied, the heat gain from lights and people will require sufficient air flow to remove the load; however, in perimeter spaces the heat losses may offset the heat gains from lights and people, resulting in a load that is close to zero. Then it is necessary to set the MIN-CFM-RATIO to provide sufficient ventilation air; either reheat or baseboard radiation is used to offset the cooling effect of the minimum allowable air supply and to supply heat to offset the heat losses.

BM007

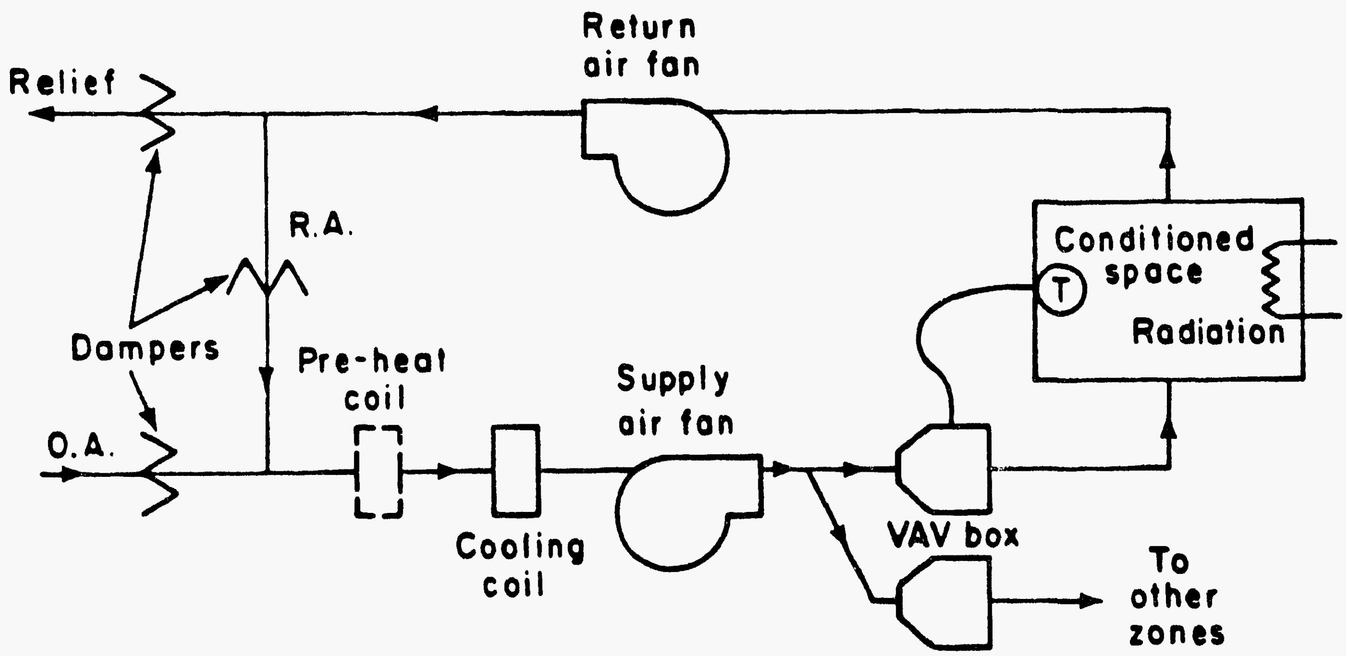


Figure 3.4: Variable Air Volume (Constant Temperature) Systems

Hybrid Systems

a. Hybrid Systems are defined here as a combination of any of the first four systems described. For example, we have VAV-Reheat Systems with a minimum stop on the supply box specified by MIN-CFM-RATIO. Typically, this system acts as a VAV system if the total air supply is above the MIN-CFM-RATIO setting. Whenever the system supply air needed is less than that allowed by the MIN-CFM-RATIO, the system conforms to a standard reheat system.

b. Another form of Hybrid System is the VAV-Dual Duct System. Again, only when the total supply air requirement is less than that allowed by the MIN-CFM-RATIO, does the system act as a typical dual duct system which mixes two air streams to satisfy the space thermostat.

c. Powered Induction Units (PIU) are a variation of the VAV system with the addition of a small fan to pull air from the ceiling plenum and mix it with air supplied from the central system.

Other System Types in DOE-2

a. Fan Coil (TPFC and FPFC). Fan Coil Units are either 4-pipe or 2-pipe. The 4-pipe units usually have two coils (one heating and one cooling), but may have one dual purpose coil. The units modulate the flow of water to the coil(s); this conforms to a variable air temperature system. Outside air for fan coil systems is usually introduced by a separate ventilation system; however, outside air may be introduced directly into the fan coil unit.

b. Packaged Units (PSZ, PMZS, PVAVS, and PTAC). These systems are similar, schematically, to the systems already described except that they are usually unitary (fans, compressors and condensers are physically cased in a single unit). In DOE-2 they perform cooling with direct expansion coils, which require data about ambient wet and dry bulb temperatures. As a result, the entire cooling calculation is done in SYSTEMS and only the resulting electrical load is passed to PLANT.

c. Incremental Heat Pump (HP). Also referred to as the Water Source Heat Pump, Water Loop Heat Pump, or Water-Air Heat Pump. These systems are composed of small self-contained cooling heating units connected to a common water loop. Units on cooling reject heat to the circuit; units on heating draw heat from this source and pump it up to a higher level. A hot water generator is a supplemental heat source when the majority of units are heating. An evaporative cooler (closed circuit cooling tower) is used to reject heat to the atmosphere when the majority of units are cooling. These latter must be input in PLANT.

d. Residential System (RESYS). It is possible to simulate the following combinations of systems, appropriate to a residential building modeled as a single zone. Cooling may be accomplished with an air-cooled electric-driven air conditioner; heating may be provided by a forced-air furnace, electric resistance air coil, or hot water baseboards. Alternatively, both heating and cooling can be supplied by an air-to-air heat pump with supplemental electric resistance heating.

e. Heating Only Systems. DOE-2 can simulate a number of heating-only systems. They are:

   i. Unit Heaters (UHT)
   ii. Unit Ventilators (UVT)
   iii. Baseboard Radiators

   UHT and UVT heating-only units are described later in detail. They are especially useful in analyzing buildings constructed before air conditioning became popular.

   Baseboard radiators can only be simulated in combination with the air systems. You must specify a value for the keyword BASEBOARD-RATING (the heating capacity of the baseboards in Btu/hr). In addition, you must specify the kind of BASEBOARD-CONTROL, either OUTDOOR-RESET (the default) or THERMOSTATIC.

f. Recovery Systems. The DOE-2 program allows you to simulate either a coil run-around heat recovery cycle or a heat wheel. The heating effect due to heat exchange between return air and colder outside air is the only configuration available. (The **cooling** effect due to heat exchange between return air and **warmer** outside air cannot be simulated.)

Specific HVAC Distribution Systems

The SYSTEMS program simulates the heat and moisture exchange processes that occur in secondary HVAC distribution systems. Likewise, it simulates the performance of air circulating fans used in these systems. You select appropriate systems (plus options) from a list of 16 different standard or familiar types of systems. There are an additional 10 system types that are used less commonly or are very difficult for a new user to input; see the *Reference Manual (2.1A)* and or the *Supplement (2.1E)*. The SYSTEMS subprogram cannot simulate two different types of air systems in one zone at the same time. For example, it is not possible to simulate the cooling of a zone by both a Single Zone Fan System (SZRH) and a Two Pipe Fan Coil System (TPFC).

System types in DOE-2 have been categorized into different generic types, built-up systems vs. packaged systems and central systems vs. zonal systems.

Built-Up Systems — Depending upon the system types chosen, *built-up systems* contain preheat coils, main heating coils, cooling coils, zone (reheat) coils, baseboard heaters, fans (supply, return, and exhaust), thermostats, humidifiers, dehumidifiers, economizers, outside air dampers, mixing dampers, throttling dampers, and air ducting. However, built-up systems are **not** usually self-contained; the central equipment (i.e., boilers, chillers, cooling towers, pumps, etc.) that produces hot or chilled water and electrical energy is separated from the distribution system. That equipment is simulated in DOE-2's PLANT subprogram. Built-up system simulations result in demands that are passed to PLANT, for hot water, chilled water, electricity, gas, and/or oil. These demands may be met in PLANT by purchased utilities or energy conversion equipment.

Packaged Systems

Packaged systems are usually self-contained units. These units are usually produced as one or more modular pieces of prematched equipment that only require installation. They possess all the necessary equipment for energy conversion and distribution and they, too, produce a utility demand for electricity, gas, and/or oil.

Zonal vs. Central Systems

Reference is sometimes made to a ***zonal system***, defined herein to mean any system with an air-handling unit in each zone and controlled by a thermostat in that zone. It may be a packaged self-contained system (fueled only by a utility) or it may be supported by a ***central system*** (supplying hot water, chilled water, warm air, or cool air). Zonal systems are UHT, UVT, TPFC, FPFC, HP, and PTAC.

The DOE-2 systems listed below are described in the following pages of this section.

SZRH	Variable temperature constant volume air-handling unit
RHFS	Reheat constant volume air-handling unit
MZS	Multizone constant volume air-handling unit
DDS	Dual duct constant volume or variable volume air-handling unit
VAVS	Variable volume air-handling unit
PIU	Powered Induction unit variable air volume air-handling unit
TPFC	Two pipe fan coil
FPFC	Four pipe fan coil
RESYS	Residential furnace and packaged condensing unit/heat pump
PSZ	Packaged single zone variable temperature DX unit
PMZS	Packaged multizone DX unit
PVAVS	Packaged variable volume DX unit
PTAC	Packaged terminal air conditioner/heat pump
PTGSD	Packaged total gas solid desiccant
UHT	Unit heater
UVT	Unit ventilator (heat only)

Other available systems that are not described here are the following. See the *Supplement (2.1E)* for details on these systems.

EVAP-COOL	Evaporative cooling unit
PVVT	Packaged variable-volume, variable-temperature unit
RESVVT	Residential variable-volume, variable-temperature unit
HP	Water source heat pumps connected to a common water loop
CBVAV	Ceiling bypass unit
TPIU	Two pipe induction unit
FPIU	Four pipe induction unit
SZCI	Ceiling induction unit
HVSYS	Heating and ventilating system
FPIU	Four pipe induction unit

In the material that follows, you will find

1) A full description of each system type, including a schematic of the system showing the location of fans, heating and cooling coils, ductwork and control devices.

2) For each system type, a suggested input that provides a no-frills simulation of that system. Square-bracketed numbers in this input are keyed to the bracketed numbers in the system schematic. A compatible PLANT input is also given. This input is compatible with the example on p.1.9 and therefore could be used to replace the example's SYSTEMS and PLANT input and thus build a new input file.

3) For each system type, a list of other capabilities that can be simulated, with pointers showing where you can find an example or a more complete description. Again, square-bracketed numbers are keyed to the bracketed numbers in the system schematic.

Single-Zone Fan System with Optional Subzone Reheat (SZRH)

In its most basic configuration SZRH provides constant volume, forced-air heating and cooling for a single zone (plus subzones) from an air-handling unit containing a heating coil, cooling coil, filters (not shown), and supply fan. Exhaust fans are optional for any or all zones. The temperature of discharge air is controlled from a thermostat that senses space conditions in the control zone. This zone is specified as the first zone entered under the keyword ZONE-NAMES. The system may be small and located within the space to be conditioned, or may be remotely located with ducted air distribution. It may provide outside air ventilation, or merely recirculate conditioned air.

Note: On the schematic, items shown in dashed boxes are optional components.

BM008

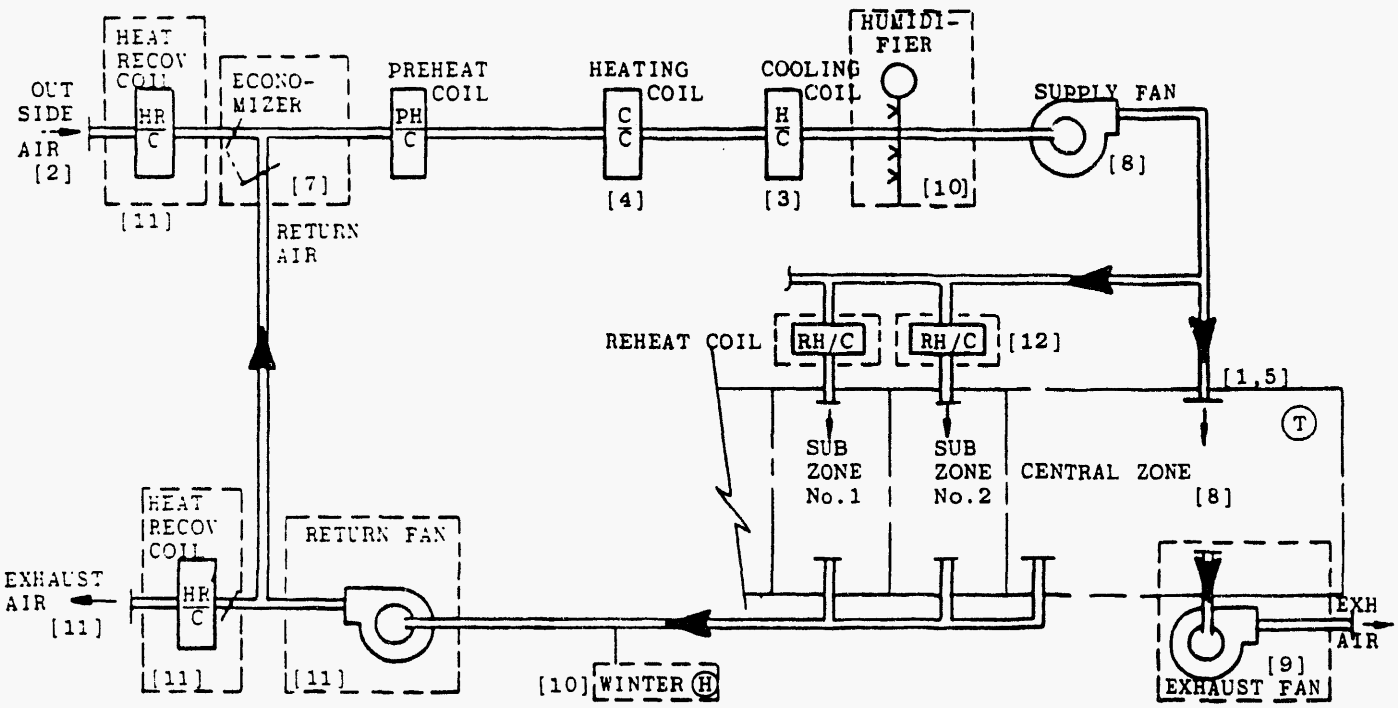


Figure 3.5: Single-Zone Fan System with Optional Subzone Reheat

Suggested minimal input for SZRH system with an economizer:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON = SCHEDULE THRU DEC 31          (WD)    (1,7)(0)
                                                (8,18)(1) (19,24)(0)
                                        (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(99)
                                                (8,18)(76) (19,24)(99)
                                        (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(55)
                                                (8,18)(72) (19,24)(55)
                                        (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31              (WD)    (1,7)(0)
                                                (8,18)(1.0) (19,24)(0)
                                        (WEH)   (1,24)(0) ..


OFFICE = ZONE             DESIGN-HEAT-T      =   72
                          DESIGN-COOL-T      =   74
                          HEAT-TEMP-SCH      =   HEATSETPT  [1]
                          COOL-TEMP-SCH      =   COOLSETPT  [1]
                          OA-CFM/PER         =   15 ..  [2]

AC-SYST = SYSTEM          SYSTEM-TYPE        =   SZRH
                          MAX-SUPPLY-T       =   110  [3]
                          MIN-SUPPLY-T       =   55  [4]
                          NIGHT-CYCLE-CTRL   =   CYCLE-ON-FIRST  [5]
                          FAN-SCHEDULE       =   FANS-ON  [6]
                          ECONO-LIMIT-T      =   68  [7]
                          OA-CONTROL         =   TEMP  [7]
                          ZONE-NAMES         =   (OFFICE) ..  [8]

P1 = PLANT-ASSIGNMENT     SYSTEM-NAMES       =   (AC-SYST)
                          DHW-BTU/HR         =   10000
                          DHW-SCH            =   DHW ..


END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
```

```
PLANT-REPORT  SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT     TYPE = DHW-HEATER        SIZE = -999 ..
HWG = PLANT-EQUIPMENT     TYPE = HW-BOILER         SIZE = -999 ..
CHR = PLANT-EQUIPMENT     TYPE = HERM-REC-CHLR     SIZE = -999 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..

END ..

COMPUTE  PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords **EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list.** [9]

2) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list. [10]

3) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) and RETURN-KW= Value (.0003 is typical) to the SYSTEM keyword list. [11]

4) To disable the economizer change OA-CONTROL = TEMP to OA-CONTROL = FIXED. [7]

5) To enable reheat coils at subzones add REHEAT-DELTA-T = Value (°F) to the SYSTEM keyword list. [12]

6) To disable the mechanical cooling year-round, so that the system operates as a Heating and Ventilating Unit, insert a schedule like this:

```
COOL-OFF  =  SCHEDULE THRU DEC 31 (ALL)  (1,24) (0) ..
```

and add

```
COOLING-SCHEDULE  =  COOL-OFF
```

to the SYSTEM keyword list.

Constant-Volume Reheat Fan System (RHFS)

In its most basic configuration, RHFS provides constant volume forced-flow heating and cooling to a number of individually controlled zones from an air-handling unit consisting of a filter (not shown), heating and cooling coils, and a draw-through supply fan. Exhaust fans are optional for any or all zones. A reheat coil is installed in the supply air distribution duct serving each individual zone. Space temperature is controlled by throttling heating fluid flow to these reheat coils. The Btu equivalent of moisture added to the air stream to maintain a minimum humidity is passed to the PLANT program as a heating load.

Note: On the schematic, items shown in dashed boxes are optional components.

BM009

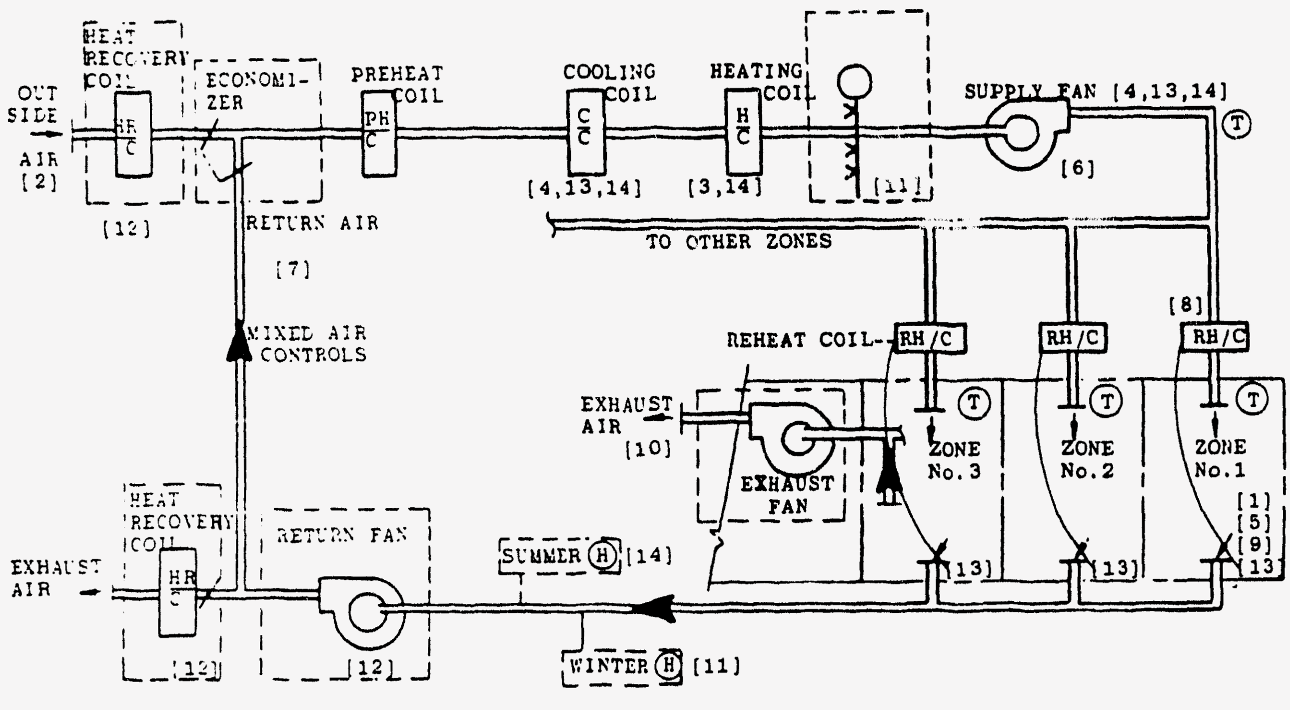


Figure 3.6: Constant-Volume Reheat Fan System (RHFS)

Suggested minimal input for RHFS system with an economizer:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                        $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31        (WD)    (1,7)(0) (8,18)(1)
                                                (19,24)(0)
                                        (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(99) (8,18)(76)
                                                (19,24)(99)
                                        (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(55) (8,18)(72)
                                                (19,24)(55)
                                        (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31              (WD)    (1,7)(0)
                                                (8,18)(1.0) (19,24)(0)
                                        (WEH)   (1,24)(0) ..


OFFICE = ZONE               DESIGN-HEAT-T       =   72
                            DESIGN-COOL-T       =   74
                            HEAT-TEMP-SCH       =   HEATSETPT  [1]
                            COOL-TEMP-SCH       =   COOLSETPT  [1]
                            OA-CFM/PER          =   15 ..  [2]

AC-SYST = SYSTEM            SYSTEM-TYPE         =   RHFS
                            MAX-SUPPLY-T        =   110  [3]
                            MIN-SUPPLY-T        =   55  [4]
                            NIGHT-CYCLE-CTRL    =   CYCLE-ON-FIRST  [5]
                            FAN-SCHEDULE        =   FANS-ON  [6]
                            OA-CONTROL          =   TEMP  [7]
                            ECONO-LIMIT-T       =   68  [7]
                            REHEAT-DELTA-T      =   55  [8]
                            ZONE-NAMES          =   (OFFICE) ..  [9]

P1 = PLANT-ASSIGNMENT       SYSTEM-NAMES        =   (AC-SYST)
                            DHW-BTU/HR          =   10000
                            DHW-SCH             =   DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
```

```
PLANT-REPORT SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER       SIZE = -999 ..
HWG = PLANT-EQUIPMENT   TYPE = HW-BOILER        SIZE = -999 ..
CHR = PLANT-EQUIPMENT   TYPE = HERM-REC-CHLR    SIZE = -999 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [10]

2) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list. [11]

3) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) and RETURN-KW= Value (.0003 is typical) to the SYSTEM keyword list. [12]

4) To disable the economizer change the OA-CONTROL = TEMP to OA-CONTROL = FIXED. [7]

5) To enable supply air temperature reset using a discriminator control insert COOL-CONTROL = WARMEST in the SYSTEM keyword list. [13]

6) An alternative method to item 5 above is to reset the supply air as a function of outside air temperature. An example of this control is covered in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 1.

7) To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY = Value (60% is allowed in the new ASHRAE 90.1 Standard) in the SYSTEM keyword list. [14]

Multizone Fan System (MZS)
In its most basic configuration MZS provides constant flow, forced-air heating and cooling to multiple, individually controlled zones from an air-handling unit containing a filter (not shown), blow-through type supply fan, heating and cooling coil (each located in a separate casing on the discharge side of the fan), and one set of mixing dampers per zone served. Exhaust fans are optional for any or all zones. The program assumes there is a preheat coil and calculates a preheat load, if and when the mixed air temperature falls below the required PREHEAT-T. To control the temperature in each zone, two air streams at different temperatures (hot deck and cold deck) are mixed by dampers located in the air-handling unit and ducted separately from the discharge of the air-handling unit to each zone.

Note: On the schematic, items shown in dashed boxes are optional components.

BM010

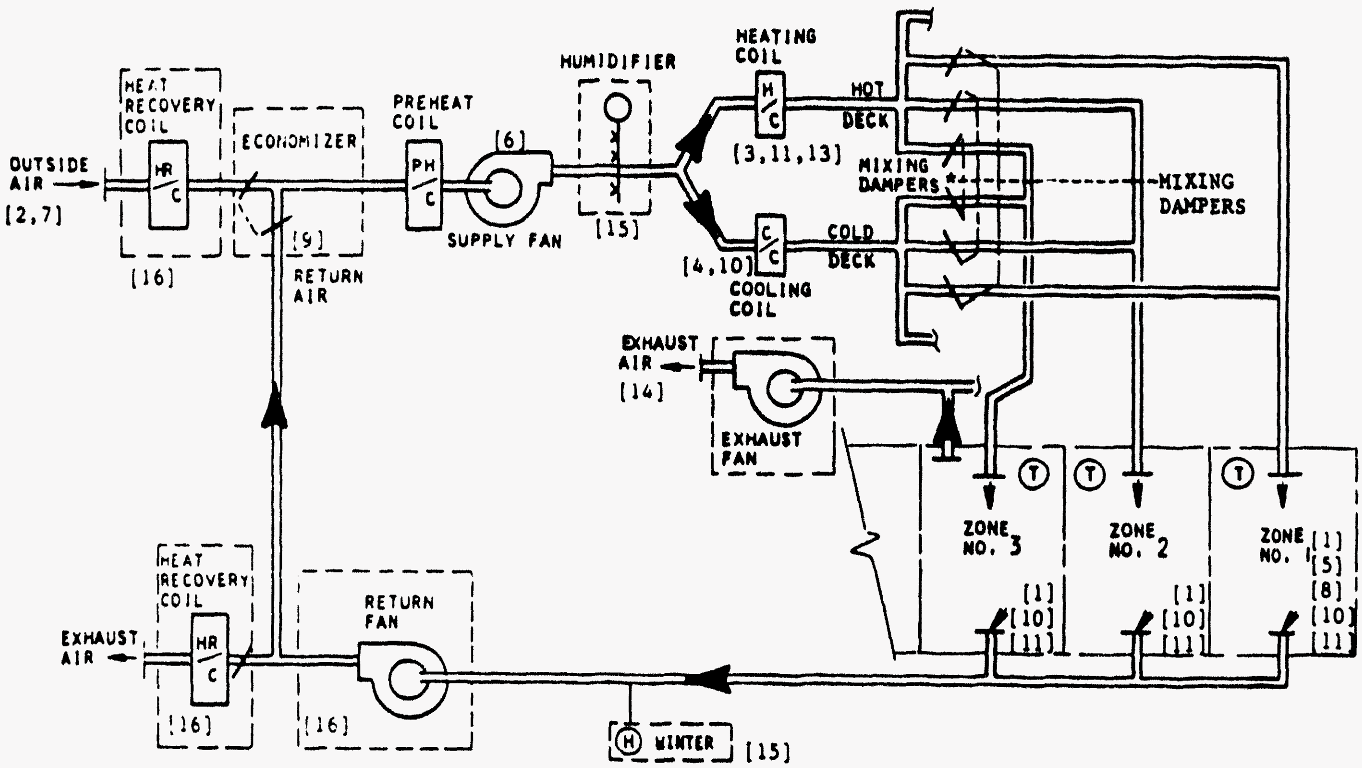


Figure 3.7: Multizone Fan System (MZS)

Suggested minimal input for MZS system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                         $ SYSTEMS SCHEDULES

FANS-ON =    SCHEDULE THRU DEC 31        (WD)     (1,7)(0) (8,18)(1)
                                                  (19,24)(0)
                                         (WEH)    (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31         (WD)     (1,7)(99) (8,18)(76)
                                                  (19,24)(99)
                                         (WEH)    (1,24)(99) ..
HEATSETPT = SCHEDULE THRU DEC 31         (WD)     (1,7)(55) (8,18)(72)
                                                  (19,24)(55)
                                         (WEH)    (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31               (WD)     (1,7)(0)
                                                  (8,18)(1.0) (19,24)(0)
                                         (WEH)    (1,24)(0) ..


OFFICE = ZONE              DESIGN-HEAT-T        =     72
                           DESIGN-COOL-T        =     74
                           HEAT-TEMP-SCH        =     HEATSETPT    [1]
                           COOL-TEMP-SCH        =     COOLSETPT    [1]
                           OA-CFM/PER           =     15 ..    [2]

AC-SYST = SYSTEM           SYSTEM-TYPE          =     MZS
                           MAX-SUPPLY-T         =     110    [3]
                           MIN-SUPPLY-T         =     55    [4]
                           NIGHT-CYCLE-CTRL     =     CYCLE-ON-FIRST    [5]
                           FAN-SCHEDULE         =     FANS-ON    [6]
                           OA-CONTROL           =     FIXED    [7]
                           ZONE-NAMES           =     (OFFICE) ..    [8]

P1 = PLANT-ASSIGNMENT      SYSTEM-NAMES         =     (AC-SYST)
                           DHW-BTU/HR           =     10000
                           DHW-SCH              =     DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER       SIZE = -999 ..
```

```
HWG = PLANT-EQUIPMENT    TYPE = HW-BOILER        SIZE = -999 ..
CHR = PLANT-EQUIPMENT    TYPE = HERM-REC-CHLR    SIZE = -999 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..

END ..

COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an economizer, add OA-CONTROL = TEMP and ECONO-LIMIT-T = 60 to the SYSTEM keyword list. [9]

2) To simulate a discriminator control of the cold deck supply air temperature add COOL-CONTROL = WARMEST to the SYSTEM keyword list. [10]

3) To simulate a discriminator control of the hot deck supply air temperature add HEAT-CONTROL = COLDEST to the SYSTEM keyword list. [11]

4) Alternatives to items 3 and 4 above are reset of cold and hot deck supply air temperature. An example of this control is is covered in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 1.

5) To simulate turning off the hot deck whenever the outside temperature is above 65°F, insert a new schedule like this: [13]

   HEAT-OFF = SCHEDULE THRU DEC 31 (ALL) (1,24) (65) ..

   and add

   HEATING-SCHEDULE = HEAT-OFF

   to the SYSTEM keyword list.

6) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [14]

7) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list. [15]

8) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) and RETURN-KW= Value (.0003 is typical) to the SYSTEM keyword list. [16]

Dual-Duct Fan System (DDS)

DDS can be either *constant volume* or *variable volume.*

Constant-volume is identical to the multizone type of system (see the description for MZS), except that the hot and cold air streams (from the warm air duct and cold air duct) are extended to individual mixing boxes, located in the zone being served, where the two air streams are mixed.

The *variable volume* dual duct system is similar to the constant-volume except that the type of mixing box used in this system is capable of reducing flow in response to a decrease in cooling demand. Mixing of the cold and hot air streams occurs only after flow has been reduced to a prescribed minimum; thus, total energy usage is reduced.

Exhaust fans are optional for any or all zones. DOE-2 assumes there is a preheat coil and calculates the preheat load, if and when the mixed air temperature falls below the required PREHEAT-T.

Note: On the schematic, items shown in dashed boxes are optional components.

BM011

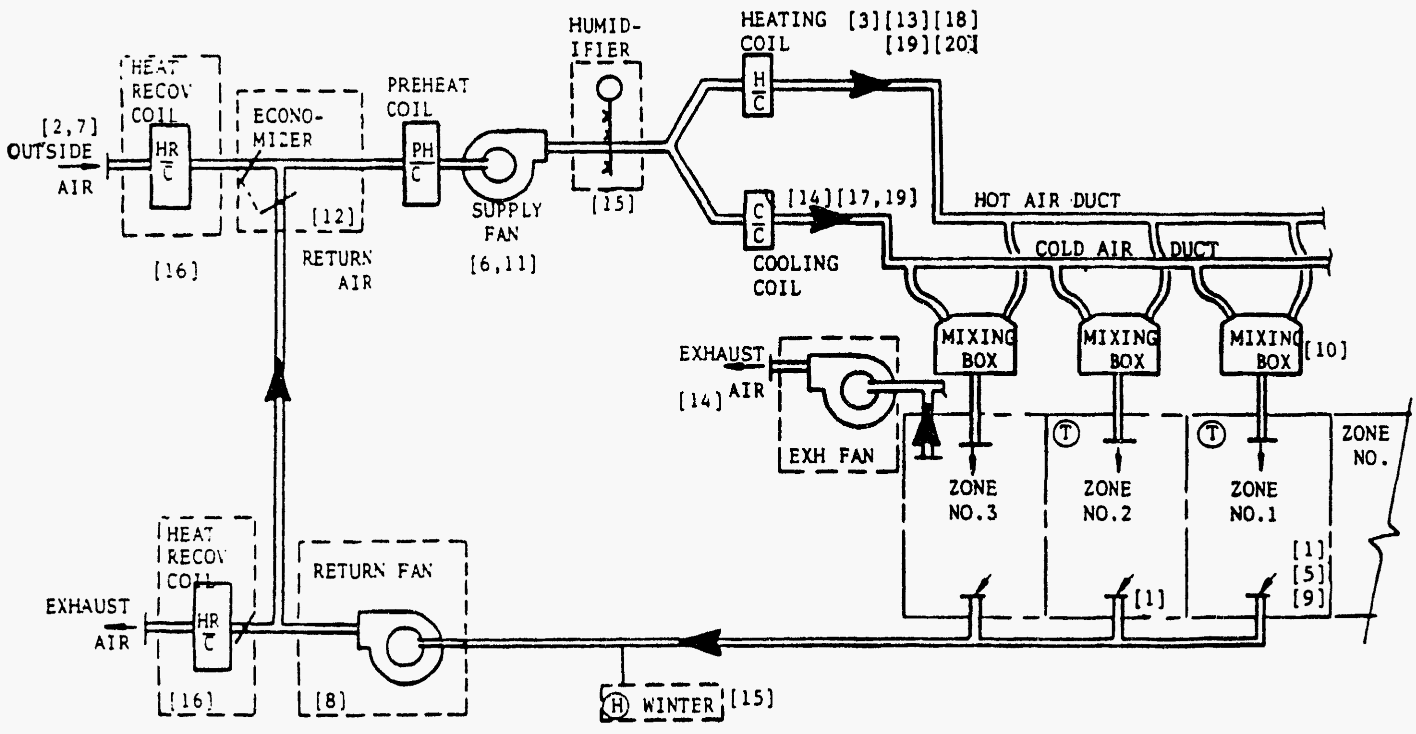


Figure 3.8: Dual-Duct Fan System (DDS)

Suggested minimal input for DDS system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                         $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31        (WD)    (1,7)(0) (8,18)(1)
                                                (19,24)(0)
                                        (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(99) (8,18)(76)
                                                (19,24)(99)
                                        (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(55) (8,18)(72)
                                                (19,24)(55)
                                        (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31              (WD)    (1,7)(0)
                                                (8,18)(1.0) (19,24)(0)
                                        (WEH)   (1,24)(0) ..

OFFICE = ZONE             DESIGN-HEAT-T        =   72
                          DESIGN-COOL-T        =   74
                          HEAT-TEMP-SCH        =   HEATSETPT     [1]
                          COOL-TEMP-SCH        =   COOLSETPT     [1]
                          OA-CFM/PER           =   15 ..    [2]

AC-SYST = SYSTEM          SYSTEM-TYPE          =   DDS
                          MAX-SUPPLY-T         =   110    [3]
                          MIN-SUPPLY-T         =   55    [4]
                          NIGHT-CYCLE-CTRL     =   CYCLE-ON-FIRST     [5]
                          FAN-SCHEDULE         =   FANS-ON    [6]
                          OA-CONTROL           =   FIXED    [7]
                          RETURN-STATIC        =   1.0    [8]
                          RETURN-EFF           =   .55    [8]
                          ZONE-NAMES           =   (OFFICE) ..    [9]

P1 = PLANT-ASSIGNMENT     SYSTEM-NAMES         =   (AC-SYST)
                          DHW-BTU/HR           =   10000
                          DHW-SCH              =   DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
```

```
PLANT-REPORT  SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT     TYPE = DHW-HEATER        SIZE = -999  ..
HWG = PLANT-EQUIPMENT     TYPE = HW-BOILER         SIZE = -999  ..
CHR = PLANT-EQUIPMENT     TYPE = HERM-REC-CHLR     SIZE = -999  ..

PLANT-PARAMETERS    HERM-REC-COND-TYPE = AIR  ..

END ..

COMPUTE  PLANT  ..
```

Additional capabilities for this system:

1) To simulate a variable volume dual duct air system add MIN-CFM-RATIO = .5 (i.e., a minimum stop of 50%) to the SYSTEM keyword list. **[10]**

2) To simulate variable speed control of the fan motor add FAN-CONTROL = SPEED to the SYSTEM keyword list; this will override the default of INLET control. **[11]**

3) To enable the economizer add OA-CONTROL = TEMP and ECONO-LIMIT-T = 60 to the SYSTEM keyword list. A second alternative is to simulate an enthalpy controlled economizer by changing OA-CONTROL = TEMP to OA-CONTROL = ENTHALPY and raise ECONO-LIMIT-T = 70 **[12]**

4) To simulate turning off the hot deck whenever the outside temperature is above 65°F and always during the summer months of JULY 1 through AUGUST 30, insert a new schedule like this: **[13]**

```
HEAT-OFF-SCHEDULE    THRU JUN 30  (ALL) (1,24) (65)
                     THRU AUG 30  (ALL) (1,24) (0)
                     THRU DEC 31  (ALL) (1,24) (65) ..
```

and add HEATING-SCHEDULE = HEAT-OFF to the SYSTEM keyword list.

5) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. **[14]**

6) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list. **[15]**

7) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) and RETURN-KW= Value (.0003 is typical) to the SYSTEM keyword list. **[16]**

8) To simulate a discriminator control of the cold deck supply air temperature add COOL-CONTROL = WARMEST to the SYSTEM keyword list. **[17]**

9) To simulate a discriminator control of the hot deck supply air temperature add HEAT-CONTROL = COLDEST to the SYSTEM keyword list. **[18]**

10) Alternatives to items 8 and 9 above are reset of cold and hot deck supply air temperature. An example of this control is is covered in the ***Sample Run Book (2.1E)***, 31-Story Office Building, Run 1. **[19]**

11) To simulate turning off the hot deck whenever the outside temperature is above 65°F, insert a new schedule like this: **[20]**

```
HEAT-OFF = SCHEDULE  THRU DEC 31  (ALL) (1,24) (65) ..
```

and add HEATING-SCHEDULE = HEAT-OFF to the SYSTEM keyword list.

Variable-Volume Fan System with Optional Reheat (VAVS)
In its most basic configuration VAVS consists of a central air-handling unit with filter (not shown), cooling and optional heating coils, and a draw-through type supply air fan. Exhaust fans are optional for any or all zones. A duct system distributes supply air (at a temperature determined by you) to variable-air volume (VAV) terminal units, located in the zones being served.

The VAV boxes (controlled by a room thermostat) vary the amount of primary air to the space to control temperature. When the space demands peak cooling, the VAV box allows maximum air flow. As space cooling requirements diminish, the primary air flow to the space is reduced proportionately to a specified minimum flow rate. If less cooling is required than that given at minimum air flow, the reheat coil is activated (if specified). When in the heating mode, the supply air flow rate is held at a constant value equal to MIN-CFM-RATIO. The supply air flow rate will rise above the MIN-CFM-RATIO only *if* you have set THERMOSTAT-TYPE = REVERSE-ACTION.
The Btu equivalent of the moisture that is added to the air stream, to maintain a minimum humidity, is passed to the PLANT program as a heating load.

Note: On the schematic, items shown in dashed boxes are optional components.

BM012

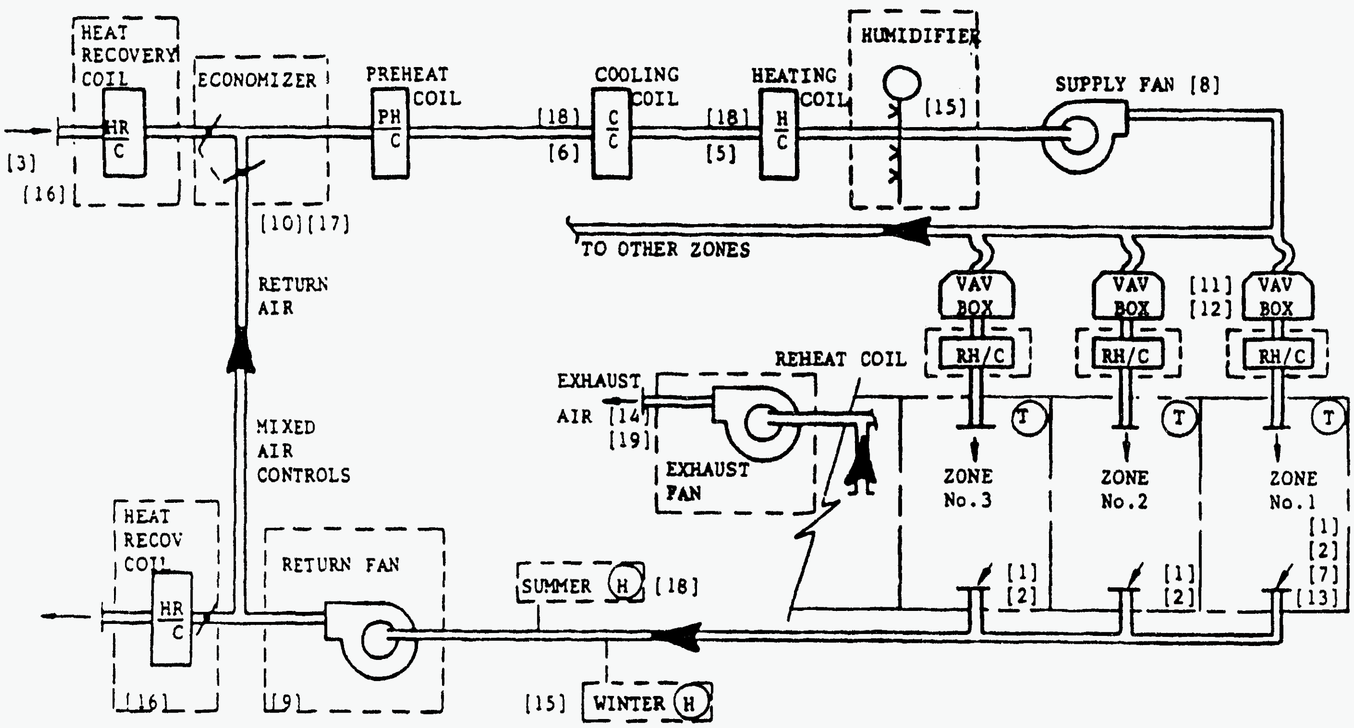


Figure 3.9: Variable-Volume Fan System with Optional Reheat (VAVS)

Suggested minimal input for VAVS system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON =    SCHEDULE THRU DEC 31       (WD)     (1,7)(0) (8,18)(1)
                                                 (19,24)(0)
                                        (WEH)    (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31        (WD)     (1,7)(99) (8,18)(76)
                                                 (19,24)(99)
                                        (WEH)    (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31        (WD)     (1,7)(55) (8,18)(72)
                                                 (19,24)(55)
                                        (WEH)    (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31              (WD)     (1,7)(0)
                                                 (8,18)(1.0) (19,24)(0)
                                        (WEH)    (1,24)(0) ..


OFFICE = ZONE           DESIGN-HEAT-T        =    72
                        DESIGN-COOL-T        =    74
                        HEAT-TEMP-SCH        =    HEATSETPT     [1]
                        COOL-TEMP-SCH        =    COOLSETPT     [1]
                        THERMOSTAT-TYPE      =    REVERSE-ACTION     [2]
                        OA-CFM/PER           =    15 ..    [3]

AC-SYST = SYSTEM        SYSTEM-TYPE          =    VAVS
                        MAX-SUPPLY-T         =    110     [4]
                        HEAT-SET-T           =    70      [5]
                        MIN-SUPPLY-T         =    55      [6]
                        NIGHT-CYCLE-CTRL     =    CYCLE-ON-FIRST     [7]
                        FAN-SCHEDULE         =    FANS-ON     [8]
                        RETURN-STATIC        =    1.0     [9]
                        RETURN-EFF           =    .55     [9]
                        OA-CONTROL           =    TEMP    [10]
                        ECONO-LIMIT-T        =    68      [10]
                        MIN-CFM-RATIO        =    .3      [11]
                        REHEAT-DELTA-T       =    55      [12]
                        ZONE-NAMES           =    (OFFICE) ..     [13]

P1 = PLANT-ASSIGNMENT   SYSTEM-NAMES         =    (AC-SYST)
                        DHW-BTU/HR           =    10000
                        DHW-SCH              =    DHW ..
```

```
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER      SIZE = -999 ..
HWG = PLANT-EQUIPMENT   TYPE = HW-BOILER       SIZE = -999 ..
CHR = PLANT-EQUIPMENT   TYPE = HERM-REC-CHLR   SIZE = -999 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..
END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [14]

2) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list. [15]

3) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) to the SYSTEM keyword list. [16]

4) To disable the economizer change the OA-CONTROL = TEMP to OA-CONTROL = FIXED. [17]

5) To reset the supply air as a function of outside air temperature see example of this control as shown in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 1.

6) To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY = Value (60% is allowed in the new ASHRAE 90.1 Standard) in the SYSTEM keyword list. [18]

7) Simulating baseboard heat in lieu or in addition to reheat coils is demonstrated in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 1.

8) To enable variable speed control of the fan motor, insert FAN-CONTROL = SPEED in the SYSTEM keyword list. [19]

Powered Induction Unit (PIU)

The basic PIU consists of a central air-handling unit with filter (not shown), cooling and optional heating coils, and a draw-through type supply air fan. A return air fan is also usually used. Exhaust fans are optional for any or all zones. The powered induction boxes are available in two configurations: *series* and *parallel*.

Note: On the schematic, items shown in dashed boxes are optional components.

BM013

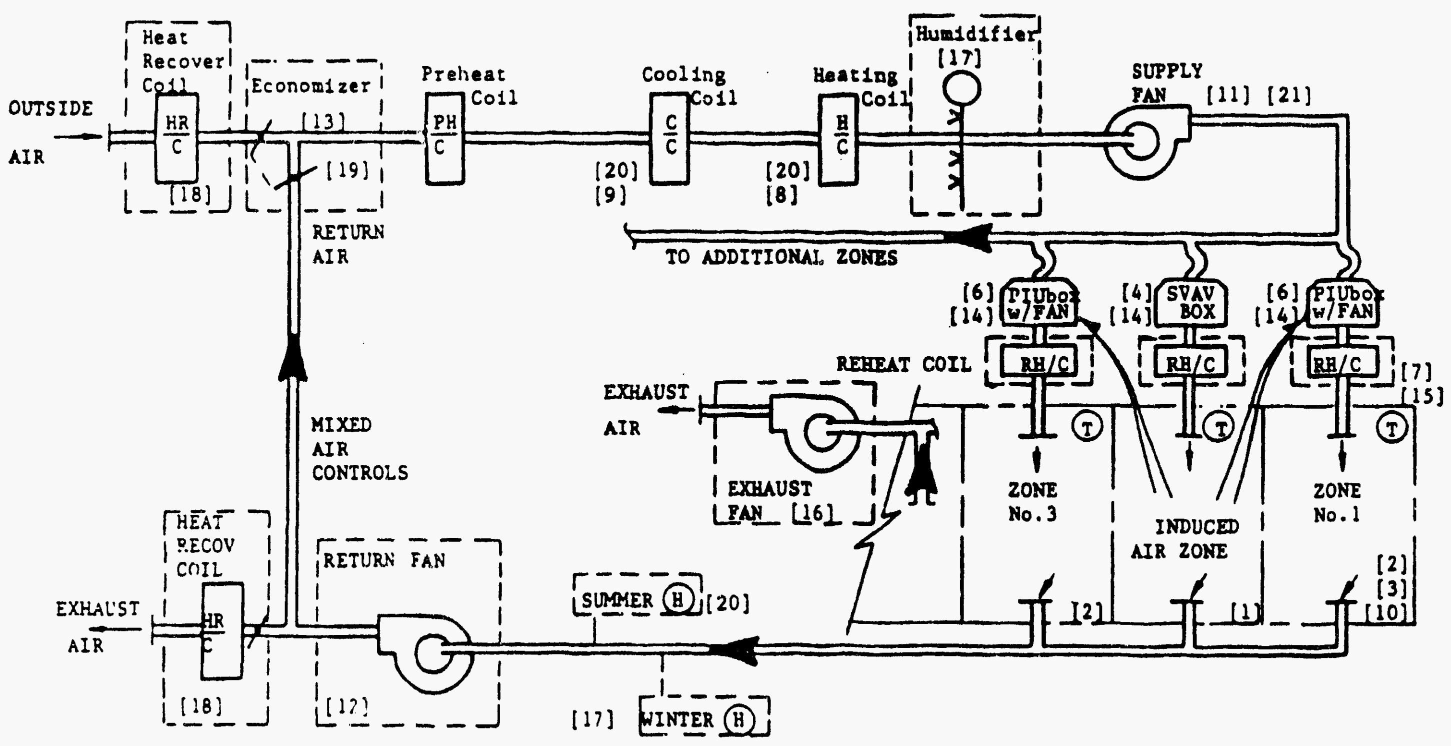


Figure 3.10: Powered Induction Unit System with Optional Reheat

The following suggested minimal input for PIU system with an economizer is shown for *series* type units configured like the sketch below. There must be more than one zone.

BM014

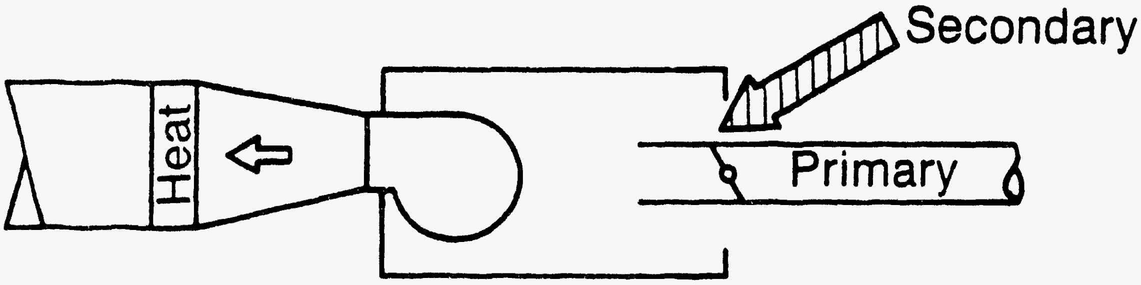


Figure 3.11: Series PIU

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                        $ SYSTEMS SCHEDULES

FANS-ON =    SCHEDULE THRU DEC 31          (WD)     (1,7)(0) (8,18)(1)
                                                    (19,24)(0)
                                           (WEH)    (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31           (WD)     (1,7)(99) (8,18)(76)
                                                    (19,24)(99)
                                           (WEH)    (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31           (WD)     (1,7)(55) (8,18)(72)
                                                    (19,24)(55)
                                           (WEH)    (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31                 (WD)     (1,7)(0)
                                                    (8,18)(1.0) (19,24)(0)
                                           (WEH)    (1,24)(0) ..
```

```
CORE = ZONE              DESIGN-HEAT-T        =   72
  [1]                    DESIGN-COOL-T        =   74
                         HEAT-TEMP-SCH        =   HEATSETPT     [3]
                         COOL-TEMP-SCH        =   COOLSETPT     [3]
                         TERMINAL-TYPE        =   SVAV    [4]
                         CFM/SQFT             =   .7
                         OA-CFM/PER           =   15 ..     [5]

OFFICE = ZONE            LIKE CORE
  [2]                    TERMINAL-TYPE        =   SERIES-PIU
                         ZONE-FAN-RATIO       =   1     [6]
                         ZONE-FAN-KW          =   .00033     [6]
                         INDUCED-AIR-ZONE     =   CORE     [1]
                         REHEAT-DELTA-T       =   55 ..     [15]

AC-SYST = SYSTEM         SYSTEM-TYPE          =   PIU
                         MAX-SUPPLY-T         =   110     [7]
                         HEAT-SET-T           =   70     [8]
                         MIN-SUPPLY-T         =   55     [9]
                         NIGHT-CYCLE-CTRL     =   ZONE-FANS-ONLY     [10]
                         FAN-SCHEDULE         =   FANS-ON     [11]
                         RETURN-STATIC        =   1.0     [12]
                         RETURN-EFF           =   .55     [12]
                         OA-CONTROL           =   TEMP     [13]
                         ECONO-LIMIT-T        =   68     [13]
                         MIN-CFM-RATIO        =   .3     [4]
                         ZONE-NAMES           =   (OFFICE) ..     [2]

P1 = PLANT-ASSIGNMENT    SYSTEM-NAMES         =   (AC-SYST)
                         DHW-BTU/HR           =   10000
                         DHW-SCH              =   DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER       SIZE = -999 ..
HWG = PLANT-EQUIPMENT    TYPE = HW-BOILER        SIZE = -999 ..
CHR = PLANT-EQUIPMENT    TYPE = HERM-REC-CHLR    SIZE = -999 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..
END ..
COMPUTE PLANT ..
```

Following is the suggested minimal input for *parallel* type PIU units like the sketch below:

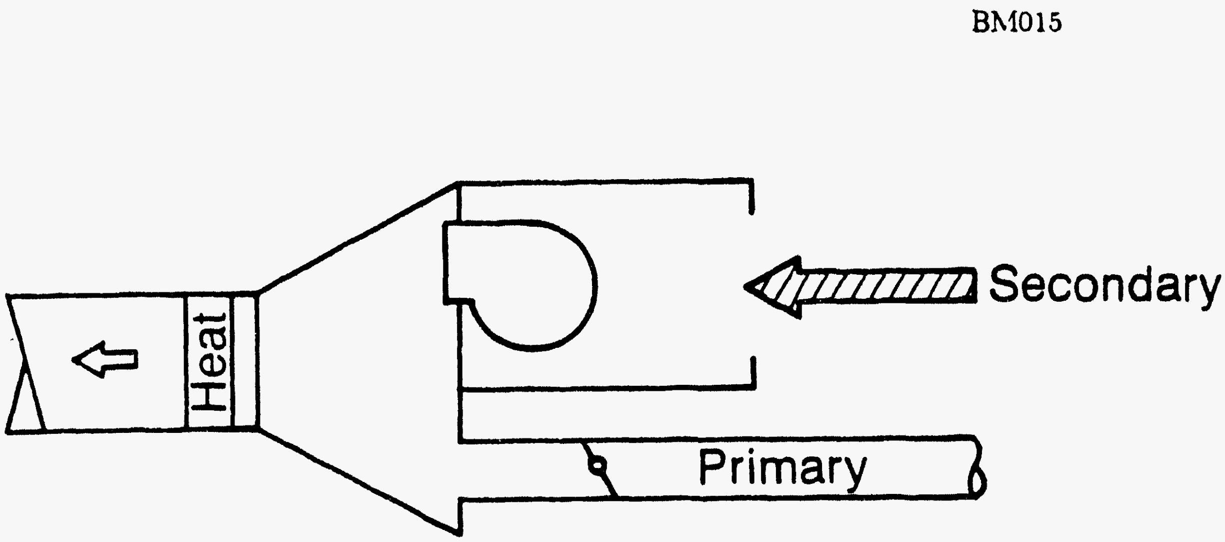


Figure 3.12: Parallel PIU

INPUT SYSTEMS ..

SYSTEMS-REPORT SUMMARY=(SS-A,SS-O) ..

$ SYSTEMS SCHEDULES

```
FANS-ON =   SCHEDULE THRU DEC 31      (WD)    (1,7)(0) (8,18)(1)
                                              (19,24)(0)
                                      (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31      (WD)    (1,7)(99) (8,18)(76)
                                              (19,24)(99)
                                      (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31      (WD)    (1,7)(55) (8,18)(72)
                                              (19,24)(55)
                                      (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31            (WD)    (1,7)(0)
                                              (8,18)(1.0) (19,24)(0)
                                      (WEH)   (1,24)(0) ..

START-Z-FAN = SCHEDULE THRU DEC 31     (WD) (1,7) (55) (8,18) (73) (19,24) (55)
                                       (WEH) (1,24) (55) ..
```

```
CORE = ZONE             DESIGN-HEAT-T        =  72
  [1]                   DESIGN-COOL-T        =  74
                        HEAT-TEMP-SCH        =  HEATSETPT   [3]
                        COOL-TEMP-SCH        =  COOLSETPT   [3]
                        TERMINAL-TYPE        =  SVAV   [4]
                        OA-CFM/PER           =  15 ..   [5]

OFFICE = ZONE           LIKE CORE
  [2]                   TERMINAL-TYPE        =  PARALLEL-PIU
                        ZONE-FAN-RATIO       =  .8   [6]
                        ZONE-FAN-KW          =  .00033   [6]
                        ZONE-FAN-T-SCH       =  START-Z-FAN   [3]
                        INDUCED-AIR-ZONE     =  CORE   [1]
                        REHEAT-DELTA-T       =  55 ..   [15]

AC-SYST = SYSTEM        SYSTEM-TYPE          =  PIU
                        MAX-SUPPLY-T         =  110   [7]
                        HEAT-SET-T           =  70   [8]
                        MIN-SUPPLY-T         =  55   [9]
                        NIGHT-CYCLE-CTRL     =  ZONE-FANS-ONLY   [10]
                        FAN-SCHEDULE         =  FANS-ON   [11]
                        RETURN-STATIC        =  1.0   [12]
                        RETURN-EFF           =  .55   [12]
                        OA-CONTROL           =  TEMP   [13]
                        ECONO-LIMIT-T        =  68   [13]
                        MIN-CFM-RATIO        =  .3   [4]
                        ZONE-NAMES           =  (OFFICE) ..   [2]

P1 = PLANT-ASSIGNMENT   SYSTEM-NAMES         =  (AC-SYST)
                        DHW-BTU/HR           =  10000
                        DHW-SCH              =  DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER      SIZE = -999 ..
HWG = PLANT-EQUIPMENT   TYPE = HW-BOILER       SIZE = -999 ..
CHR = PLANT-EQUIPMENT   TYPE = HERM-REC-CHLR   SIZE = -999 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [16]

2) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list. [17]

3) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) to the SYSTEM keyword list. [18]

4) To disable the economizer change OA-CONTROL = TEMP to OA-CONTROL = FIXED. [19]

5) To reset the supply air as a function of outside air temperature see an example of this control in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 1.

6) To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY = Value (60% is allowed in the new ASHRAE 90.1 standard) in the SYSTEM keyword list. [20]

7) Simulating baseboard heat in lieu of or in addition to reheat coils is demonstrated in the *Sample Run Book (2.1E)*, 31-Story Office Building, Runs 2 and 3.

8) To enable variable speed control of the fan motor, insert FAN-CONTROL = SPEED in the SYSTEM keyword list. [21]

Two-Pipe Fan Coil System (TPFC)

The TPFC system provides both heating and cooling to individually controlled zones. However, all zones served by the TPFC must be operating in the same mode (i.e., either heating or cooling) at any given time.

TPFC consists of a filter (not shown), combination heating/cooling coil, and fan. The coil is connected to a piping system that provides either hot or cold water, according to the prevailing mode of operation as defined by the HEATING-SCHEDULE and COOLING-SCHEDULE. The unit provides a fixed quantity of outside air ventilation or merely recirculates conditioned air. Exhaust fans are optional for any or all zones.

Temperature control is achieved by throttling the flow of water through the heating/cooling coil. The control thermostat commonly used for this type of system has separate heating and cooling setpoints.

The pumping energy associated with this system is accounted for in the PLANT program, rather than in the SYSTEMS program.

The fan coil units, particularly the smaller direct-drive units, may not be available with a fan capacity that matches the calculated value. Therefore, assignment of the fan capacity for a specific, commercially available unit is recommended for improved simulation accuracy.

Note: On the schematic, items shown in dashed boxes are optional components.

BM016

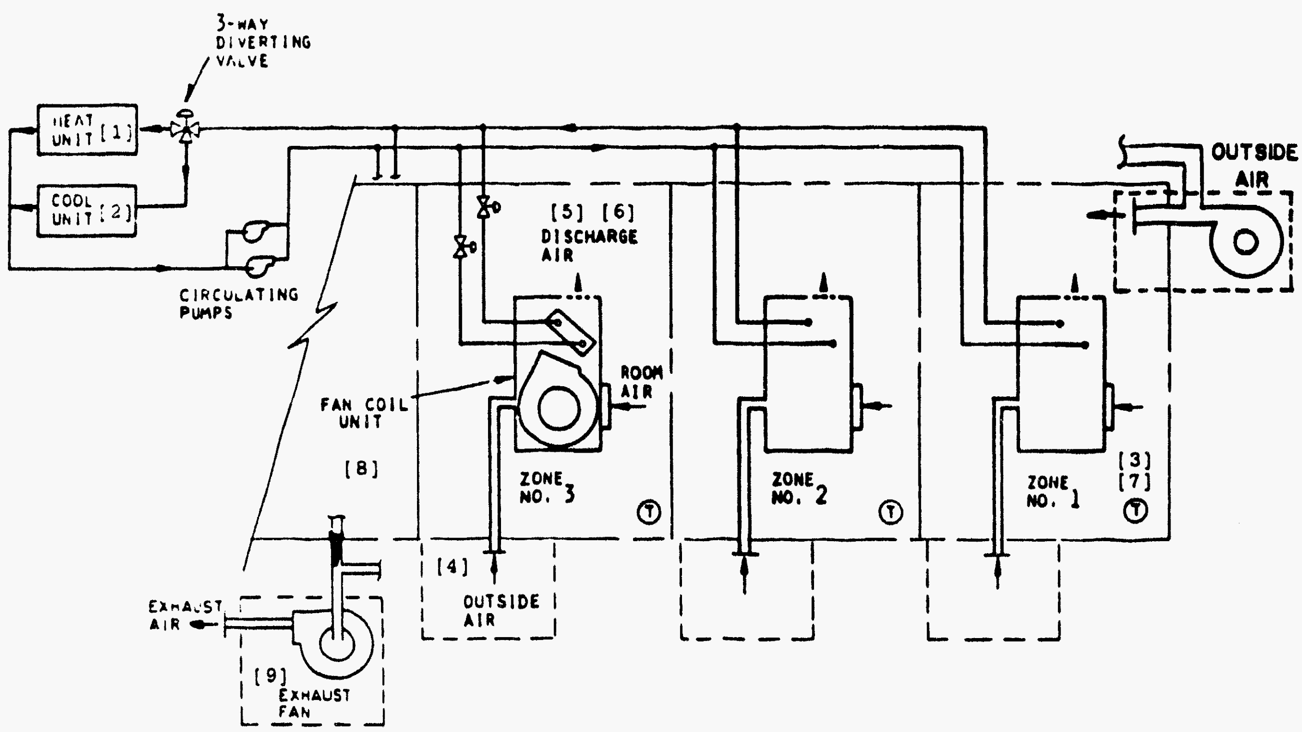


Figure 3.13: Two-Pipe Fan Coil System (TPFC)

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Centimeter

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 mm

1 2 3 4 5

Inches

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0

2 of 4

Suggested minimal input for TPFC system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31       (WD)    (1,7)(0) (8,18)(1)
                                               (19,24)(0)
                                       (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31       (WD)    (1,7)(99) (8,18)(76)
                                               (19,24)(99)
                                       (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31       (WD)    (1,7)(55) (8,18)(72)
                                               (19,24)(55)
                                       (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31             (WD)    (1,7)(0)
                                               (8,18)(1.0) (19,24)(0)
                                       (WEH)   (1,24)(0) ..


HEAT-ON = SCHEDULE   THRU   MAY 15   (ALL)   (1,24)   (1)
  [1]                THRU   SEP 15   (ALL)   (1,24)   (0)
                     THRU   DEC 31   (ALL)   (1,24)   (1) ..

COOL-ON = SCHEDULE   THRU   MAY 15   (ALL)   (1,24)   (1)
  [2]                THRU   SEP 15   (ALL)   (1,24)   (0)
                     THRU   DEC 31   (ALL)   (1,24)   (1) ..

OFFICE = ZONE          DESIGN-HEAT-T        =   72
                       DESIGN-COOL-T        =   74
                       HEAT-TEMP-SCH        =   HEATSETPT    [3]
                       COOL-TEMP-SCH        =   COOLSETPT    [3]
                       OA-CFM/PER           =   15 ..   [4]

AC-SYST = SYSTEM       SYSTEM-TYPE          =   TPFC
                       HEATING-SCHEDULE     =   HEAT-ON   [1]
                       COOLING-SCHEDULE     =   COOL-ON   [2]
                       MAX-SUPPLY-T         =   110   [5]
                       MIN-SUPPLY-T         =   55   [6]
                       NIGHT-CYCLE-CTRL     =   CYCLE-ON-ANY    [7]
                       FAN-SCHEDULE         =   FANS-ON   [8]
                       ZONE-NAMES           =   (OFFICE) ..
```

```
P1 = PLANT-ASSIGNMENT   SYSTEM-NAMES   =   (AC-SYST)
                        DHW-BTU/HR     =   10000
                        DHW-SCH        =   DHW ..

END ..

COMPUTE SYSTEMS ..

INPUT PLANT ..

P1 = PLANT-ASSIGNMENT ..

PLANT-REPORT SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER       SIZE = -999 ..
HWG = PLANT-EQUIPMENT   TYPE = HW-BOILER        SIZE = -999 ..   [1]
CHR = PLANT-EQUIPMENT   TYPE = HERM-REC-CHLR    SIZE = -999 ..   [2]

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..

END ..

COMPUTE PLANT ..
```

Additional capability for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [9]

Four-Pipe Fan Coil System (FPFC)

The FPFC system is identical to the TPFC with the following exceptions:

1) instead of an a combined heating/cooling coil, the fan coil units have separate heating and cooling coils;

2) each coil is connected to a separate piping system, one circulating cooled fluid and one circulating heated fluid. Thus, the fan coil(s) in one zone can cool at the same time that those in another zone are heating; changeover energy losses are minimal. Exhaust fans are optional for any or all zones. Except as noted above, the discussion of system design features, options, and DOE-2 input for TPFC applies to FPFC.

Note: On the schematic, items shown in dashed boxes are optional components.

BM017

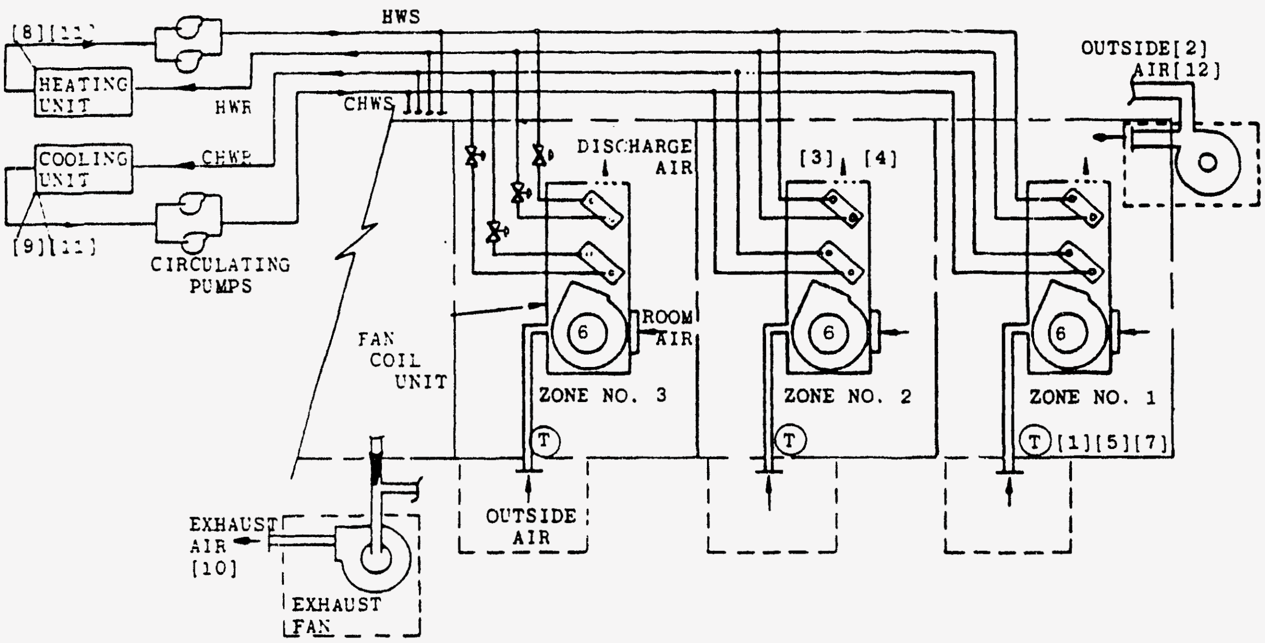

Figure 3.14: Four-Pipe Fan Coil System (FPFC)

Suggested minimal input for FPFC system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31         (WD)     (1,7)(0) (8,18)(1)
                                                  (19,24)(0)
                                         (WEH)    (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31         (WD)     (1,7)(99) (8,18)(76)
                                                  (19,24)(99)
                                         (WEH)    (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31         (WD)     (1,7)(55) (8,18)(72)
                                                  (19,24)(55)
                                         (WEH)    (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31               (WD)     (1,7)(0)
                                                  (8,18)(1.0) (19,24)(0)
                                         (WEH)    (1,24)(0) ..


OFFICE = ZONE             DESIGN-HEAT-T       =   72
                          DESIGN-COOL-T       =   74
                          HEAT-TEMP-SCH       =   HEATSETPT     [1]
                          COOL-TEMP-SCH       =   COOLSETPT     [1]
                          OA-CFM/PER          =   15 ..    [2]

AC-SYST = SYSTEM          SYSTEM-TYPE         =   FPFC
                          MAX-SUPPLY-T        =   110    [3]
                          MIN-SUPPLY-T        =   55    [4]
                          NIGHT-CYCLE-CTRL    =   CYCLE-ON-ANY     [5]
                          FAN-SCHEDULE        =   FANS-ON    [6]
                          ZONE-NAMES          =   (OFFICE) ..    [7]

P1 = PLANT-ASSIGNMENT     SYSTEM-NAMES        =   (AC-SYST)
                          DHW-BTU/HR          =   10000
                          DHW-SCH             =   DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
```

```
SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER        SIZE = -999 ..
HWG = PLANT-EQUIPMENT    TYPE = HW-BOILER         SIZE = -999 ..    [8]
CHR = PLANT-EQUIPMENT    TYPE = HERM-REC-CHLR     SIZE = -999 ..    [9]

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [10]

2) To disable the availability of either cooling or heating, insert schedules like that shown for TPFC; however, you may enter values representing outside air temperatures above and below which the cooling and heating is on, as follows: [11]

```
HEAT-ON = SCHEDULE    THRU MAY 15 (ALL) (1,24)(70)
                      THRU SEP 15 (ALL) (1,24)(0)
                      THRU DEC 31 (ALL) (1,24)(70) ..

COOL-ON = SCHEDULE    THRU MAY 15 (ALL) (1,24)(60)
                      THRU SEP 15 (ALL) (1,24)(1)
                      THRU DEC 31 (ALL) (1,24)(60) ..
```

3) Most fan coil systems do not have outside air intakes and make-up air is supplied to the corridor or to the back side of the fan coil unit. To simulate this configuration there has to be a corridor zone to which air can be supplied, because DOE-2 does not allow two air systems to be assigned to the same zone. See the example in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 3. [12]

Residential System (RESYS)
RESYS models a split system with a direct expansion air-cooled condensing unit. Residences that do not include unconditioned zones (crawl spaces and attics) can be simulated as a single-zone residence served by one system.

This is the only system in DOE-2 that simulates openable windows for natural ventilation and cooling. The ventilation is simulated through the keywords NATURAL-VENT-SCH, VENT-TEMP-SCH, and NATURAL-VENT-AC. See p.4.76, the SYSTEM-AIR section, for a discussion of simulation theory.

RESYS can be run with a cooling-only condensing unit plus a heating coil or with a cooling/heating heat pump condensing unit:

Residential System with DX Cooling and Heating Coil: This version of RESYS provides heating through a hot water coil, electric heater, gas furnace or oil furnace. It also includes a cooling coil connected to an air-cooled condensing unit, supply fan, and openable windows to provide natural ventilation and cooling. Ordinarily, the electric load for both the supply fan and compressor are included in the cooling EIR.

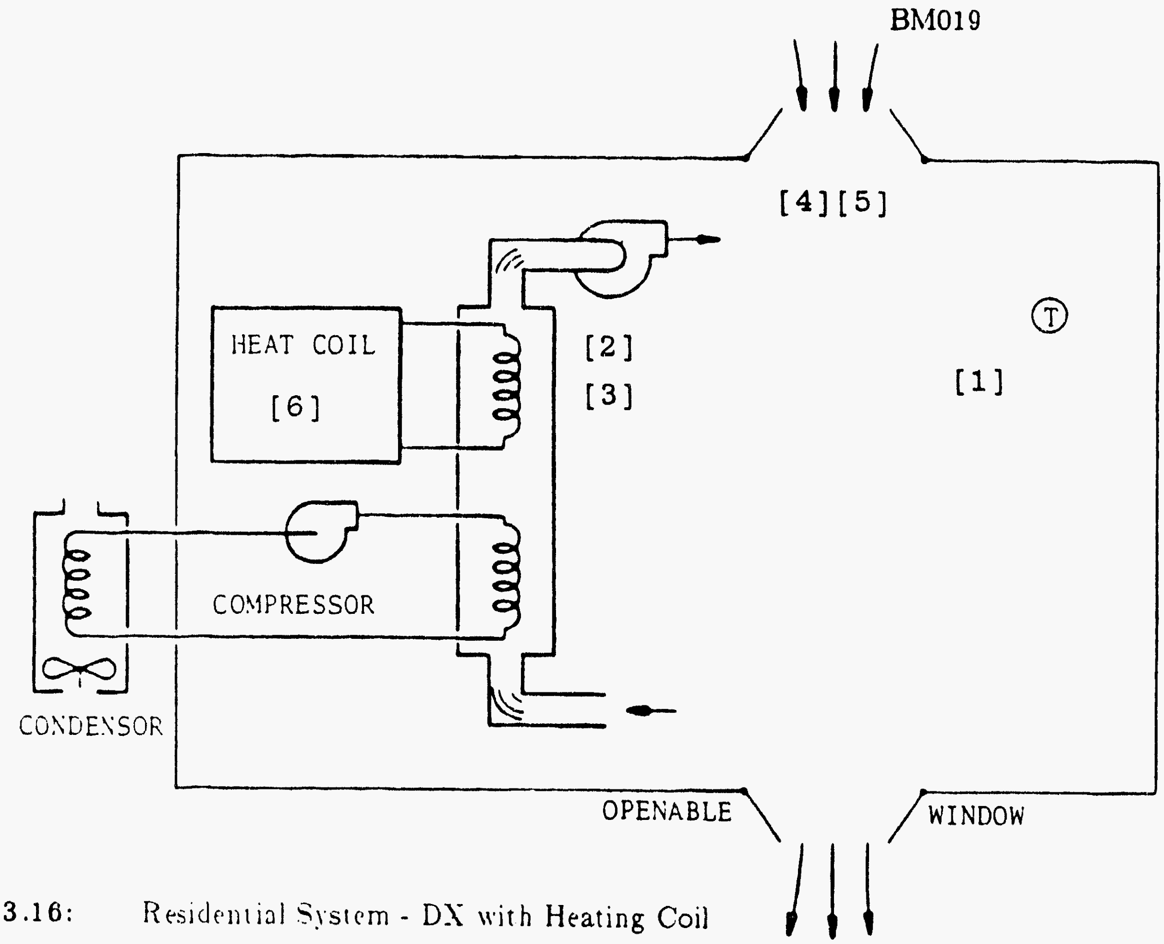

Figure 3.16: Residential System - DX with Heating Coil

Residential System with Heat Pump: This version of the system, the Residential Air-to-Air Heat Pump, is also for a single-zone constant-volume system intended for homes or offices. The rules stated in the RESYS system description apply to this version of the system. This unit provides forced-air heating and cooling. In its basic configuration it consists of a compressor, a four-way valve for reversing the refrigerant flow direction, air-cooled condenser with fan, evaporator with fan, filter (not shown), and thermostat. The condenser also serves as an evaporator and the evaporator as a condenser, depending on whether the unit is in the heating or cooling mode. The supply (indoor air) fan and the outdoor fan operate in a cycling mode. The unit may be specified with an auxiliary electrical heater. To use this type of RESYS specify HEAT-SOURCE = HEAT-PUMP. For additional heat pump capabilities, see "Heat Pump" p.A.5.

BM020

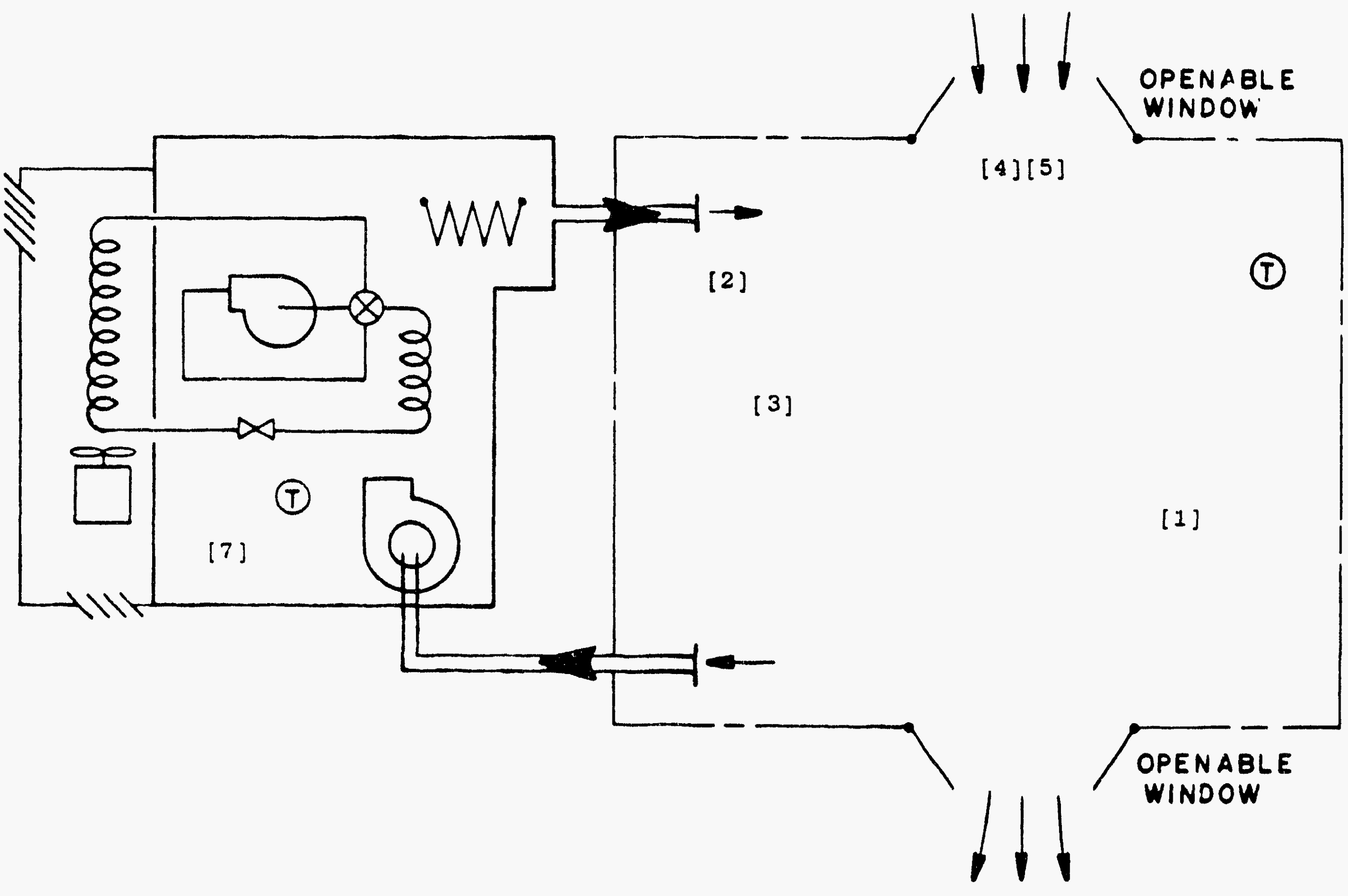

Figure 3.17: Residential Air-to-Air Heat Pump

Suggested minimal input for RESYS system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..

                         $ SYSTEMS SCHEDULES

COOLSETPT = SCHEDULE THRU DEC 31    (WD)    (1,7)(99) (8,18)(76)
                                            (19,24)(99)
                                    (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31    (WD)    (1,7)(55) (8,18)(72)
                                            (19,24)(55)
                                    (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31          (WD)    (1,7)(0)
                                            (8,18)(1.0) (19,24)(0)
                                    (WEH)   (1,24)(0) ..

WINDOWS-OPENABLE = SCHEDULE   THRU   APR 15   (ALL)   (1,24)   (1)
                              THRU   OCT 15   (ALL)   (1,24)   (0)
                              THRU   DEC 31   (ALL)   (1,24)   (1) ..

OFFICE = ZONE            DESIGN-HEAT-T       =    72
                         DESIGN-COOL-T       =    74
                         HEAT-TEMP-SCH       =    HEATSETPT   [1]
                         COOL-TEMP-SCH       =    COOLSETPT ..   [1]

AC-SYST = SYSTEM         SYSTEM-TYPE         =    RESYS
                         MAX-SUPPLY-T        =    110   [2]
                         MIN-SUPPLY-T        =    55    [3]
                         NATURAL-VENT-AC     =    10    [4]
                         NATURAL-VENT-SCH    =    WINDOWS-OPENABLE   [5]
                         HEAT-SOURCE         =    FURNACE   [6]
                                                  $ or HEAT-PUMP   [7]
                         ZONE-NAMES          =    (OFFICE) ..

P1 = PLANT-ASSIGNMENT    SYSTEM-NAMES        =    (AC-SYST)
                         DHW-BTU/HR          =    10000
                         DHW-SCH             =    DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
```

```
SHW = PLANT-EQUIPMENT  TYPE = DHW-HEATER  SIZE = -999 ..
END ..
COMPUTE PLANT ..
```

Additional capability for this system:

1) To disable the availability of either cooling or heating, insert schedules like that shown for TPFC; however, you may enter values representing outside air temperatures above and below which the cooling and heating is on, as follows:

```
HEAT-ON = SCHEDULE    THRU MAY 15 (ALL) (1,24)(70)
                      THRU SEP 15 (ALL) (1,24)(0)
                      THRU DEC 31 (ALL) (1,24)(70) ..
COOL-ON = SCHEDULE    THRU DEC 31 (ALL) (1,24)(60)
                      THRU SEP 15 (ALL) (1,24)(1)
                      THRU DEC 31 (ALL) (1,24)(60) ..
```

Packaged Single Zone Air Conditioner with Heating and Subzone Reheating Options (PSZ)

This hybrid system/plant, usually larger than a PTAC, cools by the direct expansion of a refrigerant and may optionally heat with gas, hot water, or an electric resistance heater. This unit is usually considered a commercial unit; it provides constant volume air to a control zone and constant- or variable-air volume flow to optional subzones. If you want variable volume air to all zones, that can be modeled by using the PVAVS system. This forced-air packaged unit may be either a unitary system (rooftop unit or outside-the-wall unit) or it may be a split unit (partially inside and partially outside). It may or may not require ducting. In its most basic configuration, PSZ consists of a compressor, air-cooled condenser, evaporator with a fan supplying cooled air to the indoors, filter (not shown), and thermostat. PSZ can optionally be specified with a central heating device, subzone reheating device(s), outside ventilation air, and economizer cooling. The supply fan may be either a blowthrough or a drawthrough type, with the fan motor either inside or outside the air stream. The condenser fan operates automatically on demand. An exhaust air fan and/or a return air fan may optionally be specified. The thermostat may be specified with night setback and night cycle control.

Note: On the schematic, items shown in dashed boxes are optional components.

BM021

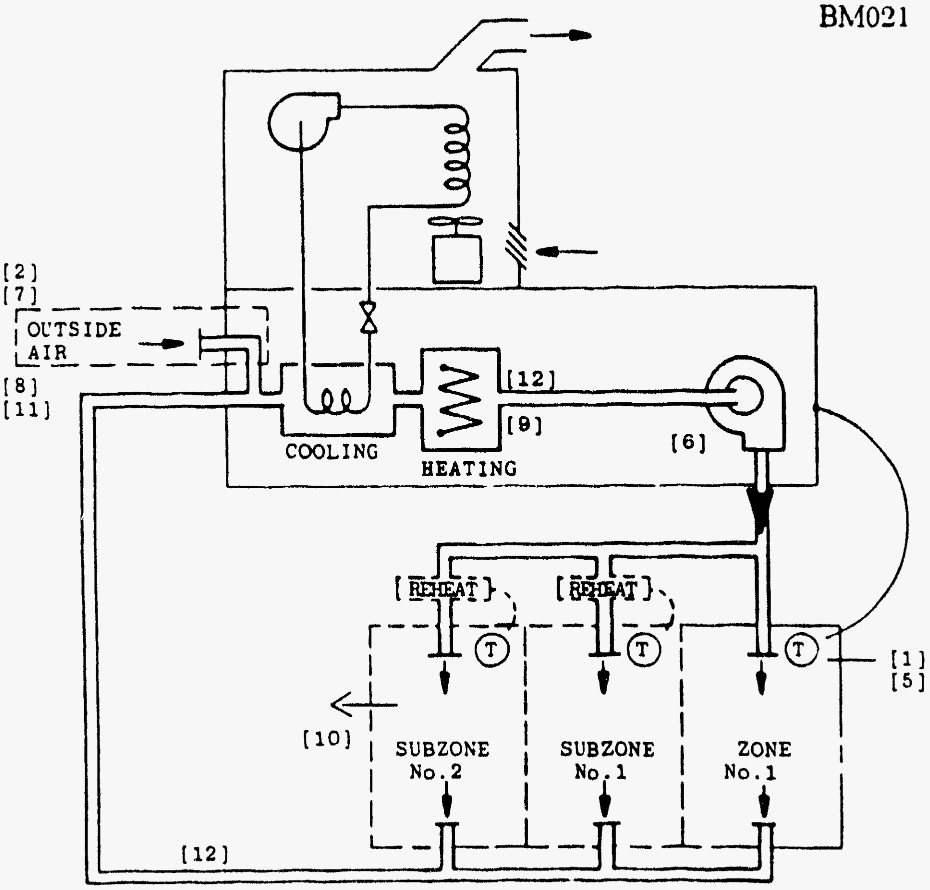

Figure 3.18: Packaged Single Zone Air Conditioner with Heating and Subzone Reheating Options (PSZ)

Suggested minimal input for PSZ system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-H,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31       (WD)    (1,7)(0) (8,18)(1)
                                               (19,24)(0)
                                       (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31       (WD)    (1,7)(99) (8,18)(76)
                                               (19,24)(99)
                                       (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31       (WD)    (1,7)(55) (8,18)(72)
                                               (19,24)(55)
                                       (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31             (WD)    (1,7)(0)
                                               (8,18)(1.0) (19,24)(0)
                                       (WEH)   (1,24)(0) ..


OFFICE = ZONE               DESIGN-HEAT-T        =    72
                            DESIGN-COOL-T        =    74
                            HEAT-TEMP-SCH        =    HEATSETPT    [1]
                            COOL-TEMP-SCH        =    COOLSETPT    [1]
                            OA-CFM/PER           =    15 ..   [2]

AC-SYST = SYSTEM            SYSTEM-TYPE          =    PSZ
                            MAX-SUPPLY-T         =    110    [3]
                            MIN-SUPPLY-T         =    55     [4]
                            NIGHT-CYCLE-CTRL     =    CYCLE-ON-FIRST    [5]
                            FAN-SCHEDULE         =    FANS-ON    [6]
                            OA-CONTROL           =    TEMP    [7]
                            ECONO-LIMIT-T        =    60     [8]
                            HEAT-SOURCE          =    FURNACE    [9]
                                                      $ or HEAT-PUMP,
                                                      $ ELECTRIC, or
                                                      $ HOT-WATER
                            ZONE-NAMES           =    (OFFICE) ..

P1 = PLANT-ASSIGNMENT       SYSTEM-NAMES         =    (AC-SYST)
                            DHW-BTU/HR           =    10000
                            DHW-SCH              =    DHW ..
```

```
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER    SIZE = -999 ..
END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [10]

2) To disable the economizer change OA-CONTROL = TEMP to OA-CONTROL = FIXED. [11]

3) To enable control of maximum humidity and use compressor superheat for reheat, insert MAXIMUM-HUMIDITY = Value (60% is allowed under the new ASHRAE 90.1 Standard) and also MAX-COND-RCVRY = Value (.5 is typical) in the SYSTEM keyword list. Note that REHEAT-DELTA-T must also be specified. [12]

4) If HOT-WATER is the type of HEAT-SOURCE selected, you must also insert a hot water generator in PLANT.

5) Water cooled condenser and water side economizer options are available for this system. See "Water Cooled Condenser Option for Packaged Units PSZ, PVAVS, and PVVT" in the *Supplement (2.1E)*.

Packaged Multizone Fan System (PMZS)

PMZS is a multizone constant-volume forced-air system (actually a hybrid system/plant) that cools by the direct expansion of a refrigerant and heats with gas, hot water, or an electric resistance heater. PMZS may have heat recovery from condenser coils. PMZS usually consists of a manufacturer-matched set of components within a single enclosure that is rooftop mounted, but it may also be a split unit (partially inside and partially outside). In its most basic configuration, PMZS consists of one or more refrigeration compressors, one or more air-cooled condensers with a fan discharging heat to the outdoors, one or more evaporators with a fan supplying cooled air to the indoors, a heating device, filter (not shown), and a thermostat in each zone. PMZS can optionally be specified with outside ventilation air, economizer cooling, an exhaust fan and a return fan. It has a blowthrough fan, with the fan motor either inside or outside the airstream. The condenser fan operates automatically on demand. The thermostat may be specified with night setback and night cycle control.

In the DOE-2 simulation of PMZS, there is individual control of temperature in the different zones, with no preconditioning of outside ventilation air.

Note: On the schematic, items shown in dashed boxes are optional components.

BM022

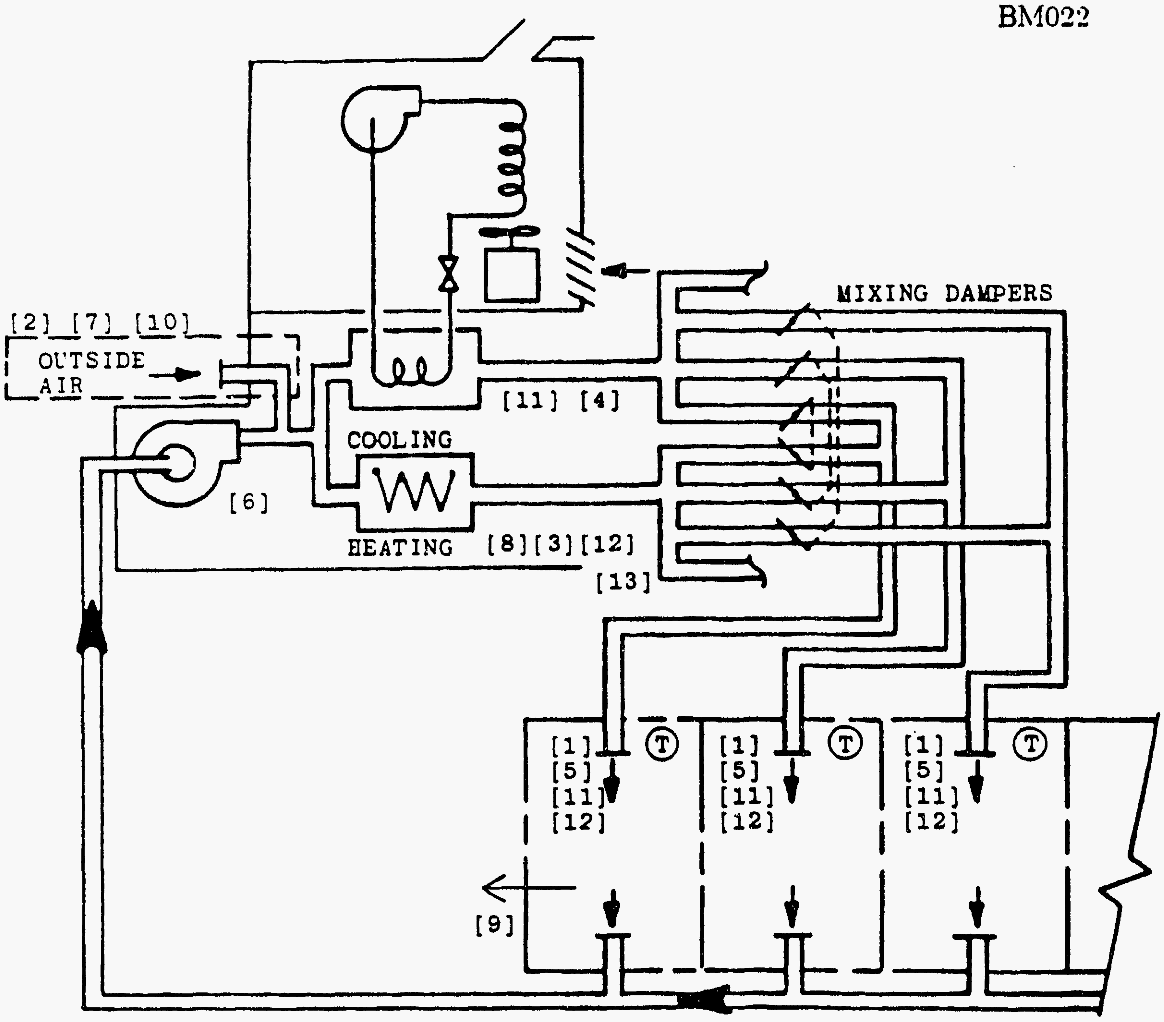

Figure 3.19: Packaged Multizone Fan System (PMZS)

Suggested minimal input for PMZS system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-H,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31       (WD)    (1,7)(0) (8,18)(1)
                                               (19,24)(0)
                                       (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31       (WD)    (1,7)(99) (8,18)(76)
                                               (19,24)(99)
                                       (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31       (WD)    (1,7)(55) (8,18)(72)
                                               (19,24)(55)
                                       (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31             (WD)    (1,7)(0)
                                               (8,18)(1.0) (19,24)(0)
                                       (WEH)   (1,24)(0) ..


OFFICE = ZONE            DESIGN-HEAT-T      =   72
                         DESIGN-COOL-T      =   74
                         HEAT-TEMP-SCH      =   HEATSETPT    [1]
                         COOL-TEMP-SCH      =   COOLSETPT    [1]
                         OA-CFM PER         =   15 ..    [2]

AC-SYST = SYSTEM         SYSTEM-TYPE        =   PMZS
                         MAX-SUPPLY-T       =   110    [3]
                         MIN-SUPPLY-T       =   55     [4]
                         NIGHT-CYCLE-CTRL   =   CYCLE-ON-ANY    [5]
                         FAN-SCHEDULE       =   FANS-ON    [6]
                         OA-CONTROL         =   TEMP    [7]
                         ECONO-LIMIT-T      =   60     [7]
                         HEAT-SOURCE        =   ELECTRIC    [8]
                         ZONE-NAMES         =   (OFFICE) ..

P1 = PLANT-ASSIGNMENT    SYSTEM-NAMES       =   (AC-SYST)
                         DHW-BTU HR         =   10000
                         DHW-SCH            =   DHW ..

END ..
COMPUTE  SYSTEMS ..
```

```
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER   SIZE = -999 ..
END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. **[9]**

2) To disable the economizer change the OA-CONTROL = TEMP to OA-CONTROL = FIXED. **[10]**

3) To simulate a discriminator control of the cold deck supply air temperature add COOL-CONTROL = WARMEST to the SYSTEM keyword list. **[11]**

4) To simulate a discriminator control of the hot deck supply air temperature add HEAT-CONTROL = COLDEST to the SYSTEM keyword list. **[12]**

5) Alternatives to items 3 and 4 above are reset of cold and hot deck supply air temperature. An example of this control is is covered in the *Sample Run Book (2.1E)* 31-Story Office Building, Run 1.

6) To simulate turning off the hot deck whenever the outside temperature is above 65°F, insert a new schedule like this: **[13]**

   HEAT-OFF = SCHEDULE THRU DEC 31 (ALL) (1,24) (65) ..

   and add

   HEATING-SCHEDULE = HEAT-OFF

   to the SYSTEM keyword list.

Packaged Variable-Air-Volume System (PVAVS)

PVAVS is a variable-volume system/plant that cools the zones by direct expansion of a refrigerant and optionally heats the zones with gas, fuel oil, hot-water, or an electric resistance heater. In the cooling mode the supply air temperature is usually constant and the volume of air is varied from minimum to maximum to satisfy the zone requirements. In the heating mode the supply air temperature is varied in response to the zone requirements and the volume of air is held at the minimum (constant). In its most basic configuration, PVAVS consists of a compressor, air-cooled condenser with a fan discharging heat to the outdoors, evaporator with a fan supplying cooled air to the indoors, reheat coils at the zone level, filter (not shown), variable-volume control boxes, and thermostats. PVAVS unit can be optionally specified with outside ventilating air, exhaust fan, return air fan, and economizer control. The supply fan may be either a blowthrough or drawthrough, with the fan motor either inside or outside the airstream. The thermostat may be specified with night setback and night cycle control.

Note: On the schematic, items shown in dashed boxes are optional components.

BM023

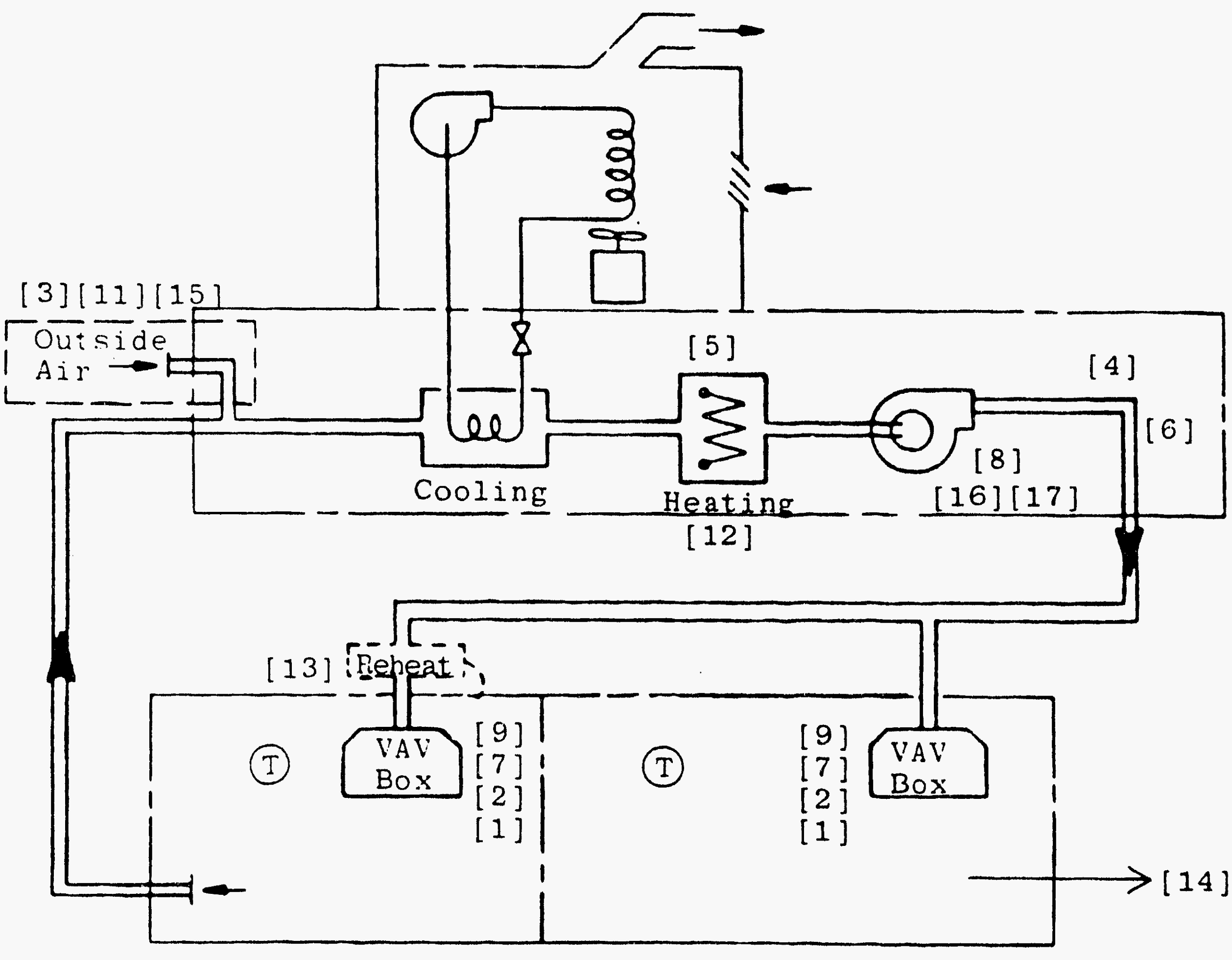

Figure 3.20: Packaged Variable-Air-Volume System (PVAVS)

Suggested minimal input for PVAVS system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-H,SS-O) ..

                        $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31        (WD)    (1,7)(0) (8,18)(1)
                                                (19,24)(0)
                                        (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(99) (8,18)(76)
                                                (19,24)(99)
                                        (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(55) (8,18)(72)
                                                (19,24)(55)
                                        (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31              (WD)    (1,7)(0)
                                                (8,18)(1.0) (19,24)(0)
                                        (WEH)   (1,24)(0) ..

OFFICE = ZONE             DESIGN-HEAT-T       =   72
                          DESIGN-COOL-T       =   74
                          HEAT-TEMP-SCH       =   HEATSETPT   [1]
                          COOL-TEMP-SCH       =   COOLSETPT   [1]
                          THERMOSTAT-TYPE     =   REVERSE-ACTION   [2]
                          OA-CFM/PER          =   15 ..   [3]

AC-SYST = SYSTEM          SYSTEM-TYPE         =   PVAVS
                          MAX-SUPPLY-T        =   110   [4]
                          HEAT-SET-T          =   70   [5]
                          MIN-SUPPLY-T        =   55   [6]
                          NIGHT-CYCLE-CTRL    =   CYCLE-ON-ANY   [7]
                          FAN-SCHEDULE        =   FANS-ON   [8]
                          MIN-CFM-RATIO       =   .3   [9]
                          REHEAT-DELTA-T      =   55   [10]
                          OA-CONTROL          =   TEMP   [11]
                          ECONO-LIMIT-T       =   60   [11]
                          HEAT-SOURCE         =   ELECTRIC   [12]
                          ZONE-HEAT-SOURCE    =   ELECTRIC   [13]
                          ZONE-NAMES          =   (OFFICE) ..

P1 = PLANT-ASSIGNMENT     SYSTEM-NAMES        =   (AC-SYST)
                          DHW-BTU/HR          =   10000
                          DHW-SCH             =   DHW ..
```

```
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER    SIZE = -999 ..
END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the ZONE keyword list. [14]

2) To enable a humidifier which requires heat to evaporate water into the air add MIN-HUMIDITY = Value (25% is typical) to the SYSTEM keyword list.

3) To enable heat recovery to exchange relief air heat with outside air heat add RECOVERY-EFF = Value (0.6 is typical) to the SYSTEM keyword list.

4) To disable the economizer change OA-CONTROL = TEMP to OA-CONTROL = FIXED. [15]

5) To enable variable speed control of the fan motor, insert FAN-CONTROL = SPEED to the SYSTEM keyword list. [16]

6) To simulate riding the fan curve with neither inlet vanes nor speed control, insert FAN-CONTROL = DISCHARGE to the keyword list. [17]

7) Water cooled condenser and water side economizer options are available for this system. See "Water Cooled Condenser Option for Packaged Units PSZ, PVAVS, and PVVT" in the *Supplement (2.1E)*.

Packaged Terminal Air Conditioner (PTAC)

PTAC systems are designed primarily for commercial installations to provide total heating and cooling for a room or zone; they are specifically designed for through-the-wall installation. These hybrid system/plant units are mostly used in hotel/motel guest rooms, apartments, hospitals, nursing homes, and office buildings. All PTAC units discharge air directly into the space without ductwork.

PTAC with DX Cooling and Electric Resistance Heating

This particular PTAC provides cooling by the direct expansion of a refrigerant and heating by an electric resistance heater. In its most basic configuration it consists of a compressor, air-cooled condenser with a fan discharging heat to the outdoors, evaporator usually with a two-speed fan supplying cooled air to the indoors, electric heater, filter (not shown), and thermostat. The unit may be specified with outside ventilation air. This PTAC unit has no return fan option and the supply fan is assumed to be a blowthrough type with the fan motor located in the airstream. Optionally, the unit may be specified with a thermostat with night setback.

Note: On the schematic, items shown in dashed boxes are optional components.

BM024

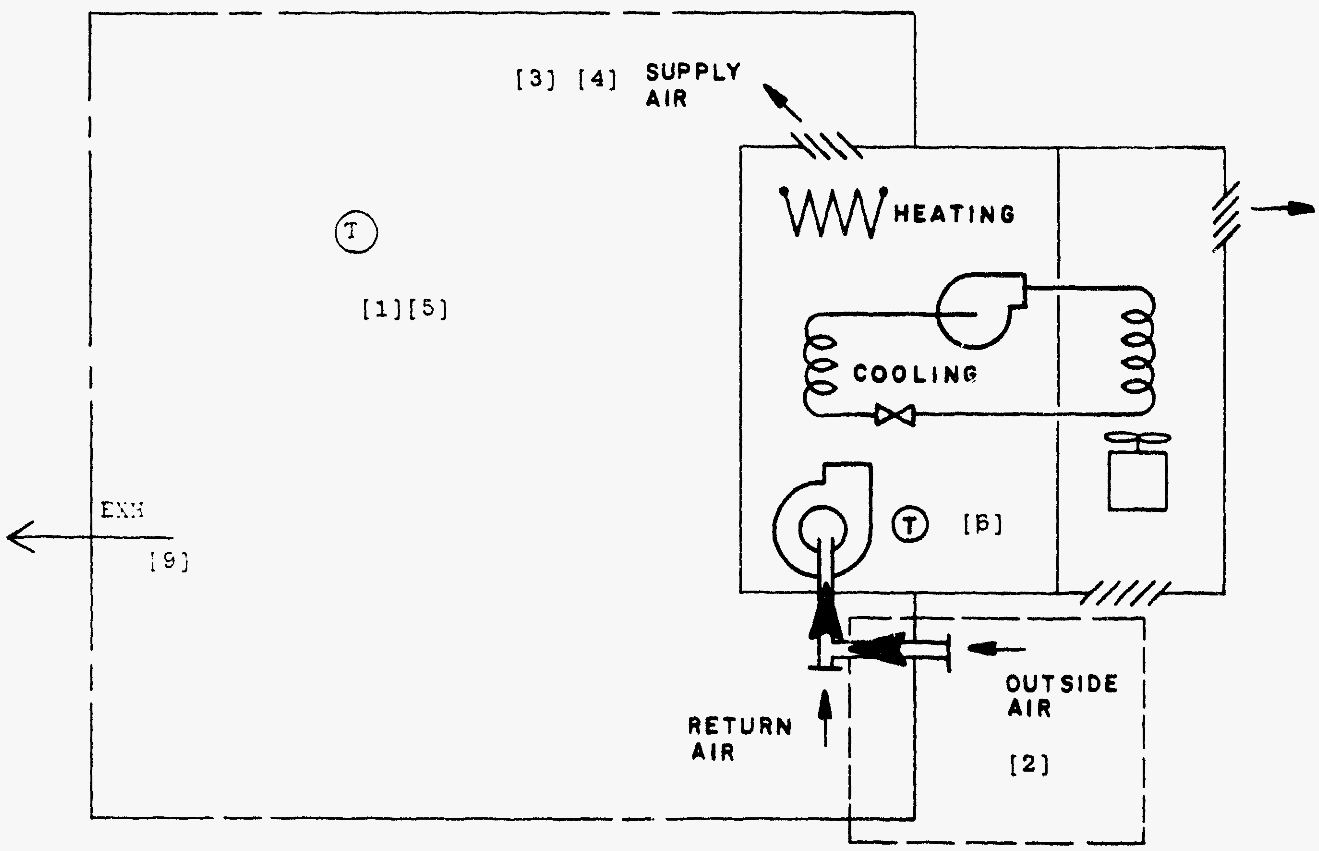

Figure 3.21: PTAC with DX Cooling

PTAC with Air-to-Air Heat Pump:

This type of PTAC provides year-round forced-air heating and cooling. It consists of a single air-to-air heat pump. In its basic configuration the heat pump unit consists of a compressor, four-way valve for reversing the refrigerant flow direction, condenser with fan, evaporator usually with a two-speed fan, filter (not shown), and thermostat. The condenser also serves as an evaporator and the evaporator as a condenser, depending upon whether the unit is in the heating or cooling mode of operation. The unit may be specified with outside ventilation air, in which case the supply fan runs continuously rather than cycling with the compressor. This PTAC has no return fan option; the supply fan is assumed to be a two-speed blowthrough type with the fan motor located in the airstream. Optionally, the unit may be specified with a thermostat with night setback.

Note: On the schematic, items shown in dashed boxes are optional components.

BM025

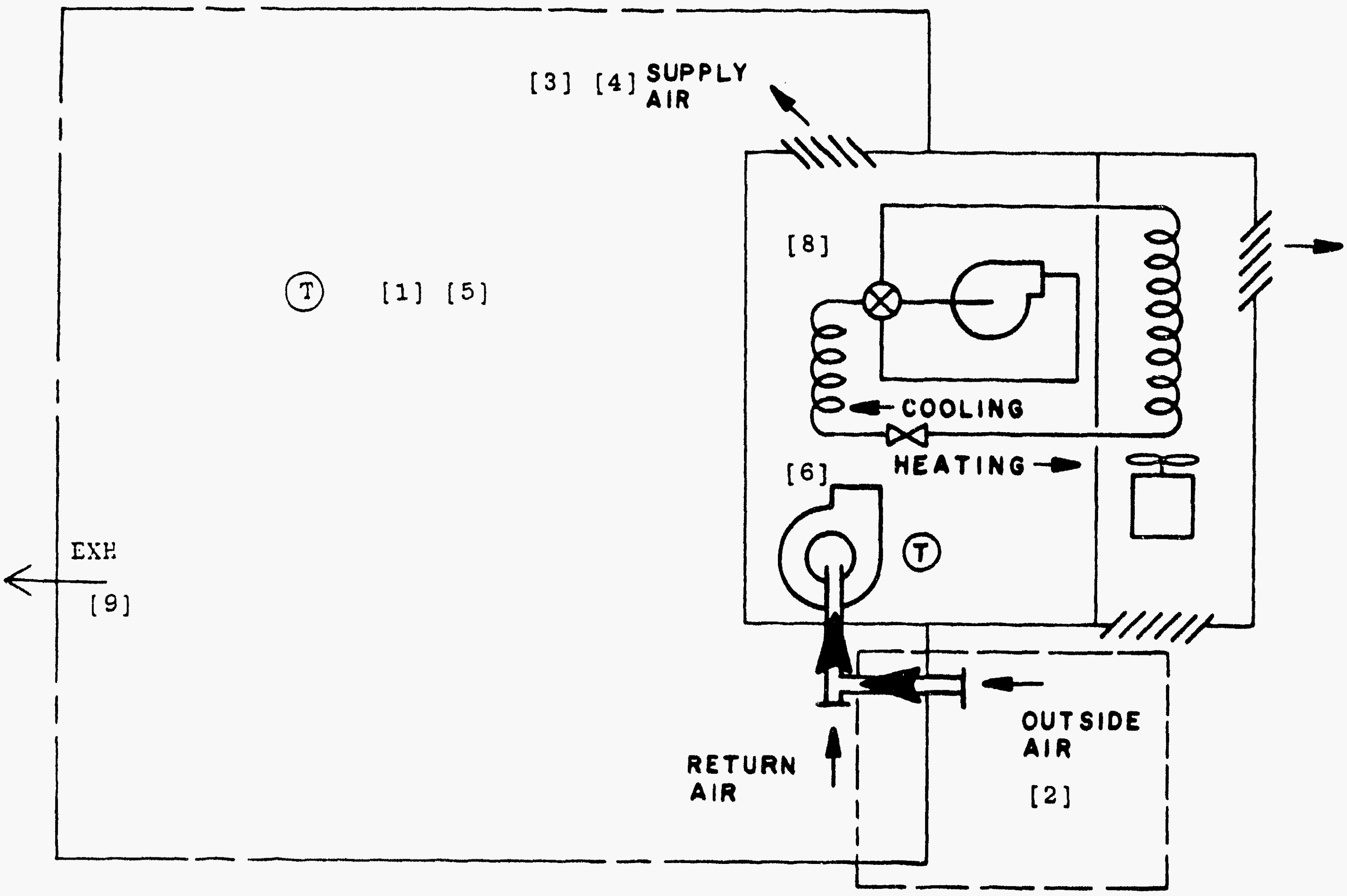

Figure 3.22: PTAC with Air-to-Air Heat Pump

Suggested minimal input for PTAC system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-H,SS-O) ..

                         $ SYSTEMS SCHEDULES

FANS-ON =    SCHEDULE THRU DEC 31         (WD)     (1,7)(0) (8,18)(1)
                                                   (19,24)(0)
                                          (WEH)    (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31          (WD)     (1,7)(99) (8,18)(76)
                                                   (19,24)(99)
                                          (WEH)    (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31          (WD)     (1,7)(55) (8,18)(72)
                                                   (19,24)(55)
                                          (WEH)    (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31                (WD)     (1,7)(0)
                                                   (8,18)(1.0) (19,24)(0)
                                          (WEH)    (1,24)(0) ..

OFFICE = ZONE             DESIGN-HEAT-T       =    72
                          DESIGN-COOL-T       =    74
                          HEAT-TEMP-SCH       =    HEATSETPT     [1]
                          COOL-TEMP-SCH       =    COOLSETPT     [1]
                          OA-CFM PER          =    15 ..    [2]
AC-SYST = SYSTEM          SYSTEM-TYPE         =    PTAC
                          MAX-SUPPLY-T        =    110    [3]
                          MIN-SUPPLY-T        =    55    [4]
                          NIGHT-CYCLE-CTRL    =    CYCLE-ON-ANY     [5]
                          FAN-SCHEDULE        =    FANS-ON    [6]
                          HEAT-SOURCE         =    ELECTRIC    [7]
                                                   $ alternatively
                                                   $ HEAT-PUMP     [8]
                          ZONE-NAMES          =    (OFFICE) ..

P1 = PLANT-ASSIGNMENT     SYSTEM-NAMES        =    (AC-SYST)
                          DHW-BTU HR          =    10000
                          DHW-SCH             =    DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
```

```
SHW = PLANT-EQUIPMENT  TYPE = DHW-HEATER  SIZE = -999 ..
END ..
COMPUTE PLANT ..
```

Additional capability for this system:

1) To enable an exhaust fan add the keywords **EXHAUST-CFM** = Value (CFM) and **EXHAUST-KW** = Value (.0001 is typical) to the **ZONE** keyword list. [9]

Packaged Total Gas Solid Desiccant System (PTGSD)*

This is a new system that has recently appeared on the market. It is a small (5 to 10 ton, 1800 - 3600 cfm) packaged unit that uses a desiccant wheel in conjunction with direct and indirect evaporative cooling, instead of the usual DX coils. It uses a gas-fired hydronic heater to regenerate the desiccant and to provide heating. The result is a unit that primarily consumes gas to provide heating and cooling.

The unit consists of supply and return air fans, a lithium chloride impregnated desiccant wheel, an indirect evaporative cooler, a heating coil, a direct evaporative cooler, and a reactivation air heater coil (see schematic). In the cooling mode, the supply fan blows 100% outside air onto the dry half of the desiccant wheel. Hot, dry air emerges from the other side of the wheel. This air is then cooled by an air-to-air heat exchanger, the other air stream being evaporatively cooled return air. Finally, the air is cooled even further by a direct evaporative cooler. The resulting supply air is then ducted to the zones. Return air is drawn through a direct evaporative cooler and is then heated by passing through the air-to-air heat exchanger (taking heat from the supply air emerging from the desiccant wheel). More heat is added by the reactivation air heater coil. Then, the return air passes through the other half of the wheel, regenerating the desiccant by carrying off the moisture absorbed by the lithium chloride. Finally the return air is exhausted to the outside.

The supply and return fans are assumed to be variable speed. The zone air temperature is controlled by varying the flow of the supply air; the system is a variable air volume system. The first named zone in the ZONE-NAMES list is the control zone.

In the heating mode, the fans are assumed to be at minimum speed. The minimum amount of outside air is brought in, mixed with return air, and heated by the heating coil. The wheel motor, reactivation heater coil, and both humidifiers (direct evaporative coolers) and their pumps are, of course, turned off.

The unit is simulated as operating in several intermediate modes. One such mode is to operate the unit as an evaporative cooler. Only the supply air humidifier and the indirect evaporative cooler (return air humidifier and air-to-air heat exchanger) are operated, no dehumidifying is done, and no gas is consumed. Another mode is to cool with outside air only, or with a mixture of outside and return air. You have no control over which operating mode is selected for each hour time step. The simulation determines which modes are capable of meeting the load and, of these, which is most efficient. Thus, the unit is simulated to use the minimum possible energy.

The PTGSD system MUST be sized by you. The DOE-2 design routine will not estimate a size from the LOAD peaks as it does for other system types. The two keywords required are SUPPLY-CFM (or SUPPLY-FLOW) and HEATING-CAPACITY in the SYSTEM command.

* The desiccant cooling system simulation in DOE-2.1D was developed with the support and collaboration of the Gas Research Institute and the GARD Division of the Chamberlain Manufacturing Corporation.

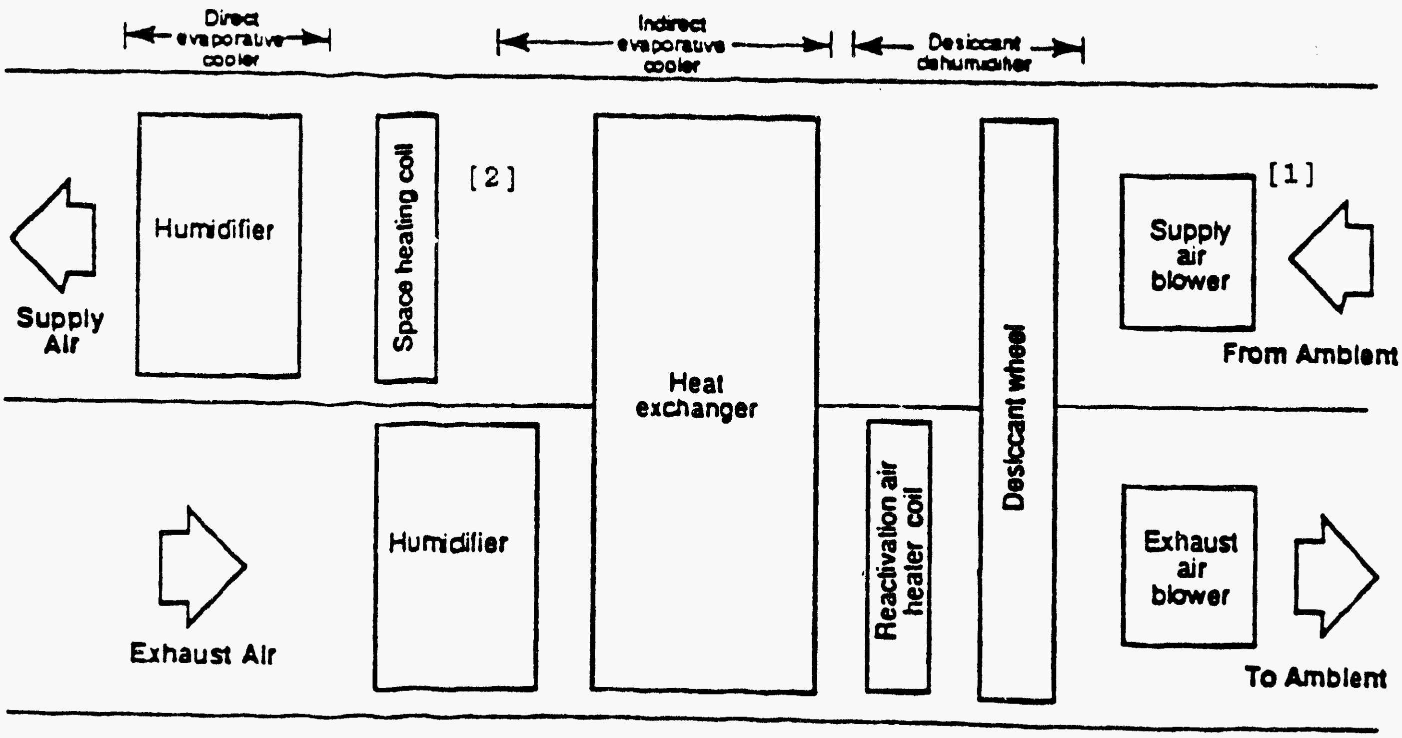

Figure 3.23: Packaged Total Gas Solid Desiccant System

Suggested minimal input for PTGSD system with an economizer:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY (SS-A,SS-H,SS-O) ..

                    $ SYSTEMS SCHEDULES

FANS-ON =    SCHEDULE THRU DEC 31       (WD)    (1,7)(0) (8,18)(1)
                                                (19,24)(0)
                                        (WEH)   (1,24)(0) ..

COOLSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(99) (8,18)(76)
                                                (19,24)(99)
                                        (WEH)   (1,24)(99) ..

HEATSETPT = SCHEDULE THRU DEC 31        (WD)    (1,7)(55) (8,18)(72)
                                                (19,24)(55)
                                        (WEH)   (1,24)(55) ..
```

```
DHW = SCHEDULE THRU DEC 31             (WD)    (1,7)(0)
                                               (8,18)(1.0) (19,24)(0)
                                       (WEH)   (1,24)(0) ..

OFFICE = ZONE              DESIGN-HEAT-T       = 72
                           DESIGN-COOL-T       = 74
                           HEAT-TEMP-SCH       = HEATSETPT
                           COOL-TEMP-SCH       = COOLSETPT
                           OA-CFM/PER          = 15
                           BASEBOARD-CTRL      = THERMOSTATIC
                           BASEBOARD-RATING    = -30000 ..

AC-SYST = SYSTEM           SYSTEM-TYPE         = PTGSD
                           FAN-SCHEDULE        = FANS-ON     [1]
                           SUPPLY-CFM          = 5000
                           HEATING-CAPACITY    = -100000     [2]
                           NIGHT-CYCLE-CTRL    = STAY-OFF
                           ZONE-NAMES          = (OFFICE) ..

P1 = PLANT-ASSIGNMENT      SYSTEM-NAMES        =
                           DHW-BTU/HR          =
                           DHW-SCH             =

END ..

COMPUTE SYSTEMS ..

INPUT PLANT ..

PLANT-REPORT  SUMMARY (BEPS)

SHW = PLANT-EQUIPMENT  TYPE DHW-HEATER   SIZE = -999 ..

END ..

COMPUTE PLANT ..
```

Additional capabilities for this system:

1) To enable an exhaust fan, add the keywords EXHAUST-CFM = Value (CFM) and EXHAUST-KW = Value (.0001 is typical) to the SYSTEM keyword list.

2) To limit the maximum humidity level insert MAX-HUMIDITY = 60 (typical) to the SYSTEM keyword list.

3) A fixed outside air system without an economizer is not compatible because the system uses 100% outside air on full cooling.

4) Baseboard heating is advisable because it can provide night heating without cycling the fan on. However, you can enable the unit fan to control the night setback by changing the keyword

NIGHT-CYCLE-CTRL = STAY-OFF
to
NIGHT-CYCLE-CTRL = CYCLE-ON-ANY.

Unit Heater (UHT)
This simulation is for a unit heater serving one zone. Multiple systems, that is, multiple zones with one unit heater each, may be simulated. This unit is not capable of introducing outside air. Space temperature control is accomplished by on-off cycling control of the fan.

BM027

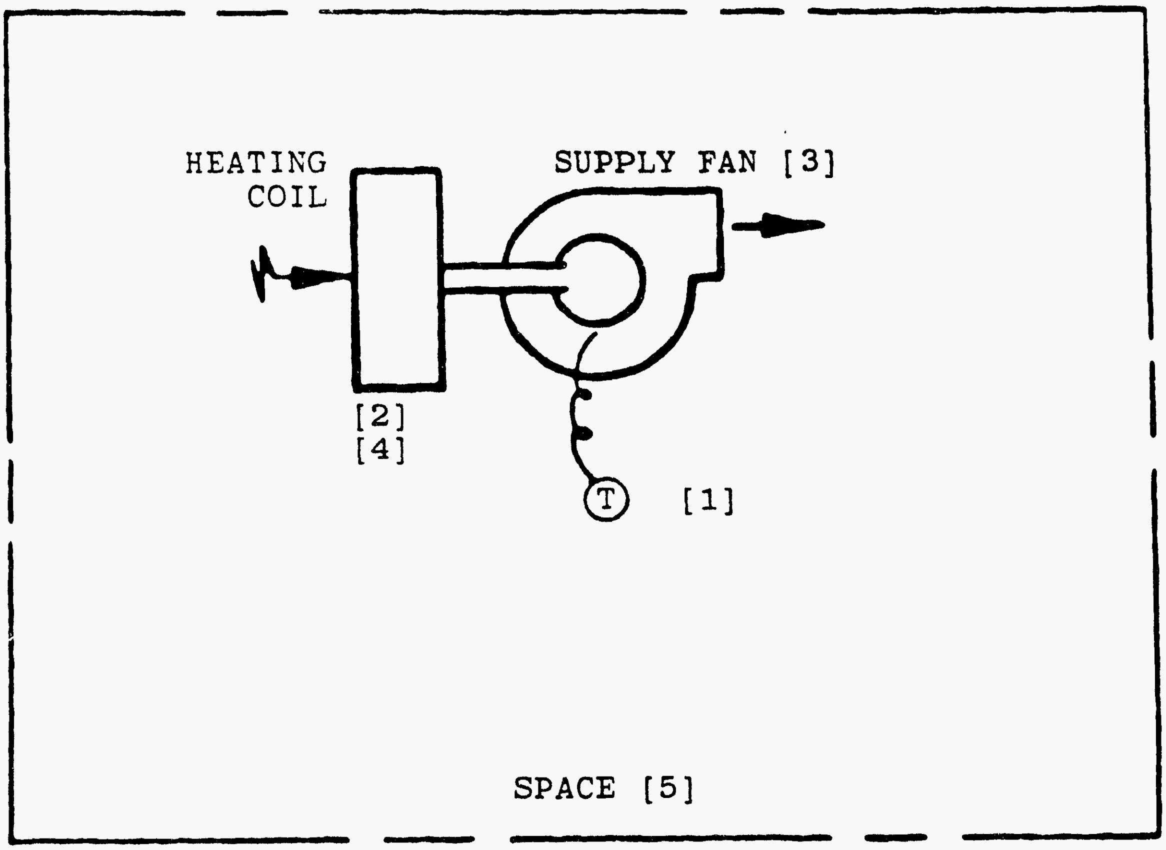

Figure 3.24: Unit Heater (UHT)

Suggested minimal input for UHT system:

INPUT SYSTEMS ..

SYSTEMS-REPORT SUMMARY=(SS-A,SS-O) ..

$ SYSTEMS SCHEDULES

FANS-ON =	SCHEDULE THRU DEC 31	(WD)	(1,7)(0) (8,18)(1) (19,24)(0)
		(WEH)	(1,24)(0) ..
HEATSETPT =	SCHEDULE THRU DEC 31	(WD)	(1,7)(55) (8,18)(72) (19,24)(55)

```
                                            (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31                  (WD)    (1,7)(0)
                                                    (8,18)(1.0) (19,24)(0)
                                            (WEH)   (1,24)(0) ..

OFFICE = ZONE              DESIGN-HEAT-T      =    72
                           HEAT-TEMP-SCH      =    HEATSETPT ..      [1]

AC-SYST = SYSTEM           SYSTEM-TYPE        =    UHT
                           MAX-SUPPLY-T       =    110    [2]
                           FAN-SCHEDULE       =    FANS-ON     [3]
                           HEAT-SOURCE        =    ELECTRIC
                                                   $ or FURNACE     [4]
                           ZONE-NAMES         =    (OFFICE) ..

P1 = PLANT-ASSIGNMENT      SYSTEM-NAMES       =    (AC-SYST)
                           DHW-BTU/HR         =    10000
                           DHW-SCH            =    DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT  TYPE = DHW-HEATER  SIZE = -999 ..
```

Unit Ventilator (UVT)

This simulation is the same as that described for Unit Heater (UHT), except that the unit ventilator is also capable of introducing a fixed amount of outside air during heating and operating an outside air damper for cooling.

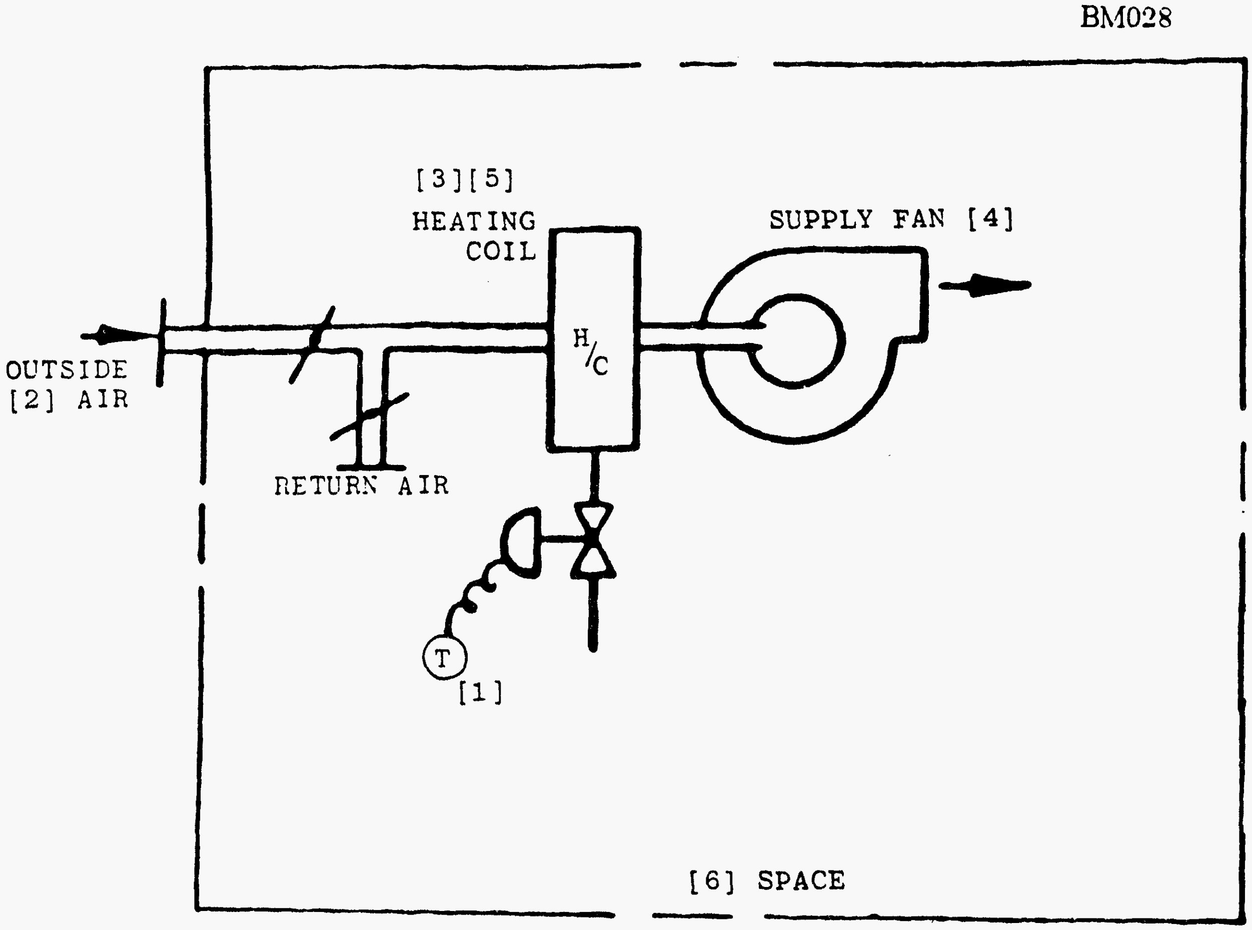

Figure 3.25: Unit Ventilator (UVT)

Suggested minimal input for UVT system:

INPUT SYSTEMS ..

SYSTEMS-REPORT SUMMARY=(SS-A,SS-O) ..

$ SYSTEMS SCHEDULES

FANS-ON =	SCHEDULE THRU DEC 31	(WD)	(1,7)(0) (8,18)(1) (19,24)(0)
		(WEH)	(1,24)(0) ..
HEATSETPT =	SCHEDULE THRU DEC 31	(WD)	(1.7)(55) (8,18)(72) (19,24)(55)

```
                                         (WEH)   (1,24)(55) ..

DHW = SCHEDULE THRU DEC 31               (WD)    (1,7)(0)
                                                 (8,18)(1.0) (19,24)(0)
                                         (WEH)   (1,24)(0) ..

OFFICE = ZONE              DESIGN-HEAT-T    =    72
                           HEAT-TEMP-SCH    =    HEATSETPT ..    [1]
                           OA-CFM/PER       =    15 ..   [2]

AC-SYST = SYSTEM           SYSTEM-TYPE      =    UVT
                           MAX-SUPPLY-T     =    110    [3]
                           FAN-SCHEDULE     =    FANS-ON    [4]
                           HEAT-SOURCE      =    ELECTRIC    [5]
                                                 $ or FURNACE
                                                 $ or HOT-WATER with
                                                 $ a HWG in PLANT
                           ZONE-NAMES       =    (OFFICE) ..    [6]

P1 = PLANT-ASSIGNMENT      SYSTEM-NAMES     =    (AC-SYST)
                           DHW-BTU/HR       =    10000
                           DHW-SCH          =    DHW ..

END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
P1 = PLANT-ASSIGNMENT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT  TYPE = DHW-HEATER  SIZE = -999 ..
```

Description of SYSTEMS Input Instructions

Limitation on the Number of Commands

The maximum number of each SYSTEMS command that the program can accept in a single run is shown below. A building that cannot be specified within these limits should be modeled as two separate buildings.

Command	Maximum Number
DAY-RESET-SCH and/or DAY-SCHEDULE	300 combined
PLANT-ASSIGNMENT	4
RESET-SCHEDULE and/or SCHEDULE	100 combined
SYSTEM	100
SYSTEM-AIR	50
SYSTEM-CONTROL	50
SYSTEM-EQUIPMENT	50
SYSTEM-FANS	50
SYSTEM-FLUID	50
SYSTEM-TERMINAL	50
SYSTEMS-REPORT	1 command (200 reports)
TITLE	5
u-names	180
WEEK-SCHEDULE	200
ZONE	128
ZONE-AIR	50
ZONE-CONTROL	50

Description of SYSTEMS Input Instructions

This section contains descriptions of all SYSTEMS input instructions required to run the SYSTEMS program at a basic level; additional commands and keywords are listed in the *Reference Manual (2.1A)* and the *Supplement (2.1E)*. The order of presentation follows the hierarchy of the *BDL Summary (2.1E)*.

In the previous description of DOE-2 system types, only two commands were used: ZONE and SYSTEM. In the following material, SUBCOMMANDS are re-introduced; remember in the discussion of loads input (LOADS) that SPACE-CONDITIONS was introduced as a sub-command of the SPACE command. Sub-commands are used to "group" keywords of similar meaning and use into a separate list that makes discussion of them a manageable task. You have the option of either separating the input into separate lists using sub-commands or combining them all into one list under the command itself, as we did in the "suggested minimal inputs" for different system types, p.3.10.

The first instruction in the list of SYSTEMS input is

```
INPUT SYSTEMS ..
```

Because schedules in SYSTEMS follow the same pattern of those in LOADS, their explanations will not be repeated here. RESET schedules, however, have some unique rules that need to be covered and the discussion will start with them.

Reset Schedule Instructions

DAY-RESET-SCH and **RESET-SCHEDULE**

The function of the reset schedule instruction is to define the relationships between a system control parameter and the outside air temperature for each hour of the RUN-PERIOD. The instructions are applicable to control of hot deck temperature, cold deck temperature, and baseboard heating.

RESET-SCHEDULE is almost identical to SCHEDULE. The LIKE keyword is not applicable to RESET-SCHEDULE, but it is applicable to DAY-RESET-SCH. In the DAY-RESET-SCH instruction, rather than entering 24 hourly values, as usually entered for a DAY-SCHEDULE instruction, four keywords and their associated values are entered. All four keywords are *required* if this command is specified.

DAY-RESET-SCH defines how a system control parameter is to vary in response to changes in outside air temperature. A u-name for each DAY-RESET-SCH instruction is required in order to reference it.

An example of a RESET-SCHEDULE is shown in the explanation for the keyword BASEBOARD-SCH (under SYSTEM-CONTROL), p.3.74.

SUPPLY-HI	is the upper supply air setpoint temperature corresponding to the user-input value for OUTSIDE-LO. When this instruction is specified for the reset of cooling air or heating air temperature, the user-input is a temperature. The range, in this case, is from 0.0 to 120.0°F. (See keywords HEAT-RESET-SCH and COOL-RESET-SCH in the SYSTEM-CONTROL subcommand.) Fig. 3.26 illustrates this application. When this instruction is specified for baseboard heating, the user-input is a heating output ratio. (See keyword BASEBOARD-SCH in the SYSTEM-CONTROL subcommand.) The heating output is expressed as a decimal fraction of the maximum zone baseboard heating capacity (see keyword BASEBOARD-RATING in the ZONE-CONTROL subcommand). Fig. 3.27 illustrates this application.
SUPPLY-LO	is the lower supply air setpoint temperature (or output ratio) corresponding to the input value for OUTSIDE-HI; see also the discussion for SUPPLY-HI. The range, for temperature input, is from 0.0 to 120.0°F.
OUTSIDE-HI	is the outside dry-bulb air temperature which corresponds to the input value for SUPPLY-LO (lower supply air setpoint temperature).
OUTSIDE-LO	is the outside dry-bulb air temperature which corresponds to the input value for SUPPLY-HI (upper supply air setpoint temperature). The value for OUTSIDE-LO must *not* be equal to or greater than the value for OUTSIDE-HI (the program will abort and give an error message if this occurs).

BM029

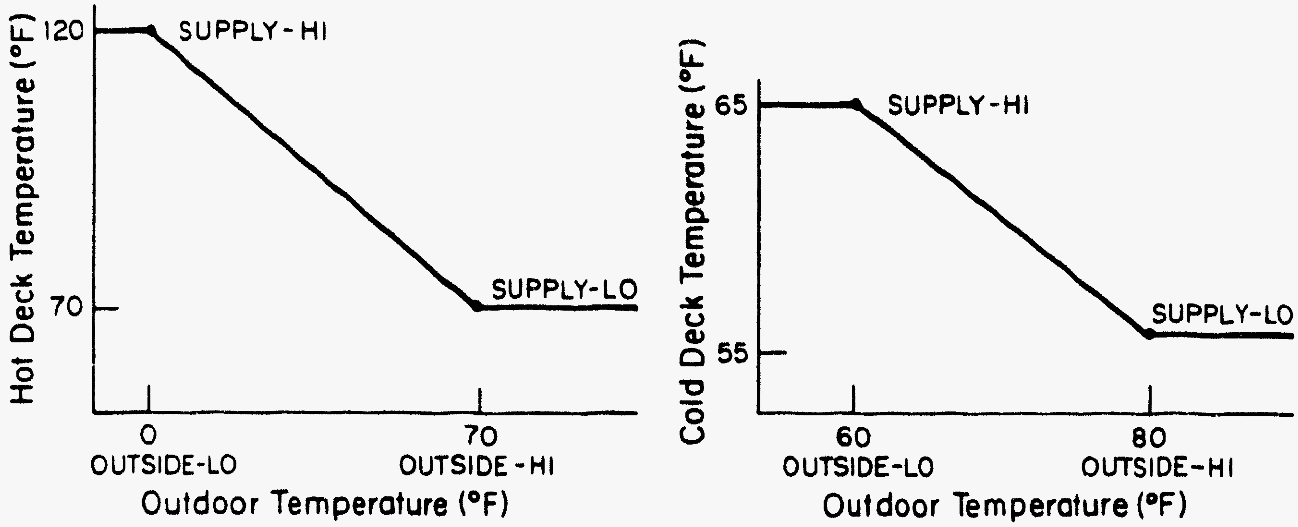

Figure 3.26: Typical DAY-RESET-SCH when used for simulation of hot deck or cold deck temperature control.

BM030

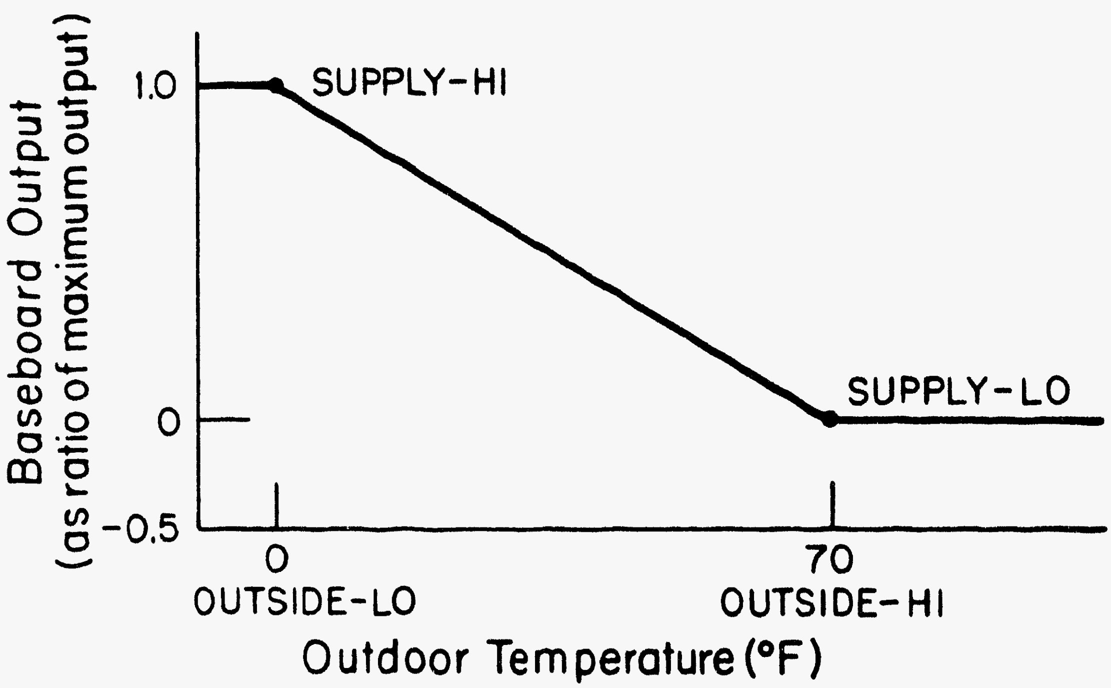

Figure 3.27: Typical DAY-RESET-SCH when used for simulation of baseboard heating output.

DAY-RESET-SCH cannot be nested; that is, the following is **NOT** permitted:

```
RS-1 =    RESET-SCHEDULE  THRU DEC 31  (ALL)
          SUPPLY-HI  = 120
          SUPPLY-LO  =  70
          OUTSIDE-HI =  70
          OUTSIDE-LO =   0 ..
```

The correct input looks like this.

```
DSR-1 =   DAY-RESET-SCH
          SUPPLY-HI  = 120
          SUPPLY-LO  =  70
          OUTSIDE-HI =  70
          OUTSIDE-LO =   0 ..
RS1 =     RESET-SCHEDULE  THRU DEC 31  (ALL) DSR-1  ..
```

ZONE–CONTROL

ZONE–CONTROL provides information on zone temperature control characteristics such as set-point, thermostat type, and throttling range. A number of ZONE–CONTROL instructions may be entered to account for zone-to-zone variations in these characteristics and/or to permit comparison studies. ZONE–CONTROL is a "subcommand" of the ZONE command and, as such, can be used to input a subset of data to ZONE.

u–name	is required.
DESIGN-HEAT-T	specifies the space temperature that the program uses to calculate the supply air flow rate required to meet peak (or design day) heating loads for the zone. The default is 70°F.
HEAT-TEMP-SCH	is the u-name of the SCHEDULE instruction that specifies the setpoint of the zone heating thermostat. If no data entry is made, the program assumes that the zone has no zone-activated heating control.
DESIGN-COOL-T	specifies the space temperature used to calculate the supply air flow rate required to meet peak (or design day) cooling loads for the zone. The default is 76°F.
COOL-TEMP-SCH	is the u-name of the SCHEDULE instruction that specifies the setpoint of the zone cooling thermostat. If no data entry is made, the program assumes that the zone has no zone-activated cooling control.
BASEBOARD-CTRL	Input for this keyword is a code-word that specifies the method used for controlling the output of the baseboard heating element in the zone. The applicable code-words are:
THERMOSTATIC	(default) temperature control of the baseboard element is by a thermostat located within the zone.
OUTDOOR-RESET	temperature control of the baseboard element is by a thermostat located outside the building.
	If code-word THERMOSTATIC is entered, the program assumes that the baseboard element adds heat as required, up to the maximum capacity of the element, to maintain zone temperature within the heating throttling range. The baseboards are sequenced on prior to zone reheat coils (if any) in response to a drop in space temperature.

Note that the italicized words in the left column are *code-words*, not keywords

THERMOSTAT-TYPE — identifies the type of thermostat action to be simulated. Note that the program assumes the same type of thermostat action for both cooling and heating. The applicable code-words are:

PROPORTIONAL — (default) Thermostat throttles heat addition rate (or heat extraction rate) in linear proportion to the difference between zone setpoint temperature and actual zone temperature. You input the proportional band (see keyword THROTTLING-RANGE).

TWO-POSITION — Specifies an on-off type thermostat (which is simulated as a very narrow fixed throttling range around each setpoint). This code-word is only used for the Residential System (RESYS).

REVERSE-ACTION — In variable air volume systems, this thermostat type allows the air flow rate to go above the design minimum cfm for heating, as defined by MIN-CFM-RATIO. Otherwise, the effect is the same as for THERMOSTAT-TYPE=PROPORTIONAL.

THROTTLING-RANGE — specifies the number of degrees that room temperature must change to go from full heating to zero heating and/or from full cooling to zero cooling. Zone temperature setpoint is assumed to be at the midpoint of the throttling range. This keyword is appropriate to PROPORTIONAL and REVERSE-ACTION thermostats only.

Note that the italicized words in the left column are *code-words*, not keywords.

ZONE-AIR

All air quantities should be input at sea level (standard) values because the program makes a correction for altitude. Input of air quantities corrected for altitude above sea level will result in a double correction. ZONE-AIR is a "subcommand" of ZONE and, as such, can be used to input a subset of data to ZONE.

u-name	is required.
ASSIGNED-CFM	allows you to set (in standard cfm) the design supply air flow rate (sometimes referred to as the recirculated air rate) for the zone. If data entry is omitted for ASSIGNED-CFM and for the following two keywords (AIR-CHANGES/HR and CFM/SQFT), the program will calculate design flow rate based on peak heating/cooling loads calculated by the LOADS program and the temperature differential between design supply and zone conditions. Note that if you want to input design air flow rates and not have the program convert them to sea-level rates, the ALTITUDE keyword in the BUILDING-LOCATION command in LOADS should be set to zero.
AIR-CHANGES/HR	sets the minimum design supply air flow rate that is to be given to the zone. It is expressed in terms of the number of times per hour that this flow rate would replace the total volume of air in the zone. ASSIGNED-CFM takes precedence over this input.
CFM/SQFT	sets the minimum design supply air flow rate that is to be given to the zone. It is expressed as the ratio of the design supply air flow rate (in standard, or sea level, cfm) to the total floor area of the zone. ASSIGNED-CFM takes precedence over this input.

The following keywords are associated with outside ventilation air. Although the specified quantities may be modified by the program for the sake of consistency, the flow of outside ventilation air is an uninterrupted flow as long as the fans are operating.

OUTSIDE-AIR-CFM	sets or specifies the minimum flow rate of outside air (in standard, or sea level, cfm) for the zone.
OA-CHANGES	is the minimum flow rate of outside air for the zone expressed in terms of the number of times per hour that this flow rate would replace the total volume of air in the zone. OUTSIDE-AIR-CFM takes precedence over this input.
OA-CFM/PER	is the minimum flow rate of outside air (in standard, or sea level, cfm) per zone occupant at peak occupancy. OUTSIDE-AIR-CFM takes precedence over this input.

EXHAUST-CFM — is the flow rate (in standard, or sea level, cfm) of direct exhaust from the zone. This data entry can be omitted if there is no exhaust from the zone, or if there is only central exhaust by way of the system return. DOE-2 will not allow MIN-OUTSIDE-AIR to be less than the sum of EXHAUST-CFMs for all zones divided by the sum of supply cfm's for all zones. That is, MIN-OUTSIDE-AIR will not restrict the operation of exhaust fans.

EXHAUST-STATIC — is the total pressure (in inches of water) produced by the exhaust fan serving the zone. This data entry is applicable only if a data entry is made for the keyword EXHAUST-CFM.

EXHAUST-EFF — is the combined efficiency of the zone exhaust fan and motor at design conditions. This data entry is applicable only if a data entry is made for the keyword EXHAUST-CFM. The program calculates exhaust fan horsepower on the basis of the value of this data entry and the entries for the keywords EXHAUST-CFM and EXHAUST-STATIC. The exhaust fan is assumed to be constant flow (not greater than the supply air flow rate) and to operate only when the system supply and return fans operate (see the keyword FAN-SCHEDULE in the SYSTEM-FANS instruction).

EXHAUST-KW — is an alternative to using EXHAUST-STATIC and EXHAUST-EFF. It provides information about the electrical energy consumption of the exhaust fan in this zone. It is expressed in kW consumed by the fan per cfm of exhaust.

ZONE

The ZONE instruction is used to specify information on those secondary HVAC distribution system characteristics specific to a thermal zone. This includes air flow rate (supply air, exhaust air, and outside air), space temperature setpoint, thermostat characteristics, and maximum heating and or cooling capacity. Each zone to be simulated must also be listed in the ZONE-NAMES keyword of the SYSTEM command for the system serving the zone.

u-name	is required for ZONE; it must match u-name used for SPACE in LOADS
ZONE-CONTROL	takes the u-name of a previously defined ZONE-CONTROL subcommand.
ZONE-AIR	takes the u-name of a previously defined ZONE-AIR subcommand.
BASEBOARD-RATING	is the baseboard heating element capacity for the zone. The input for this keyword should be a negative number.

The following keywords apply only to PIU systems.

TERMINAL-TYPE	specifies the type of terminal serving the zone for a PIU system. The same type of terminal box does not have to be used for the entire system. Typically, a PIU system will contain a mixture of fan powered terminal boxes and regular VAV or constant volume reheat units. The available code-words are:
SVAV	(the default) stands for Standard Variable Air Volume; i.e., regular VAV or constant volume.
SERIES-PIU	indicates that the fan draws air from both the secondary and primary air streams, and that the blower runs all the time.
PARALLEL-PIU	indicates that the fan draws air from the secondary air stream (ceiling plenum) only, and that the blower runs intermittently.
INDUCED-AIR-ZONE	(required keyword) takes as a value the u-name of another zone. It is assumed that the PIU zone is taking its secondary air from the return air of the zone named as the INDUCED-AIR-ZONE. Usually, the core zone, served by a non-PIU terminal, will be designated the INDUCED-AIR-ZONE. Zones with PIU boxes will usually be exterior zones that need the heat reclaimed from the core zone. An exception would be a zone (such as a classroom) where the

Note that the italicized words in the left column are *code-words*, not keywords.

primary concern is air movement, not energy conservation. In such a case, the corridors can be specified as the INDUCED-AIR-ZONE even though there is no heat to reclaim from them. The program treats this situation in the same way as it does when a core plenum is at a temperature lower than the exterior zone. For zones in which TERMINAL-TYPE = SERIES-PIU or PARALLEL-PIU,

REHEAT-DELTA-T

should be specified (if reheat or booster heat is desired) for the PIU system only. This is a keyword in both the SYSTEM and ZONE commands, and the ZONE level use takes precedence over the SYSTEM level. (At the zone level, this keyword does not apply to any other system types.)

ZONE-FAN-CFM

allows you to size the fan. If ZONE-FAN-CFM is not specified, the program will size the fan assuming series PIU fans. The blower is sized to the zone cfm; i.e., the maximum of the cfm input via ASSIGNED-CFM, AIR-CHANGES/HR, or CFM/SQFT; or the cfm derived from the heating and cooling peaks from LOADS.

For parallel PIU's, ZONE-FAN-CFM must be input. The ZONE level cfm keywords are assumed to refer to the primary air from the central system. The range is from 0.0 to 99999999.0 cfm.

ZONE-FAN-RATIO

allows you to enter a value which sets the ZONE-FAN-CFM as a fraction of the primary air. If both ZONE-FAN-CFM and ZONE-FAN-RATIO are specified, ZONE-FAN-CFM takes precedence.

ZONE-FAN-KW

specifies the power consumption of the fan. The default is .00033 kW/cfm. The range is from 0.0 to 0.01.

ZONE-FAN-T-SCH

is the u-name of a schedule which gives, for zones with parallel PIU's, the space temperature at which the terminal blower turns on. This temperature must be above the heating range. This keyword is required for zones with TERMINAL-TYPE = PARALLEL-PIU.

MIN-CFM-RATIO

should be specified for PIU at the ZONE level. The usual input for PIU terminals should be to specify a ratio that just satisfies the minimum ventilation air requirements of the zone. This keyword applies to other types of VAV systems and will override any value assigned at the SYSTEM level.

MIN-CFM-SCH

is the u-name of a schedule which has values that are to be used in place of the MIN-CFM-RATIO keyword to allow an hourly variation of MIN-CFM-RATIO. This schedule will always override the value specified or calculated for MIN-CFM-RATIO, unless the scheduled value is equal to -999.0 for an hour. When the value is equal to -999.0, then the calculated or specified value of MIN-CFM-RATIO (found on report SV-A for each zone) is used for that hour. This schedule can be used with a value of 1.0 during warmup periods and -999.0 for other hours to simulate full open VAV boxes during a warmup cycle.

SYSTEM-CONTROL

The SYSTEM-CONTROL instruction provides information on supply air temperature (setpoint, control strategy, and limits) and humidity limits, and identifies the appropriate equipment operating schedules. SYSTEM-CONTROL is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

u-name	is required.
MAX-SUPPLY-T	is the *highest allowable temperature for air entering the ZONE(s)*, that is, the highest allowed diffuser temperature. The program will use this value to determine the design air flow rate. This value is also used as an upper limit for supply air temperature control. MAX-SUPPLY-T should be greater than DESIGN-HEAT-T.
HEATING-SCHEDULE	is referenced by the u-name of the SCHEDULE instruction that specifies the time periods (hours and days) during which *heating is available from the plant for this system.* If no data entry is made, the program will assume that heating is always available when needed. A zero value for this schedule means that heating is not available. A non-zero value indicates that mechanical heating is available. If the HEATING-SCHEDULE is set to a value greater than 1.0, the program interprets this value as an outside ambient temperature above which the heating is unavailable or off.
HEAT-CONTROL	Input for this keyword is the code-word that identifies the strategy to be used for control of the heating air temperature leaving the main system heating coil. See COOL-CONTROL for the code-words and a brief description of the control strategy each represents.
HEAT-SET-T	has two main functions depending upon the type of system being specified. a. For systems that use the keyword HEAT-CONTROL (MZS, DDS, and PMZS), this is the value used as the supply air temperature setpoint when HEAT-CONTROL is equal to CONSTANT; it defaults to MAX-SUPPLY-T. b. For variable volume systems it is always advisable to input HEAT-SET-T because it enables a main air-handler heating coil; the value assigned is the maximum temperature off this coil. For single duct systems (VAVS, PVAVS, and PIU), the default is MIN-SUPPLY-T (indicating no central heating coil).

HEAT-SET-SCH

is the u-name used to identify the schedule for controlling heating air supply temperature when HEAT-CONTROL = SCHEDULED. For example, define:

```
HOT-COIL-SCH-1 = SCHEDULE
                 THRU APR 30 (ALL) (1,24) (120)
                 THRU SEP 30 (ALL) (1,24) (90)
                 THRU DEC 31 (ALL) (1,24) (120) ..
```

Then, in SYSTEM, the schedule is referenced by setting

```
HEAT-CONTROL = SCHEDULED
HEAT-SET-SCH = HOT-COIL-SCH-1
```

HEAT-RESET-SCH

is the u-name of the RESET-SCHEDULE instruction that defines the relationship between heating air temperature and outside air temperature, and specifies the days of the year during which this relationship applies. This keyword is used only if the RESET control strategy is selected.

The following is an example. First define:

```
HOT-DECK-1 = DAY-RESET-SCH
SUPPLY-HI = 120
SUPPLY-LO = 70
OUTSIDE-HI = 70
OUTSIDE-LO = 0 ..
HOT-RESET-1 = RESET-SCHEDULE
              THRU DEC 31 (ALL) HOT-DECK-1 ..
```

Then, in SYSTEM, the schedule is referenced by setting

```
HEAT-CONTROL = RESET
HEAT-RESET-SCH = HOT-RESET-1
```

MIN-SUPPLY-T

is the lowest allowable temperature for air entering the ZONE(s); i.e., it is the lowest allowed diffuser temperature. The program will use this temperature to determine design supply air flow rate.

COOLING-SCHEDULE

is u-name of the SCHEDULE instruction that specifies the time periods (hours and days) during which *cooling is available from the plant for this system.* If no data entry is made, the program will assume that cooling is always available when needed. A zero value for this schedule means that cooling is not available except through ventilation from an air economizer. A non-zero value indicates that mechanical cooling is available. Additionally, if the schedule has a value greater than 1.0, DOE-2 interprets this value as an outside ambient temperature below which the mechanical cooling is unavailable or off.

COOL-CONTROL

Input for this keyword is a code-word that identifies the strategy to be used for control of the air temperature leaving the system (central) cooling coil. The code-words and a brief description of the control strategy each represents for either heating or cooling are as follows:

CONSTANT

Sets heating supply and/or cooling supply air temperature to a fixed value. Values should then be entered for keywords HEAT-SET-T and/or COOL-SET-T, respectively.

COLDEST

Sets the heating coil (hot deck) temperature each hour to adequately heat the ZONE with the lowest temperature. The limits on the supply air temperature are governed by coil capacities, heating schedules, and MAX-SUPPLY-T.

WARMEST

Sets the cooling coil (cold deck) temperature each hour to adequately cool the ZONE with the highest temperature. The limits on the supply air temperature are governed by coil capacities, cooling schedules, and MIN-SUPPLY-T.

RESET

Specifies use of HEAT-RESET-SCH or COOL-RESET-SCH for control of heating and/or cooling air supply temperature, based upon outdoor air temperature.

SCHEDULED

Specifies use of HEAT-SET-SCH or COOL-SET-SCH for control of heating and/or cooling air supply temperature.

COOL-RESET-SCH

is the u-name of the RESET-SCHEDULE instruction that defines the relationship between cooling air temperature and outside air temperature, and specifies the days of the year during which this relationship applies. This data entry is used only when the RESET control strategy is selected and entry for keyword COOL-CONTROL = RESET.

COOL-SET-SCH

is the u-name used to identify the schedule for controlling cooling air supply temperature when COOL-CONTROL = SCHEDULED.

MAX-HUMIDITY

is the highest allowable relative humidity in the return air from zones served by the system. Because the program calculates the relative humidity in the return air, dehumidification is based on the average humidity condition for all the zones served by the system, as weighted by the relative return air flow rate from each zone. This data entry should be used only for those systems that have the components required for control of excess humidity (i.e., a humidistat and a heating coil downstream of the cooling coil). If no data entry is made, the program will assume that humidity control capability does not

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Note that the italicized words in the left column are *code-words*, not keywords.

exist. The default value of 100% is intended to specify no upper limit on humidity, that is, no humidity control.

DOE-2 will not force the cooling coil to perform beyond its dehumidification capability. The program will not be able to hold a specified MAX-HUMIDITY if MIN-SUPPLY-T is not low enough. Fig. 3.28 shows one type of dehumidification cycle.

MAX-HUMIDITY causes the simulation to function differently for system types SZRH, PSZ, and PVAVS. For SZRH, if the MAX-HUMIDITY level is exceeded, the system reverts to a full reheat. The cooling coil leaving air temperature is driven lower and reheat is added at the fan unit to satisfy the first-named zone. Further, for PSZ and PVAVS systems, specification of MAX-COND-RCVRY will activate the use of condenser recovery to accomplish a similar result. If a lower MAX-HUMIDITY is required to meet desired space conditions, a lower MIN-SUPPLY-T should be entered.

MIN-HUMIDITY

is the lowest allowable relative humidity in the return air from zones served by the system. This data entry should be used only for those systems that have the components required for minimum humidity control (i.e., humidistat and humidifier). If no data entry is made, the program will assume that minimum humidity control capability does not exist. The program simulates the use of a humidifier and the required heat for humidification is passed to PLANT as a steam or hot water load.

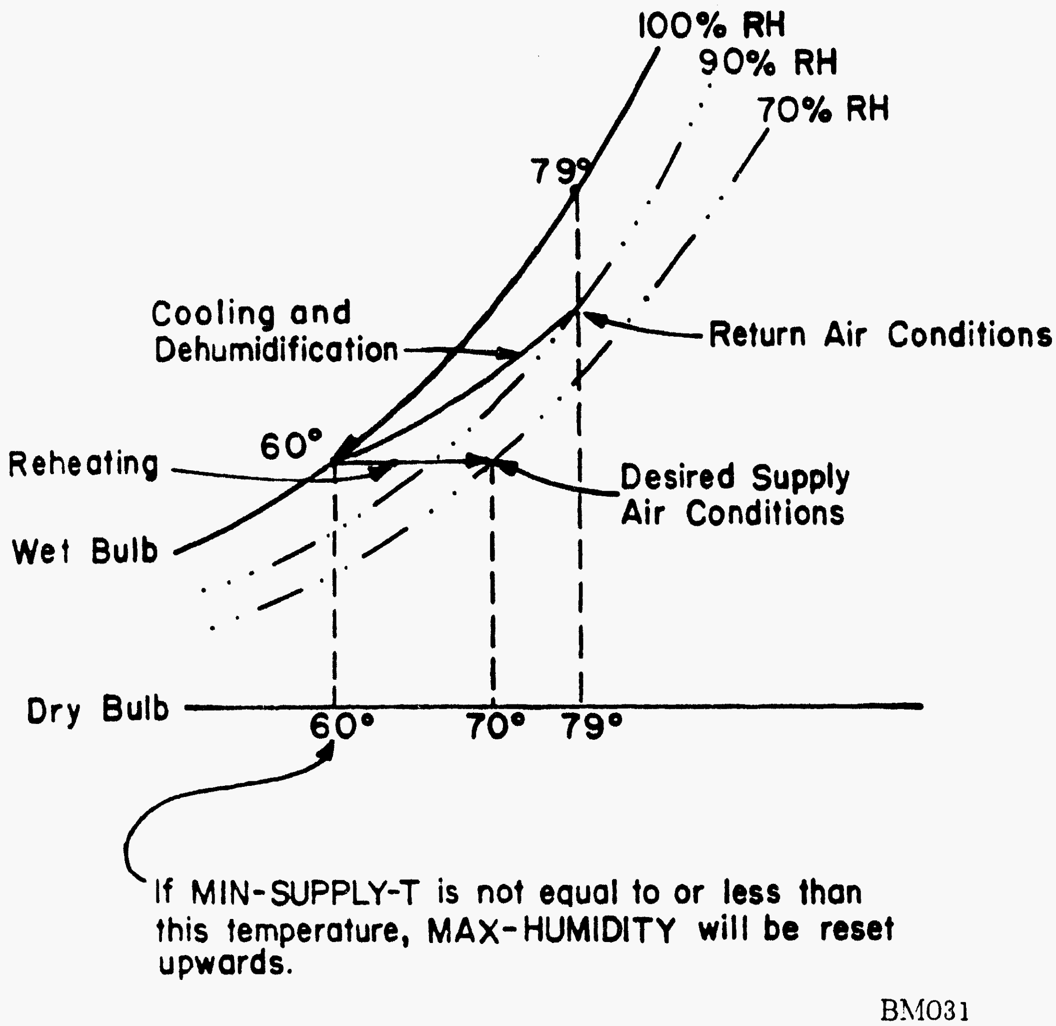

Figure 3.28: Relationship of MAX-HUMIDITY to MIN-SUPPLY-T

BASEBOARD-SCH — is the u-name of the RESET-SCHEDULE instruction that defines the relationship between baseboard heat output and outside air temperature, and specifies the days of the year during which this relationship applies. This keyword applies only if the ZONE-CONTROL keyword BASEBOARD-CTRL = OUTDOOR-RESET and the capacity is defined using BASEBOARD-RATING = value (negative) at the zone level.

ECONO-LIMIT-T — is the outside air temperature above which the economizer returns to minimum outside air operation as shown in Fig. 3.29. ECONO-LIMIT-T will default to the return air temperature.

PREHEAT-T — is the minimum temperature of air leaving the preheat coil. The SYSTEMS program calculates the necessary preheat coil energy input to maintain this temperature.

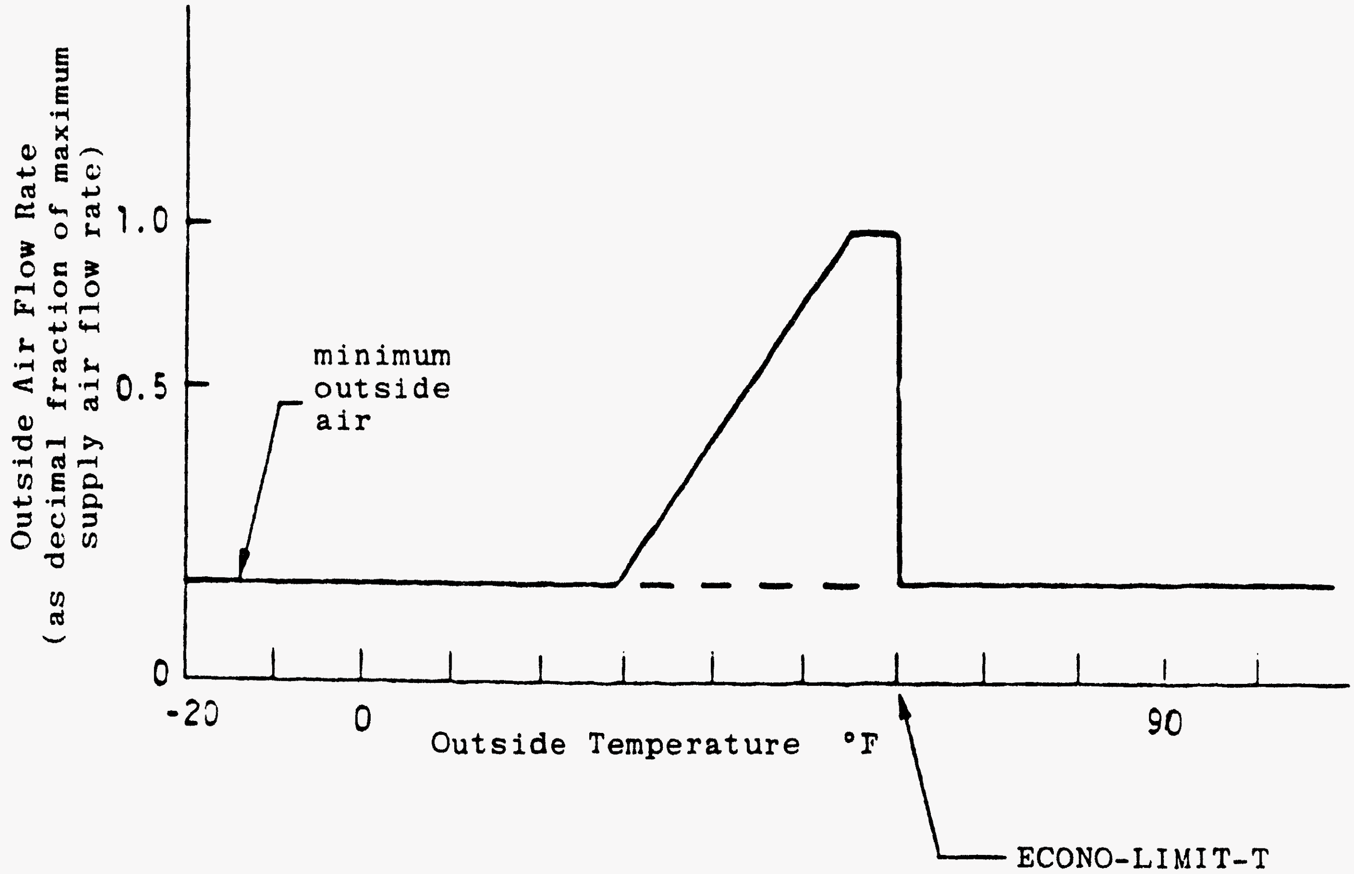

Figure 3.29: Typical curve of air flow vs outside air temperature for systems with temperature type economizer (illustrating use of keyword ECONO-LIMIT-T)

SYSTEM-AIR

The SYSTEM-AIR instruction provides information on system supply air and outside air flow rate. SYSTEM-AIR is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM. All air quantities should be input as sea level (standard) values because the program makes a correction for altitude. Input of air quantities corrected for altitude above sea level will result in a double correction.

u-name — is required.

SUPPLY-CFM — is the design capacity (in standard, or sea level, cfm) of the system air supply fan. *This entry is normally omitted, unless fan capacity is a known value and different from the air flow rates calculated by the program.* You will improve the simulation accuracy for existing buildings by inputting known system SUPPLY-CFM. The program proportions the specified total supply air into zone air quantities as follows:

$$\text{Adj. CFM} = \left(\frac{<\text{SUPPLY-CFM}>}{\sum \text{Calculated Zone Air CFMs}} \right) * (\text{Calculated Zone Air})$$

where Adj. CFM = Adjusted Zone Air CFM.

Note that user-inputs of zone-level ASSIGNED-CFM and EXHAUST-CFM replace the "Calculated Zone Air CFM" in the summation (but only when the latter exceeds calculated zone CFM).

MIN-OUTSIDE-AIR — is the minimum acceptable *constant* flow rate of fresh air, expressed as a decimal fraction of the maximum air supply flow rate. You may alternatively, or additionally, specify outside air quantities at the zone level (keywords OA-CHANGES, OA-CFM PER, or OUTSIDE-AIR-CFM in the ZONE-AIR instruction). If a value is specified for this keyword and values are also specified for the zone level keywords OUTSIDE-AIR-CFM, OA-CHANGES, OA-CFM/PER, or EXHAUST-CFM, the zone level values take precedence over the system level value. If no zone level value(s) are specified, the value specified here will be used. If MIN-AIR-SCH is used, the value of the outside air flow rate, to be used in the design calculations, should be specified either in this keyword or in the zone level keywords. The program will not allow MIN-OUTSIDE-AIR to be less than the sum of EXHAUST-CFMs for all zones divided by the sum of all supply cfm's for all zones. That is, the exhaust fan operation will override MIN-OUTSIDE-AIR, if MIN-OUTSIDE-AIR is set too low.

MIN-AIR-SCH

allows an hourly variation of the minimum outside air. Any fractional input defines the hourly value of the minimum outside air damper position as a ratio of design flowrate; it also enables the economizer. The two exceptions to this definition are when the schedule has a value of either zero or -999.0, in which case special meanings are assumed. When the value is zero, a no outside air situation with no movable dampers (economizer inactive if specified) is simulated. This usage is common for nighttime heating or a warmup cycle. If this schedule has a value of -999.0, the calculated or specified value for MIN-OUTSIDE-AIR (found on report SV-A for the SYSTEM or for each zone for zonal systems) is used as the minimum damper position for the current hour. If this value is zero, the discussion above for that special value applies. During a warmup period, this schedule is normally set to zero and can then be set to -999.0 during other hours to allow the specified or calculated ventilation minimum damper position to be used.

OA-CONTROL

Input for this keyword is the code-word for the type of outside air control strategy selected. See code-words below. This keyword must equal FIXED if you do *not* want an economizer; otherwise, it will default to TEMP, which will simulate a temperature-controlled economizer. If no outside air has been specified, no movable dampers are simulated, even if OA-CONTROL equals TEMP or ENTHALPY.

FIXED

No movable dampers. Outside air quantity is a fixed amount specified, calculated, or scheduled.

TEMP

Temperature-controlled economizer. In response to the mixed air temperature going above the controller setpoint (equal to the supply air setpoint for the hour), the outside air damper is opened. (This assumes a cooling mode and that the outside air is cooler than the return air.) The outside air quantity returns to its minimum (outside air dampers close but minimum outside air dampers remain open) when the outside air temperature is at or above the ECONO-LIMIT-T.

ENTHALPY

Enthalpy-controlled economizer. Same as TEMP above except that if the return air enthalpy is less than the outside air enthalpy, the dampers are forced to minimum outside air position.

RECOVERY-EFF

is applicable only to those systems provided with heat recovery coils (or other devices) for the exchange of heat between the air exhausted from the building (by the return air fan) and the fresh air supplied to the building. The input is the ratio

---

Note that the italicized words in the left column are *code-words*, not keywords (decimal fraction) of the energy actually exchanged to the total sensible energy that would be exchanged if the exhaust air were cooled to outside air temperature. The program uses this ratio (plus outside air and return air temperatures and return air flow rate) to calculate the energy that can be added to the outside air make-up. If the recoverable energy is greater than that needed by the supply air, the program will use the smaller quantity. If the outside air temperature is above the temperature setpoint of the mixed air, no energy is exchanged. If the difference between return and outside air temperatures is less than 10 degrees, no recovery is simulated.

Note: heat recovery can be simulated only when the return air is *warmer* than the outside air.

(If the heat recovery occurs through a single heat exchanger, i.e., heat pipe or thermal wheel, then RECOVERY-EFF is identical to the heat exchanger effectiveness. See Kays and London. *Compact Heat Exchangers*, 2nd edition, McGraw-Hill, 1964).

VENT-TEMP-SCH

accepts as input the u-name of a schedule giving the hourly minimum temperature setpoint for the natural venting algorithm. This keyword is appropriate to system type RESYS only. The hourly values that should be specified in the SCHEDULE referenced by VENT-TEMP-SCH are the indoor dry-bulb temperatures, cooled through natural ventilation in lieu of mechanical cooling. This hourly temperature is generally below the hourly temperature in the SCHEDULE referred to by COOL-TEMP-SCH. This latter schedule specifies the zone cooling thermostat setpoint. The windows are assumed to be closed if the temperature in the room falls below this point. If VENT-TEMP-SCH is not specified, all its hourly SCHEDULE values will default to the temperature at the top of the heating THROTTLING-RANGE as defined by HEAT-TEMP-SCH.

NATURAL-VENT-AC

is the peak number of air changes per hour due to natural ventilation through open windows. This value is constant and is not a function of wind speed. This keyword is appropriate only to system type RESYS.

NATURAL-VENT-SCH

is the u-name of a schedule which determines when the windows can be open vs. when they are always closed. The hourly values given in the SCHEDULE (and referenced by this keyword) are 0, 1, or -1. This keyword is appropriate only to system type RESYS.

A schedule value of zero (0) indicates that the windows are always closed for this hour.

A schedule value of one (1) indicates that the windows will be opened, for part or all of this hour, only if this provides enough cooling to keep the zone temperature within or below the throttling range associated with COOL-TEMP-SCH. The zone may be cooled down to the hourly minimum value specified by VENT-TEMP-SCH. Note that this assumes the occupant will open the windows if the condition is met.

A schedule value of minus one (-1) indicates that the windows will be opened, for part or all of this hour, only if the condition for the value of one (1) is met (above) and also that the outside air enthalpy is lower than the inside air enthalpy. The zone may be cooled down to the hourly minimum value specified by VENT-TEMP-SCH. This assumes the occupant will open the windows if both the conditions are met.

To further illustrate, assume that the occupant arises at 6:00 a.m., goes to work at 8:00 a.m., returns from work at 5:00 p.m., and retires at 10:00 p.m. every day of the year. The DAY-SCHEDULE describing the window management w uld be:

```
VENT-DAY = DAY-SCHEDULE (1,6) (0) (7,8) (1) (9,17) (0) (18,22) (-1) (23,24) (0) ..
```

The schedule for the year becomes:

```
VENTING = SCHEDULE THRU DEC 31 (ALL) VENT-DAY ..
```

Having defined the schedule, the entry under the SYSTEM-AIR subcommand would be:

```
HOME-AIR = SYSTEM-AIR
                  .
                  .
                  .
      NATURAL-VENT-SCH = VENTING
                  .
                  .
                  .  ..
```

If the values in VENT-DAY during the sleeping hours were 1's, it would imply that the occupant got out of bed, as often as necessary, to open and close the windows, whenever the conditions called for it. If you want to specify "temperature limits" for cooling by natural ventilation, you should specify VENT-TEMP-SCH in the SYSTEM-AIR subcommand. For example, suppose this schedule describes the cooling setpoint of the mechanical system:

```
MECH-COOL-TEMP = SCHEDULE THRU DEC 31 (ALL) (1,8) (78) (9,17) (90) (18,24) (78) ..
```

The following schedule describes the minimum below which the windows will be closed.

```
MIN-VENT-TEMP = SCHEDULE THRU DEC 31 (ALL) (1,6) (60) (7,22) (68) (23,24) (60) ..
```

Then, under ZONE-CONTROL, you should specify COOL-TEMP-SCH = MECH-COOL-TEMP, while under SYSTEM-AIR, VENT-TEMP-SCH should be set to MIN-VENT-TEMP. The preceding example can be restated as the following:

SCHEDULE hours (clock time)	Temperature Range*
1,6 (midnight to 6 a.m.)	78°F max (provided by mechanical cooling)
7,8 (6 a.m. to 8 a.m.	78°F max (provided by mech cooling) 68°F min (provided by occupant operating windows)
9,17 (8 a.m. to 5 p.m.)	90°F max (provided by mechanical cooling)
18,22 (5 p.m. to 10 p.m.)	78°F max (provided by mechanical cooling) 68°F min (provided by occupant operating windows)
23,24 (10 p.m. to midnight)	78°F max (provided by mechanical cooling)

* Note that during the hours when the windows are constantly closed (10 p.m. to 6 a.m. and 8 a.m. to 5 p.m.), the temperatures referenced by VENT-TEMP-SCH are disabled. Note also that VENT-TEMP-SCH does not necessarily say that cooling by natural ventilation will be done satisfactorily. VENT-TEMP-SCH only sets the minimum indoor temperature limits for natural ventilation. The conditions specified in NATURAL-VENT-SCH, determine when, and if, cooling by natural ventilation is done.

SYSTEM-FANS

The function of the SYSTEM-FANS instruction is to provide information on supply and return fan operating schedules, control modes, static pressures, and efficiencies. In short, this instruction provides everything the program needs to know (with the exception of fan capacity and flow rate) for calculation of the energy consumed by and the heat input from these fans. The same type of information is provided for exhaust fans, if any, at the zone level (keywords EXHAUST-CFM, EXHAUST-STATIC, etc. in ZONE-AIR instruction). SYSTEM-FANS is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

u-name	is required.
FAN-SCHEDULE	is the u-name of the SCHEDULE instruction giving the time periods (hours and days) during which this system's fans (supply, return, and exhaust) are operating and not operating. If the hourly values in the SCHEDULE that is referenced by FAN-SCHEDULE are positive, such as 1, the fans are on. If the hourly SCHEDULE values are 0, the fans are off but may be turned on by NIGHT-CYCLE-CTRL if ZONE temperatures warrant it. If the hourly SCHEDULE values are negative, such as -1, the fans are not permitted to be on for any reason. If you don't specify a SCHEDULE, the program will assume the fans run continuously. When the fans are scheduled to be off, baseboard units (if specified) can be operational.
FAN-CONTROL	equals a code-word that specifies the kind of flow reduction or control methods to be simulated. Listed below are the code-words and a brief description of the method each represents. The program calculates the part-load horsepower consumption for the supply fan and return fan (if any), on the basis of the part-load versus fan horsepower characteristics that are typical for the control mode selected (see Fig. 3.30). The program assumes that both supply and return fans have the same kind of flow control.
SPEED	Variable speed motor (Curve #1 in Fig. 3.30). [For systems that have variable flow central air-handlers only.] Note, the PTGSD system defaults to SPEED control.
INLET	Fan inlet vanes (Curve #2 in Fig. 3.30). [For systems that have variable flow central air-handlers only.]
DISCHARGE	Damper in fan discharge (Curve #3 in Fig. 3.30). [For systems that have variable flow central air-handlers only.]
CYCLING	Cycles on and off (Curve #4 in Fig. 3.30)

Note that the italicized words in the left column are *code-words*, not keywords.

TWO-SPEED	High or low speed (for PTAC only - represented as 100% and another point lower on Curve #1)
CONSTANT-VOLUME	Volume kept constant

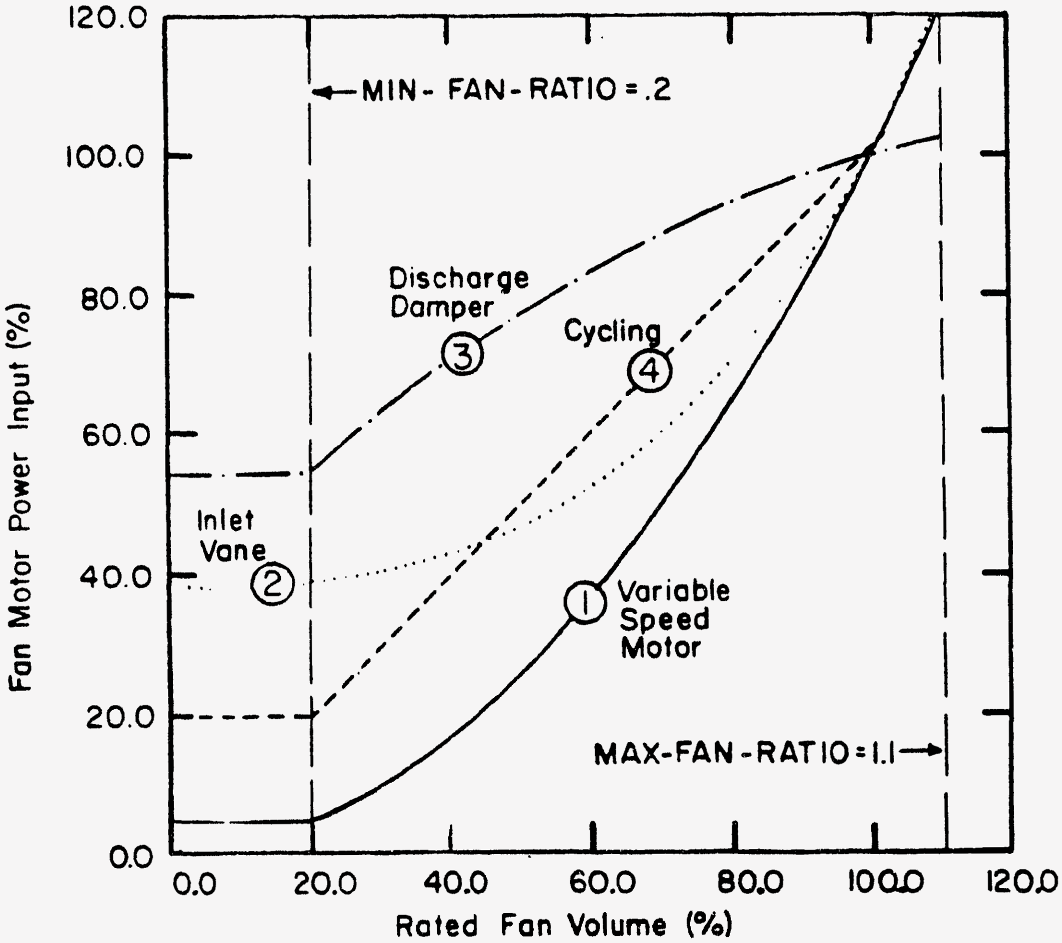

Figure 3.30: Typical power requirements at part-load operation for four different methods of capacity control (Note that with the CYCLING code-word, the MIN-FAN-RATIO is meaningless for those hours when the fan is off.)

SUPPLY-DELTA-T	is used in conjunction with SUPPLY-KW. It is the temperature rise in the air stream across the supply fan. It is expressed in °F and its default value can be found in Table 3.1, based on SYSTEM-TYPE.
SUPPLY-KW	is used in conjunction with SUPPLY-DELTA-T. It is the design full load power consumption of the supply fan per unit of supply air moved for one hour. It is expressed in kW/cfm at sea level (or kW standard cfm) and its default value can be found in Table 3.1, based on SYSTEM-TYPE.

TABLE 3.1

Default Value for SYSTEM-TYPE	Effective Default Value for SUPPLY-DELTA-T (°F)	Default Value for Total SUPPLY-KW (kW/std. cfm)	Effective Default Value for FAN-STATIC* (inches, W.G.)	FAN-EFFICIENCY* (fraction)
SZRH	2.42	.000783	4	.6
RHFS	3.11	.00101	6	.7
MZS	2.723	.00088	4.5	.6
DDS	3.37	.00109	6.5	.7
VAVS	3.37	.00109	6.5	.7
PIU	3.37	.00109	6.5	.7
TPFC	.218	.00007	.3	.5
FPFC	.218	.00007	.3	.5
RESYS	.396	.000128	.6	.55
PSZ	1.815	.000587	3	.6
PMZS	2.117	.000685	3.5	.6
PVAVS	2.117	.000685	3.5	.6
PTAC	.218	.00007	.3	.5
PTGSD	1.2	*	*	*
UHT	.218	.00007	.3	.5
UVT	.182	.000059	.3	.6

* Not applicable as supply fan and pump energy are included in a fixed Electric-Input of .098 w/CFM for this system at full load.

RETURN-DELTA-T is used in conjunction with RETURN-KW. It is the temperature rise in the air stream across the return air fan. It is expressed in °F and its default value is zero.

RETURN-KW is used in conjunction with RETURN-DELTA-T. It is the design full load power consumption of the return fan per unit of return air moved for one hour. It is expressed in kW/cfm at sea level (or kW/standard cfm) and its default value is zero. You must enter a value in order for the program to simulate a return fan.

NIGHT-CYCLE-CTRL Input for this keyword is the code-word that specifies the behavior of the system fans when the FAN-SCHEDULE is off. The fans are off when the hourly values in the SCHEDULE that is referenced by FAN-SCHEDULE are equal to 0. If the hourly SCHEDULE values are positive, the fans are on and if the hourly SCHEDULE values are negative, the fans are not permitted to be on under any circumstances.

NIGHT-CYCLE-CTRL also cycles fans on when the temperature goes above the COOL-TEMP-SCH's throttling range. To lock out this feature you must input a -1 in the FAN-SCHEDULE for the summer (cooling) period.

NIGHT-CYCLE-CTRL only affects the fan operation. Once the fans have cycled on, the availability of heating or cooling is controlled by the HEATING SCHEDULE and COOLING-SCHEDULE.
The code-words for NIGHT-CYCLE-CTRL are:

STAY-OFF — indicates that regardless of conditions, the fans are to stay off (default value).

CYCLE-ON-ANY — means that if the temperature in ***any*** ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, the fans are cycled on for that hour.

CYCLE-ON-FIRST — indicates that if the temperature in the ***first***, or control, ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, the fans are cycled on for that hour.

ZONE-FANS-ONLY — applies only to PIU. If input, the main or central system PIU fan will remain off; however, the individual zone terminal fans will cycle on separately to satisfy the heating setback temperature for each zone.

Note that the italicized words in the left column are *code-words*, not keywords.

SYSTEM

The SYSTEM instruction gives specifications for the secondary HVAC distribution system. The information provided includes system type, size, zones served, optional components, operating schedules, temperature and humidity limits, control strategies, outside air requirements, and fan static pressures and efficiencies. In addition, you may reference "subcommands" (SYSTEM-CONTROL, SYSTEM-AIR and SYSTEM-FANS) that contain the needed information.

u-name — required input for SYSTEM

SYSTEM-TYPE — identifies the type of system to be simulated. You must select one of 16 types of commonly used energy distribution systems. A discussion of the features of each system and a "suggested minimal input" for each system type can be found on p.3.10ff.

Code-word	Description of System Type	Generic Type
SZRH	Single Zone Fan System with Optional Subzone Reheat	built-up/central
RHFS	Constant Volume Reheat Fan System	built-up/central
MZS	Multizone Fan System	built-up/central
DDS	Dual Duct Fan System	built-up/central
VAVS	Variable Volume Fan System with Optional reheat	built-up/central
PIU	Powered Induction Unit	built-up/central
TPFC	Two Pipe Fan Coil System	built-up/zonal
FPFC	Four Pipe Fan Coil System	built-up/zonal
RESYS	Residential System	packaged/central
PSZ	Packaged Single Zone Air Conditioner with Optional Heating and Subzone Reheat	packaged/central
PMZS	Packaged Multizone Fan System	packaged/central
PVAVS	Packaged Variable Air Volume System	packaged/central
PTAC	Package Terminal Air Conditioner	packaged/zonal
PTGSD	Package Total Gas Solid Desiccant	packaged/central
UHT	Unit Heater	built-up/zonal
UVT	Unit Ventilator	built-up/zonal

SYSTEM-CONTROL — references the u-name of a previously assigned SYSTEM-CONTROL instruction.

SYSTEM-AIR — references the u-name of a previously assigned SYSTEM-AIR instruction.

SYSTEM-FANS — references the u-name of a previously assigned SYSTEM-FANS instruction.

HEAT-SOURCE is the keyword that identifies the heat source for the distribution system for heating coils. This is the appropriate keyword for UHT, UVT, TPFC, FPFC and PTAC zone heating coils since they are all served by a central distribution system. HEAT-SOURCE defaults to GAS-HYDRONIC for the Packaged Total Gas Solid Desiccant (PTGSD) system; it should not be changed nor applied to any other system type.

The following HEAT-SOURCE code-words also apply to ZONE-HEAT-SOURCE, PREHEAT-SOURCE, and BASEBOARD-SOURCE.

ELECTRIC The source of heat is an electric resistance element. This code-word is appropriate for central heating coils, preheat coils, baseboard heaters, and zone heating coils.

FURNACE The source of heat is a furnace, which will be simulated in SYSTEMS.

GAS-HYDRONIC Applies to BASEBOARD-SOURCE and HEAT-SOURCE for PTGSD system only. The source in this case is a gas-fired hot water generator.

HEAT-PUMP The source of heat is an electric air-to-air heat pump. Note: This code-word is appropriate only as a HEAT-SOURCE for the RESYS, PSZ, and PTAC systems. It should not be used for any other system types.

HOT-WATER The source of heat is hot-water, provided by conventional equipment specified in the PLANT program. This code-word is appropriate for central heating coils, preheat coils, baseboard heaters, and zone heating coils.

ZONE-HEAT-SOURCE	identifies the heat source for the zone heating coils (reheat coils) in central air handler systems. See HEAT-SOURCE for the applicable code-words, and Appendix F for default values.
PREHEAT-SOURCE	identifies the heat source for the preheat coils. See HEAT-SOURCE for the applicable code-words, and Appendix F for default values.
BASEBOARD-SOURCE	identifies the heat source for the baseboard heaters. See HEAT-SOURCE for the applicable code-words, and Appendix F for default values. BASEBOARD-SOURCE defaults to GAS-HYDRONIC for the Packaged Total Gas Solid Desiccant (PTGSD) system: it should not be changed nor applied to any other system type.
HUMIDIFIER-TYPE	defines the source of heat used to provide humidification in those SYSTEM-TYPEs that allow MIN-HUMIDITY to be specified. It takes one of the standard heat source code-words: HOT-WATER (default), ELECTRIC or FURNACE. Use the furnace source with caution since the same HIR and part-load functions are used as for other furnaces specified in the same system.
SIZING-RATIO	is used to deliberately oversize or undersize all equipment in the system.
ZONE-NAMES	is a list of zone names (enclosed in parentheses) of the ZONEs that are assigned to this SYSTEM. This data entry, with the u-name of at least *one ZONE*, is required. If the SYSTEM being simulated is the type that serves both a central zone and one or more subzones (i.e., SZRH, PSZ and RESYS), the u-name of the control ZONE must be listed *first*. Example: ZONE-NAMES=(ZONE-1,ZONE-2)
MAX-COND-RCVRY	enables recovery of condenser heat from packaged single zone units (PSZ). The input is the fraction of recoverable heat from the condenser for reheating.
REHEAT-DELTA-T	is the maximum increase in temperature for supply air passing through the zone (or subzone) reheat coils. The value specified here applies to all zones in the system.
MIN-CFM-RATIO	is the minimum allowable supply air flow rate, expressed as a decimal fraction of design flow rate. This keyword applies only to variable-volume type systems. (This keyword appears also under the ZONE command. The value specified here in the SYSTEM command applies to all zones in the system that do not have an overriding specification at the zone level in the

ZONE command.) A low value for MIN-CFM-RATIO can result in reducing the flow of air below that set by MIN-OUTSIDE-AIR, thus simulating the system operation below minimum ventilation criteria.

HEATING-CAPACITY is **required** for the PTGSD system and is input as a minus value; **you must size it.**

PLANT-ASSIGNMENT

The PLANT-ASSIGNMENT command is used to identify both the system or group of systems that compose the PLANT, and also the "building resources", which are sources of energy that do not contribute to the space heating or cooling loads.* In the following, the type of fuel (natural gas, oil, etc.) associated with fuel-related keywords (INT-FUEL-BTU/HR, etc.) is specified with the ENERGY-RESOURCE command in PLANT (p.4.16).

SYSTEM-NAMES	Is a list of the u-names of all systems that make up this particular plant assignment.
INT-FUEL-BTU/HR	Is the consumption in Btu/hr of fuel that is consumed in the interior of the building, but that does not contribute to the space cooling load. See "Building Resources in SYSTEMS" in the *Supplement (2.1E)*, p.3.13.
INT-FUEL-SCH	Identifies the schedule that is used to specify the building-level fuel use as a function of time. Schedule inputs are fractions of the quantity given by the keyword INT-FUEL-BTU/HR. If INT-FUEL-SCH is not input, the schedule values will all default to zero and no fuel usage will occur, regardless of the value specified for INT-FUEL-BTU/HR.
EXT-FUEL-BTU/HR	Is the consumption in Btu/hr of fuel that is consumed exterior to the building. Decorative gas torches and pool heaters are examples.
EXT-FUEL-SCH	Schedule of exterior fuel use.
INT-ELEC-KW	Is electricity consumed in kW within the building that does not contribute to space conditioning loads. Included in this category are elevators and escalators.
INT-ELEC-SCH	Schedule that corresponds to INT-ELEC-KW.
EXT-ELEC-KW	Is electricity consumed in kW outside of the building. Power for fountains, pool pumps, and exterior lighting is included in this category.
EXT-ELEC-SCH	Schedule of exterior electricity use.
DHW-GAL/MIN	Is the supply flow of building-level domestic hot water (gallons per minute). This flow is multiplied hourly by the DHW-SCH schedule value. This is *in addition* to that specified with SOURCE-TYPE = HOT-WATER in SPACE-CONDITIONS in LOADS, and does not contribute to

* Prior to DOE-2.1E, these were specified in the BUILDING-RESOURCE command in LOADS.

space thermal loads. The hot water demand calculated from this and the following DHW- keywords is passed to PLANT where it is satisfied by a domestic hot water heater or boiler.

DHW-SCH	Is the schedule of building-level domestic hot water use. It multiplies DHW-GAL/MIN.
DHW-SUPPLY-T	Is the building-level domestic hot water supply temperature (°F); the default is 140°F.
DHW-INLET-T-SCH	Is the schedule of building-level domestic hot water inlet temperature (°F). The default is the monthly ground temperature from the weather tape.
PROCESS-HW-BTU/HR	Is a process hot water load in Btu/hr. This load increases the total plant heating load as shown in report SS-D, and is passed on to the boilers or other heating equipment in PLANT. A manufacturing process which uses hot water is an example of a process hot water load.
PROCESS-HW-SCH	Is the schedule for the process hot water load.
PROCESS-CHW-BTU/HR	Is a process chilled water load in Btu/hr. This load increases the total plant cooling load as shown in report SS-D, and is passed on to the chillers or other cooling equipment in PLANT. A computer room which has computers directly cooled by chilled water is an example of a process cooling load. (The electricity consumed by these computers should be input using the INT-ELEC-KW keyword.)
PROCESS-CHW-SCH	Is the schedule for the process chilled water load.

SYSTEMS-REPORT

This instruction defines which SYSTEMS reports will be output. Users can select from *verification* reports and *summary* reports. Verification reports echo user-input; summary reports show calculation results, usually monthly and annually.

Format:

```
SYSTEMS-REPORT    VERIFICATION = (code-word list)
                  SUMMARY = (code-word list) ..
```

Example:

```
SYSTEMS-REPORT    VERIFICATION = (SV-A)
                  SUMMARY = (SS-A, SS-O) ..
```

will print verification report SV-A, "System Design Parameters", and summary reports SS-A, "System Monthly Loads Summary", and SS-O, "Temperature Scatter Plot".

A definition of the basic SYSTEMS reports, with corresponding code-words, is given in Appendix C.

PLANT

Introduction

The PLANT program translates the energy supplied to space heating and cooling equipment into the energy actually consumed by boilers, chillers, pumps, engines, etc. It sums the hourly demands of the electricity used by lights, fans, and equipment and of the fuel used by boilers and engines. It also accounts for any heat recovered. From these totals it generates reports on monthly and yearly usage.

For each hour simulated the following information is passed from SYSTEMS to PLANT:

For Boilers, Chiller, Electric Utility or Total Energy Plant

Heating Load in Btu/hr Cooling Load in Btu/hr Electric Load in kW Hot water in Btu/hr Gas in Btu/hr Oil in Btu/hr	As modified by SYSTEMS

For Cooling Tower Simulation

Ambient air temperature in °F
Humidity ratio in lb water/lb dry air

Utility usage is based on a conversion factor called SOURCE-SITE-EFF; it reflects the energy consumed at the source used to create the utility-supplied energy. All energy conversions are based on actual curve fits of representative equipment. You should examine the default parameters to be sure that they represent the equipment you want to simulate.

Suggested Sequence of PLANT Program Input

First enter an

INPUT PLANT ..

instruction. Next, describe each piece of equipment (boiler, chiller, cooling tower, etc.) in the plant using a

PLANT-EQUIPMENT

instruction. The following instructions may then be entered as desired or required:

PART-LOAD-RATIO
PLANT-PARAMETERS
HEAT-RECOVERY
ENERGY-RESOURCE

After the keywords and values required by the above instructions are specified, an END instruction is entered to indicate that the input data is finished; finally, an instruction is entered that tells the PLANT program to perform the desired computations:

END ..
COMPUTE PLANT ..

In the following, you will find:

- A description of each type of plant equipment.
- A sample input for each type of equipment. For trial purposes, these inputs can be used to replace the PLANT input on p.B.11 (Appendix B).
- A list of other capabilities for each type of equipment.

Description of ELEC-STM-BOILER

The electric boiler in DOE-2 is a multi-staged electric resistance unit. The default condition is no electricity use for feed water or condensate pumps. Suggested minimal input for ELEC-STM-BOILER is:

```
STM-B = PLANT-EQUIPMENT
        TYPE = ELEC-STM-BOILER
        SIZE = -999  ..
```

Note that SIZE = -999 will cause the program to automatically size the boiler based on the peak demand calculated by SYSTEMS.

Additional Capabilities for ELEC-STM-BOILER:

1. To simulate additional electricity use for feed water or condensate pumps, insert the command

```
PART-LOAD-RATIO  TYPE  = ELEC-STM-BOILER
                 E-1-R = 1.05  ..
```

This provides a 5% additional electric requirement for pumping, which is assumed to vary proportionately to the load on the boiler.

Description of STM-BOILER

The steam boiler in DOE-2 is gas-fired with an induced draft fan. The default for the combined electricity use of the power burner and draft fan is 2.2% of the boiler size. Suggested minimal input for STM-BOILER is as follows:

```
STM-B = PLANT-EQUIPMENT
        TYPE = STM-BOILER
        SIZE = -999  ..
```

Additional Capabilities for STM-BOILER:

1. To simulate an oil-fired rather than a gas-fired boiler, insert the command:

   ENERGY-RESOURCE RESOURCE = FUEL-OIL ..

2. To simulate additional electricity use for feed water or condensate pumps, refer to the "Additional Capabilities for ELEC-STM-BOILER" above.

Description of HW-BOILER

The hot water boiler is also referred to as a hot water generator. It is a gas-fired unit with a default of 2.2% added electric for power burner and an induced draft fan. A hot water recirculating pump is automatically included by the program and is sized to the system peak. Suggested minimal input for HW-BOILER is as follows:

```
HWG = PLANT-EQUIPMENT
      TYPE = HW-BOILER
      SIZE = -999 ..
```

Additional Capabilities for HW-BOILER:

1. To simulate a unit without a power gas burner and induced draft fan, insert:

```
PART-LOAD-RATIO   TYPE = HW-BOILER   E-I-R = 0 ..
```

2. To change either the pumping requirements or the efficiency of the burner, there are a number of keywords to use:

```
PLANT-PARAMETERS   HCIRC-SIZE-OPT        = INST-PLANT-EQUIP
                   HCIRC-PUMP-TYPE       = VARIABLE-SPEED
                   HCIRC-DESIGN-T-DROP   = value desired
                   HCIRC-HEAD            = value desired
                   BOILER-HIR            = 1.25 ..  $ 1/efficiency
```

Description of ELEC-HW-BOILER

The electric hot water boiler is a multi-stage electric resistance hot water generator with a hot water pump. See HW-BOILER.

Description of ABSOR1-CHLR

The one-stage absorption chiller in DOE-2 is a unit that can be supplied by either 12-lb steam or 240°F water. The solution pumps for the unit require only 0.4% additional electric energy based on the size of the unit. A chilled water pump is called automatically and sized on the peak system requirement. You must input either a steam boiler, a hot water boiler, or district steam to supply heat to drive the absorption chiller. A cooling tower is also called automatically; you can input it if you want, but you are cautioned not to input either the size or the number of units. Suggested minimal input for ABSOR1-CHLR is as follows:

```
AB-CHLR = PLANT-EQUIPMENT
          TYPE = ABSOR1-CHLR
          SIZE = -999 ..
```

Additional Capabilities for ABSOR1-CHLR:

1. To increase the electric requirements for solution pumps insert:

```
PART-LOAD-RATIO   TYPE  = ABSOR1-CHLR
                  E-I-R = value desired
```

2. To input a cooling tower explicitly, insert:

```
CTOW = PLANT-EQUIPMENT
       TYPE = COOLING-TWR
       SIZE = -999 ..
```

We suggest you *not* enter the size of the tower; in DOE-2, size refers to the tower cell size and INSTALLED-NUMBER refers to the number of cells.

3. To change the pumping requirements to suit specific project needs, use PLANT-PARAMETERS:

```
PLANT-PARAMETERS   CHILL-WTR-T            = value desired
                   ABSOR1-HIR             = .66 is default, but old
                                             units may have degraded
                                             to as low as .4
                   TWR-SETPT-CTRL         = FIXED or WETBULB-RESET
                   TWR-SETPT-T            = value desired
                                            (use if FIXED selected)
                   TWR-DESIGN-WETBULB     = value desired
                   TWR-PUMP-HEAD          = value desired
                                            (condenser water pump)
                   CCIRC-DESIGN-T-DROP    = value desired
                   CCIRC-HEAD             = value desired
                   CCIRC-SIZE-OPT         = INST-PLANT-EQUIP
                   CCIRC-PUMP-TYPE        = VARIABLE-SPEED   ..
```

4. To supply steam to the building for space heating or for the absorption chiller from a district steam (or hot water) system, use:

   ENERGY-RESOURCE RESOURCE = STEAM ..

Description of ABSOR2-CHLR

The two-stage absorption chiller in DOE-2 is the same as the one-stage chiller (ABSOR1-CHLR), except that it operates with 125-lb steam or 400°F hot water. The electric requirement for solution pumps in 0.7% of the unit size. All of the additional capabilities described for the ABSOR1-CHLR also apply here. Suggested minimal input for ABSOR2-CHLR is:

```
AB2-CHLR = PLANT-EQUIPMENT   TYPE = ABSOR2-CHLR
                             SIZE = -999 ..
```

Description of ABSORG-CHLR

The direct gas-fired absorption chiller can also operate as a hot water generator. Therefore, all accessories (such as the cooling tower, chilled water pump, condenser water pump, and hot water pump) are called. The solution pumps default to 0.7% of the unit size since this, too, is a two-stage unit. All of the additional capabilities described for ABSOR1-CHLR apply, with the following additions:

```
PLANT-PARAMETERS   ABSORG-HIR         = value desired (1.0 is default)
                   ABSORG-HEAT-XEFF   = value desired for the HWG
                                        efficiency (decimal fraction) ..
```

Description of HERM-CENT-CHLR

The hermetic centrifugal chiller in DOE-2 has a default COP of 4.55 and a KW/Ton of .77, which makes it a very conservatively rated unit for present day practice. The cooling tower, condenser water pump, and chilled water pump are all called by default; however, you can modify the selection of these auxiliaries by using the keywords described for ABSOR1-CHLR. Suggested minimal input for HERM-CENT-CHLR is as follows:

```
CHL = PLANT-EQUIPMENT    TYPE = HERM-CENT-CHLR    SIZE = -999 ..
```

Additional Capabilities for HERM-CENT-CHLR:

1. To change to an air-cooled condenser, specify:

   ```
   PLANT-PARAMETERS    HERM-CENT-COND-TYPE = AIR ..
   ```

2. To change the COP of the unit to 5.0 (0.7 KW/Ton), set ELEC-INPUT-RATIO, which is the inverse of COP, as follows:

   ```
   PART-LOAD-RATIO    TYPE = HERM-CENT-CHLR    E-I-R = .2 ..
   ```

Description of HERM-REC-CHLR
The hermetic reciprocating chiller in DOE-2 is a unit characteristic of multi-compressor or unloading compressor types. It has a default COP of 3.65 or a KW/Ton of .96, which is still reasonable for today. You can change the unit to an air-cooled condenser (the default is a cooling tower with condenser water pump) and chilled water pump. The unit can be modified as described for ABSOR1-CHLR. Suggested minimal input for HERM-REC-CHLR is:

```
CHL =   PLANT-EQUIPMENT      TYPE = HERM-REC-CHLR  SIZE = -999 ..
        PLANT-PARAMETERS     HERM-REC-COND-TYPE = AIR ..
```

Description of DBUN-CHLR
The double bundle chiller in DOE-2 is a centrifugal type chiller with two condenser tube bundles, one of which is piped to the cooling tower and the other piped to the building hot water heating circuit. The unit operates as a straight chiller whenever there is no call for heat and operates as a heat pump to reject heat to the heating circuit up to its maximum capacity; it is then supplemented by a hot water boiler. Suggested minimal input for DBUN-CHLR is:

```
HP-CHLR   = PLANT-EQUIPMENT    TYPE = DBUN-CHLR    SIZE = -999 ..
HWG       = PLANT-EQUIPMENT    TYPE = HW-BOILER    SIZE = -999 ..
```

Additional Capabilities for DBUN-CHLR:

1. In the building heating mode, to change the leaving water temperature from the condenser (default = 105°F), insert:

   ```
   PLANT-PARAMETERS    DBUN-COND-T-REC = value desired ..
   ```

2. If there is a chiller other than the double bundle, the program will stage the units to favor the double bundle when heating is required. When entering another chiller, you should size both units, since the program doesn't know what split is required.

   ```
   CHLR = PLANT-EQUIPMENT    TYPE = HERM-CENT-CHLR
                             SIZE  = value (millions of Btu/hr) ..
   ```

Description of ENG-CHLR
The gas engine chiller in DOE-2 is a nominal 150-ton twin screw compressor chiller driven by a modified diesel engine. The unit capacity is controlled by varying the speed of the engine to

meet the building load: it has a default evaporator/engine COP of 1.4. It is possible to recover heat from the engine to satisfy space heating loads and/or provide service hot water. The unit defaults to cooling tower but can also be air-cooled. Suggested minimal input for ENG-CHLR is as follows:

```
ECHL = PLANT-EQUIPMENT    TYPE = ENG-CHLR    SIZE = -999 ..
```

Additional Capabilities for ENG-CHLR:

1. To recover heat from the engine for both space heat and service hot water, insert:

```
HEAT-RECOVERY    SUPPLY-1 = (ENG-CHLR)
                 DEMAND-1 = (SPACE-HEAT,PROCESS-HEAT) ..
```

2. To change the unit to air-cooled, insert:

```
PLANT-PARAMETERS    ENG-CH-COND-TYPE = AIR ..
```

Description of COOLING-TWR

The cooling tower in DOE-2 is an induced draft tower with a propeller type fan at the top. There are numerous plant parameters that allow you to modify the design wet bulb temperature and to satisfy other specific requirements. Most users do not input the tower because DOE-2 automatically calls for one and sizes it whenever one is needed. However, the default design wet bulb is 78°F, which is acceptable for some locations but not all. Suggested minimal input for COOLING-TWR is as follows:

```
CTW = PLANT-EQUIPMENT    TYPE = COOLING-TWR    SIZE = -999 ..
```

Additional Capabilities for COOLING-TWR:

1. To change the design wet bulb, insert:

```
PLANT-PARAMETERS    TWR-DESIGN-WETBULB = value desired ..
```

2. To change from a one-speed fan (the default) to a multiple-speed fan, insert:

```
PLANT-PARAMETERS    TWR-CAP-CTRL = TWO-SPEED-FAN ..
or
PLANT-PARAMETERS    TWR-CAP-CTRL = VARIABLE-SPEED-FAN ..
```

Description of DHW-HEATER and ELEC-HEATER

The service hot water heaters in DOE-2 are standard units. The DHW-HEATER is gas fired (default). There is no pumping assigned to either unit type, but you can use the PART-LOAD-RATIO command to assign pumping if desired. If you want to recover waste heat (previously demonstrated for ENG-CHLR), a hot water heater must not be entered because it locks out recovery. Also, to simulate an indirect exchanger inside the hot water generator for service hot water heating, a hot water heater should not be entered.

Description of PLANT Input Instructions

Limitation on the Number of Commands

The maximum allowable number of PLANT instructions for specifying required PLANT data is as follows:

Instruction	Maximum Number
ENERGY-RESCURCE	7
HEAT-RECOVERY	1
PLANT-ASSIGNMENT	1
PLANT-EQUIPMENT	60
PLANT-PARAMETERS	1
PLANT-REPORT	1 command
TITLE	5
u-names	118

PLANT-EQUIPMENT

This command tells the PDL that the following data specifies plant equipment. If at least one PLANT-EQUIPMENT instruction is not entered, then the PLANT program generates an error message.

u-name — is not required but is advisable in order to identify equipment in reports.

TYPE — is the type of equipment to be used. See Table 4.1 for allowed code-words.

SIZE — is the nominal rated output capacity, expressed in units of one million Btu's per hour (MBtu/hr), for the item of equipment being specified. For example, a 100-ton chiller should be specified as SIZE = 1.20 since the conversion factor is 12,000 Btu/hr per ton. A ten million Btu/hr boiler is specified as SIZE = 10.0.

If SIZE = −999 is entered, PLANT automatically sizes, in accordance with peak load, the following types of equipment: all boilers, chillers, towers, and diesel and gas electric generators. Steam turbine generators will not be automatically sized.

Hot water and chilled water circulation pumps are **always** automatically sized by the PLANT program. The flow rate, electrical power, and heat gain are calculated from the values of PLANT-PARAMETERS keywords as follows:

Flow Rate: $GPM_p = \frac{\text{Design-Load}}{\text{X-DESIGN-T-DROP} \times 60 \text{ min/h} \times 8.34 \text{ Btu/gallon-}^{o}\text{F}}$

Power: $Elect_p = \frac{\text{X-HEAD} \times GPM_p \times 0.643 \text{ Btu-min/ft-gallon-hr}}{\text{X-MOTOR-EFF} \times \text{X-IMPELLER-EFF}}$

Heat Gain: $Gain_p = (\text{Design-Load} \times \text{X-LOSS}) + (Elect_p \times \text{X-MOTOR-EFF})$

INSTALLED-NUMBER is the total number of units of the type and size previously specified. As an example, if three 100-ton chillers have been specified, enter INSTALLED-NUMBER = 3.

Note: input the actual sizes and number of equipment when known (such as in retrofit studies) in order to improve the accuracy of the simulation.

TABLE 4.1

TYPE Code-Words for PLANT-EQUIPMENT

Equipment	Code-Word
Heating	
Electric boiler	ELEC-STM-BOILER
Steam boiler	STM-BOILER
Hot-water boiler	HW-BOILER
Electric hot-water boiler	ELEC-HW-BOILER
Cooling	
One-stage absorption chiller	ABSOR1-CHLR
Two-stage absorption chiller with economizer	ABSOR2-CHLR
Absorption chiller 'HWG (gas fired)	ABSORG-CHLR
Hermetic centrifugal compression chiller	HERM-CENT-CHLR
Hermetic reciprocating compression chiller	HERM-REC-CHLR
Double bundle chiller	DBUN-CHLR
Cooling tower	COOLING-TWR
Gas Engine driven reciprocating chiller	ENG-CHLR
Domestic Hot Water*	
Domestic hot-water heater	DHW-HEATER
Electric domestic hot-water heater	ELEC-DHW-HEATER

* If a domestic hot water heater is not input, hot water loads input in SYSTEMS through the PLANT-ASSIGNMENT instruction or through the SOURCE-BTU/HR keyword in the (LOADS) SPACE-CONDITIONS subcommand will be passed to other heating equipment. If no heating equipment is defined, the domestic hot water demand will appear as a load not met.

PLANT-ASSIGNMENT

PLANT-ASSIGNMENT identifies the HVAC system or systems supported by PLANT. The instruction has the form

u-name = PLANT-ASSIGNMENT ..

where u-name is the name of the corresponding PLANT-ASSIGNMENT instruction defined in the SYSTEMS program input.

PART-LOAD-RATIO

The equipment PART-LOAD-RATIO instruction specifies the nominal electric power input ratio to operate the equipment and/or supporting electric auxiliaries. PART-LOAD-RATIO tells the PLANT processor that the data to follow are related to the part-load operation of a specific type of equipment.

TYPE — is the code-word selected from Table 4.1 that identifies the type of equipment that applies to the part-load ratios specified. Only one TYPE may be specified per instruction.

ELEC-INPUT-RATIO — The electric input to nominal capacity ratio is expressed as

$$\text{ratio} = \frac{\text{electric power input to electric auxiliaries (Btu/hr)}}{\text{nominal capacity of equipment being defined (Btu/hr)}}$$

or

ratio = 1/COP for refrigeration machines

See Table 4.2 for default values.

This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself. For an absorption refrigeration chiller, the electric power input to the solution pump must be considered. Similarly, for a fossil-fueled boiler, the electric power input to the boiler draft fan and power burners must be considered. However, when defining the ELEC-INPUT-RATIO for this equipment, you should realize that the electric power delivered to the hot, chilled, and condenser water pumps is calculated separately and size and capacities are controlled through PLANT-PARAMETER keywords. This is also true for cooling tower fans.

TABLE 4.2

Equipment PART-LOAD-RATIO Default Values

TYPE Code-Word		Electric Input to Nominal Capacity
Heating Equipment		(default)
ELEC-STM-BOILER	Electric boiler	1.000
STM-BOILER	Steam boiler	0.022
HW-BOILER	Hot water boiler	0.022
ELEC-HW-BOILER	Electric hot water boiler	1.000
Cooling Equipment		
ABSOR1-CHLR	One-stage absorption chiller	0.004
ABSOR2-CHLR	Two-stage absorption chiller w/economizer	0.0071
ABSORG-CHLR	Gas-driven absorption chiller	0.0071
HERM-CENT-CHLR	Hermetic centrifugal chiller	0.220
HERM-REC-CHLR	Hermetic reciprocating chiller	0.274
DBUN-CHLR	Double-bundle chiller	0.220
ENG-CHLR	Twin screw compressor chiller	0.0053
Domestic Hot Water		
DHW-HEATER	Water heater	0.000
ELEC-DHW-HEATER	Electric water heater	1.000

[Table revised 11/91]

PLANT-PARAMETERS

PLANT-PARAMETERS is used to change the value of many of the variables used by the PLANT program in the simulation of plant components. Detailed descriptions of how the variables represented by each keyword are used in the PLANT program calculations are provided in the *DOE-2 Engineers Manual*, p.V.12ff. Following is additional discussion of specific keywords.

Chillers

CHILL-WTR-T	is the chilled water temperature at the middle of the throttling range for chillers. Default is 44°F.
MIN-COND-AIR-T	is the minimum entering air temperature allowed for an air-cooled condenser (°F). This is the minimum operating temperature below which control action is initiated to maintain at least this temperature.
ABSOR1-HIR	is the full-load heat input ratio for a 1-stage absorption chiller. The heat input ratio is the ratio of heat energy input to cooling energy output.
ABSOR2-HIR	is the full-load heat input ratio for a 2-stage absorption chiller with an economizer (see ABSOR1-HIR).
ABSORG-HIR	is the full-load heat input ratio for a direct gas fired absorption chiller.
ABSORG-HEAT-XEFF	is the efficiency of the hot water heat exchanger used in the heating mode. The default is 0.8.
ENG-CH-COP	is the overall COP of the engine driven reciprocating chiller, or the evaporator capacity of the chiller divided by the heat input of the engine. The default is 1.4, which is appropriate when the engine operates at nominal speed to meet its design load. A COP in the range of 1.1 to 1.2 should be entered for a machine that is anticipated to operate at full speed to meet the design load.
ENG-CH-COND-TYPE	accepts a code-word that specifies how heat is rejected from the chiller. The default is TOWER and the alternative is AIR (for air cooled).

HERM-CENT-COND-TYPE — accepts a code-word that specifies the condenser heat rejection method for a hermetic centrifugal chiller. The default code-word is TOWER, used when heat is rejected through an evaporative cooling tower. The alternative is AIR, which implies an air-cooled condenser.

HERM-REC-COND-TYPE — is the code-word that specifies the condenser type for a hermetic reciprocating chiller (see HERM-CENT-COND-TYPE keyword description).

DBUN-COND-T-REC — is the leaving condenser temperature when the chiller is in the heat recovery mode. This parameter is used in calculating adjustment factors for the capacity and power consumption. The leaving condenser temperature in both the heat-recovery mode and the non-heat-recovery mode at the design point (calculated from DBUN-COND-T-ENT, ELEC-INPUT-RATIO, and DBUN-TO-TWR-WTR) is used to calculate the condenser temperature rise in the heat recovery mode. The temperature rise is then used in the functions DBUN-CAP-FTRISE and DBUN-EIR-FTRISE.

Towers

MIN-TWR-WTR-T — specifies the minimum temperature for leaving tower cooling water when TWR-SETPT-CTRL = WETBULB-RESET. If the temperature falls below this minimum operating temperature, control action is initiated to maintain at least this temperature. The default is 65°F.

TWR-DESIGN-WETBULB — is the wet-bulb temperature used in the cooling tower design calculations. The default is 78°F.

TWR-CAP-CTRL — accepts a code-word that specifies the control method for regulating the tower water exit temperature. Acceptable values are ONE-SPEED-FAN (the default), TWO-SPEED-FAN, VARIABLE-SPEED-FAN, and FLUID-BYPASS.

TWR-PUMP-HEAD — is the pressure head in the tower water circulation loop. The default is 60ft.

TWR-SETPT-CTRL — accepts a code-word that defines how the exiting water temperature is to be determined. FIXED (the default) controls the tower to the fixed setpoint specified by TWR-WTR-SETPT. WETBULB-RESET causes the setpoint to drop as the wet bulb drops.

TWR-SETPT-T — specifies the exiting water temperature setpoint when TWR-SETPT-CTRL is set to FIXED. The default is 80°F.

Boilers

HW-BOILER-HIR — For a hot-water boiler it is the ratio of fuel input (Btu) to heat energy output at full load.

STM-BOILER-HIR — for a steam boiler it is the ratio of fuel input (Btu) to heat energy output.

Domestic Hot-Water Heaters

DHW-HIR — For a domestic water heater at full load it is the ratio of fuel input (Btu) to heat energy produced.

Pumps

CCIRC-DESIGN-T-DROP — is the temperature drop in the chilled water circulation loop at design; it is used to establish the appropriate water flow rate.

CCIRC-HEAD — is the head pressure in the chilled water circulation loop. Setting this keyword to zero will result in a circulation pump power of zero.

CCIRC-LOSS — is the fraction of the design load in the chilled water circulation loop that is lost to the environment and therefore does no useful cooling.

HCIRC-DESIGN-T-DROP — is the temperature drop in the hot water circulation loop at design conditions. It is used to establish the appropriate water flow rate. This keyword is ignored if you have input a STM-BOILER, ELEC-STM-BOILER, or FURNACE. Note also that the heating load satisfied by a DHW-HEATER or ELEC-DHW-HEATER is not considered to be a part of this heating circulation loop.

HCIRC-HEAD — specifies the head pressure in the hot water circulation loop. If this is set equal to 0., circulation pump power will also be set to zero.

HCIRC-LOSS — is the fraction of the design load that is lost to the environment from the hot water circulation loop and therefore does no useful heating. In the case of a hot water boiler, this value does not include heat gain caused by pump energy. If you have input a FURNACE, this keyword is ignored.

CCIRC-SIZE-OPT — accepts a code-word that indicates how much load the chilled water circulation pumps will be sized to meet. The allowable code-words are SYSTEM-PEAK (the default) and INST-PLANT-EQUIP. Specifying SYSTEM-PEAK will result in the pumps being sized to meet the peak load passed from SYSTEMS. Specifying INST-PLANT-EQUIP will result in the pumps being sized to meet the total installed capacity of PLANT-EQUIPMENT specified (regardless of whether this equipment was specified by default or input by you).

HCIRC-SIZE-OPT
: accepts a code-word that indicates how much load the hot water circulation pumps will be sized to meet. The allowable code-words and definitions are identical to those available for CCIRC-SIZE-OPT.

CCIRC-PUMP-TYPE
: accepts a code-word that specifies whether the chilled water circulation pumps are fixed- or variable-speed pumps. The allowable code-words are FIXED-SPEED (the default) and VARIABLE-SPEED. If this keyword is set equal to VARIABLE-SPEED, then losses will be determined on the basis of the actual loads being served by the pumps.

HCIRC-PUMP-TYPE
: accepts a code-word that specifies whether the hot water circulation pumps are fixed- or variable-speed pumps. The allowable code-words and definitions are identical to those available for CCIRC-PUMP-TYPE.

CCIRC-MIN-PLR
: accepts a numeric value between 0.0^+ and 1.0 that places a low limit on the electricity consumption of the chilled water circulation pumps. It is expressed as as a fraction of the full load electricity consumption of the pumps. The default is 0.50.

HCIRC-MIN-PLR
: accepts a numeric value between 0.0^+ and 1.0 that places a low limit on the electricity consumption of the hot water circulation pumps. It is expressed as fraction of the full load electricity consumption of the pumps. The default is 0.50.

HEAT-RECOVERY

The HEAT-RECOVERY instruction specifies the equipment or process from which energy can be recovered and directs that energy to a process or other equipment. Only one HEAT-RECOVERY instruction is allowed per PLANT run. If a double-bundle chiller is specified without defining a HEAT-RECOVERY instruction, the heat rejected from the double bundle is delivered only to space heating. See p.V.77ff of the *DOE-2 Engineers Manual* for a description of heat recovery in equipment simulations.

SUPPLY-1 thru SUPPLY-5 — You enter a list of code-words that describes the equipment or process that *supplies* recoverable heat. For example

SUPPLY-1 = (DBUN-CHLR)

assigns the waste heat from the double bundle chiller to the highest temperature level to meet demands. Among the chillers in DOE-2, heat can also be recovered from the gas engine chiller, ENG-CHLR.

DEMAND-1 thru DEMAND-5 — You enter a list of code-words that describes the equipment or process that *demands* recoverable heat. For example,

DEMAND-1 = (SPACE-HEAT, PROCESS HEAT)

specifies that the heat from the sources indicated in SUPPLY-1 is to go to fulfill the unmet demand for space heating and for domestic hot water or process heat, which will be done in proportion to their corresponding loads.

ENERGY-RESOURCE

ENERGY-RESOURCE allows you to enter information about the types of energy used in PLANT. The instruction can be used to specify up to seven different types of energy. An ENERGY-RESOURCE command must be entered if a steam/hot-water (code-word STEAM) or a chilled water (code-word CHILLED-WATER) utility is to be used.

RESOURCE — accepts a code-word that tells the simulation which fuel or utility will be used. It is assumed that only one type of fuel is used. However, the *Supplement (2.1E)*, p.4.5-6, describes how multiple fuel types may be simulated. Acceptable code-words are these:

CHILLED-WATER
COAL
DIESEL-OIL
ELECTRICITY
FUEL-OIL
LPG
METHANOL
NATURAL-GAS
STEAM

SOURCE-SITE-EFF — is the generating efficiency of the fuel or utility prior to its use in the building being simulated. Failure to specify an ENERGY-RESOURCE command for a fuel or utility will result in the use of the default values for SOURCE-SITE-EFF listed below.

TABLE 4.3
Source-to-Site Generating Efficiency
Default Values for ENERGY-RESOURCE

RESOURCE	SOURCE-SITE-EFF
CHILLED-WATER	1.5*
COAL	1.0
DIESEL-OIL	1.0
ELECTRICITY	0.333
FUEL-OIL	1.0
LPG	1.0
METHANOL	1.0
NATURAL-GAS	1.0
STEAM	0.60**

* Efficient electrically-driven chillers in a central chilled-water plant.

** Steam produced by heat-only boiler in a central steam generation plant.

PLANT-REPORT

This instruction defines which PLANT reports will be output. Users can select from *verification* reports and *summary* reports. Verification reports echo your input; summary reports show calculation results, usually monthly and annually.

Format:

```
PLANT-REPORT    VERIFICATION = (code-word list)
                SUMMARY = (code-word list) ..
```

Example:

```
PLANT-REPORT    VERIFICATION = (PV-A)
                SUMMARY = (PS-D, BEPS) ..
```

will print verification report PV-A, "Equipment Sizes", and summary reports PS-D, "Plant Loads Satisfied", and BEPS, "Building Energy Performance Summary".

A definition of all reports, with corresponding code-words, is given in Appendix C.

ECONOMICS

Introduction
In the ECONOMICS sub-program there are three basic commands used for the calculation of energy costs: they are UTILITY-RATE, BLOCK-CHARGE, and SCHEDULE.

- The UTILITY-RATE command describes the most basic features of a tariff: units, uniform energy and demand costs, monthly charges, minimum charges, etc.
- The BLOCK-CHARGE command is used to define energy or demand charges that vary according to the amount used.
- The SCHEDULE command is used to coordinate the operation of UTILITY-RATEs and BLOCK-CHARGEs.

Example ECONOMICS Input
The best way to learn to input tariffs in ECONOMICS is to study the input examples in conjunction with the following command and keyword descriptions. A simple example is given below. See also Appendix B and Examples 1 through 5 at the end of this section.

```
INPUT   ECONOMICS    ..

ELEC-TARIFF = UTILITY-RATE
              RESOURCE      = ELECTRICITY
              BLOCK-CHARGES = (INVBLK)  ..

INVBLK      = BLOCK-CHARGE
              BLOCK1-TYPE   = ENERGY
              BLOCK1-DATA   = (500, .0535
                               400, .0725
                                 1, .1245  ..

GAS-TARIFF  = UTILITY-RATE
              RESOURCE      = NATURAL-GAS
              MONTH-CHGS    = (15.)
              ENERGY-COST   = .75  ..

ECONOMICS-REPORT     SUMMARY = (ES-D)  ..

END  ..

COMPUTE  ECONOMICS   ..
```

Description of ECONOMICS Input Instructions

This section contains descriptions of the input instructions required to run the energy cost calculations in ECONOMICS at a basic level. Additional commands and keywords are listed in the *Supplement (2.1E)*. (The ECONOMICS program can also be used to do life-cycle cost analysis; see the *Reference Manual (2.1A)*.)

UTILITY-RATE

This command contains the most basic features of a tariff: units, uniform energy and demand cost rates, monthly charges, minimum charges, etc. One UTILITY-RATE command is entered for each type of energy or fuel used in the previous PLANT run. UTILITY-RATE also allows costs to be defined for energy that varies by time, but not by quantity. For charges that vary by quantity, such as blocks of energy with different costs, this command references one or more BLOCK-CHARGE commands. When energy is billed in a time of use format a UTILITY-RATE keyword accepts the u-name of a schedule which defines these charges for the entire year. Time of use demand charges are more complicated and must be defined using the BLOCK-CHARGE command.

On an hourly basis, each UTILITY-RATE defined in ECONOMICS sums the energy into total and peak values for each billing period. If a time of use energy charge schedule has been defined, the hourly values are multiplied by the scheduled value and summed for the billing period. The UTILITY-RATE also passes the hourly data to the associated BLOCK-CHARGEs. During each billing cycle, the UTILITY-RATE adjusts the metered energy and demand values for any minimum quantities required. These adjusted billing quantities are then used as the basis for the energy cost calculations. Block costs computed by any associated BLOCK-CHARGEs are then added. The costs are then adjusted by any minimum monthly charges and/or rate limitations.

u-name	required so that each rate can be listed in the summary reports. Up to 15 different UTILITY-RATEs may be defined.
RESOURCE	is a required keyword that determines which fuel or energy type is being valued. The code-words associated with this keyword are the same as in PLANT: STEAM, CHILLED-WATER, ELECTRICITY, NATURAL-GAS, LPG, DIESEL-OIL, FUEL-OIL, COAL, METHANOL, or OTHER-FUEL. When OTHER-FUEL is referenced, the OTHER-FUEL-NAME as defined in PLANT will be used in all reports as the RESOURCE.
MONTH-CHGS	accepts a list in parentheses of up to 12 numeric values that add a fixed monthly charge to each billing cycle. Many utilities refer to this as a customer charge. This value can range from 0.0 to 100,000 $/month and defaults to 0.0. If a single value is entered, the value will be used for all 12 billing periods. If fewer than 12 are entered, the last value entered will be used for all remaining billing periods. This is true of all numeric lists in ECONOMICS.

ENERGY-CHG accepts a numeric value that allows you to specify an energy charge that is constant with time and quantity. The units are $/UNIT and can range from $0.0 to $100,000,000/UNIT. In the absence of any other charges, this keyword will default in accordance with Table 5.1. The UNIT value is the unit as defined or defaulted in the ENERGY-RESOURCE command of PLANT.

Table 5.1

Default ENERGY-CHG Values for UTILITY-RATE

RESOURCE	VALUE	$/UNIT
CHILLED-WATER	12,000 Btu/ton	0.12
COAL	24,580,000 Btu/ton	30.00
DIESEL-OIL	138,700 Btu/gal	1.05
ELECTRICITY	3,412.97 Btu/kWh	0.07
FUEL-OIL	138,700 Btu/gal	1.19
LPG	95,500 Btu/gal	0.97
METHANOL	63,500 Btu/gal	1.13
NATURAL-GAS	100,000 Btu/therm	0.50
OTHER-FUEL	1,000,000 Btu/unit	0.95
STEAM	1,000,000 Btu/unit	13.00

ENERGY-CHG-SCH accepts the u-name of a SCHEDULE which specifies an ENERGY-CHG that varies by time of day, week and/or season. The units in the schedule should be $/UNIT. This schedule is used for all time of use energy billing (demand time of use billing is more complex, and requires the use of multiple BLOCK-CHARGEs). If both an ENERGY-CHG and ENERGY-CHG-SCH are defined, the values will add.

DEMAND-CHGS accepts a list in parentheses of 12 values that allows you to specify a demand charge that is constant with quantity but may vary by billing period. The units are $/peak-UNIT and can range from $0.0 to $100,000,000/peak-UNIT. The default is 0.0. As with other lists, as few as one value may be entered in the list, and the last value will be used for the remaining billing periods.

BLOCK-CHARGE	accepts a list in parentheses of up to 10 u-names of BLOCK-CHARGEs. These BLOCK-CHARGEs can be used to calculate either energy or demand charges that vary according to quantity. In addition, time of use demand charges are calculated using the BLOCK-CHARGE format.
MIN-MON-CHGS	accepts a list in parentheses of 12 values that place a floor on the cost of a fuel or utility for each billing period in which costs are calculated. This value can range from $0 to $100,000,000 per month and defaults to $0. As with other lists, not all 12 values need be entered; the last value entered will be used for all remaining billing periods. Note that the minimum charge excludes any customer charge, taxes, surcharges, or energy cost adjustments.
MIN-MON-DEM-CHGS	accepts a list in parentheses of up to 12 values that specify a variable minimum monthly charge calculated on the basis of billing demand. The value entered has units of $/kW, and the default is 0. Some utilities do not charge directly for demand, but embed demand charges in kWh/kW rate structures. This keyword allows demand charges to be levied in the event actual demand is exceptionally high relative to total energy use. The total minimum month charges will be the sum of the constant and variable minimum charges as specified by MIN-MON-CHGs and MIN-MON-DEM-CHGs.
RATE-LIMITATION	accepts a numeric value in dollars per unit that places a ceiling on the maximum effective rate that will be assessed on a utility or fuel for any month. This value can range from $0.0 to $100,000,000/UNIT and defaults to $100,000,000/UNIT. The RATE-LIMITATION excludes MONTH-CHGs and charges arising from ENERGY-COST-ADJustments. In addition, the RATE-LIMITATION cannot cause the total bill to drop below the fixed MIN-MON-CHGs plus the MIN-MON-DEM-CHGs.
BILLING-DAYS	accepts a list in parentheses of up to 12 values. If you input less than 12, the last value entered will be the default for all unentered values. The default is 31, or the last day of the month. All costs, etc. reported in output reports will be based on the billing-day. For example, if the billing-day is 17, energy usage for each month listed in the reports will be from the 18th day of the previous month, through the 17th day of the current month. You may elect to explicitly enter the billing day for each month when it is desired to closely match existing utility bills. This may be important if the meter is not regularly read on the same day each month.

BLOCK-CHARGE

BLOCK-CHARGEs are used to calculate energy or demand costs that vary according to the amount consumed. BLOCK-CHARGEs are also used for time of use demand charges. Up to 30 BLOCK-CHARGEs may be defined, and up to 10 may be referenced by each UTILITY-RATE. The same BLOCK-CHARGE may be referenced by more than one UTILITY-RATE; the program automatically makes as many working copies as are required.

u-name	is a unique user-defined name that must be entered to identify this command.
BLOCK-SCH	accepts the u-name of a SCHEDULE which defines the period over which energy or demand specified in the parent UTILITY-RATE is accumulated. For all energy charges, the schedule is used only for seasonal changes in block charges, such as winter vs. summer rates; time of use rates should be defined directly in the UTILITY-RATE via the ENERGY-CHG-SCH. It is not necessary for seasons to begin and end on the BILLING-DAYS; the program will prorate charges when a seasonal change occurs in the middle of the billing period. You should be careful, however, to ensure that one or more other BLOCK-CHARGEs are defined for the periods in which this BLOCK-CHARGE is inactive. This schedule may be used to define as many seasons as may be required. For conventional block demand charges, seasonal changes are handled identically to energy block charges. For demand charges levied on a time of use basis, such as peak, shoulder, and off-peak, this schedule may vary on an hourly and daily basis, as well as seasonal basis.
SCH-FLAG	specifies the flag value in the BLOCK-SCH that indicates when this BLOCK-CHARGE is active. The default is 1.0
BLOCK1-TYPE	accepts a code-word used to define the type of block calculation that will follow.
ENERGY	the default; used when the cost calculations will be done on a per unit basis of energy consumption.
KWH/KW	is used to specify calculations for energy consumption where each block size is defined as a multiplier on demand. When the number of kWh that can be in a given kWh/kW block is limited to a maximum value, a limit can be specified (see BLOCK-DATA).
KWH/KW-LIMITSUM	is used when the sum of the kWh in a series of ENERGY blocks is limited by a kWh/kW value. The maximum value is specified in the BLOCK-DATA.

In the [illegible] above, bold-faced words are commands, non-bold words are keywords, and italicized words are code-words.

DEMAND specifies that this set of BLOCK-CHARGEs will be used for calculating demand charges.

BLOCK1-DATA accepts a list enclosed by parentheses of up to 10 sets of data. For ENERGY and DEMAND blocks, each set consists of two entries in the order (block-size, cost/unit). For KWH/KW and KWH/KW-LIMITSUM types, each set consists of three entries in the order (block-size, cost/unit, limit).

The first entry of each set indicates the size of the block to which the cost/unit will be applied. Blocks are increments; hence each successive BLOCK-DATA entry covers the next size block and its cost. Rates written as "up to X" must be translated. The range is from 0.0 to 100,000,000 and there is no default.

The second entry of each set indicates the cost/unit to be applied against the energy or demand falling within this block.

For KWH/KW and KWH/KW-LIMITSUM types, the third entry is the limit. An entry of 0.0 means there is no limit.

1. When the BLOCK-UNIT is KWH/KW, the limit has units of kWh and is the maximum quantity of energy that can be charged in this block.
2. When the BLOCK-UNIT is KWH/KW-LIMITSUM, this entry has units of kWh/kW and, when multiplied by demand, is the maximum sum of all energy that can be charged in this block and all previous blocks. Usually, one limit will apply to a series of blocks. In this case, the same limit should be entered for each of the affected blocks.

Example: A utility charges $0.05 for the first 5,000 kWh, $0.04 for the next 10,000 kWh, and $0.035 for the remainder. Input is as follows:

```
BLOCK1-TYPE    =ENERGY
               $kWh, COST
BLOCK1-DATA    =( 5000, .05,     $ SET #1
                 10000, .04,     $ SET #2
                     1, .035)    $ SET #3
```

Assuming that the BLOCK1-DATA is not followed by an entry for BLOCK2-DATA, all remaining energy will go into the last block; therefore, its size does not matter. Note also that, while this format is easy to read, it is not mandatory. All data could have been entered on a single line.

BLOCK2-TYPE When energy calculations are being made, this keyword allows the type of energy calculation to change. For example, a utility may start with a series of ENERGY blocks and then change to kWh/kW blocks. Alternatively, energy blocks may switch to demand.

BLOCK2-DATA

This keyword is used in an identical fashion to BLOCK1-DATA. When BLOCK2-TYPE is the same as BLOCK1-TYPE, this keyword allows an additional 10 sets of data to be entered. If the previous example also contained kWh/kW blocks, input might be as follows:

BLOCK1-TYPE =	ENERGY		
	$kWh	COST	
BLOCK1-DATA =	(5000,	.05,	$ SET #1
	10000,	.04,	$ SET #2
	30000,	.035)	$ SET #3
BLOCK2-TYPE =	KWH/KW		
	$kWh/kW	COST	MAX kWh
BLOCK2-DATA =	(100,	.03,	40000,
	200,	.02,	0,
	1,	.015,	0)

Note that data for kWh/kW is entered in sets of three, with the third entry being the limit. The limit must be specified, even if it is zero (no limit).

BLOCK3-TYPE

Same

BLOCK3-DATA

Same

TOU-SEASON-LINKS

This keyword is used only with a time of use rate where different BLOCK-CHARGEs are used at different times of the day, and is required only when seasonal changes in rates occur on a day which does not coincide with the billing-day. In this case, the two BLOCK-CHARGEs overlap in the same billing period and must be linked so that the correct energy and/or demand charges can be determined for both blocks. (Charges for each block must be based on the same use period, such as on-peak, and then prorated based on the number of hours each block was active during the billing period. See the section on Yearly, Seasonal, and Time of Use BLOCK-CHARGEs for more information).

Input is a list of u-name(s) in parenthesis of the linked BLOCK-CHARGE(s) which share the same billing period. Both BLOCK-CHARGEs must reference each other via this keyword. If only two seasons are used, this BLOCK-CHARGE will overlap with only one other BLOCK-CHARGE, so that only one u-name is entered. If more than two seasons are used, such as winter, spring, summer and fall, this BLOCK-CHARGE will overlap with two other BLOCK-CHARGEs. For example, a BLOCK-CHARGE representing spring will overlap with both winter and summer BLOCK-CHARGEs. In this case, the u-names of the winter and summer BLOCK-CHARGEs are input.

If a UTILITY-RATE has a block structure for both energy and demand charges, the same BLOCK-CHARGE may be used to model both. When modeling both, the energy and demand BLOCK-TYPE keywords may be specified in any order. Alternatively, separate BLOCK-CHARGEs can be used for energy and demand. This may be useful when the BLOCK-SCH for the energy and demand charges do not coincide. As previously described, each UTILITY-RATE can reference up to 10 BLOCK-CHARGEs.

Yearly, Seasonal, and Time of Use BLOCK-CHARGEs

BLOCK-CHARGEs can be used to model yearly, seasonal, or time of use (i.e., time of day) rates:

Example of a BLOCK-CHARGE Yearly Rate

A yearly rate is very straightforward to model. One or more BLOCK-CHARGEs are defined without defining a BLOCK-SCH. The rate will then be used all year. For example, the following input models a yearly rate:

```
ELEC-TARIFF = UTILITY-RATE
              RESOURCE        = ELECTRICITY
              BLOCK-CHARGES   = (INVBLK) ..

INVBLK      = BLOCK-CHARGE
              BLOCK1-TYPE     = ENERGY
                                $SIZE  COST
              BLOCK1-DATA     = (500,  .0535,
                                 400,  .0725,
                                   1,  .1245)  ..
```

Example of a BLOCK-CHARGE Seasonal Rate

A seasonal rate is also straightforward. As before, one or more BLOCK-CHARGEs are defined, and a BLOCK-SCH is also defined to indicate when each BLOCK-CHARGE is actively used. The following is an example of a seasonal rate:

```
ELEC-TARIFF = UTILITY-RATE
              RESOURCE        = ELECTRICITY
              BILLING-DAYS    = (31)
              BLOCK-CHARGES   = (WINTER-BLK,
                                 SUMMER-BLK) ..

WINTER-BLK  = BLOCK-CHARGE
              BLOCK-SCH       = SEASONS-SCH
              SCH-FLAG        = 1
              BLOCK1-TYPE     = ENERGY
                                $SIZE  COST
              BLOCK1-DATA     = (1000, .07,
                                    1, .10 )  ..

SUMMER-BLK = BLOCK-CHARGE
             BLOCK-SCH        = SEASONS-SCH
             SCH-FLAG         = 2
             BLOCK1-TYPE      = ENERGY
                                $SIZE  COST
             BLOCK1-DATA      = (500,  .06,
                                   1,  .09)  ..
```

```
SEASONS-SCH = SCHEDULE    THRU MAY 15  (ALL)  (1,24) (1)
                          THRU SEP 15  (ALL)  (1,24) (2)
                          THRU DEC 31  (ALL)  (1,24) (1)  ..
```

Note that in this example, the season changes from winter to summer on May 15, but the billing day is at the end of the month. This means that, during the month of May, the winter block-charge is used in the first half of the month, and the summer block-charge is used for the latter half. In this case, DOE-2 prorates the costs between the two block-charges in the same way that most utilities do:

a. Costs for each BLOCK–CHARGE are computed using all of the energy consumed during the entire billing period. For example, the cost for the WINTER–BLOCK is computed using the energy billed for the entire month of May, not just the energy metered for the first half of the month.

b. The costs are then prorated based on the number of hours each BLOCK–CHARGE was active. For example, the cost computed for WINTER–BLOCK is multiplied by 15/31 days.

The above example is for an energy type BLOCK–CHARGE
(BLOCK1–TYPE = ENERGY, KWH/KW, or KWH/KW–LIMITSUM).
DEMAND type blocks are handled similarly:

a. The cost for each DEMAND type BLOCK–CHARGE is computed using the maximum demand found in the entire billing period.

b. The costs are then prorated based on the number of hours each BLOCK–CHARGE was active.

Both DOE-2 and the utility companies prorate charges based on the number of days rather than on actual energy consumed because the standard utility meter accumulates a single value of energy and a single value of demand for the billing period; information on the distribution of energy and demand usage is not available. Report ES-F shows how the proration is done. For each BLOCK–CHARGE, the "metered energy" is the energy metered during the period defined by the BLOCK–SCH. The "billing energy" is the energy metered during the entire billing period (i.e. the month). The billing energy is the amount used to compute the cost. Usually, the metered energy and the billing energy will be the same except when the season changes in the middle of a billing period. In this case, the "prorate factor" is used to adjust the actual charges. Logically, the prorate factors of two seasonal BLOCK–CHARGEs sharing the same billing period will add up to 1.0

Example of a BLOCK-CHARGE Time of Use Rate

Time of use rates are somewhat more complex because energy and/or demand charges vary according to the time of day and day of week. Accordingly, the BLOCK-SCH must be defined to switch from one BLOCK-CHARGE to another on an hourly basis. The following is an example of a time of use rate:

```
TIME-OF-USE = UTILITY-RATE
                 RESOURCE          = ELECTRICITY
                 BILLING-DAYS      = (31)
                 BLOCK-CHARGES     = (WIN-PK,WIN-OFFPK,
                                   =  SUM-PK, SUM-OFFPK)   ..

WIN-PK      = BLOCK-CHARGE
                BLOCK-SCH        =  SCH-BLOCK
                SCH-FLAG         =  1.2
                BLOCK1-TYPE      =  KWH/KW
                                   $SIZE COST LIMIT
                BLOCK1-DATA      =  (100,  .05,  0,
                                       0,  .04,  0)  ..

WIN-OFFPK   = BLOCK-CHARGE
                BLOCK-SCH        =  SCH-BLOCK
                SCH-FLAG         =  1.1
                BLOCK1-TYPE      =  KWH/KW
                                   $SIZE COST LIMIT
                BLOCK1-DATA      =  (100,  .04,  0,
                                       0,  .03,  0)  ..

SUM-PK      = BLOCK-CHARGE
                BLOCK-SCH        =  SCH-BLOCK
                SCH-FLAG         =  2.2
                BLOCK1-TYPE      =  KWH/KW
                                   $SIZE COST LIMIT
                BLOCK1-DATA      =  ( 100,.09,   0,
                                        0,.08,   0)  ..
```

```
SUM-OFFPK = BLOCK-CHARGE
            BLOCK-SCH       =  SCH-BLOCK
            SCH-FLAG        =  2.1
            BLOCK1-TYPE     =  KWH/KW
                              $SIZE COST LIMIT
            BLOCK1-DATA     =  (100,  .05,   0,
                                  0,  .04,   0)  ..

SCH-BLOCK = SCHEDULE  THRU APR 30  (WD)     (1,6)  (1.1)
                                           (7,18)  (1.2)
                                          (19,24)  (1.1)
                                   (WEH)   (1,24)  (1.1)
                      THRU OCT 30  (WD)    (1,12)  (2.1)
                                          (12,18)  (2.2)
                                          (19,24)  (2.1)
                                   (WEH)   (1,24)  (2.1)
                      THRU DEC 31  (WD)     (1,6)  (1.1)
                                           (7,18)  (1.2)
                                          (19,24)  (1.1)
                                   (WEH)   (1,24)  (1.1)  ..
```

For a customer to utilize a time of use rate, the utility must provide a meter which is capable of recording the distribution of energy (and demand) consumption, not just the total amount used in the billing period. DOE-2 reflects this; in the above example, the costs for each block charge will be computed using only the energy consumed during the period defined by the BLOCK-SCH.

In the above example, energy costs are computed using kWh/kW blocks. The actual size of the block is therefore based on demand. By default, the demand used for each BLOCK-CHARGE is the maximum demand encountered during the block's active period, as defined by its BLOCK-SCH.

In the above time of use examples, the BILLING-DAYS and the SCH-BLOCK were defined so that the winter season changed to summer on the billing day. What happens when the season changes in the middle of the billing period? Usually, the utility will compute the charges for each peak (or off-peak) BLOCK-CHARGE using the energy consumed during the entire on-peak time of the billing period (i.e., the energy used in the computation for each on-peak BLOCK-CHARGE is the sum of the energy used in both the winter and summer on-peak blocks). The utility will then prorate the costs between the winter and summer BLOCK-CHARGEs as described previously.

For this seasonal change to computed properly, how does DOE-2 know which summer and winter blocks share the on-peak (or mid-peak, off-peak, etc.) periods? It does this through the TOU-SEASON-LINK keyword. The following example illustrates how seasonal blocks can be linked together. This is the same example as before, except that the BILLING-DAYS = (15) so that the billing day and the seasonal change no longer coincide. For clarity, the changes have been underlined:

```
TIME-OF-USE = UTILITY-RATE
              RESOURCE            =  ELECTRICITY
              BILLING-DAYS        =  (15)
              -----------------------
              BLOCK-CHARGES       =  (WIN-PK,WIN-OFFPK,
                                      SUM-PK,SUM-OFFPK)   ..

WIN-PK      = BLOCK-CHARGE
              BLOCK-SCH           =  SCH-BLOCK
              SCH-FLAG            =  1.2
              TOU-SEASON-LINKS    =  (SUM-PK)
              ---------------------------
              BLOCK1-TYPE         =  KWH/KW
                                    $SIZE   COST   LIMIT
              BLOCK1-DATA         =  (  100,   .05,     0,
                                          0,   .04,     0)  ..

WIN-OFFPK   = BLOCK-CHARGE
              BLOCK-SCH           =  SCH-BLOCK
              SCH-FLAG            =  1.1
              TOU-SEASON-LINKS    =  (SUM-OFFPK)
              ------------------------------
              BLOCK1-TYPE         =  KWH/KW
                                     $SIZE   COST   LIMIT
              BLOCK1-DATA         = (  100,   .04,     0,
                                         0,   .03,     0)  ..

SUM-PK      = BLOCK-CHARGE
              BLOCK-SCH           =  SCH-BLOCK
              SCH-FLAG            =  2.2
              TOU-SEASON-LINKS    =  (WIN-PK)
              ------------------------------
              BLOCK1-TYPE         =  KWH/KW
                                    $ SIZE   COST   LIMIT
              BLOCK1-DATA         =  (  100,   .09,     0,
                                          0,   .08,     0)  ..
```

```
SUM-OFFPK     = BLOCK-CHARGE
                BLOCK-SCH          =   SCH-BLOCK
                SCH-FLAG           =   2.1
                TOU-SEASON-LINKS   =   (WIN-OFFPK)
                ..................................
                BLOCK1-TYPE        =   KWH/KW
                                       $ SIZE   COST   LIMIT
                BLOCK1-DATA        =   ( 100,   .05,     0,
                                           0,   .04,     0)  ..

SCH-BLOCK = SCHEDULE  THRU APR 30 (WD)      (1,6)  (1.1)
                                           (7,18)  (1.2)
                                          (19,24)  (1.1)
                                  (WEH)    (1,24)  (1.1)
                      THRU OCT 30 (WD)     (1,12)  (2.1)
                                          (12,18)  (2.2)
                                          (19,24)  (2.1)
                                  (WEH)    (1,24)  (2.1)
                      THRU DEC 31 (WD)      (1,6)  (1.1)
                                           (7,18)  (1.2)
                                          (19,24)  (1.1)
                                  (WEH)    (1,24)  (1.1)  ..
```

To summarize, the TOU-SEASON-LINKS keyword is required only when a time of use rate is being simulated and the BILLING-DAYS does not coincide with the change in season. In this case, report ES-F will report the "metered energy" for each BLOCK-CHARGE as the energy metered during the period defined by the BLOCK-SCH, the "billing energy" as the sum of the energy metered for this block and its linked block, and the "prorate factor" as the number of hours that this block was active relative to its linked block (i.e., prorate factor = Hours1 (Hours1−Hours2) where Hours1 is the number of active hours of this block, and Hours2 is the number of active hours of the linked block). As for a non time of use seasonal change, the prorate factors of two linked blocks should always add up to 1.0

How does DOE-2 know whether a BLOCK-CHARGE is being used in a yearly, seasonal, or time of use format? It does this by looking at the number of times the BLOCK-SCH changes during the course of the year. If the schedule never changes, the block must be yearly. If it changes no more than once in each billing period, it is seasonal. If it changes more than once in any billing period, it is considered to be a time of use block. Report ES-F indicates whether each BLOCK-CHARGE is yearly, seasonal, or time of use. You should always review this report to confirm that the program is modeling your BLOCK-CHARGEs as intended.

SCHEDULE

This command, along with DAY-SCHEDULE and WEEK-SCHEDULE, is used to coordinate the operation of the UTILITY-RATEs, BLOCK-CHARGEs and RATCHETs. Because a utility's rate structure may be complex, a SCHEDULE may need to coordinate a large number of different items. For this purpose, SCHEDULEs may be provided with user-defined flag values which are used to activate different rates, blocks, or ratchets at different times of the day or season.

You are already familiar with schedule flags. For example, the FAN-SCHEDULE in SYSTEMS uses the flag values of 0 and 1; 0 means the fan is off, and 1 means the fan is on. In ECONOMICS, 1 may represent the winter season, and 2 the summer. Similarly, for time of use demand pricing, 1.1, 1.2 and 1.3 may represent the peak, shoulder, and off-peak demand periods in winter, while 2.1, 2.2, and 2.3 are for the summer. Using flags, a time of use demand schedule can be defined as follows.

```
TOU-SCHEDULE = SCHEDULE  THRU MAR 31  (WD)   (1,6)  (1.3)
                                             (7,12)  (1.2)
                                            (13,18)  (1.1)
                                            (19,24)  (1.3)
                                      (WEH)  (1,24)  (1.3)

                         THRU OCT 15  (WD)   (1,6)  (2.3)
                                             (7,12)  (2.2)
                                            (13,18)  (2.1)
                                            (19,24)  (2.3)
                                      (WEH)  (1,24)  (2.3)

                         THRU DEC 31  (WD)   (1,6)  (1.3)
                                             (7,12)  (1.2)
                                            (13,18)  (1.1)
                                            (19,24)  (1.3)
                                      (WEH)  (1,24)  (1.3)  ..
```

Each BLOCK-CHARGE associated with one of these periods references the schedule, and also references a specific flag. For example, the BLOCK-CHARGE defined with the peak summer period would reference the flag value 2.1. Note that you define the flag values; any numbers acceptable by the SCHEDULE commands are acceptable.

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Examples of Electricity Tariffs

To illustrate the use of the ECONOMICS commands and keywords, a series of examples of electricity tariffs is presented. These examples can be extended to other fuels and utilities.

Example 1: Basic Tariff

The most basic tariff is a uniform charge levied on all units consumed in a month. For this example, all kilowatt-hours cost $0.05 and there is a monthly customer charge of $15.00. The minimum bill is $17.00 and there are no demand charges.

```
ELEC-TARIFF = UTILITY-RATE
                RESOURCE      = ELECTRICITY   $required
                MONTH-CHGS    = (15.)
                ENERGY-COST   = .05
                MIN-MON-CHGS  = (17.)  ..
```

MONTH-CHGS and MIN-MON-CHGS take lists specifying the charges for 12 months. Since only a single value was entered, this value will be used for all 12 months.

Example 2: Simple Block Tariff

Although block rates have been used for years, many of them now incorporate marginal-cost and equity-related concerns. A recent example of the latter, currently in wide usage among residential customers, are inverted block rates. The basic idea is that increased consumption is discouraged by increased per unit costs. A simple inverted block has three tiers. In this example the first 500 kWh of consumption (sometimes referred to a "baseline" or "life line" quantity) are charged at $.0535 per kWh. All kWh consumed in excess of 500 kWh, but less than 900 kWh, are charged at $.0725 per kWh. The third tier covers all consumption in excess of 900 kWh at a charge of $.1245 per kWh. There is no seasonal variation in this rate and we will ignore minimum and fixed monthly charges in this example.

```
ELEC-TARIFF = UTILITY-RATE  RESOURCE      = ELECTRICITY $required
                            BLOCK-CHARGES = (INVBLK)  ..

INVBLK      = BLOCK-CHARGE  BLOCK1-TYPE   = ENERGY
                                             $SIZE  COST
                            BLOCK1-DATA   = (500.  .0535,
                                             400,  .0725,
                                               1.  .1245 )  ..
```

Note that the size of the last block can be any number. Since BLOCK1-DATA is not followed by BLOCK2-DATA, all remaining energy will be assessed at the rate in the last set.

Example 3: Seasonal Block Tariff

Most utilities are faced with demands for electricity that are not evenly distributed throughout the year. They reflect the fact that changing levels of demand result in differing costs of service by introducing seasonal variations in the rates for electricity. These variations may have different size blocks associated with them, as well. In this next example, there is a winter season that lasts from October to May and a summer season that lasts from June to September. This utility is winter-peaking, but recognizes the need for increased life line allowances at this time of year.

```
ELEC-TARIFF = UTILITY-RATE
               RESOURCE      =  ELECTRICITY  $REQUIRED
               BLOCK-CHARGES =  (WINTER-BLK, SUMMER-BLK)  ..

WINTER-BLK = BLOCK-CHARGE
             BLOCK-SCH     =  SEASONS-SCH
             SCH-FLAG      =  1
             BLOCK1-TYPE   =  ENERGY  $REQUIRED
                            $ SIZE   COST
             BLOCK1-DATA   =  ( 1000, .07,
                                   1, .10 )  ..

SUMMER-BLK = BLOCK-CHARGE
             BLOCK-SCH    =  SEASONS-SCH
             SCH-FLAG     =  2
             BLOCK1-TYPE  =  ENERGY
                           $ SIZE COST
             BLOCK1-DATA  =  (   500, .06,
                                   1, .09)  ..

SEASONS-SCH = SCHEDULE   THRU MAY 31   (ALL)   (1,24)  (1)
                         THRU SEP 30   (ALL)   (1,24)  (2)
                         THRU DEC 31   (ALL)   (1,24)  (1)  ..
```

Note how the use of the SCH-FLAG keyword allowed both BLOCK-CHARGEs to reference the same schedule.

Example 4: Demand Charges

The most significant difference between residential and commercial electricity tariffs is the inclusion of demand charges. These tariffs can also include rate limitation features to ensure that when the charges are all totaled, the effective rate per kWh is less than or equal to a specified amount. In this example the demand charge is $12/kW. There is a flat charge on energy of $0.05/kWh but in no circumstance can the effective rate (i.e., including the demand charges) exceed $.07/kWh.

```
ELEC-TARIFF  =  UTILITY-RATE
                RESOURCE         = ELECTRICITY
                ENERGY-CHGS      = (0.05)
                DEMAND-CHGS      = (12.00)
                RATE-LIMITATION  = 0.07   ..
```

Example 5: Time of Use and Seasonal Demand Charges

The most recent innovation in rate design has been the introduction of time of use rates wherein the time of day, week, and year that energy is consumed get broken into different costing periods and have different charges assigned to them. The charges, moreover, can be for demand and energy, and for each of these the definition of the periods can change. In this example, there is a winter and summer season. Energy charges vary by season and also by on-peak and off-peak. Demand charges vary by season only, and are charged at $5.00/kW during the winter (Oct-Mar) and $8.00/kW during the summer.

```
TIME-OF-USE  =  UTILITY-RATE
                RESOURCE         = ELECTRICITY
                ENERGY-CHG-SCH   = ENERGY-SCH
                DEMAND-CHGS      = (5,5,5,8,8,8,8,8,8,
                                     5,5,5)   ..

ENERGY-SCH  =  SCHEDULE   THRU MAR 31 (WD)    (1,8)   (.04)
                                              (9,22)  (.06)
                                              (23,24) (.04)
                                      (WEH)   (1,24)  (.04)
                          THRU SEP 31 (WD)    (1,8)   (.05)
                                              (9,20)  (.07)
                                              (21,24) (.05)
                                      (WEH)   (1,24)  (.05)
                          THRU DEC 31 (WD)    (1,8)   (.04)
                                              (9,22)  (.06)
                                              (23,24) (.04)
                                      (WEH)   (1,24)  (.04)  ..
```

Shoulder periods are those times during the day when the utility experiences moderate use; they can be easily incorporated by including additional times in the ENERGY-SCH.

ECONOMICS-REPORT

This instruction defines which ECONOMICS reports will be output. Users can select from *verification* reports and *summary* reports. Verification reports echo your input, summary reports show calculation results usually monthly and annually.

Format:

```
ECONOMICS-REPORT    VERIFICATION = (code-word list)
                    SUMMARY = (code-word list) ..
```

Example:

```
ECONOMICS-REPORT    VERIFICATION = (none required)
                    SUMMARY = (ES-D, ES-E) ..
```

will print summary reports ES-D, "Summary of Fuel and Utility Use and Costs", and ES-E, "Summary of Electricity Charges". A definition of all reports, with corresponding code-words, is given in Appendix D.

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Appendix A

Additional Capabilities of DOE-2

DOE-2 has many capabilities in addition to those covered in the main text of this manual; following is a list of some of these capabilities. Items in the list point to other pieces of DOE-2 documentation where you will find the capability as it was presented originally or in some cases, modified and enhanced. The *Sample Run Book (2.1E)* is referred to in order to demonstrate the simulation method. Because there are other phrases or terms that are often used to reference the capability that may be of interest, we have cross referenced a number of them in this list.

The items in the list appear alphabetically and are not separated into the LOADS, SYSTEMS, PLANT, and ECONOMICS subprograms.

ASHRAE Constructions for Walls and Roofs	Instead of entering a LAYERS command, you can use the ASHRAE pre-specified layers found in the *Reference Manual (2.1A)*, Table 26, pp.III.63-66.
ASHRAE Materials Library	Instead of using the materials library provided in this manual you can use the ASHRAE pre-specified materials found in the *Reference Manual (2.1A)*, Table 8, pp.III.63-66.
ASHRAE Weather Design Criteria	see **Design Day**
Atrium	see **Sunspace**
Building Coordinate System	An X Y Z three-dimensional description of the building and shading surfaces can be entered. The method is described in detail in the *Reference Manual (2.1A)*, p.III.8; additional features are described on p.2.74 of the *Supplement (2.1E)*. Specifying surface coordinates is generally only necessary in three instances: (1) there are building shades (other than those specified with the window fin and overhang keywords); (2) daylighting is simulated; or (3) sunspaces are simulated. For an example, see p.9.6 of the *Sample Run Book (2.1E)*, Single Family Residence.
Casework Heat Recovery	see **Refrigerated Casework**
Chilled Water Storage	see **Energy Storage**

Cogeneration	using either gas turbine, diesel, or natural gas engines can be modeled. See the writeup on p.5.15 of the *Supplement (2.1E)*, and p.3.39 of the *Sample Run Book (2.1E)*, 31-Story Office Building, LOAD2, Run 5.
Curve Fit	allows you to input new performance curves. Since most vendor-supplied equipment information is provided in the form of curves or tabulated data, you can enter new data and overwrite the curves stored in the program. A detailed description of how to input the data is found on p.IV.180 of the *Reference Manual (2.1A)*. Examples appear on pp.2.11 and 3.64 of the *Sample Run Book (2.1E)*.
Custom Weighting Factors	allow you to tailor the weighting factors used in the load calculations to the building being modeled. This improves the accuracy of the calculation. Custom Weighting Factors are calculated when FLOOR-WEIGHT = 0 is specified for a space. A detailed discussion is found on pp.III.141-153 of the *Reference Manual (2.1A)*. For an example, see Single Family Residence on p.9.6 in the *Sample Run Book (2.1E)*.
Daily Reports	see **Hourly Reports**
Daylighting	simulates control of lighting fixtures in response to the level of natural lighting from the sun, sky, and reflection off the inside surfaces of the space. Both dimming and step control can be modeled. Window shade management to control solar gain and/or glare can be modeled. See pp.2.37ff of the *Supplement (2.1E)*. The example starting on p.10.8 of the *Sample Run Book (2.1E)* covers the method of input and shows the reports available.
Demand Ratchets	allow you to adjust energy demand charges; see the *Supplement (2.1E)*, p.5.8.

Desiccant Cooling	see System Type PTGSD in this manual and the PTGSD writeup on p.3.72 of the *Supplement (2.1E)*.
Desiccant Add-On Units	see writeup on p.3.79 of the *Supplement (2.1E)* for "Add-On (Integrated) Desiccant Cooling", covering both solid and liquid systems.
Design Day	is a feature that allows you to enter the design criteria for outside weather conditions. Peak loads are calculated based on these conditions rather than those on the weather tape. The automatic sizing for systems is based on the design criteria; the plant is sized on the maximum loads that occur during the systems design day run period. See the *Sample Run Book (2.1E)*, p.1.18.
Energy Storage	Hot and cold water storage is described on pp.V.73-81 of the *Reference Manual (2.1A)*. The *Sample Run Book (2.1E)* shows an example of cold water storage on p.2.32 and hot water storage on p.3.15. Ice storage systems are described on pp.4.15ff of the *Supplement (2.1E)* and an example is given in the *Sample Run Book (2.1E)* under "Office Building and Open Atrium", section 7.
Energy Meters	allow you to meter different energy end uses: see the *Supplement (2.1E)*, p.3.4 and p.4.3.
Evaporative Cooling	see writeup on three configurations of evaporative cooling in the *Supplement (2.1E)*: Stand-alone Evaporative Cooling, p.3.64, Add-on Evaporative Cooling, p.3.65, Residential Direct Evaporative Cooling, p.3.70.
Fabric Roof Pressurization	see **Night Ventilation**

Fan Power

can be input using alternative keywords for fan location, total static pressure, and fan efficiency. Most building codes use watts/cfm to determine limits for fan power and the program defaults to these approximate values. However, the alternative capability is often preferred by design engineers. The keywords are discussed on pp.IV.224-227 of the *Reference Manual (2.1A)*. Also, see the *Sample Run Book (2.1E)*, p.2.10.

Functions

see **Input Functions**

Gas Heat Pumps

See p.3.48 of the *Supplement (2.1E)*, for modeling gas-engine-driven heat pumps

Glass Coefficients

for windows is an alternative, and more accurate, method of calculating solar gains through window glazings than the shading coefficient method. See **Window Library**; also refer to p.2.99 of the *Supplement (2.1E)*.

Grocery Store Heat Recovery Systems

see **Refrigerated Casework**

Heat Pumps

with user-defined type of defrost control and of supplemental heat in lieu of electric resistance heat is covered in detail on p.3.26 of the *Supplement (2.1E)*.

Hot Water Storage

see **Energy Storage**

Hourly Reports

are a means of displaying user-selected hourly values calculated by the program. Hourly reports also give daily sums, maxima, minima, and averages. See pp.1.10, 1.29, 1.33 and *Appendix A* of the *Supplement (2.1E)*, and pp.III.127-130 of the *Reference Manual (2.1A)*. The *Sample Run Book (2.1E)* has an example starting on p.10.26ff.

Ice Rink Modeling

see **Refrigerated Casework**

Ice Storage

see **Energy Storage**

Infiltration Modeling	using the CRACK Method is found on p.III.50 of the *Reference Manual (2.1A)*. Infiltration modeling using the Sherman-Grimsrud Method is found on p.2.86 of the *Supplement (2.1E)*.
Input Functions	In LOADS, this allows you to replace DOE-2 code with your own algorithms to model options like non-linear dimming controls, complex window management, etc. In SYSTEMS, this allows you to replace DOE-2 code with your own algorithms to model things like non-standard economizer controls, control of supply air with a return air controller, etc. A detailed discussion with numerous examples is found on pp.1.3ff of the *Supplement (2.1E)*. Also, see the *Sample Run Book (2.1E)*, p.10.5 and 10.7.
Input Macros	allow keywords to be set equal to the result of adding, subtracting, multiplying and/or dividing other values. See p.1.42ff of the *Supplement (2.1E)*.
Interior Walls	The different types of interior walls that can be specified (STANDARD, AIR, ADIABATIC, and INTERNAL) are described on pp.2.91ff of the *Supplement (2.1E)*. For a discussion of convective heat transfer across interior walls between a sunspace (atrium) and adjacent space, see the *Supplement (2.1E)*, p.2.9ff.
Life Cycle Cost Analysis	see Economics Component-Costs on p.VI.6 of the *Reference Manual (2.1A)*. See also the *Sample Run Book (2.1E)*, p.1.126ff.
Lighting Control	see **Daylighting**

Load Assignment — is a feature in PLANT that makes it possible to control the operation of plant equipment based on operating range or selection, e.g. switching from a centrifugal chiller to an absorption chiller for peak shaving. See the *Reference Manual (2.1A)*, p.V.52 and the *Supplement (2.1E)*, p.4.47ff. An example is shown in the *Sample Run Book (2.1E)*, p.2.32.

Load Management — is used in combination with load assignment to control the operation of plant equipment based on scheduling requirements, etc. See the *Reference Manual (2.1A)*, p.V.59 and the *Sample Run Book (2.1E)*, p.2.32.

Loads Reports — see *Appendix C* of the *Supplement (2.1E)* for a description of all reports available.

Management of Plant Equipment Operation — see **Load Assignment** and **Load Management**

Mfr's Equipment Data — see **Curve Fit**

Metric Input/Output — allows you to enter and report values in metric (SI) units rather than English (Imperial) units. See the *Supplement (2.1E)*, p.1.35ff.

Meters — Different energy end uses can be assigned to separate meters for energy cost calculations and for reporting. See the *Supplement (2.1E)*, p.3.4 and p.4.3.

Monthly Reports — see **Hourly Reports**

Motorized Drapes or Blinds — see **Window Management**

Natural Ventilation — Enhancements for residential models can be found on p.3.122 of the *Supplement (2.1E)*. The model simulates the amount of air movement through the space due to open windows as a function of wind speed and features of the surrounding terrain. See the *Sample Run Book (2.1E)*, p.11.7.

Night Insulation of Windows — see **Window Management**

Night Ventilation	uses outside air to purge and precool the building, primarily at night. The method can also be used to simulate pressurization of fabric roof arenas. See the *Supplement (2.1E)*, p.3.112ff and the *Sample Run Book (2.1E)*, pp.2.10ff.
Optimum Fan Start	simulates advancing the system start time to bring a building to comfort conditions at start of occupancy. See the *Supplement (2.1E)*, p.3.101ff and the *Sample Run Book (2.1E)*, p.3.13.
Outside Air Economizers (nonstandard)	see **Input Functions**
Parametric Input	is a convenient feature when many DOE-2 runs are necessary. You can change one parameter (or additional related parameters) at the top of the input file and replacements are made automatically in the body of the input. This is especially helpful for the researcher. See the *Reference Manual (2.1A)*, p.II.8.
Peak Integrated Cooling Load	is information that is needed for Thermal Energy Storage Systems. Report SS-J shows both the day on which the peak hour occurs and the day on which the sum of the peaks occur. See the *Supplement (2.1E)*, p.3.139 and *Appendix C*, p.C.88.
Peak Shaving	see **Load Management**
Plant Reports	see *Appendix C* the *Supplement (2.1E)* for a description of all reports available.

Plenums	for return air systems can be found on p.IV.198 of the *Reference Manual (2.1A)*. Note that it is unnecessary to define plenums in both LOADS and SYSTEMS if you request RETURN-AIR-PATH = DUCT. This input is sufficient to simulate light heat from return air vented lighting fixtures. There are other ways to apply the plenum model for areas that are used to vent adjacent spaces; for applicable keywords see p.iii. "Miscellaneous Changes", of the *Supplement (2.1E)*, and p.3.115 for heating of these spaces.
Predefined Input Segments	see **Input Macros**
Refrigerated Casework	applies primarily to food stores where there is considerable interest in recovering the heat from the refrigeration compressors serving the casework. The reason for this is that the cold air off the display cases drops the temperature in the store approximately 10°F, and heating is required even in mild weather. Control of the relative humidity in the space to limit the build-up of frost on the evaporator coils also requires heat. The algorithms can also be used to simulate ice rinks. See the *Supplement (2.1E)*, p.3.103ff and the *Sample Run Book (2.1E)*, p.6.6ff.
Replacing DOE-2 Code	see **Functions**
Reports	Refer to the *Supplement (2.1E)*, *Appendix A: Hourly Report Variable List*, and *Appendix C: Verification and Summary Reports*.
Screw Chillers	DOE-2.1E allows you to simulate screw-type chillers. This is done by entering the performance data of a screw compressor chiller into a reciprocating-type chiller, as described on p.4.26 of the *Supplement (2.1E)*.
Self Shading	When one surface of a building shades another, see p.2.79 of the *Supplement (2.1E)*.

Shading by adjacent buildings is discussed on p.III.35 of the *Reference Manual (2.1A)* and on p.2.74ff of the *Supplement (2.1E)*. Except for "fins and overhangs" the simulation of shading requires you to input the building surfaces that are involved into a three-dimensional coordinate system; see **Building Coordinate System**. Also, see the *Sample Run Book (2.1E)*, p.4.4, for an example.

Sunspace is a feature that is used to simulate atria for large buildings and for attached sunrooms for residences. It is possible to simulate the effect of solar radiation through both exterior and interior space glazing. Air movement between spaces can be simulated either by natural convection or forced using a fan. See pp.2.4ff of the *Supplement (2.1E)*, and p.11.1ff of the *Sample Run Book (2.1E)*.

Sun Control Shading see **Window Management**

Switchable Glazing that changes from clear to colored depending on ambient conditions can be modeled. An example is electrochromic glass. See p.2.119 of the *Supplement (2.1E)*, and section 6, "Office Building and Atrium Deli/Restaurant", in the *Sample Run Book (2.1E)*.

System Equipment Default Curves are listed on p.3.141 of the *Supplement (2.1E)*. You should plot and look at the default curves before replacing them with other data.

System Reports see *Appendix C* of the *Supplement (2.1E)* for a description of all reports available.

System Types

- Single Zone Ceiling Induction (SZCI)
- Ceiling Bypass (CBVAV)
- Two Pipe Induction (TPIU)
- Four Pipe Induction (FPIU)
- Floor Panel Heating System (PH)
- Central Ventilation (HVSYS)
- Packaged Variable Volume/Variable Temperature (PVVT)

- Residential Variable Volume/Variable Temperature (RESVVT)
- Evaporative Cooling (EVAP-COOL)
- Water Loop Heat Pump (HP)
- Sums Zone Loads(SUM)
- User-Defined (FNSYS1)

are the 12 system types that are available in addition to those covered in this manual: they are discussed on pp.IV.33-81 of the *Reference Manual (2.1A)* and in the *Supplement (2.1E)*.

Thermal Energy Storage — see **Energy Storage**. Also see "Ice and Eutectic Thermal Energy Storage" on p.4.15ff of the *Supplement (2.1E)*.

Three Dimensional Building Input — see **Building Coordinate System**

Trombe Walls — Vented and unvented Trombe walls can be simulated. See p.2.70ff of the *Supplement (2.1E)*.

Unconditioned Spaces — such as attics and basements can be modeled. See p.IV.198 of the *Reference Manual (2.1A)*.

VAV Systems
- Warm-Up Cycle — see p.2.29 of the *Sample Run Book (2.1E)*.
- Baseboard Heat with Outside Air Reset — see p.2.53 of the *Sample Run Book (2.1E)*
- Supply Air Reset — see p.1.26 of the *Sample Run Book (2.1E)*

Venting of Sunspace — see **Sunspace**

Water Cooled Condensers
Water Side Economizers — may be applied to system types PSZ and PVAVS. See p.3.83 of the *Supplement (2.1E)*.

Window Library — a library of 200 entries covering commonly-available glazings and experimental electrochromic glazings is discussed in detail on p.2.99 of the *Supplement (2.1E)*.

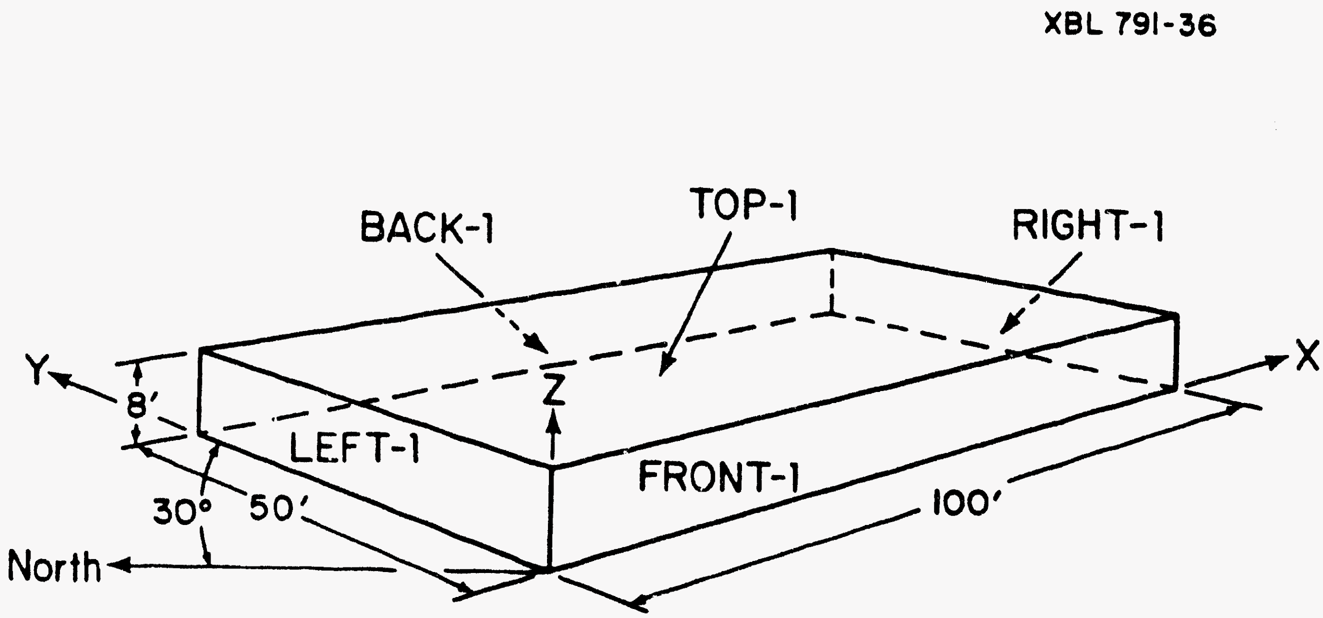
Window Management to control solar gain or daylight glare; window management is discussed in detail on p.2.35 of the *Supplement (2.1E)*. For examples, see p.2.4 and p.10.4 of the *Sample Run Book (2.1E)*.

Appendix B

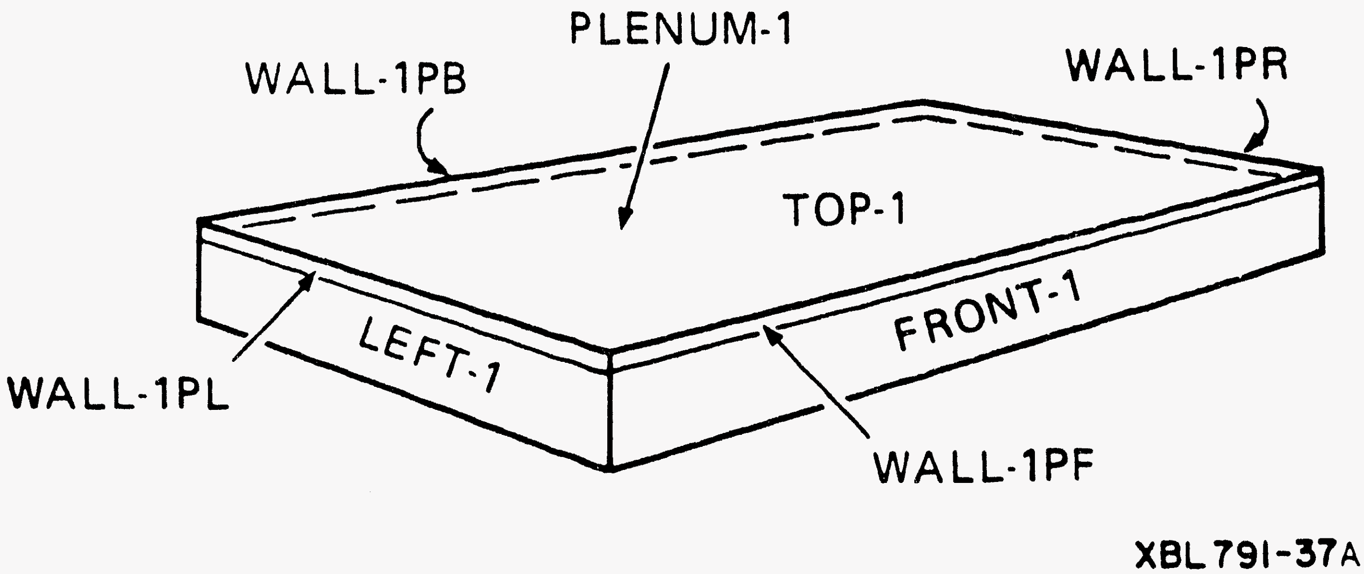
Example of DOE-2 Input and Output

This Appendix gives a sample input and output of a DOE-2 run with annotations that direct you to items of interest. This run is similar to the one shown in the introductory section of this manual, but with the following modifications:

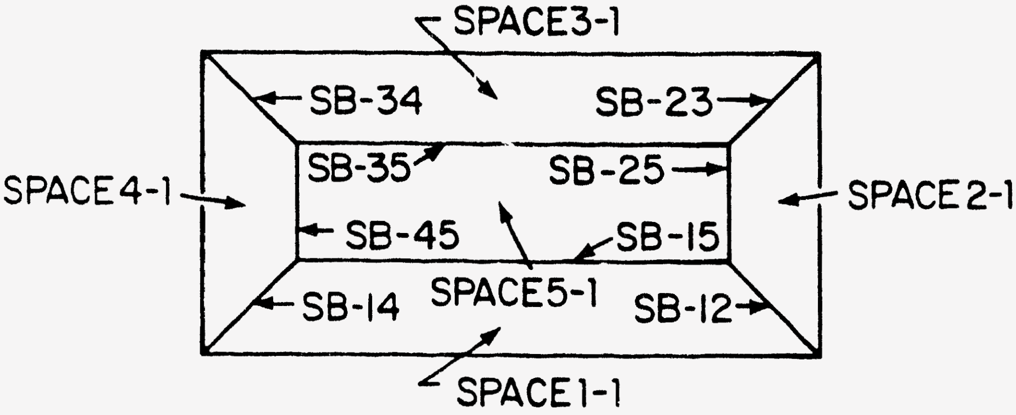
- the input is "three dimensional", i.e., the X,Y,Z coordinates of walls and the X,Y coordinates of windows and doors are specified;
- instead of one single zone the floor space has been separated into five zones, a core zone and four perimeter zones;
- there is a return air plenum;
- there is a time-of-day electric rate structure;
- additional output reports are shown; and
- the input and output have been annotated to highlight important features.



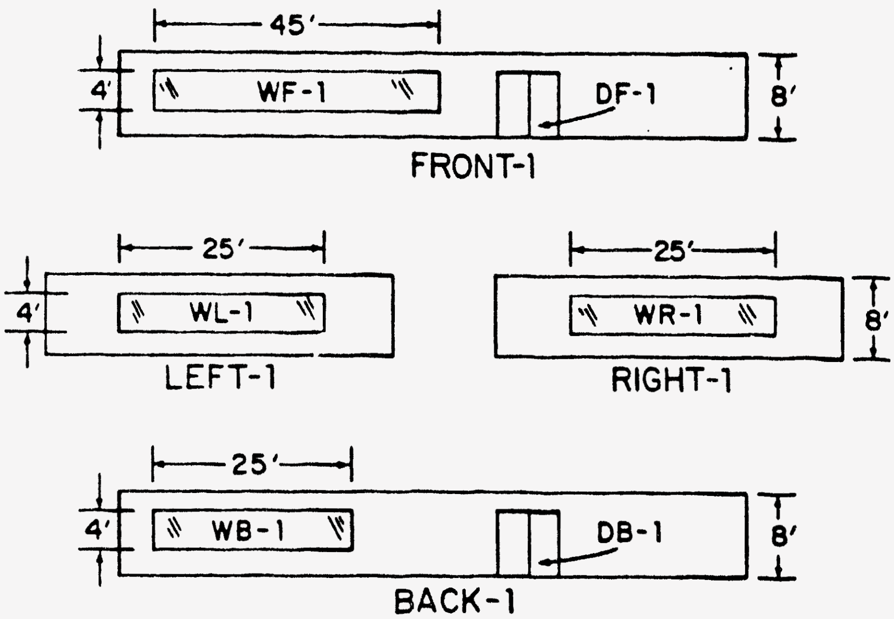
Isometric view of basic building showing orientation. FRONT–1, RIGHT–1, etc., are u-names (user-defined names) for the front wall, right-hand wall, etc. The building coordinate axes (X, Y, and Z) are shown. The building is oriented 30° from true North.



Basic building showing plenum and its walls (u-named WALL–1PF, WALL–1PL, etc.).



Plan view showing zoning and u-names of spaces and interior walls.



Elevations showing placement of windows and doors

Sample Input

(U-names are italicized)

```
INPUT LOADS ..
TITLE           LINE-1 *SIMPLE STRUCTURE, CHICAGO *
                LINE-2 *EXAMPLE FOR DOE-2 BASICS MANUAL*  ..

ABORT              ERRORS  ..
DIAGNOSTIC         WARNINGS  ..

RUN-PERIOD         JAN 1 1974 THRU DEC 31 1974    ..
LOADS-REPORT       VERIFICATION = (LV-D)
                   SUMMARY      = (LS-C,LS-D)  ..

                      $ CHICAGO LOCATION

BUILDING-LOCATION  LATITUDE = 42.0  LONGITUDE = 88.0
                   ALTITUDE = 610   TIME-ZONE = 6
                   AZIMUTH  = 30  ..

                      $ CONSTRUCTIONs AND GLASS-TYPE

WA-1-2  = LAYERS  MATERIAL = (WD01,PW03,IN02,GP01)  ..
RB-1-1  = LAYERS  MATERIAL = (RG01,BR01,IN46,WD01)
                 INSIDE-FILM-RES = .76  ..

WALL-1  = CONSTRUCTION      LAYERS  = WA-1-2  ..
ROOF-1  = CONSTRUCTION      LAYERS  = RB-1-1  ..
CLNG-1  = CONSTRUCTION      U-VALUE = 0.27  ..
SB-U    = CONSTRUCTION      U-VALUE = 1.5   ..
FLOOR-1 = CONSTRUCTION      U-VALUE = 0.05  ..

W-1     = GLASS-TYPE        SHADING-COEF = .45  PANES = 2  ..

                     $ OCCUPANCY SCHEDULE

OCCUPY-1      = SCHEDULE  THRU DEC 31
                          (MON,FRI) (1,8)  (0)  (9,11)  (1)
                                    (12,14)  (.8,.4,.8)  (15,18)  (1)
                                    (19,21)  (.5,.1,.1)  (22,24)  (0)
                          (SAT,HOL) (1,24)  (0.0)    ..
```

Annotations:

- AZIMUTH = 30: Building is oriented 30 degrees from true North
- (WD01,PW03,IN02,GP01) / (RG01,BR01,IN46,WD01): These are building material code words. They were selected from the DOE-2 library
- RB-1-1: A user-chosen name (u-name) that is assigned, then referenced
- (1,8) (0): Hours 1 to 8 (midnight to 8 am) are at zero occupancy
- (15,18) (1): Hours 15 to 18 (2 pm to 6 pm) are at full occupancy

```
        $ LIGHTING SCHEDULE

LIGHTS-1      = SCHEDULE   THRU DEC 31
                           (WD) (1,8) (.05) (9,14) (.9,.95,1,.95,.8,.9)
                                (15,18) (1.) (19,21) (.6,.2,.2)
                                (22,24) (.05)
                           (WEH) (1,24) (.05)    ..
```

"Weekdays"; same as (MON,FRI)

"Weekends and Holidays"; same as (SAT, HOL)

```
        $ OFFICE EQUIPMENT SCHEDULE
```

Comment lines start with $; they are ignored by the program

```
EQUIP-1       = SCHEDULE   THRU DEC 31
                           (WD) (1,8) (.02) (9,14) (.8)
                                (15,20) (.8,.7,.5,.5,.3,.3)
                                (21,24) (0.2)
                           (WEH) (1,24) ( 02)    ..

        $ INFILTRATION SCHEDULE

INFIL-SCH     = SCHEDULE   THRU MAR 31 (ALL) (1,24) (1)
                           THRU OCT 31 (ALL) (1,24) (0)
                           THRU DEC 31 (ALL) (1,24) (1)  ..
```

Infiltration is on only during winter

```
        $ SET DEFAULT VALUES

    SET-DEFAULT FOR SPACE    FLOOR-WEIGHT = 70   ..
    SET-DEFAULT FOR WINDOW   HEIGHT = 4.0
                             GLASS-TYPE = W-1   ..
```

Assigns default values for later use

```
        $ GENERAL SPACE CONDITIONS

OFFICE        = SPACE-CONDITIONS PEOPLE-SCHEDULE    = OCCUPY-1
                                 NUMBER-OF-PEOPLE   = 50
                                 PEOPLE-HEAT-GAIN   = 400
                                 LIGHTING-SCHEDULE  = LIGHTS-1
                                 LIGHTING-TYPE      = REC-FLUOR-RV
                                 LIGHT-TO-SPACE     = .80
                                 LIGHTING-W/SQFT    = 1.5
                                 EQUIP-SCHEDULE     = EQUIP-1
                                 EQUIPMENT-W/SQFT   = 1
                                 INF-METHOD         = AIR-CHANGE
                                 AIR-CHANGES/HR     = 0.25
                                 INF-SCHEDULE       = INFIL-SCH ..
```

Maximum number of people; is multiplied each hour by OCCUPY-1 schedule value

The previously-defined infiltration schedule is referenced here

```
$ SPECIFIC SPACE DETAILS

$ PLENUM

PLENUM-1        = SPACE            ZONE-TYPE = PLENUM  AREA = 5000
                                   VOLUME = 10000  FLOOR-WEIGHT = 5  ..

   WALL-1PF     = EXTERIOR-WALL    HEIGHT = 2  WIDTH = 100
                                   X = 0  Y = 0  Z = 0
                                   AZIMUTH = 180
                                   CONSTRUCTION = WALL-1  ..

   WALL-1PR     = EXTERIOR-WALL    HEIGHT = 2  WIDTH = 50
                                   X = 0  Y = 0  Z = 0
                                   AZIMUTH = 90
                                   CONSTRUCTION = WALL-1  ..

   WALL-1PB     = EXTERIOR-WALL    HEIGHT = 2  WIDTH = 100
                                   X = 0  Y = 0  Z = 0
                                   AZIMUTH = 0
                                   CONSTRUCTION = WALL-1  ..

   WALL-1PL     = EXTERIOR-WALL    HEIGHT = 2  WIDTH = 50
                                   X = 0  Y = 0  Z = 0
                                   AZIMUTH = 270
                                   CONSTRUCTION = WALL-1  ..

   TOP-1        = ROOF             HEIGHT = 50  WIDTH = 100
                                   X = 0  Y = 0  Z = 10
                                   AZIMUTH = 180
                                   TILT = 0  GND-REFLECTANCE = 0
                                   CONSTRUCTION = ROOF-1  ..

$ OCCUPIED SPACES

SPACE1-1        = SPACE            SPACE-CONDITIONS = OFFICE
                                   AREA = 1056  VOLUME = 8448
                                   NUMBER-OF-PEOPLE = 11  ..

   FRONT-1      = EXTERIOR-WALL    HEIGHT = 8          WIDTH = 100
                                   X = 0  Y = 0  Z = 0  AZIMUTH = 180
                                   CONSTRUCTION = WALL-1  ..
```

"X = 0 Y = 0 Z = 0" (WALL-1PF): Location of lower left corner of wall in the space coordinate system

"TILT = 0" (TOP-1): Tilt = 0 gives a horizontal roof; the tilt of the walls in this space (WALL-1PF, etc.) defaults to 90 deg, so they are vertical

"SPACE-CONDITIONS = OFFICE" (SPACE1-1): Assigns the general conditions called "OFFICE" to the space

```
WF-1      = WINDOW             WIDTH = 45
                               OVERHANG-A = 1   OVERHANG-B = .5
                               OVERHANG-W = 47  OVERHANG-D = 4 ..
```

Input for a 4ft x 47ft overhang on the south window

```
C1-1      = INTERIOR-WALL      AREA = 1056   NEXT-TO  PLENUM-1
                               CONSTRUCTION = CLNG-1   ..

F1-1      = UNDERGROUND-FLOOR  AREA = 1056  CONSTRUCTION = FLOOR-1 ..

SB12      = INTERIOR-WALL      AREA =135.7  NEXT-TO SPACE2-1
                               CONSTRUCTION = SB-U   ..

SB14      = INTERIOR-WALL      LIKE SB12  NEXT-TO SPACE4-1   ..
SB15      = INTERIOR-WALL      AREA = 608    NEXT-TO SPACE5-1
                               CONSTRUCTION = SB-U   ..

SPACE2-1  = SPACE              SPACE-CONDITIONS = OFFICE
                               AREA = 456  VOLUME = 3648
                               NUMBER-OF-PEOPLE = 5   ..

RIGHT-1   = EXTERIOR-WALL      HEIGHT = 8  WIDTH = 50
                               X = 100  Y = 0   Z = 0  AZIMUTH = 90
                               CONSTRUCTION = WALL-1  ..

WR-1      = WINDOW             WIDTH = 25   ..
```

Notice the input hierarchy: space, then wall in that space, then window in that wall

```
C2-1      = INTERIOR-WALL      AREA = 456  NEXT-TO PLENUM-1
                               CONSTRUCTION = CLNG-1   ..
```

This is the ceiling of SPACE2-1. It is shared by the plenum. (The plenum also shares the ceilings of the other four occupied spaces)

```
F2-1      = UNDERGROUND-FLOOR  AREA = 456  CONSTRUCTION = FLOOR-1  ..

SB23      = INTERIOR-WALL      AREA = 135.7  NEXT-TO SPACE3-1
                               CONSTRUCTION = SB-U   ..

SB25      = INTERIOR-WALL      AREA = 208  NEXT-TO SPACE5-1
                               CONSTRUCTION = SB-U   ..

SPACE3-1  = SPACE              LIKE  SPACE1-1 ..
```

Copies the SPACE-CONDITIONS, VOLUME, AREA, and NUMBER-OF-PEOPLE data from SPACE1-1 and applies them to SPACE3-1. The walls and floor from SPACE1-1 are *not* copied.

```
BACK-1    = EXTERIOR-WALL      HEIGHT = 8  WIDTH = 100
                               X = 100  Y = 50  Z = 0  AZIMUTH = 0
```

```
                                        CONSTRUCTION = WALL-1  ..

     WB-1        = WINDOW              WIDTH = 45    ..

     C3-1        = INTERIOR-WALL       AREA = 1056  NEXT-TO PLENUM-1
                                       CONSTRUCTION = CLNG-1    ..

     F3-1        = UNDERGROUND-FLOOR   AREA = 1056
                                       CONSTRUCTION = FLOOR-1    ..

     SB34        = INTERIOR-WALL       AREA = 135.8  NEXT-TO SPACE4-1
                                       CONSTRUCTION = SB-U    ..

     SB35        = INTERIOR-WALL       AREA = 608  NEXT-TO SPACE5-1
                                       CONSTRUCTION = SB-U    ..

  SPACE4-1       = SPACE               SPACE-CONDITIONS = OFFICE
                                       AREA = 456  VOLUME = 3648
                                       NUMBER-OF-PEOPLE = 5    ..

     LEFT-1      = EXTERIOR-WALL       HEIGHT = 8  WIDTH = 50
                                       X = 0  Y = 50  Z = 0  AZIMUTH = 270
                                       CONSTRUCTION = WALL-1  ..

     WL-1        = WINDOW              WIDTH = 25    ..

     C4-1        = INTERIOR-WALL       AREA = 456  NEXT-TO PLENUM-1
                                       CONSTRUCTION = CLNG-1    ..

     F4-1        = UNDERGROUND-FLOOR   AREA = 456
                                       CONSTRUCTION = FLOOR-1    ..

     SB45        = INTERIOR-WALL       AREA = 208  NEXT-TO SPACE5-1
                                       CONSTRUCTION = SB-U    ..

  SPACE5-1       = SPACE               SPACE-CONDITIONS = OFFICE
                                       AREA = 1976  VOLUME = 15808
                                       NUMBER-OF-PEOPLE = 20    ..

     C5-1        = INTERIOR-WALL       AREA = 1976  NEXT-TO PLENUM-1
                                       CONSTRUCTION = CLNG-1    ..
```

```
    F5-1        = UNDERGROUND-FLOOR   AREA = 1976   CONSTRUCTION = FLOOR-1 ..

END  ..
COMPUTE   LOADS    ..

INPUT SYSTEMS    ..

SYSTEMS-REPORT   SUMMARY = (SS-A)   ..

                    $ SYSTEMS SCHEDULES

FAN-SCHED       = SCHEDULE      THRU DEC 31
                          (WD)  (1,6) (0) (7,8) (-999 ) (9,18) (1)  (19,24) (0)
                         (WEH)  (1,24)  (0)   ..

HEAT-SCHED      = SCHEDULE      THRU DEC 31
                          (WD)  (1,8) (55)  (9,18) (70)  (19,24) (55)
                         (WEH)  (1,24) (55)   ..

COOL-SCHED      = SCHEDULE      THRU DEC 31
                          (WD)  (1,8) (99)   (9,18) (78)  (19,24) (99)
                         (WEH)  (1,24) (99)   ..

COOLOFF         = SCHEDULE     THRU DEC 31 (ALL)  (1,24)  (60)   ..
HEATOFF         = SCHEDULE     THRU DEC 31 (ALL)  (1,24)  (60)   ..

R1              = DAY-RESET-SCH   SUPPLY-HI   = 60    SUPPLY-LO   = 52
                                  OUTSIDE-LO  = 30    OUTSIDE-HI  = 75   ..
SAT-RESET       = RESET-SCHEDULE  THRU DEC 31 (ALL) R1   ..


                    $ ZONE DESCRIPTION

CONTROL     = ZONE-CONTROL    DESIGN-HEAT-T    = 70
                              DESIGN-COOL-T    = 78
                              HEAT-TEMP-SCH    = HEAT-SCHED
                              COOL-TEMP-SCH    = COOL-SCHED
                              THERMOSTAT-TYPE  = REVERSE-ACTION   ..

SPACE1-1    = ZONE            ZONE-CONTROL   = CONTROL
                              SIZING-OPTION  = ADJUST-LOADS
                              OA-CFM/PER     = 20   ..
```

In the fan schedule, -999 indicates an optimum start period from 6am to 8 am

The heating setpoint of the thermostat is 70F during the day and 55F at night

The cooling setpoint is 78F during the day

Cooling is available year round when outside temperature is higher than 60F

Heating is available when outside temperature is lower than 60F

The minimum ventilation rate per person

```
SPACE2-1   = ZONE            LIKE SPACE1-1      ..
SPACE3-1   = ZONE            LIKE SPACE1-1      ..
SPACE4-1   = ZONE            LIKE SPACE2-1      ..
SPACE5-1   = ZONE            LIKE SPACE1-1      ..

PLENUM-1   = ZONE            ZONE-TYPE          = PLENUM
                             SIZING-OPTION      = ADJUST-LOADS
                             DESIGN-HEAT-T      = 50
                             DESIGN-COOL-T      = 95   ..

                  $ SYSTEM DESCRIPTION

S-CONT     = SYSTEM-CONTROL  COOLING-SCHEDULE   = COOLOFF
                             HEATING-SCHEDULE   = HEATOFF
                             HEAT-SET-T         = 65
                             COOL-CONTROL       = RESET
                             COOL-RESET-SCH     = SAT-RESET
                             MIN-SUPPLY-T       = 60 ..

SYST-1     = SYSTEM          SYSTEM-TYPE        = VAVS
                             SYSTEM-CONTROL     = S-CONT
                             FAN-SCHEDULE       = FAN-SCHED
                             FAN-CONTROL        = SPEED
                             SUPPLY-STATIC      = 5.5
                             SUPPLY-EFF         = .55
                             NIGHT-CYCLE-CTRL   = CYCLE-ON-ANY
                             REHEAT-DELTA-T     = 58
                             MIN-CFM-RATIO      = .3
                             ECONO-LIMIT-T      = 65
                             RETURN-AIR-PATH    = PLENUM-ZONES
                             PLENUM-NAMES       = (PLENUM-1)
                             ZONE-NAMES         = (SPACE5-1,SPACE1-1,
                                                   SPACE2-1,SPACE3-1,
                                                   SPACE4-1,PLENUM-1)  ..

END   ..
COMPUTE SYSTEMS   ..


INPUT PLANT   ..
```

The ZONE u-names here in SYSTEMS match the SPACE u-names in LOADS

A variable-air-volume system (VAVS) has been selected

Assignment of spaces (zones) to the VAVS system

```
PLANT-REPORT  SUMMARY = (BEPS)  ..

                    $ 400,000 BTU/HR HOT-WATER BOILER

SBOILI      =PLANT-EQUIPMENT  TYPE = HW-BOILER
                              SIZE = .4 ..
```

Boiler capacity is 0.4 MBtu/hr (400,000 Btu/hr) at rated conditions

```
                    $ 15-TON (180,000 BTU/HR) AIR-COOLED
                    $ RECIPROCATING CHILLER

CHILI       =PLANT-EQUIPMENT  TYPE = HERM-REC-CHLR
                              SIZE = .18 ..

PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR ..
```

Specifies an air-cooled condenser for the chiller. The default is water cooled.

```
END ..
COMPUTE PLANT ..


INPUT ECONOMICS  ..

ECONOMICS-REPORT    SUMMARY = (ES-D,ES-E) ..

                    $ ELECTRICITY TARIFF (TIME-OF-DAY RATE)

ENERGY-SCH =SCHEDULE  THRU DEC 31 (WD) (1,8)(.05)         $OFF-PEAK
                                       (9,12)(.06)        $SHOULDER
                                       (13,17)(.07)       $PEAK
                                       (18,22)(.06)       $SHOULDER
                                       (23,24)(.05)       $OFF-PEAK

                                 (SAT) (1,8)(.05)         $OFF-PEAK
                                       (9,17)(.06)        $SHOULDER
                                       (18,24)(.05)       $OFF-PEAK

                             (SUN,HOL) (1,24)(.05)  ..    $OFF-PEAK

ELEC-TARIFF =UTILITY-RATE   RESOURCE = ELECTRICITY
                            ENERGY-CHG-SCH = ENERGY-SCH ..
```

Electricity charge varies from $0.05/kWh to $0.07/kWh depending on time of day. There are no demand charges.

```
                    $ GAS TARIFF (FLAT RATE)

GAS-RATE   =UTILITY-RATE    RESOURCE = NATURAL-GAS
                            ENERGY-CHG = .60  ..

END ..
COMPUTE ECONOMICS  ..
STOP ..
```

Sample Output

SIMPLE STRUCTURE, CHICAGO EXAMPLE FOR DOE-2 BASICS MANUAL DOE-2.1E-005 Thu Mar 24 09:44:11 1994LDL RUN 1
REPORT- LV-D DETAILS OF EXTERIOR SURFACES IN THE PROJECT WEATHER FILE- TRY CHICAGO

NUMBER OF EXTERIOR SURFACES 9 RECTANGULAR 9 OTHER 0
(U-VALUE INCLUDES OUTSIDE AIR FILM; WINDOW INCLUDES FRAME, IF DEFINED)

SURFACE	SPACE	- - - W I N D O W S - - - U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	- - - - W A L L - - - - U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	-W A L L + W I N D O W S- U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	AZIMUTH
WALL-1PB	PLENUM-1	0.000	0.00	0.067	200.00	0.067	200.00	NORTH
BACK-1	SPACE3-1	0.467	180.00	0.067	620.00	0.157	800.00	NORTH
RIGHT-1	SPACE2-1	0.467	100.00	0.067	300.00	0.167	400.00	EAST
WALL-1PR	PLENUM-1	0.000	0.00	0.067	100.00	0.067	100.00	EAST
WALL-1PF	PLENUM-1	0.000	0.00	0.067	200.00	0.067	200.00	SOUTH
FRONT-1	SPACE1-1	0.467	180.00	0.067	620.00	0.157	800.00	SOUTH
WALL-1PL	PLENUM-1	0.000	0.00	0.067	100.00	0.067	100.00	WEST
LEFT-1	SPACE4-1	0.467	100.00	0.067	300.00	0.167	400.00	WEST
TOP-1	PLENUM-1	0.000	0.00	0.047	5000.00	0.047	5000.00	ROOF
F1-1	SPACE1-1	0.000	0.00	0.050	1056.00	0.050	1056.00	UNDERGRND
F2-1	SPACE2-1	0.000	0.00	0.050	456.00	0.050	456.00	UNDERGRND
F3-1	SPACE3-1	0.000	0.00	0.050	1056.00	0.050	1056.00	UNDERGRND
F4-1	SPACE4-1	0.000	0.00	0.050	456.00	0.050	456.00	UNDERGRND
F5-1	SPACE5-1	0.000	0.00	0.050	1976.00	0.050	1976.00	UNDERGRND

A verification report that summarizes your input for walls and windows

SIMPLE STRUCTURE, CHICAGO EXAMPLE FOR DOE-2 BASICS MANUAL DOE-2.1E-005 Thu Mar 24 09:44:11 1994LDL RUN 1
REPORT- LV-D DETAILS OF EXTERIOR SURFACES IN THE PROJECT WEATHER FILE- TRY CHICAGO
---(CONTINUED)--------

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.467	0.067	0.139	180.00	820.00	1000.00
EAST	0.467	0.067	0.147	100.00	400.00	500.00
SOUTH	0.467	0.067	0.139	180.00	820.00	1000.00
WEST	0.467	0.067	0.147	100.00	400.00	500.00
ROOF	0.000	0.047	0.047	0.00	5000.00	5000.00
ALL WALLS	0.467	0.067	0.142	560.00	2440.00	3000.00
WALLS+ROOFS	0.467	0.054	0.082	560.00	7440.00	8000.00
UNDERGRND	0.000	0.050	0.050	0.00	5000.00	5000.00
BUILDING	0.467	0.052	0.070	560.00	12440.00	13000.00

SIMPLE STRUCTURE, CHICAGO   EXAMPLE FOR DOE-2 BASICS MANUAL   DOE-2.1E-005 Thu Mar 24 09:44:11 1994LDL RUN 1
REPORT- LS-C BUILDING PEAK LOAD COMPONENTS   WEATHER FILE- TRY CHICAGO

*** BUILDING ***

FLOOR AREA	5000	SQFT	465	SQMT
VOLUME	50000	CUFT	1416	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 4PM		JAN 1 4AM	
DRY-BULB TEMP	94F	34C	3F	-16C
WET-BULB TEMP	74F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (KW)	LATENT (KBTU/H)	LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	4.652	1.363	0.000	0.000	-8.071	-2.365
ROOF CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
WINDOW GLASS+FRM COND	4.870	1.427	0.000	0.000	-17.279	-5.063
WINDOW GLASS SOLAR	11.439	3.352	0.000	0.000	1.967	0.576
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-1.500	-0.440	0.000	0.000	-7.500	-2.197
OCCUPANTS TO SPACE	11.302	3.312	6.776	1.985	0.000	0.000
LIGHT TO SPACE	17.469	5.118	0.000	0.000	1.024	0.300
EQUIPMENT TO SPACE	11.113	3.256	0.000	0.000	0.341	0.100
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-10.335	-3.028
TOTAL	59.345	17.388	6.776	1.985	-39.853	-11.677
TOTAL LOAD	66.121 KBTU/H		19.373 KW		-39.853 KBTU/H	-11.677 KW
TOTAL LOAD / AREA	13.22BTU/H.SQFT		41.707 W /SQMT		7.971BTU/H.SQFT	25.138 W /SQMT

Building peak sensible load

NOTE 1) THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2) TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

SIMPLE STRUCTURE, CHICAGO   EXAMPLE FOR DOE-2 BASICS MANUAL   DOE-2.1E-005 Thu Mar 24 09:44:11 1994LDL RUN 1

REPORT- LS-D BUILDING MONTHLY LOADS SUMMARY   WEATHER FILE- TRY CHICAGO

	- - - C O O L I N G - - -						- - - H E A T I N G - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	3.61765	25	16	48.F	42.F	32.370	-10.718	1	4	3.F	2.F	-39.853	2900.	11.500
FEB	2.91748	28	15	52.F	42.F	29.969	-10.155	4	6	7.F	6.F	-39.308	2519.	11.500
MAR	4.38126	7	15	51.F	44.F	32.935	-8.068	24	5	9.F	8.F	-39.848	2785.	11.500
APR	8.35311	26	16	76.F	60.F	46.253	-2.829	8	6	32.F	29.F	-18.915	2889.	11.500
MAY	10.47598	21	14	72.F	65.F	50.639	-1.483	6	5	39.F	35.F	-12.469	2900.	11.500
JUN	12.92988	20	15	90.F	77.F	56.127	-0.405	23	5	52.F	48.F	-6.481	2657.	11.500
JUL	17.19420	9	15	94.F	74.F	59.345	-0.016	1	5	60.F	54.F	-1.445	2900.	11.500
AUG	15.89793	20	15	88.F	72.F	57.303	-0.040	5	5	55.F	54.F	-3.582	2900.	11.500
SEP	11.40049	11	14	87.F	72.F	54.144	-0.755	23	6	37.F	34.F	-11.212	2657.	11.500
OCT	9.45966	10	17	71.F	52.F	46.758	-2.082	21	6	30.F	29.F	-15.509	2900.	11.500
NOV	4.79854	1	16	72.F	59.F	45.574	-6.278	30	22	34.F	32.F	-25.352	2542.	11.500
DEC	3.74102	10	15	41.F	35.F	32.366	-9.719	8	20	18.F	16.F	-34.249	2785.	11.500
	---------					----------	---------					----------	--------	-------
TOTAL	105.167						-52.546						33336.	
MAX						59.345						-39.853		11.500

SIMPLE STRUCTURE, CHICAGO   EXAMPLE FOR DOE-2 BASICS MANUAL   DOE-2.1E-005 Thu Mar 24 09:44:11 1994SDL RUN 1

REPORT- SV-A SYSTEM DESIGN PARAMETERS   SYST-1   WEATHER FILE- TRY CHICAGO

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
SYST-1	VAVS	1.020	5000.0	52.

All air flows in this report are at building's altitude
(CFM at building's altitude = 1.02 x CFM at sea level)

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
4287.	4.933	3.6	0.	0.000	0.0	0.247	138.293	0.751	-36.909	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
SPACE5-1	1282.	0.	0.000	0.300	408.	0.00	0.00	24.91	-80.28	-66.44	1.0
SPACE1-1	943.	0.	0.000	0.300	224.	0.00	0.00	18.33	-59.05	-48.87	1.0
SPACE2-1	557.	0.	0.000	0.300	102.	0.00	0.00	10.82	-34.88	-28.87	1.0
SPACE3-1	970.	0.	0.000	0.300	224.	0.00	0.00	18.86	-60.78	-50.30	1.0
SPACE4-1	535.	0.	0.000	0.300	102.	0.00	0.00	10.41	-33.54	-27.76	1.0
PLENUM-1	0.	0.	0.000	0.000	0.	0.00	0.00	0.00	0.00	0.00	1.0

System design air flow

Zone design air flow

Air handling unit cooling coil capacity

Heating capacity of zone reheat coils

SIMPLE STRUCTURE, CHICAGO EXAMPLE FOR DOE-2 BASICS MANUAL DOE-2.1E-005 Thu Mar 24 09:44:11 1994SDL RUN 1
REPORT- SS-A SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1 WEATHER FILE- TRY CHICAGO

	- - - - C O O L I N G - - - -						- - - - H E A T I N G - - - -						- - E L E C - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-23.934	7	7	0.F	0.F	-350.612	3087.	12.870
FEB	0.00000					0.000	-18.851	11	8	5.F	4.F	-339.455	2675.	13.146
MAR	0.00000					0.000	-12.056	25	8	14.F	12 F	-324.[illegible]48	2923.	12.9[illegible]2
APR	0.86978	29	18	69.F	65.F	27.563	-3.158	1	8	43.F	39.F	-204.168	3008.	12.129
MAY	3.12705	21	14	85.F	75.F	82.950	-0.411	13	9	47.F	43.F	-24.252	3072.	13.370
JUN	10.06826	20	18	91.F	78.F	128.275	0.000					0.000	2995.	14.226
JUL	19.69629	8	16	92.F	74.F	135.655	0.000					0.000	3571.	16.285
AUG	16.73584	26	17	94.F	76.F	119.250	0.000					0.000	3438.	14.786
SEP	6.23417	11	16	86.F	72.F	98.931	-0.082	23	9	39.F	36.F	-25.422	2900.	14.106
OCT	1.61761	31	15	76.F	65.F	42.963	-1.307	21	8	30.F	29.F	-160.970	3016.	12.608
NOV	0.28201	1	16	72.F	59.F	40.150	-9.284	18	8	34.F	34.F	-243.553	2661.	12.746
DEC	0.00000					0.000	-17.754	9	8	13.F	12.F	-319.821	2941.	12.540
TOTAL	58.631						-86.836						36287.	
MAX						135.655						-350.612		16.285

Total cooling coil load passed to the chiller

Maximum cooling load passed to the chiller

Includes lights, plug loads, and fans

ENERGY TYPE:	ELECTRICITY	NATURAL-GAS
UNITS: MBTU		
CATEGORY OF USE		
AREA LIGHTS	74.7	0.0
MISC EQUIPMT	39.0	0.0
SPACE HEAT	6.8	141.4
SPACE COOL	19.7	0.0
HEAT REJECT	4.4	0.0
PUMPS & MISC	3.6	0.0
VENT FANS	10.1	0.0
TOTAL	158.4	141.4

TOTAL SITE ENERGY	299.72 MBTU	59.9 KBTU/SQFT-YR GROSS-AREA	59.9 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY	616.51 MBTU	123.3 KBTU/SQFT-YR GROSS-AREA	123.3 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.1
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

SIMPLE STRUCTURE, CHICAGO   EXAMPLE FOR DOE-2 BASICS MANUAL   DOE-2.1E-005 Thu Mar 24 09:44:11 1994EDL RUN 1

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELEC-TARIFF	ELECTRICITY	1 2 3 4 5	46403. KWH	2943.	0.0634	YES
GAS-RATE	NATURAL-GAS	1 2 3 4 5	1414. THERM	848.	0.6000	YES
				3792.		

ENERGY COST/GROSS BLDG AREA: 0.76

ENERGY COST/NET BLDG AREA: 0.76

Total charge divided by metered energy

```
SIMPLE STRUCTURE, CHICAGO              EXAMPLE FOR DOE-2 BASICS MANUAL          DOE-2.1E-005  Thu Mar 24 09:44:11 1994EDL RUN  1
REPORT- ES-E  SUMMARY OF UTILITY-RATE:  ELEC-TARIFF
-------------------------------------------------------------------------------------------------------------------------------

UTILITY-RATE:  ELEC-TARIFF              RESOURCE:  ELECTRICITY          DEMAND-WINDOW:  HOUR                  3413. BTU/KWH
                                          METERS:  1 2 3 4 5              BILLING-DAY:  31           RATE-LIMITATION:    0.0000
                                    POWER-FACTOR:  0.80           EXCESS KVAR-FRAC:  0.30           EXCESS-KVAR-CHG:    0.0000


RATE-QUALIFICATIONS                     BLOCK-CHARGES                           DEMAND-RATCHETS      MIN-MON-RATCHETS
-------------------------------         ----------------------------------      ---------------      ---------------
   MIN-ENERGY:          0.0
   MAX-ENERGY:          0.0
   MIN-DEMAND:          0.0
   MAX-DEMAND:          0.0
 QUALIFY-RATE:  ALL-MONTHS
 USE-MIN-QUAL:           NO
```

MONTH	METERED ENERGY KWH	BILLING ENERGY KWH	METERED DEMAND KW	BILLING DEMAND KW	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	3718	3718	15.8	15.8	233	0	0	0	0	0	0	0.0626	233
FEB	3176	3176	16.1	16.1	199	0	0	0	0	0	0	0.0627	199
MAR	3302	3302	15.9	15.9	208	0	0	0	0	0	0	0.0629	208
APR	3307	3307	16.6	16.6	210	0	0	0	0	0	0	0.0634	210
MAY	3588	3588	22.4	22.4	229	0	0	0	0	0	0	0.0637	229
JUN	4338	4338	27.5	27.5	278	0	0	0	0	0	0	0.0640	278
JUL	5881	5881	30.1	30.1	375	0	0	0	0	0	0	0.0638	375
AUG	5495	5495	27.6	27.6	351	0	0	0	0	0	0	0.0639	351
SEP	3785	3785	25.5	25.5	242	0	0	0	0	0	0	0.0639	242
OCT	3379	3379	19.3	19.3	215	0	0	0	0	0	0	0.0636	215
NOV	3006	3006	18.4	18.4	189	0	0	0	0	0	0	0.0630	189
DEC	3429	3429	15.5	15.5	216	0	0	0	0	0	0	0.0629	216
TOTAL	46403	46403	30.1		2943	0	0	0	0	0		0.0634	2943

Summary of electricity charges

```
SIMPLE STRUCTURE, CHICAGO            EXAMPLE FOR DOE-2 BASICS MANUAL        DOE-2.1E-005  Thu Mar 24 09:44:11 1994EDL RUN  1
REPORT- ES-E  SUMMARY OF UTILITY-RATE:  GAS-RATE
-----------------------------------------------------------------------------------------------------------------------------

UTILITY-RATE:  GAS-RATE          RESOURCE:  NATURAL-GAS        DEMAND-WINDOW:  HOUR               100000. BTU/THERM
                                   METERS:  1 2 3 4 5            BILLING-DAY:  31           RATE-LIMITATION:    0.0000


RATE-QUALIFICATIONS               BLOCK-CHARGES                         DEMAND-RATCHETS     MIN-MON-RATCHETS
------------------------------    ----------------------------------    ---------------     ---------------
  MIN-ENERGY:          0.0
  MAX-ENERGY:          0.0
  MIN-DEMAND:          0.0
  MAX-DEMAND:          0.0
 QUALIFY-RATE:  ALL-MONTHS
 USE-MIN-QUA':          NO
```

MONTH	METERED ENERGY THERM	BILLING ENERGY THERM	METERED DEMAND THERMS	BILLING DEMAND THERMS	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	382	382	4.5	4.5	229	0	0	0	0	0	0	0.6000	229
FEB	301	301	4.4	4.4	181	0	0	0	0	0	0	0.6000	181
MAR	199	199	4.2	4.2	120	0	0	0	0	0	0	0.6000	120
APR	55	55	2.9	2.9	33	0	0	0	0	0	0	0.6000	33
MAY	9	9	0.4	0.4	5	0	0	0	0	0	0	0.6000	5
JUN	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0000	0
JUL	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0000	0
AUG	0	0	0.0	0.0	0	0	0	0	0	0	0	0.0000	0
SEP	2	2	0.5	0.5	1	0	0	0	0	0	0	0.6000	1
OCT	24	24	2.4	2.4	15	0	0	0	0	0	0	0.6000	15
NOV	155	155	3.3	3.3	93	0	0	0	0	0	0	0.6000	93
DEC	286	286	4.2	4.2	171	0	0	0	0	0	0	0.6000	171
TOTAL	1414	1414	4.5		848	0	0	0	0	0		0.6000	848

Summary of gas charges

REPORT LV-A
GENERAL PROJECT AND BUILDING INPUT

```
SIMPLE STRUCTURE RUN 3, CHICAGO         DIVIDE INTO ZONES: ADD PLENUM          DOE-2.1E-001  Thu Nov  4 15:19:02 1993LDL RUN  3
DESIGN-DAY SIZING OF VAV SYSTEM         SHOW ALL REPORTS
REPORT- LV-A  GENERAL PROJECT AND BUILDING INPUT                                              WEATHER FILE- TRY  CHICAGO
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PERIOD OF STUDY

STARTING DATE	ENDING DATE	NUMBER OF DAYS
3 AUG 1974	5 AUG 1974	3
5 JAN 1974	7 JAN 1974	3
6 APR 1974	8 APR 1974	3
1 JAN 1974	31 DEC 1974	365

SITE CHARACTERISTIC DATA

STATION NAME	LATITUDE (DEG)	LONGITUDE (DEG)	ALTITUDE (FT)	TIME ZONE	BUILDING AZIMUTH (DEG)
TRY CHICAGO	42.0	88.0	610.	6 CST	30.0

Appendix C

Basic Reports: Examples and Descriptions

This Appendix shows examples of the verification and summary reports printed by the DOE-2 LOADS, SYSTEMS, PLANT and ECONOMICS sub-programs. A description of the contents of each summary report and selected verification reports is given. The corresponding input for these reports can be found in the *Sample Run Book (2.1E)* for the building indicated in the first line of the report title.

Table of Contents

REPORT LV-D
DETAILS OF EXTERIOR SURFACES IN THE PROJECT

SIMPLE STRUCTURE RUN 3, CHICAGO   DIVIDE INTO ZONES; ADD PLENUM   DOE-2.1E-001 Thu Nov 4 15:19:02 1993LDL RUN 3
DESIGN-DAY SIZING OF VAV SYSTEM   SHOW ALL REPORTS
REPORT- LV-D DETAILS OF EXTERIOR SURFACES IN THE PROJECT   WEATHER FILE- TRY CHICAGO

NUMBER OF EXTERIOR SURFACES 9   RECTANGULAR 9   OTHER 0
(U-VALUE INCLUDES OUTSIDE AIR FILM; WINDOW INCLUDES FRAME, IF DEFINED)

		---W I N D O W S---		----W A L L----		-W A L L + W I N D O W S-		
SURFACE	SPACE	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	AZIMUTH
WALL-1PB	PLENUM-1	0.000	0.00	0.067	200.00	0.067	200.00	NORTH
BACK-1	SPACE3-1	0.565	229.00	0.067	571.00	0.210	800.00	NORTH
RIGHT-1	SPACE2-1	0.467	100.00	0.067	300.00	0.167	400.00	EAST
WALL-1PR	PLENUM-1	0.000	0.00	0.067	100.00	0.067	100.00	EAST
WALL-1PF	PLENUM-1	0.000	0.00	0.067	200.00	0.067	200.00	SOUTH
FRONT-1	SPACE1-1	0.587	244.00	0.067	556.00	0.226	800.00	SOUTH
WALL-1PL	PLENUM-1	0.000	0.00	0.067	100.00	0.067	100.00	WEST
LEFT-1	SPACE4-1	0.467	100.00	0.067	300.00	0.167	400.00	WEST
TOP-1	PLENUM-1	0.000	0.00	0.168	5000.00	0.168	5000.00	ROOF
F1-1	SPACE1-1	0.000	0.00	0.050	1056.00	0.050	1056.00	UNDERGRND
F2-1	SPACE2-1	0.000	0.00	0.050	456.00	0.050	456.00	UNDERGRND
F3-1	SPACE3-1	0.000	0.00	0.050	1056.00	0.050	1056.00	UNDERGRND
F4-1	SPACE4-1	0.000	0.00	0.050	456.00	0.050	456.00	UNDERGRND
F5-1	SPACE5-1	0.000	0.00	0.050	1976.00	0.050	1976.00	UNDERGRND

	AVERAGE U-VALUE/WINDOWS (BTU/HR-SQFT-F)	AVERAGE U-VALUE/WALLS (BTU/HR-SQFT-F)	AVERAGE U-VALUE WALLS+WINDOWS (BTU/HR-SQFT-F)	WINDOW AREA (SQFT)	WALL AREA (SQFT)	WINDOW+WALL AREA (SQFT)
NORTH	0.565	0.067	0.181	229.00	771.00	1000.00
EAST	0.467	0.067	0.147	100.00	400.00	500.00
SOUTH	0.587	0.067	0.194	244.00	756.00	1000.00
WEST	0.467	0.067	0.147	100.00	400.00	500.00
ROOF	0.000	0.168	0.168	0.00	5000.00	5000.00
ALL WALLS	0.544	0.067	0.174	673.00	2327.00	3000.00
WALLS+ROOFS	0.544	0.136	0.170	673.00	7327.00	8000.00
UNDERGRND	0.000	0.050	0.050	0.00	5000.00	5000.00
BUILDING	0.544	0.101	0.124	673.00	12327.00	13000.00

REPORT LS-B

SPACE PEAK LOAD COMPONENTS

This report gives a breakdown of cooling and heating peak loads, according to the source of the load, for each space. A "load" here is defined as the amount of heat that must be added or removed from the space air per hour to maintain a *constant* air temperature equal to the TEMPERATURE keyword value in SPACE-CONDITIONS. These loads are modified in the SYSTEMS program to account for time-varying air temperatures.

1. WALL CONDUCTION
   is the load due to conduction through exterior walls (TILT $\geq 45°$).

2. ROOF CONDUCTION
   is the load due to conduction through roof sections (exterior walls with TILT $< 45°$).

3. WINDOW GLASS+FRM COND
   is the load due to UAΔT heat gain through all the exterior windows (glass plus frames) *plus* solar energy absorbed by the glass and frames and conducted into the space.

4. WINDOW GLASS SOLAR
   is the load caused by direct and diffuse solar radiation transmitted by the window glass into the space. Note that all sensible loads are calculated as ***delayed in time with weighting factors*** so that it is possible to have load contributions from WINDOW GLASS SOLAR at night.

5. DOOR CONDUCTION
   is the load due to conduction through external doors in the space.

6. INTERNAL SURFACE COND
   is the load due to conduction through INTERIOR-WALLs such as partitions and drop ceilings. These loads will be zero in this report if you choose the same LOADS calculation temperature for all spaces.

7. UNDERGROUND SURF COND
   is the load due to conduction through basement floors and walls or slabs on grade.

8. The next five entries are the loads due to

   occupants
   (resulting from user-supplied entries for keywords PEOPLE-SCHEDULE, NUMBER-OF-PEOPLE, AREA-PERSON, and PEOPLE-HEAT-GAIN),

   electric lighting
   (keywords LIGHTING-SCHEDULF, LIGHTING-TYPE, LIGHTING-W/SQFT, TASK-LT-W/SQFT, etc.),

   equipment
   (keywords EQUIP-SCHEDULE, EQUIPMENT-W/SQFT, etc.),

   process
   (keywords SOURCE-SCHEDULE, SOURCE-TYPE, SOURCE-BTU/HR, etc.), and

   infiltration of outside air
   (keywords INF-SCHEDULE, INF-METHOD, AIR-CHANGES/HR, etc.).

9. The RUN number in the upper right hand corner refers to the number of the pass through the LOADS program. For example, if you were doing parametric runs as part of the same job, successive passes through LOADS would be recorded as RUN 1, RUN 2, RUN 3, etc.

SPACE SPACE1-1

MULTIPLIER	1.0		FLOOR MULTIPLIER	1.0
FLOOR AREA	1056 SQFT	98 M2		
VOLUME	8448 CUFT	239 M3		

	COOLING LOAD		HEATING LOAD	
TIME	NOV 8 3PM		JAN 12 8AM	
DRY-BULB TEMP	60F	16C	-7F	-22C
WET-BULB TEMP	49F	9C	-7F	-22C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (KW)	COOLING LATENT (KBTU/H)	COOLING LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	1.700	0.498	0.000	0.000	-2.726	-0.799
ROOF CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
WINDOW GLASS+FRM COND	1.936	0.567	0.000	0.000	-9.976	-2.923
WINDOW GLASS SOLAR	22.696	6.650	0.000	0.000	0.775	0.227
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-0.950	-0.278	0.000	0.000	-1.584	-0.464
OCCUPANTS TO SPACE	2.335	0.684	1.433	0.420	0.120	0.035
LIGHT TO SPACE	3.598	1.054	0.000	0.000	0.464	0.136
EQUIPMENT TO SPACE	2.538	0.744	0.000	0.000	0.188	0.055
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	-0.136	-0.040	0.000	0.000	-1.689	-0.495
TOTAL	33.718	9.879	1.433	0.420	-14.429	-4.228

	COOLING		HEATING	
TOTAL LOAD	35.151 KBTU/H	10.299 KW	-14.429 KBTU/H	-4.228 KW
TOTAL LOAD / AREA	33.29BTU/H.SQFT	104.981 W / M2	13.664BTU/H.SQFT	43.093 W / M2

NOTE 1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

REPORT LS-C

BUILDING PEAK LOAD COMPONENTS

This report is similar in format to LS-B. The major difference is that LS-C is generated at the "building level", i.e., the space loads are summed each hour to give the building coincident load and the peak values of this load are shown here.

"Floor area" in this report is that of conditioned spaces only (ZONE-TYPE=CONDITIONED); it *excludes* plenums and other unconditioned spaces (ZONE-TYPE=PLENUM or UNCONDITIONED). "Volume" is that of conditioned spaces and plenums; it *excludes* ZONE-TYPE = UNCONDITIONED.

The building coincident peak load does not include plenums (ZONE-TYPE=PLENUM) or other unconditioned spaces (ZONE-TYPE=UNCONDITIONED).

Although no infiltration is indicated for the peak cooling load in this example, the user should realize how DOE-2 treats infiltration loads. The sensible portion is treated as an instantaneous heat gain or loss. The latent portion is reported in LOADS, but is passed to SYSTEMS as a CFM with the calculated humidity ratio for each hour. The contribution of the latent heat (negative or positive in relation to room humidity) is then calculated from a mass balance of moisture in the space, to determine the return air humidity ratio. In dry climates the infiltration may actually result in a decreased space latent load and thus a decreased total SYSTEMS load. The opposite is true in humid climates where infiltration acts to increase the SYSTEMS load.

The heat gain or loss that occurs in plenums, including heat due to lights, is accounted for in the SYSTEMS simulation and causes a temperature change in the return air flowing through the plenum. Therefore, you should **not** specify plenums unless they are actually return air plenums. Unconditioned, non-return-air spaces should be specified in the SPACE command with ZONE-TYPE = UNCONDITIONED.

*** BUILDING ***

FLOOR AREA	5000	SQFT	465	SQMT
VOLUME	50000	CUFT	1416	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 19	6PM	MAR 24	6AM
DRY-BULB TEMP	90F	32C	8F	-13C
WET-BULB TEMP	71F	22C	7F	-14C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (KW)	COOLING LATENT (KBTU/H)	COOLING LATENT (KW)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (KW)
WALL CONDUCTION	4.297	1.259	0.000	0.000	-6.888	-2.018
ROOF CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
WINDOW GLASS+FRM COND	8.963	2.626	0.000	0.000	-22.096	-6.474
WINDOW GLASS SOLAR	29.977	8.783	0.000	0.000	1.992	0.584
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-1.000	-0.293	0.000	0.000	-7.750	-2.271
OCCUPANTS TO SPACE	11.607	3.401	6.776	1.985	0.026	0.008
LIGHT TO SPACE	17.920	5.251	0.000	0.000	1.079	0.316
EQUIPMENT TO SPACE	8.679	2.543	0.000	0.000	0.367	0.107
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-11.157	-3.269
TOTAL	80.443	23.570	6.776	1.985	-44.428	-13.017

TOTAL LOAD	87.218 KBTU/H	25.555 KW	-44.428 KBTU/H	-13.017 KW
TOTAL LOAD / AREA	17.44BTU/H.SQFT	55.014 W /SQMT	8.886BTU/H.SQFT	28.023 W /SQMT

NOTE 1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
---- 2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION

REPORT LS-D
BUILDING MONTHLY LOADS SUMMARY

This report gives a summary of monthly cooling, heating, and electrical requirements plus annual total energy requirements and maximum monthly peak loads. Unconditioned spaces (ZONE-TYPE = UNCONDITIONED or PLENUM) are not included in this report's monthly load.

Once again, you should be aware that these loads are based on a constant temperature within each SPACE (that is, no setback, no floating, and no other temperature variations within the SPACE). Additionally, these loads do not account for conditioning of outside ventilation air. Later, in SYSTEMS, these items will be accounted for.

1. COOLING, HEATING, and ELEC
   are the three sections of this building level report.

2. COOLING ENERGY
   (millions of Btu) is the monthly sensible cooling load for all SPACEs in the building.

3. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) is the peak sensible space cooling load. To the left of this column are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

4. HEATING ENERGY
   (millions of Btu) is the monthly heating load.

5. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) is the peak space heating load. To the left of this column are the day and hour of the peak heating load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

6. ELECTRICAL ENERGY (kWh)
   is the monthly electrical consumption for lights, convenience outlets, and non-HVAC equipment.

7. MAXIMUM ELEC LOAD (kW)
   is the monthly peak electrical consumption in a one-hour period for lights, convenience outlets, and miscellaneous equipment input as SOURCE.

8. TOTAL
   is the annual total for the cooling load, heating load, and electrical load of the building.

9. MAX
   is the highest monthly peak cooling load, heating load, and electrical load.

	- - - C O O L I N G - - -						- - - H E A T I N G - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	4.78164	25	16	48.F	42.F	49.888	-11.550	12	8	-7.F	-7.F	-44.074	2821.	11.500
FEB	4.43467	15	16	31.F	26.F	51.672	-10.628	4	6	7.F	6.F	-44.237	2451.	11.500
MAR	6.38896	5	17	57.F	46.F	51.477	-7.794	24	6	8.F	7.F	-44.428	2709.	11.500
APR	12.44952	26	15	78.F	61.F	68.359	-2.422	8	6	32.F	29.F	-21.366	2810.	11.500
MAY	15.49518	20	15	77.F	68.F	68.505	-1.047	6	5	39.F	35.F	-12.132	2821.	11.500
JUN	19.14147	20	15	90.F	77.F	75.856	-0.233	23	5	52.F	48.F	-5.822	2585.	11.500
JUL	24.68539	9	15	94.F	74.F	80.255	-0.006	1	1	63.F	54.F	-0.240	2821.	11.500
AUG	22.43433	19	17	90.F	71.F	80.443	-0.009	5	5	55.F	54.F	-2.692	2821.	11.500
SEP	16.82664	26	16	82.F	61.F	77.270	-0.537	22	6	35.F	31.F	-12.155	2585.	11.500
OCT	13.10616	10	16	68.F	53.F	71.816	-1.883	21	6	30.F	29.F	-17.395	2821.	11.500
NOV	6.53109	8	15	60.F	49.F	66.382	-6.602	15	6	28.F	26.F	-28.497	2473.	11.500
DEC	4.46447	10	15	41.F	35.F	52.291	-10.857	8	20	18.F	16.F	-37.581	2709.	11.500
TOTAL	150.740						-53.568						32429.	
MAX						80.443						-44.428		11.500

REPORT LS–K
SPACE INPUT FUELS SUMMARY

This report gives monthly summaries of the fuel inputs required by each space for lighting, equipment, and processes. Following the reports for each space is a separate building level report that gives the sum of the input fuels for the building as a whole.

Lighting, equipment, and process are the three major sections of this report, which is printed once for each space and once for the building as a whole.

1. TASK LIGHTING
   (kilowatt hours) is the electricity used by the space for all task lighting.

2. TOTAL LIGHTING
   (kilowatt hours) is the electricity used by the space for all lighting including task and overhead.

3. GENERAL EQUIPMENT
   (kilowatt hours) is the electricity used by the space for running all equipment (i.e., computers, typewriters, etc.). For the building report, this includes building equipment such as elevators which may not be included in any space.

4. PROCESS ELECTRIC
   (kilowatt hours) is all electricity used to maintain any of the processes in the space.

5. PROCESS GAS
   (millions of Btu) is all gas used to maintain any of the processes in the space.

6. PROCESS HOT WATER
   (millions of Btu) is the total hot water used in all processes in the space.

SPACE SPACE1-1

MONTH	TASK LIGHTING (KWH)	TOTAL LIGHTING (KWH)	GENERAL EQUIPMENT (KWH)	PROCESS ELECTRIC (KWH)	PROCESS GAS (MBTU)	PROCESS HOT WATER (MBTU)
	- - - - L I G H T I N G - - - -		E Q U I P M E N T	- - - - - - - - - - P R O C E S S	- - - - - - - - - -	
JAN	0.00	402.18	193.67	0.00	0.0000	0.0000
FEB	0.00	349.67	167.88	0.00	0.0000	0.0000
MAR	0.00	386.57	185.58	0.00	0.0000	0.0000
APR	0.00	400.28	193.16	0.00	0.0000	0.0000
MAY	0.00	402.18	193.67	0.00	0.0000	0.0000
JUN	0.00	369.07	176.99	0.00	0.0000	0.0000
JUL	0.00	402.18	193.67	0.00	0.0000	0.0000
AUG	0.00	402.18	193.67	0.00	0.0000	0.0000
SEP	0.00	369.07	176.99	0.00	0.0000	0.0000
OCT	0.00	402.18	193.67	0.00	0.0000	0.0000
NOV	0.00	353.47	168.90	0.00	0.0000	0.0000
DEC	0.00	386.57	185.58	0.00	0.0000	0.0000
ANNUAL	0.00	4625.43	2223.36	0.00	0.0000	0.0000

REPORT SV–A
SYSTEM DESIGN PARAMETERS

This report echoes your input to the program as interpreted by the SYSTEMS design routines. See Section IV.D of the *Reference Manual (2.1A)* and "System Sizing", p.3.130. for a discussion of SYSTEMS design calculations. The report is divided into two sections: System-Level Design Values and Zone-Level Design Values.

Note: the quantities in this report have been adjusted for altitude even though DOE-2 requires that any CFMs you enter in SYSTEMS be at sea level.

System-Level Design Values

1. SYSTEM NAME
   is the u-name of the system.

2. SYSTEM TYPE
   is the code-word identifying the type of system. See "Applicability of Commands and Keywords to System Types" in the *BDL Summary (2.1E)* for a list of allowed system types.

3. ALTITUDE MULTIPLIER
   is the altitude adjustment factor for air flows; it multiplies air flows at sea level to get air flows at the actual altitude of the building.

4. FLOOR AREA
   is the total floor area of all zones served by the system that have ZONE–TYPE = CONDITIONED or UNCONDITIONED, or, for ZONE–TYPE = PLENUM, have non-zero occupancy.

5. MAX PEOPLE
   is the maximum number of people in all of the zones served by the system that have ZONE–TYPE = CONDITIONED or UNCONDITIONED, or, for ZONE–TYPE = PLENUM, that have non-zero occupancy. (The maximum number of people in a zone is determined by the NUMBER-OF-PEOPLE or AREA/PERSON keywords in the SPACE–CONDITIONS command in LOADS; any variation in occupancy resulting from PEOPLE-SCHEDULE is ignored in calculating MAX PEOPLE.)

6. SUPPLY FAN (CFM)
   is the calculated system design air flow rate. It should be equal to the user-input SUPPLY–CFM multiplied by the value of ALTITUDE MULTIPLIER. If not user-specified, the value will be calculated from the peak loads. For a constant volume system or if SIZING–OPTION = NON-COINCIDENT, the number will be the sum of the design cfms for the zones on the system. If the system is a variable-air-volume system, SIZING–OPTION = COINCIDENT, and this is the only system in the PLANT-ASSIGNMENT, the value is calculated from the building coincident peak load.

7. ELEC (KW)
   is the electrical energy consumed by the central system supply fan at design flow. It will be calculated from the value in column 1 and the user input (or default) for SUPPLY–KW or from the ratio of SUPPLY–STATIC and SUPPLY–EFF.

8. DELTA-T (F)
is the value of SUPPLY-DELTA-T, the rise in temperature of the air caused by the supply fan.

9. The next three entries, RETURN FAN (CFM), ELEC (KW), AND DELTA-T (F) are the corresponding values for the return air fan. In the sample report these are all zero because no return fan has been specified.

10. OUTSIDE AIR RATIO
is the ratio of outside air flow to supply air flow at design conditions for central systems. Its value is either the user input value of MIN-OUTSIDE-AIR or is calculated by SYSTEMS from the ventilation or exhaust input at the zone level divided by the supply fan cfm in column 1. This is a design quantity and so does not reflect values entered through the MIN-AIR-SCH keyword. For zonal systems, this value will be zero.

    When OUTSIDE AIR RATIO is determined from zone ventilation rates, it is the sum of the values under OUTSIDE AIR FLOW (in column 6 opposite the zone u-names) divided by the value under SUPPLY FAN. This outside air ratio is what the program will use as the minimum outside air ratio. It is assumed that the outside air is brought in at the main system fan and is distributed to the individual zones in proportion to the supply air to each zone.

    Note: The SYSTEMS design routine does not examine the values entered in schedules. Consequently, if you specify the outside air ratio through MIN-AIR-SCH but want SYSTEMS to size the equipment, you should also specify MIN-OUTSIDE-AIR.

11. COOLING CAPACITY (KBTU/HR)
is either the value you enter for the keyword COOLING-CAPACITY at the system level or is computed by SYSTEMS from the peak (sensible plus latent) cooling load. If the cfm chosen for the system is different from the user-specified value of RATED-CFM, COOLING CAPACITY may reflect a correction for off-rated performance.

12. SENSIBLE (SHR)
is the sensible heat ratio, i.e., the fraction of the total cooling capacity that is sensible cooling capacity at the peak or design condition, adjusted for RATED-CFM. If you have not entered COOL-SH-CAP at the system level for a central system, this value is calculated from a simulation of the conditions at peak loads, adjusted for RATED-CFM.

13. HEATING CAPACITY (KBTU/HR)
is the maximum value for heating; it reflects either the user input or a calculation from peak loads. Like COOLING CAPACITY, this value will be zero for zonal systems, where the capacity is shown at the zone level.

14. COOLING EIR and HEATING EIR (BTU/BTU)
are the electric input ratios for cooling and heating, respectively. Values are taken from user input or are default values. Values may be modified if the supply cfm differs from the RATED-CFM.

Zone-Level Design Values

The following quantities 15-21 apply to the base zone and have *not* been multiplied by the number of identical zones (as given by the product of MULTIPLIER and FLOOR-MULTIPLIER).

15. SUPPLY FLOW
is the calculated or user-specified supply cfm for each zone. Only if you have specified a value for the ASSIGNED-CFM keyword in the ZONE-AIR command will the value here correspond to your input. The ZONE-AIR keywords AIR-CHANGES/HR and CFM/SQFT will be accepted by SYSTEMS only if they are consistent with the user-supplied HEATING-CAPACITY and COOLING-CAPACITY, and are equivalent to a cfm larger than that of the exhaust from or the ventilation to the zone. The ALTITUDE MULTIPLIER will be applied.

16. FAN (KW)
is the total of the zone supply and exhaust fan electrical consumption at design conditions. This is zero in the example because there are no zone fans.

17. MINIMUM FLOW RATIO
reflects the your input for MIN-CFM-RATIO, unless that input is in conflict with exhaust or ventilation requirements. In the absence of user input, SYSTEMS will calculate the minimum cfm ratio for VAV systems from the minimum cfm needed to meet the the minimum ventilation requirements and the required heating capacity.

18. OUTSIDE AIR FLOW
reflects the user-specified outside air quantity entered at the zone level. If OUTSIDE-AIR-CFM is specified, its value is multiplied by the ALTITUDE MULTIPLIER and reported here. Otherwise the reported value is the maximum of the cfm-equivalent values of OA-CHANGES and OA-CFM/PER, multiplied by ALTITUDE MULTIPLIER. For the actual amount of outside air delivered to the zone for central systems, see OUTSIDE AIR RATIO above.

19. COOLING CAPACITY (KBTU/HR),
at the zone level, will be zero for central systems. For zonal systems it will either be the value you specify for COOLING-CAPACITY or it will be calculated by SYSTEMS to meet the peak loads at the rated conditions for HP, PTAC, TPFC, and FPFC systems or at any conditions for FPIU and TPIU systems. This is done similarly for HEATING CAPACITY for the above-mentioned systems and for UVT and UHT systems.

20. SENSIBLE (SHR)
is the sensible part of the cooling capacity for zonal systems.

21. EXTRACTION RATE (KBTU/HR)
is the extraction rate (cooling) at design conditions. This is not the value used in the simulation; that value is recalculated hourly and depends upon the loads, the conditions, the thermostat type, and the thermostatic throttling range. ADDITION RATE (heating) is treated similarly.

22. MULTIPLIER
is the user-specified number of identical zones (product of MULTIPLIER and FLOOR-MULTIPLIER for the zone).

SYSTEM NAME	SYSTEM TYPE	ALTITUDE MULTIPLIER	FLOOR AREA (SQFT)	MAX PEOPLE
SYST-1	VAVS	1.020	5000.0	52.

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
6354.	7.311	3.6	0.	0.000	0.0	0.167	195.964	0.770	-44.161	0.00	0.37

ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW RATIO	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
SPACE5-1	1454.	0.	0.000	0.300	408.	0.00	0.00	25.13	-91.09	-75.39	1.0
SPACE1-1	1909.	0.	0.000	0.300	224.	0.00	0.00	32.99	-119.59	-98.98	1.0
SPACE2-1	887.	0.	0.000	0.300	102.	0.00	0.00	15.33	-55.58	-46.00	1.0
SPACE3-1	1268.	0.	0.000	0.300	224.	0.00	0.00	21.92	-79.45	-65.75	1.0
SPACE4-1	835.	0.	0.000	0.300	102.	0.00	0.00	14.42	-52.28	-43.26	1.0
PLENUM-1	0.	0.	0.000	0.000	0.	0.00	0.00	0.00	0.00	0.00	1.0

REPORT SS-A
SYSTEM MONTHLY LOADS SUMMARY

This report is always printed by the program for each HVAC system modeled. It shows monthly cooling, heating, and electrical loads. The loads shown are the sum of zone-level loads and central air-handling-unit loads. (Zone-level loads are shown separately in Report SS-G.). This report is for comparison of monthly cooling and heating needs for the HVAC system. DX cooling loads are reported here (for PSZ, PMZS, PVAVS, PTAC, PVVT, RESVVT and RESYS systems) but are not passed to the PLANT program.

1. The title of the report shows the user name of the HVAC system being summarized (SYST-1).

2. COOLING, HEATING, and ELEC are the three sections of this system-level report.

3. COOLING ENERGY
   (millions of Btu) is the monthly sum of energy (sensible and latent) extracted by the HVAC system during the operation hours of the system and passed as a load to PLANT.

4. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) includes sensible and latent space cooling loads, ventilation air, and fan heat. The peak cooling load shown here is often the start-up load after the system has been shut down overnight. Notice, however, that when the system size is inadequate to meet the start-up load there is no indication of this problem on the report. You should first inspect the PLANT program BEPS report, which shows the "Percent of Hours Any System Zone Outside of Throttling Range", for a macro view, and Report SS-O or SS-F for a zonal report of where "Loads not met" conditions prevail.

   To the left of the MAXIMUM COOLING LOAD column are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

5. HEATING ENERGY
   (millions of Btu) is the monthly sum of heat delivered by the secondary HVAC system during the operation hours of the system and passed as a load to PLANT.

6. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) includes space heating loads, ventilation, and humidification. Again, the peak heating load is often due to start-up conditions after the system has been shut down overnight. To the left of this column are the day and hour of the peak heating load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

7. ELECTRICAL ENERGY (kWh)
   is the monthly electrical consumption for lights, convenience outlets, supply and return fans, and energy consumed by packaged HVAC units. The electrical consumption by the pumps is reported in the PLANT program.

8. MAXIMUM ELEC LOAD (kW)
   is the monthly peak electrical consumption in a one-hour period for lights, convenience outlets, energy consumed by packaged HVAC units, and fans for the zones served by the HVAC system.

REPORT- SS-A SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1 WEATHER FILE- TRY CHICAGO

	- - - - - - - - C O O L I N G - - - - - - - -						- - - - - - - - H E A T I N G - - - - - - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-32.540	7	8	-1.F	-1.F	-441.109	3078.	12.721
FEB	0.00000					0.000	-25.221	4	8	7.F	6.F	-419.194	2665.	12.701
MAR	0.00000					0.000	-15.190	25	8	14.F	12.F	-377.563	2904.	12.371
APR	1.52664	29	18	69.F	65.F	68.311	-3.705	8	8	30.F	27.F	-246.024	2992.	13.298
MAY	5.10064	21	14	85.F	75.F	132.661	-0.420	9	9	43.F	39.F	-40.320	3085.	14.424
JUN	14.55954	20	16	90.F	77.F	178.041	0.000					0.000	3054.	15.339
JUL	28.78266	8	16	92.F	74.F	214.902	0.000					0.000	3779.	18.322
AUG	23.67940	19	16	90.F	71.F	183.011	0.000					0.000	3545.	17.242
SEP	9.23581	11	16	86.F	72.F	138.083	-0.227	23	8	36.F	34.F	-99.033	2932.	15.530
OCT	2.26933	4	17	78.F	61.F	49.778	-2.190	21	8	30.F	29.F	-258.277	2994.	12.617
NOV	0.35773	1	16	72.F	59.F	54.561	-12.995	25	8	27.F	25.F	-325.673	2644.	13.017
DEC	0.00000					0.000	-25.768	26	8	15.F	15.F	-393.064	2940.	12.345
TOTAL	85.512						-118.258						36610.	
MAX						214.902						-441.109		18.322

REPORT SS–D

PLANT MONTHLY LOADS SUMMARY

Multiple central plants that serve the building's HVAC systems can be simulated. The PLANT-ASSIGNMENT command assigns HVAC systems to central plants. The name of the plant is reported in the title line. In this example, no u-name was specified, and so a default name (DEFAULT-PLANT) is printed. The cooling, heating, and electrical energy required by the systems and zones served by the plant are reported monthly along with the peak cooling, heating, and electrical loads for the combined systems, and the time of occurrence. Note that these peak loads may result from startup after the building has been shut down overnight. Cooling done in SYSTEMS by DX units is not included here in cooling loads but in electrical loads.

1. COOLING ENERGY
   (millions of Btu) is the sensible and latent monthly cooling required by the HVAC systems from the central plant specified in the PLANT-ASSIGNMENT command. For water loop heat pump systems the value reported here is the heat rejected to the plant's cooling tower.
2. TIME OF MAX
   gives the day and hour that the maximum cooling load occurs.
3. DRY-BULB TEMP and WET-BULB TEMP
   are the outside dry-bulb wet-bulb temperatures during the peak cooling load.
4. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) gives the peak cooling load for each month and for the year.
5. HEATING ENERGY
   (millions of Btu) is the total monthly heating required by the HVAC systems from the specified central plant. For water loop heat pump systems the value reported here is the supplementary heat from the plant's hot water boiler.
6. TIME OF MAX
   shows the day and hour of maximum heating load.
7. DRY-BULB TEMP and WET-BULB TEMP
   are the outside dry-bulb wet-bulb temperatures during the peak heating load.
8. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) gives the peak heating load for each month and for the year.
9. ELECTRICAL ENERGY
   (kWh) is the monthly electrical requirement for lights and convenience outlets for the building *zones* served by the plant. In addition, the electrical energy contains the fan energy requirement for the HVAC systems and electric energy for cooling and heating in packaged units. It does *not* include the electrical energy associated with pumps, cooling towers and chillers. These are reported in the PLANT program.
10. MAXIMUM ELEC LOAD
    (kW) gives the monthly peak electrical consumption in a one-hour period for the items in 9 (ELECTRICAL ENERGY).
11. Bottom of Report
    At the bottom of SS–D are shown the integrated cooling loads for the peak day for both the design day run (if any) and the annual run. These numbers are used by PLANT to size cold storage systems.

REPORT- SS-D PLANT MONTHLY LOADS SUMMARY FOR DEFAULT-PLANT WEATHER FILE- TRY CHICAGO

	- - - - - - - - - C O O L I N G - - - - - - - - -						- - - - - - - - - H E A T I N G - - - - - - - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.00000					0.000	-32.540	7	8	-1.F	-1.F	-441.109	3078.	12.721
FEB	0.00000					0.000	-25.221	4	8	7.F	6.F	-419.194	2665.	12.701
MAR	0.00000					0.000	-15.190	25	8	14.F	12.F	-377.563	2904.	12.371
APR	1.52664	29	18	69.F	65.F	68.311	-3.705	8	8	30.F	27.F	-246.024	2992.	13.298
MAY	5.10064	21	14	85.F	75.F	132.661	-0.420	9	9	43.F	39.F	-40.320	3085.	14.424
JUN	14.55954	20	16	90.F	77.F	178.041	0.000					0.000	3054.	15.339
JUL	28.78266	8	16	92.F	74.F	214.902	0.000					0.000	3779.	18.322
AUG	23.67940	19	16	90.F	71.F	183.011	0.000					0.000	3545.	17.242
SEP	9.23581	11	16	86.F	72.F	138.083	-0.227	23	8	36.F	34.F	-99.033	2932.	15.530
OCT	2.26933	4	17	78.F	61.F	49.778	-2.190	21	8	30.F	29.F	-258.277	2994.	12.617
NOV	0.35773	1	16	72.F	59.F	54.561	-12.995	25	8	27.F	25.F	-325.673	2644.	13.017
DEC	0.00000					0.000	-25.768	26	8	15.F	15.F	-393.064	2940.	12.345
	---------					----------	---------					----------	--------	-------
TOTAL	85.512						-118.258						36610.	
MAX						214.902						-441.109		18.322

MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY) 2274.994 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE) 2147.572 (KBTU)

REPORT SS-H
SYSTEM MONTHLY LOADS SUMMARY

This report gives monthly values of electrical energy for fans, gas/oil energy for heating and cooling, and electrical energy for heating and cooling for an HVAC system. The name of the system (SYST-1) is shown in the title.

1. FAN ELEC
   shows the total and maximum hourly electrical consumption of the supply, return, exhaust, and zonal fans.

2. FUEL HEAT
   shows the total oil and gas consumption by packaged systems for heating, in Btu-equivalents. This will be zero unless you have made at least one of the heat sources FURNACE.

3. FUEL COOL
   shows the total oil and gas consumption by packaged systems for cooling, in Btu-equivalents.

4. ELEC HEAT
   shows the electrical consumption for heating. This will include electric baseboards and reheat coils as well as the electrical load attributable to the heating cycle of a heat pump.

5. ELEC COOL
   shows the electrical consumption and hourly maxima for cooling.

REPORT- SS-H SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1 WEATHER FILE- TRY CHICAGO

	--FAN ELEC---		--FUEL HEAT--		--FUEL COOL--		-ELEC HEAT--		-ELEC COOL--	
MONTH	FAN ENERGY (KWH)	MAXIMUM FAN LOAD (KW)	GAS OIL ENERGY (MBTU)	MAXIMUM GAS OIL LOAD (KBTU/HR)	GAS OIL ENERGY (MBTU)	MAXIMUM GAS OIL LOAD (KBTU/HR)	ELECTRIC ENERGY (KWH)	MAXIMUM ELECTRIC LOAD (KW)	ELECTRIC ENERGY (KWH)	MAXIMUM ELECTRIC LOAD (KW)
JAN	256.	3.984	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
FEB	215.	3.878	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
MAR	195.	3.320	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
APR	182.	2.198	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
MAY	263.	2.955	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
JUN	469.	4.156	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
JUL	958.	7.304	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
AUG	724.	5.987	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
SEP	346.	4.123	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
OCT	173.	1.794	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
NOV	171.	3.021	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
DEC	231.	3.543	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000
TOTAL	4181.		0.000		0.000		0.		0.	
MAX		7.304		0.000		0.000		0.000		0.000

REPORT SS-L
FAN ELECTRIC ENERGY FOR <system>

This report gives a breakdown of monthly electric energy for fans (central and zone-level) and fan part load operation for an HVAC system.

The energy quantities on the left-hand side of the report are given for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours.

1. FAN ELECTRIC ENERGY DURING HEATING
   gives the total electric energy used by the fans in all hours when only heating is required.

2. FAN ELECTRIC ENERGY DURING COOLING
   gives the total electric energy used by the fans in all hours when only cooling is required.

3. FAN ELECTRIC ENERGY DURING HEATING-COOLING
   gives the total electric energy used by the fans in all hours when both heating and cooling are required.

4. FAN ELECTRIC ENERGY DURING FLOATING
   gives the total electric energy used by the fans when neither heating nor cooling is provided.

The right-hand side of the report shows the part-load operation of the fans. The number of operating hours within each percentage part load band (0-10%, 0-20% , etc.) is given as well as the total hours of operation. If the fan operates during an hour, its part load in percent is determined as 100*(total flow)/(design SUPPLY-CFM).

SIMPLE STRUCTURE RUN 3. CHICAGO DIVIDE INTO ZONES; ADD PLENUM DOE-2.1E-001 Thu Nov 4 15:19:02 1993SDL RUN 1
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REPORT- SS-L FAN ELECTRIC ENERGY SYST-1 WEATHER FILE- TRY CHICAGO

MONTH	FAN ELEC DURING HEATING (KWH)	FAN ELEC DURING COOLING (KWH)	FAN ELEC DURING HEAT & COOL (KWH)	FAN ELEC DURING FLOATING (KWH)	Number of hours within each PART LOAD range 00 10	10 20	20 30	30 40	40 50	50 60	60 70	70 80	80 90	90 100	100 +	TOTAL RUN HOURS
JAN	256.361	0.000	0.000	0.000	0	0	0	286	10	4	4	1	0	0	0	305
FEB	214.658	0.000	0.000	0.000	0	0	0	239	10	3	3	1	0	0	0	256
MAR	188.892	0.000	0.000	5.833	0	0	0	242	3	1	2	0	0	0	0	248
APR	77.282	59.311	0.000	45.241	0	0	0	216	11	2	0	0	0	0	0	229
MAY	29.165	172.787	0.000	61.428	0	0	0	144	45	27	4	0	0	0	0	220
JUN	0.000	465.212	0.000	3.377	0	0	0	23	49	80	51	4	0	0	0	207
JUL	0.000	957.790	0.000	0.000	0	0	0	1	9	35	72	66	29	28	1	241
AUG	0.000	723.851	0.000	0.000	0	0	0	9	24	62	91	40	12	0	0	238
SEP	9.505	303.856	0.000	32.739	0	0	0	88	45	37	32	3	0	0	0	205
OCT	63.882	77.672	0.729	31.766	0	0	0	224	1	0	0	0	0	0	0	225
NOV	148.524	13.215	0.000	8.918	0	0	0	200	5	2	2	0	0	0	0	209
DEC	230.728	0.000	0.000	0.000	0	0	0	259	11	0	6	0	0	0	0	276
ANNUAL	1218.994	2773.703	0.729	189.301	0	0	0	1931	223	253	267	115	41	28	1	2859

REPORT SS-M
FAN ELECTRIC ENERGY FOR PLANT

This report gives a breakdown of fan electric energy for each month passed to PLANT. The quantities are given for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours. The quantities are calculated by summing the individual space quantities.

1. FAN ELECTRIC ENERGY DURING HEATING
   gives the total electric energy used by the fans in all hours when only heating is required.

2. FAN ELECTRIC ENERGY DURING COOLING
   gives the total electric energy used by the fans in all hours when only cooling is required.

3. FAN ELECTRIC ENERGY DURING HEATING-COOLING
   gives the total electric energy used by the fans in all hours when both heating and cooling are required.

4. FAN ELECTRIC ENERGY DURING FLOATING
   gives the total electric energy used by the fans when neither heating nor cooling is provided.

MONTH	FAN ELECTRIC ENERGY DURING HEATING (KWH)	FAN ELECTRIC ENERGY DURING COOLING (KWH)	FAN ELECTRIC ENERGY DURING HEATING-COOLING (KWH)	FAN ELECTRIC ENERGY DURING FLOATING (KWH)
JAN	256.361	0.000	0.000	0.000
FEB	214.658	0.000	0.000	0.000
MAR	188.892	0.000	0.000	5.833
APR	77.282	59.311	0.000	45.241
MAY	29.165	172.787	0.000	61.428
JUN	0.000	465.212	0.000	3.377
JUL	0.000	957.790	0.000	0.000
AUG	0.000	723.851	0.000	0.000
SEP	9.505	303.856	0.000	32.739
OCT	63.882	77.672	0.729	31.766
NOV	148.524	13.215	0.000	8.918
DEC	230.728	0.000	0.000	0.000
ANNUAL	1218.994	2773.703	0.729	189.301

REPORT SS-N
RELATIVE HUMIDITY SCATTER PLOT

In this scatter plot, the ordinate, appearing in the left column, shows relative humidity bins. The abscissa, shown at the top, gives hours of the day. Entered in each cell of the plot is the number of hours during the RUN-PERIOD for which the relative humidity of the system return air was in the particular relative humidity bin for this particular hour of the day. Only hours for which the fans are on are counted in this plot.

The column at the far right is the sum of the entries in each row. It shows the frequency of relative humidity values for the RUN-PERIOD. (Because the relative humidity counts are made only for hours when the fans are on, summing the totals column will not sum to the number of hours in the run.)

Note: If fans are on due to NIGHT-CYCLE-CTRL, the hours will not be counted in the plot.

TOTAL HOURS AT RELATIVE HUMIDITY LEVEL AND TIME OF DAY

HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
80-100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
70-80	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	4
60-70	0	0	0	0	0	0	0	6	5	5	5	4	4	2	2	3	3	3	0	0	0	0	0	0	42
50-60	0	0	0	0	0	0	0	45	58	57	53	32	33	29	28	34	35	4	0	0	0	0	0	0	408
40-50	0	0	0	0	0	0	0	42	43	45	41	60	61	69	66	59	61	9	0	0	0	0	0	0	556
30-40	0	0	0	0	0	0	0	26	62	61	57	49	38	48	52	55	51	27	0	0	0	0	0	0	526
0-30	0	0	0	0	0	0	0	7	83	84	96	107	116	103	103	100	101	83	0	0	0	0	0	0	983

REPORT SS-O
TEMPERATURE SCATTER PLOT

In this scatter plot, the ordinate, appearing in the left column, shows temperature bins. The abscissa, shown at the top, gives hours of the day. Entered in each cell of the plot is the number of hours during the RUN-PERIOD for which the zone air temperature was in the particular bin for this particular hour of the day. Only hours for which the fans are on are counted in this plot.

The column at the far right is the sum of the entries in each row. It shows the frequency of temperature values for the RUN-PERIOD. (Because the temperature counts are only made for hours when the fans are on, summing the totals column will not sum to the number of hours in the run.)

Note: If fans are on due to NIGHT-CYCLE-CTRL, the hours will not be counted in the plot.

TOTAL HOURS AT TEMPERATURE LEVEL AND TIME OF DAY

HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
ABOVE 85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80-85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
75-80	0	0	0	0	0	0	0	88	90	96	100	106	119	132	141	144	139	15	0	0	0	0	0	0	1170
70-75	0	0	0	0	0	0	0	38	162	156	152	145	132	119	110	107	112	110	0	0	0	0	0	0	1343
65-70	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	0	0	0	0	0	0	7
60-65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BELOW 60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

REPORT PS–A
PLANT ENERGY UTILIZATION SUMMARY

PS–A gives site and source energy use in MBtu(10^6 Btu) for thermal quantities and MWh(10^6Wh) for electrical quantities.

In DOE-2.1E, PS–A was modified so that electrical consumption is displayed in units of MWh; the second line showing electrical consumption for each month has been eliminated. Numbers shown in this report may be different than shown in earlier program releases. Previously, energy consumed in SYSTEMS for electrical and fuel usage for heating and cooling did not appear under the heating and cooling categories, only in the total categories; this has been corrected. Also, the figures for total site and source energy were incorrect when a cogeneration plant is a net exporter of electricity; this has been corrected.

1. MONTH

2. TOTAL HEAT LOAD
   Total heating energy = load from SYSTEMS + load from PLANT (absorption chillers + steam turbines + heat dissipated from storage tanks + domestic hot water + heat stored in tanks but not used) + circulation loop losses. The values here are identical to those in the HEATING ENERGY column of the SYSTEMS SS–D report except that the heat energy delivered to an absorption chiller, steam turbine, domestic hot water, and circulation losses is included. Also included is the heat input to a storage tank from a boiler.

3. TOTAL COOLING LOAD
   This is the total of the values shown in the SS–D report plus tank and circulation loop losses; it represents the cooling energy needed each month.

4. TOTAL ELECTR LOAD
   This is the total electrical energy consumed by lights, equipment, and system fans plus the additional energy consumed by chiller motors, pumps, cooling towers, and any other electrical site use including energy entered into the program under BUILDING–RESOURCE.

5. RECVRED ENERGY
   These values are recovered heat used to reduce heating loads. This is waste heat from turbines, diesels, and double-bundle chillers, and solar energy delivered to the load via HEAT-RECOVERY.

6. WASTED RECVRABL ENERGY
   The values in this column represent the heat that *could* have been recovered, had there been a need for it.

7. FUEL INPUT COOLING
   The fuel used to drive engine chillers and gas fired absorption chiller/heaters, and regeneration fuel for desiccant cooling systems.

8. ELEC INPUT COOLING
The electric energy used to drive chillers and to supply power for peripheral cooling equipment, such as circulation pumps, cooling towers, and cold storage tanks.

9. FUEL INPUT HEATING
This column reports the fuel used for heating by boilers, furnaces, and hot water heaters.

10. ELEC INPUT HEATING
The electrical energy used in association with supplying heating, including the electrical consumption by draft fans, circulation pumps, electric boilers, and hot water storage pumps.

11. FUEL INPUT ELEC
The fuel used by diesel and gas turbine generators.

12. TOTAL FUEL INPUT
The sum of fossil fuels use.

13. TOTAL SITE ENERGY
The sum of purchased fossil fuel, electricity, chilled water and steam.

14. TOTAL SOURCE ENERGY
The energy used at the source. For each RESOURCE, the energy consumption at the site is divided by the corresponding SOURCE-SITE-EFF to arrive at the energy consumed and transmitted by the generating station; the results are summed.

SIMPLE STRUCTURE RUN 3, CHICAGO DIVIDE INTO ZONES; ADD PLENUM DOE-2.1E-001 Thu Nov 4 15:19:02 1993PDL RUN 1
DESIGN-DAY SIZING OF VAV SYSTEM SHOW ALL REPORTS
REPORT- PS-A PLANT ENERGY UTILIZATION SUMMARY WEATHER FILE- TRY CHICAGO

	S I T E E N E R G Y												SOURCE
	2	3	4	5	6	7	8	9	10	11	12	13	14
MONTH	TOTAL HEAT LOAD (MBTU)	TOTAL COOLING LOAD (MBTU)	TOTAL ELECTR LOAD (MWH)	RCVRED ENERGY (MBTU)	WASTED RCVRABL ENERGY (MBTU)	FUEL INPUT COOLING (MBTU)	ELEC INPUT COOLING (MWH)	FUEL INPUT HEATING (MBTU)	ELEC INPUT HEATING (MWH)	FUEL INPUT ELECT (MBTU)	TOTAL FUEL INPUT (MBTU)	TOTAL SITE ENERGY (MBTU)	TOTAL SOURCE ENERGY (MBTU)
JAN	33.5	0.0	3.9	0.0	0.0	0.0	0.0	51.6	0.8	0.0	51.6	64.9	91.7
FEB	26.0	0.0	3.3	0.0	0.0	0.0	0.0	40.2	0.7	0.0	40.2	51.5	74.3
MAR	15.9	0.0	3.4	0.0	0.0	0.0	0.0	25.0	0.5	0.0	25.0	36.5	59.6
APR	4.0	1.8	3.4	0.0	0.0	0.0	0.3	6.4	0.1	0.0	6.4	18.0	41.4
MAY	0.5	5.6	3.9	0.0	0.0	0.0	0.7	0.9	0.0	0.0	0.9	14.0	40.4
JUN	0.0	15.4	4.9	0.0	0.0	0.0	1.9	0.0	0.0	0.0	0.0	16.8	50.5
JUL	0.0	29.8	7.0	0.0	0.0	0.0	3.2	0.0	0.0	0.0	0.0	23.9	71.6
AUG	0.0	24.7	6.4	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	21.7	65.0
SEP	0.3	9.9	4.2	0.0	0.0	0.0	1.3	0.4	0.0	0.0	0.4	14.8	43.4
OCT	2.5	2.7	3.5	0.0	0.0	0.0	0.4	3.9	0.1	0.0	3.9	15.9	40.0
NOV	13.6	0.4	3.1	0.0	0.0	0.0	0.1	21.3	0.4	0.0	21.3	31.9	53.0
DEC	26.6	0.0	3.7	0.0	0.0	0.0	0.0	41.5	0.7	0.0	41.5	53.9	78.9
TOTAL	122.8	90.5	50.6	0.0	0.0	0.0	10.7	191.1	3.4	0.0	191.1	363.9	709.7

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REPORT PS-B
MONTHLY PEAK AND TOTAL ENERGY USE

This report shows the monthly total consumption and peak hourly consumption (demand) of up to five of the following purchased fuels:

ELECTRICITY
CHILLED-WATER
STEAM
NATURAL-GAS
LPG
FUEL-OIL
DIESEL-OIL
COAL
METHANOL
OTHER-FUEL

Usage is displayed in the actual units of consumption (kWh, therms, etc.).

The final section of the report gives, for each "fuel", the total energy use for the run period (ONE YEAR USE), and, below this, the peak hourly energy use (PEAK) for the run period.

SIMPLE STRUCTURE RUN 3, CHICAGO   DIVIDE INTO ZONES; ADD PLENUM   DOE-2.1E-001 Thu Nov 4 15:19:02 1993PDL RUN 1
DESIGN-DAY SIZING OF VAV SYSTEM   SHOW ALL REPORTS
REPORT- PS-B MONTHLY UTILITY AND FUEL USE SUMMARY   WEATHER FILE- TRY CHICAGO

MONTH	BTU/UNIT:	ELECTRICITY METER-1 3413./KWH	NATURAL-GAS METER-1 100000./THERMS
JAN			
	ENERGY CONSUMPTION (UNITS/MO)	3918.1	515.5
	PEAK DEMAND (UNITS/HR OR DAY)	16.2	5.6
	PEAK DAY/HR	7/ 9	7/ 8
FEB			
	ENERGY CONSUMPTION (UNITS/MO)	3333.6	401.5
	PEAK DEMAND (UNITS/HR OR DAY)	16.1	5.3
	PEAK DAY/HR	4/ 9	4/ 8
MAR			
	ENERGY CONSUMPTION (UNITS/MO)	3377.5	250.2
	PEAK DEMAND (UNITS/HR OR DAY)	15.8	4.9
	PEAK DAY/HR	25/ 9	25/ 8
APR			
	ENERGY CONSUMPTION (UNITS/MO)	3417.1	63.8
	PEAK DEMAND (UNITS/HR OR DAY)	22.2	3.4
	PEAK DAY/HR	29/15	8/ 8
MAY			
	ENERGY CONSUMPTION (UNITS/MO)	3857.1	8.8
	PEAK DEMAND (UNITS/HR OR DAY)	28.4	0.7
	PEAK DAY/HR	21/14	9/ 9
JUN			
	ENERGY CONSUMPTION (UNITS/MO)	4933.9	0.0
	PEAK DEMAND (UNITS/HR OR DAY)	33.8	0.0
	PEAK DAY/HR	20/16	0/ 0
JUL			
	ENERGY CONSUMPTION (UNITS/MO)	6989.9	0.0
	PEAK DEMAND (UNITS/HR OR DAY)	39.2	0.0
	PEAK DAY/HR	8/15	0/ 0
AUG			
	ENERGY CONSUMPTION (UNITS/MO)	6351.4	0.0
	PEAK DEMAND (UNITS/HR OR DAY)	36.0	0.0
	PEAK DAY/HR	19/16	0/ 0
SEP			
	ENERGY CONSUMPTION (UNITS/MO)	4196.0	4.4
	PEAK DEMAND (UNITS/HR OR DAY)	30.7	1.7
	PEAK DAY/HR	11/15	23/ 8
OCT			
	ENERGY CONSUMPTION (UNITS/MO)	3519.4	39.2
	PEAK DEMAND (UNITS/HR OR DAY)	19.8	3.6
	PEAK DAY/HR	31/15	21/ 8
NOV			
	ENERGY CONSUMPTION (UNITS/MO)	3098.8	212.8
	PEAK DEMAND (UNITS/HR OR DAY)	21.1	4.3
	PEAK DAY/HR	1/15	25/ 8
DEC			
	ENERGY CONSUMPTION (UNITS/MO)	3651.2	414.6
	PEAK DEMAND (UNITS/HR OR DAY)	15.8	5.1
	PEAK DAY/HR	9/11	26/ 8
TOTAL			
	ENERGY CONSUMPTION (UNITS/YR)	50644.1	1910.8
	PEAK DEMAND (UNITS/HR OR DAY)	39.2	5.6

REPORT PS-D
PLANT LOADS SATISFIED

This report flags those situations where the plant is not able to meet the loads imposed by both systems and other plant equipment. This is of special importance when equipment is intentionally undersized to improve part load performance or to reduce costs.

MBTU SUPPLIED
is the output energy from each piece of equipment.

PCT OF TOTAL LOAD
is the following ratio (in percent): MBTU SUPPLIED divided by TOTAL LOAD ON PLANT. This will be 100% only if all of the load is satisfied.

When a hot or cold storage tank is included, additional entries are given at the bottom of the first page which describe the contribution to the heating and cooling demands made by the storage tank(s).

TOTAL LOAD ON PLANT
for heating (cooling) is the sum of the demand from SYSTEMS, the consumption by PLANT, the loss from the storage tank and the heat (cold) remaining in the storage tank at the end of the run. The last, of course, is still recoverable and is reported as RESIDUAL (not shown in this example: see the PS-D report for the 31-story Office Building, Run 2 in the *Sample Run Book (2.1E)*).

In the second part of this report, "SUMMARY OF LOADS MET", TOTAL OVERLOAD is that portion of a load that requires equipment to operate above its nominal rated capacity. PEAK OVERLOAD is the largest hourly overload.

SIMPLE STRUCTURE RUN 3, CHICAGO　　DIVIDE INTO ZONES; ADD PLENUM　　DOE-2.1E-001 Thu Nov 4 15:19:02 1993PDL RUN 1
DESIGN-DAY SIZING OF VAV SYSTEM　　SHOW ALL REPORTS
REPORT- PS-D PLANT LOADS SATISFIED　　WEATHER FILE- TRY CHICAGO

HEATING LOADS	MBTU SUPPLIED	PCT OF TOTAL LOAD
HW-BOILER	122.8	100.0
LOAD SATISFIED	122.8	100.0
TOTAL LOAD ON PLANT	122.8	

COOLING LOADS	MBTU SUPPLIED	PCT OF TOTAL LOAD
HERM-REC-CHLR	90.5	100.0
LOAD SATISFIED	90.5	100.0
TOTAL LOAD ON PLANT	90.5	

ELECTRICAL LOADS	KWH SUPPLIED	PCT OF TOTAL LOAD
ELECTRICITY	50644.1	100.0
LOAD SATISFIED	50644.1	100.0
TOTAL LOAD ON PLANT	50642.9	

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING LOADS	122.8	122.8	0.000	0.000	0
COOLING LOADS	90.5	90.5	0.000	0.000	0
ELECTRICAL LOADS	172.8	172.8	0.000	0.000	0

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REPORT PS–G
ELECTRICAL LOAD SCATTER PLOT

In this scatter plot the ordinate, shown in the left-most column, is the electrical demand divided into 13 bins which range from zero to just above the peak electrical demand. The abscissa shown at the top is the hour of the day. Entered in each cell of the plot is the number of days during the year for which the electrical demand was less than the ordinate shown but larger than the next lower ordinate at that hour of the day.

The right-most column is the sum of the entries in each row and shows the frequency of the electrical demand throughout the run period.

The bottom row shows the distribution of electrical demand for each hour of the average day. The number here is the electrical consumption for the run period for a *particular* hour of the day divided by the total electrical consumption for *all hours of the day* for run period.

The chart at the bottom is a breakdown of the peak electrical demand into the contributing components. The SYSTEMS LOAD includes the lighting and equipment electrical loads from LOADS as well as that from system fans.

TOTAL HOURS AT HOURLY DEMAND AND TIME OF DAY

	HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2
	37	0	0	0	0	0	0	0	0	2	1	2	2	1	3	6	5	3	3	0	0	0	0	0	0	28
	34	0	0	0	0	0	0	0	0	0	2	5	4	2	6	8	9	9	6	0	0	0	0	0	0	51
	31	0	0	0	0	0	0	0	0	4	4	4	5	7	13	23	24	14	13	0	0	0	0	0	0	111
D	28	0	0	0	0	0	0	0	0	8	11	14	20	15	26	26	27	28	31	0	0	0	0	0	0	206
E	25	0	0	0	0	0	0	0	2	13	23	33	30	30	22	16	14	22	22	0	0	0	0	0	0	227
M K	21	0	0	0	0	0	0	0	2	23	21	11	10	17	12	9	8	11	10	0	0	0	0	0	0	134
A W	18	0	0	0	0	0	0	0	3	19	13	32	17	14	14	14	15	11	9	0	0	0	0	0	0	161
N	15	0	0	0	0	0	0	0	8	146	151	136	138	99	110	128	111	62	65	0	0	0	0	0	0	1154
D	12	0	0	0	0	0	0	0	9	37	26	15	26	67	46	21	38	92	93	0	0	0	0	0	0	470
	9	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41
	6	9	9	14	10	13	11	15	104	5	4	5	5	4	3	4	5	4	4	260	5	6	8	8	8	523
	3	356	356	351	355	352	354	350	196	108	109	108	108	109	110	109	108	109	109	105	360	359	357	357	357	5652
PERCENT TOTAL DEMAND		0.4	0.4	0.4	0.4	0.4	0.4	0.5	2.5	8.1	8.4	8.8	8.8	8.3	8.9	9.5	9.3	8.8	8.7	3.1	1.6	0.9	0.4	0.4	0.4	

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KW	PCT
SYSTEMS LOAD	18.322	46.8
CIRCULATION PUMPS	0.711	1.8
HERM-REC-CHLR	20.155	51.4
TOTAL	39.188	

REPORT BEPS
BUILDING ENERGY PERFORMANCE SUMMARY

This report makes it possible to quickly review annual building energy use according to energy type (ELECTRICITY, NATURAL-GAS, etc.) and category of use (AREA, LIGHTS, SPACE, HEAT, etc.). The energy types shown are those that you have specified with the ENERGY-RESOURCE command in PLANT (see "Energy Meters in PLANT", p.4.3). The categories of use (also called energy end uses) are defined under "Metering and Reporting of Energy End Uses" in the section "Energy End Uses and Meters" p.3.4.
Only categories of use with non-zero consumption are shown.

TOTAL SITE ENERGY
is the overall energy use *at the building site* for all energy types and categories of use.

TOTAL SOURCE ENERGY
is the energy use at point of production; it is obtained by dividing site energy use by the user-specified SOURCE-SITE-EFF value in the ENERGY-RESOURCE command.

Site and source energy are given per unit of net area (the sum of the floor areas of conditioned zones) and per unit of gross area (the value of GROSS-AREA in the BUILDING-LOCATION command in LOADS, which defaults to net area).

It should be pointed out that this report is not designed to work when there is a steam turbine among the specified plant equipment items. The numbers reported when a steam turbine is present will not be reliable.

When a hot storage tank is present, a note is printed on the BEPS report stating that the hot water storage tank can get energy from many sources. Any time there is residual energy in the storage tanks, the totals in the BEPS report will not agree with those in report PS-B, because the BEPS report includes only the energy used for the above categories, whereas PS-B includes the energy that is left in the tanks as well.

ENERGY TYPE: UNITS: MBTU	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
AREA LIGHTS	74.7	0.0
MISC EQUIPMT	35.9	0.0
SPACE HEAT	9.0	191.1
SPACE COOL	27.9	0.0
HEAT REJECT	5.7	0.0
PUMPS & MISC	5.3	0.0
VENT FANS	14.3	0.0
TOTAL	172.8	191.1

TOTAL SITE ENERGY 363.93 MBTU 72.8 KBTU/SQFT-YR GROSS-AREA 72.8 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 709.67 MBTU 141.9 KBTU/SQFT-YR GROSS-AREA 141.9 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 1.7
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

REPORT ES-D
ENERGY COST SUMMARY

This report summarizes the yearly energy consumption and cost for all UTILITY-RATEs defined.

1. UTILITY-RATE
   lists the u-name of each UTILITY-RATE

2. RESOURCE
   lists the RESOURCE

3. METERS
   lists the meter numbers to which each UTILITY-RATE applies.

4. METERED ENERGY
   is the actual metered energy from PLANT, not adjusted for any minimum energy requirements.

5. TOTAL CHARGE
   is total yearly charge.

6. VIRTUAL RATE
   is the total yearly charge divided by the metered energy.

7. RATE USED ALL YEAR
   if NO, the rate was not used for all 12 billing cycles, either because the rate did not qualify all months, the QUAL-SCH was not active all months, or the run period was less than 12 months.

8. ENERGY COST/ GROSS BLDG AREA
   ENERGY COST/ NET BLDG AREA
   give the energy cost per unit area. Here, gross building area is the value of the keyword GROSS-AREA in the BUILDING-LOCATION command in LOADS. GROSS-AREA defaults to the net building area, which is the sum of the floor areas of the conditioned zones.

The program does a check to ensure that all energy passed from PLANT is accounted for in one or more UTILITY-RATEs. If not, or if double counting of energy has occurred, a warning will be printed at the bottom of this report.

REPORT- ES-D ENERGY COST SUMMARY

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
ELEC-TARIFF	ELECTRICITY	1 2 3 4 5	50644. KWH	3223.	0.0636	YES
GAS-RATE	NATURAL-GAS	1 2 3 4 5	1911. THERMS	1146.	0.6000	YES
				==========		
				4369.		

ENERGY COST/GROSS BLDG AREA: 0.87
ENERGY COST/NET BLDG AREA: 0.87

REPORT ES–E
SUMMARY OF UTILITY–RATE: U–NAME

This report summarizes the key costs for each UTILITY–RATE. The top of the report contains general information regarding the UTILITY–RATE as input by the user or defaulted. The remainder of the report summarizes costs by month.

1. MONTH
   is the billing period ending with the BILLING–DAY.

2. METERED ENERGY
   is the energy in the meters as passed by the PLANT program.

3. BILLING ENERGY
   is the energy used for billing purposes. This amount may be greater than the metered energy if a minimum energy qualifier is used. This amount will be 0.0 if the UTILITY–RATE did not qualify for this month.

4. METERED DEMAND
   is the maximum demand in the meters in this billing period as passed by the PLANT program. The value will be either the hourly or daily demand as specified by the DEMAND–WINDOW.

5. BILLING DEMAND
   is the demand used for billing purposes. This amount may be either greater or less than the metered demand depending on the minimum demand qualifier and/or ratchets. This value will be 0.0 if the UTILITY–RATE did not qualify for this month.

6. ENERGY CHARGE
   are all energy charges, including BLOCK–CHARGEs.

7. DEMAND CHARGE
   are all demand charges, including BLOCK–CHARGEs.

8. ENERGY CST ADJ
   are the energy cost adjustment.

9. TAXES
   are the sum of per unit and percentage taxes

10. SURCHARGES
    are the sum of per unit and percentage surcharges

11. FIXED CHARGE
    are the MONTH–CHGS defined by the user.

12. MINIMUM CHARGE
is the minimum monthly charge as determined by the MIN-MON-CHG or the MIN-MON-DEM-CHG.

13. VIRTUAL RATE
is the total charge divided by the metered energy. This rate should not exceed the RATE-LIMITATION plus fixed charges.

14. TOTAL CHARGE
is the sum of all charges.

SIMPLE STRUCTURE RUN 3, CHICAGO   DIVIDE INTO ZONES: ADD PLENUM   DOE-2.1E-001 Thu Nov 4 15:19:02 1993EDL RUN 1
DESIGN-DAY SIZING OF VAV SYSTEM   SHOW ALL REPORTS
REPORT- ES-E SUMMARY OF UTILITY-RATE: ELEC-TARIFF

UTILITY-RATE: ELEC-TARIFF

RESOURCE: ELECTRICITY
METERS: 1 2 3 4 5
POWER-FACTOR: 0.80

DEMAND-WINDOW: HOUR
BILLING-DAY: 31
EXCESS-KVAR-FRAC: 0.30

3413. BTU/KWH
RATE-LIMITATION: 0.0000
EXCESS-KVAR-CHG: 0.0000

RATE-QUALIFICATIONS

MIN-ENERGY: 0.0
MAX-ENERGY: 0.0
MIN-DEMAND: 0.0
MAX-DEMAND: 0.0
QUALIFY-RATE: ALL-MONTHS
USE-MIN-QUAL: NO

BLOCK-CHARGES

DEMAND-RATCHETS

MIN-MON-RATCHETS

MONTH	METERED ENERGY KWH	BILLING ENERGY KWH	METERED DEMAND KW	BILLING DEMAND KW	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	3918	3918	16.2	16.2	245	0	0	0	0	0	0	0.0624	245
FEB	3334	3334	16.1	16.1	208	0	0	0	0	0	0	0.0625	208
MAR	3378	3378	15.8	15.8	212	0	0	0	0	0	0	0.0629	212
APR	3417	3417	22.2	22.2	218	0	0	0	0	0	0	0.0637	218
MAY	3857	3857	28.4	28.4	247	0	0	0	0	0	0	0.0641	247
JUN	4934	4934	33.8	33.8	318	0	0	0	0	0	0	0.0644	318
JUL	6990	6990	39.2	39.2	448	0	0	0	0	0	0	0.0641	448
AUG	6351	6351	36.0	36.0	408	0	0	0	0	0	0	0.0642	408
SEP	4196	4196	30.7	30.7	270	0	0	0	0	0	0	0.0643	270
OCT	3519	3519	19.8	19.8	225	0	0	0	0	0	0	0.0639	225
NOV	3099	3099	21.1	21.1	196	0	0	0	0	0	0	0.0631	196
DEC	3651	3651	15.8	15.8	229	0	0	0	0	0	0	0.0626	229
TOTAL	50644	50644	39.2		3223	0	0	0	0	0		0.0636	3223

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Appendix D

DOE-2 Materials Library

Table of Contents

1. Thermal Properties of Building Materials

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity Btu-Ft/ Hr-Ft^2-^{o}F	Density Lb/ Ft^3	Specific Heat Btu/ Lb-^{o}F	Resistance Hr-Ft^2-^{o}F/ Btu
	Acoustic Tile					
AC01	3/8 inch	0.0313	0.0330	18.0	0.32	0.95
AC02	1/2 inch	0.0417	0.0330	18.0	0.32	1.26
AC03	3/4 inch	0.0625	0.0330	18.0	0.32	1.89
AS01	**Aluminum or Steel Siding**	0.0050	26.000	480.0	0.10	
	Asbestos-Cement					
AB01	1/8 inch Board	0.0104	0.3450	120.0	0.2	0.03
AB02	1/4 inch Board	0.0208	0.3450	120.0	0.2	0.06
AB03	Shingle					0.21
AB04	1/4 inch Lapped Siding					0.21
AV01	**Asbestos-Vinyl Tile**				0.3	0.05
	Asphalt					
AR01	Roofing Roll			70.0	0.35	0.15
AR02	Shingle and Siding			70.0	0.35	0.44
AR03	Tile				0.30	0.05
	Brick					
BK01	4 inch Common	0.3333	0.4167	120.0	0.20	0.80
BK02	8 inch Common	0.6667	0.4167	120.0	0.20	1.60
BK03	12 inch Common	1.0000	0.4167	120.0	0.20	2.40
BK04	3 inch Face	0.2500	0.7576	130.0	0.22	0.33
BK05	4 inch Face	0.3333	0.7576	130.0	0.22	0.44
	Building Paper					
BP01	Permeable Felt					0.06
BP02	2-Layer Seal					0.12
BP03	Plastic Film Seal					0.01
BR01	**Built-up Roofing 3/8 inch**	0.0313	0.0939	70.0	0.35	0.33
	Carpet					
CP01	With Fibrous Pad				0.34	2.08
CP02	With Rubber Pad				0.34	1.23

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity Btu-Ft/ Hr-Ft^2-°F	Density Lb/ Ft^3	Specific Heat Btu/ Lb-°F	Resistance Hr-Ft^2-°F/ Btu
	Cement					
CM01	1 inch Mortar	0.0833	0.4167	116.0	0.2	0.20
CM02	1.75 inch Mortar	0.1458	0.4167	116.0	0.2	0.35
CM03	1 inch Plaster with Sand Aggregate	0.0833	0.4167	116.0	0.2	0.20
	Clay Tile, Hollow					
CT01	3 inch 1 Cell	0.2500	0.3125	70.0	0.2	0.80
CT02	4 inch 1 Cell	0.3333	0.2999	70.0	0.2	1.11
CT03	6 inch 2 Cells	0.5000	0.3300	70.0	0.2	1.52
CT04	8 inch 2 Cells	0.6667	0.3600	70.0	0.2	1.85
CT05	10 inch 2 Cells	0.8333	0.3749	70.0	0.2	2.22
CT06	12 inch 3 Cells	1.0000	0.4000	70.0	0.2	2.50
	Clay Tile, Paver					
CT11	3/8 inch	0.0313	1.0416	120.0	0.2	0.03
	Concrete Heavy Weight Dried Aggregate, 140 lbs					
CC01	1.25 inch	0.1042	0.7576	140.0	0.2	0.14
CC02	2 inch	0.1667	0.7576	140.0	0.2	0.22
CC03	4 inch	0.3333	0.7576	140.0	0.2	0.44
CC04	6 inch	0.5000	0.7576	140.0	0.2	0.66
CC05	8 inch	0.6667	0.7576	140.0	0.2	0.88
CC06	10 inch	0.8333	0.7576	140.0	0.2	1.10
CC07	12 inch	1.0000	0.7576	140.0	0.2	1.32
	Concrete, Heavy Weight Undried Aggregate, 140 lbs					
CC11	3/4 inch	0.0625	1.0417	140.0	0.2	0.06
CC12	1 3/8 inch	0.1146	1.0417	140.0	0.2	0.11
CC13	3 1/4 inch	0.2708	1.0417	140.0	0.2	0.26
CC14	4 inch	0.3333	1.0417	140.0	0.2	0.32
CC15	6 inch	0.5000	1.0417	140.0	0.2	0.48
CC16	8 inch	0.6667	1.0417	140.0	0.2	0.64
	Concrete Light Weight, 80 lb					
CC21	3/4 inch	0.0625	0.2083	80.0	0.2	0.30
CC22	1.25 inch	0.1042	0.2083	80.0	0.2	0.50
CC23	2 inch	0.1667	0.2083	80.0	0.2	0.80
CC24	4 inch	0.3333	0.2083	80.0	0.2	1.60
CC25	6 inch	0.5000	0.2083	80.0	0.2	2.40
CC26	8 inch	0.6667	0.2083	80.0	0.2	3.20

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-°F	Lb/ Ft^3	Btu/ Lb-°F	Hr-Ft^2-°F/ Btu
	Concrete, Light Weight, 30 lb					
CC31	3/4 inch	0.0625	0.0751	30.0	0.2	0.83
CC32	1.25 inch	0.1042	0.0751	30.0	0.2	1.39
CC33	2 inch	0.1667	0.0751	30.0	0.2	2.22
CC34	4 inch	0.3333	0.0751	30.0	0.2	4.44
CC35	6 inch	0.5000	0.0751	30.0	0.2	6.66
CC36	8 inch	0.6667	0.0751	30.0	0.2	8.88
	Concrete Block, 4 inch Heavy Weight					
CB01	Hollow	0.3333	0.4694	101.0	0.2	0.71
CB02	Concrete Filled	0.3333	0.7575	140.0	0.2	0.44
CB03	Perlite Filled	0.3333	0.3001	103.0	0.2	1.11
CB04	Partially Filled Concrete*	0.3333	0.5844	114.0	0.2	0.57
CB05	Concrete and Perlite**	0.3333	0.4772	115.0	0.2	0.70
	Concrete Block, 6 inch Heavy Weight					
CB06	Hollow	0.5000	0.5555	85.0	0.2	0.90
CB07	Concrete Filled	0.5000	0.7575	140.0	0.2	0.66
CB08	Perlite Filled	0.5000	0.2222	88.0	0.2	2.25
CB09	Partially Filled Concrete*	0.5000	0.6119	104.0	0.2	0.82
CB10	Concrete and Perlite**	0.5000	0.4238	104.0	0.2	1.18
	Concrete Block, 8 inch Heavy Weight					
CB11	Hollow	0.6667	0.6060	69.0	0.2	1.10
CB12	Concrete Filled	0.6667	0.7575	140.0	0.2	0.88
CB13	Perlite Filled	0.6667	0.2272	70.0	0.2	2.93
CB14	Partially Filled Concrete*	0.6667	0.6746	93.0	0.2	0.99
CB15	Concrete and Perlite**	0.6667	0.4160	93.0	0.2	1.60
	Concrete Block, 12 inch Heavy Weight					
CB16	Hollow	1.0000	0.7813	76.0	0.2	1.28
CB17	Concrete Filled	1.0000	0.7575	140.0	0.2	1.32
CB18	Partially Filled Concrete*	1.0000	0.7773	98.0	0.2	1.29
	Concrete Block, 4 inch Medium Weight					
CB21	Hollow	0.3333	0.3003	76.0	0.2	1.11
CB22	Concrete Filled	0.3333	0.4456	115.0	0.2	0.75
CB23	Perlite Filled	0.3333	0.1512	78.0	0.2	2.20
CB24	Partially Filled Concrete*	0.3333	0.3306	89.0	0.2	1.01
CB25	Concrete and Perlite**	0.3333	0.2493	90.0	0.2	1.34

* One filled and reinforced concrete core every 24 inches of wall length.

** One filled and reinforced concrete core every 24 inches of wall length with the remaining cores filled with Perlite insulation.

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-^{o}F	Lb/ Ft^3	Btu/ Lb-^{o}F	Hr-Ft^2-^{o}F/ Btu
	Concrete Block, 6 inch Medium Weight					
CB26	Hollow	0.5000	0.3571	65.0	0.2	1.40
CB27	Concrete Filled	0.5000	0.4443	119.0	0.2	1.13
CB28	Perlite Filled	0.5000	0.1166	67.0	0.2	4.29
CB29	Partially Filled Concrete*	0.5000	0.3686	83.0	0.2	1.36
CB30	Concrete and Perlite**	0.5000	0.2259	84.0	0.2	2.21
	Concrete Block, 8 inch Medium Weight					
CB31	Hollow	0.6667	0.3876	53.0	0.2	1.72
CB32	Concrete Filled	0.6667	0.4957	123.0	0.2	1.34
CB33	Perlite Filled	0.6667	0.1141	56.0	0.2	5.84
CB34	Partially Filled Concrete*	0.6667	0.4348	76.0	0.2	1.53
CB35	Concrete and Perlite**	0.6667	0.2413	77.0	0.2	2.76
	Concrete Block, 12 inch Medium Weight					
CB36	Hollow	1.0000	0.4959	58.0	0.2	2.02
CB37	Concrete Filled	1.0000	0.4814	121.0	0.2	2.08
CB38	Partially Filled Concrete*	1.0000	0.4919	79.0	0.2	2.03
	Concrete Block, 4 inch Light Weight					
CB41	Hollow	0.3333	0.2222	65.0	0.2	1.50
CB42	Concrete Filled	0.3333	0.3695	104.0	0.2	0.90
CB43	Perlite Filled	0.3333	0.1271	67.0	0.2	2.62
CB44	Partially Filled Concrete*	0.3333	0.2808	78.0	0.2	1.19
CB45	Concrete and Perlite**	0.3333	0.2079	79.0	0.2	1.60
	Concrete Block, 6 inch Light Weight					
CB46	Hollow	0.5000	0.2777	55.0	0.2	1.80
CB47	Concrete Filled	0.5000	0.3819	110.0	0.2	1.31
CB48	Perlite Filled	0.5000	0.0985	57.0	0.2	5.08
CB49	Partially Filled Concrete*	0.5000	0.3189	73.0	0.2	1.57
CB50	Concrete and Perlite**	0.5000	0.1929	74.0	0.2	2.59
	Concrete Block, 8 inch Light Weight					
CB51	Hollow	0.6667	0.3333	45.0	0.2	2.00
CB52	Concrete Filled	0.6667	0.4359	115.0	0.2	1.53
CB53	Perlite Filled	0.6667	0.0963	48.0	0.2	6.92
CB54	Partially Filled Concrete*	0.6667	0.3846	68.0	0.2	1.73
CB55	Concrete and Perlite**	0.6667	0.2095	69.0	0.2	3.18

* One filled and reinforced concrete core every 24 inches of wall length.

** One filled and reinforced concrete core every 24 inches of wall length with the remaining cores filled with Perlite insulation.

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity Btu-Ft/Hr-Ft^2-°F	Density Lb/Ft^3	Specific Heat Btu/Lb-°F	Resistance Hr-Ft^2-°F/Btu
	Concrete Block					
	12 inch Light Weight					
CB56	Hollow	1.0000	0.4405	49.0	0.2	2.27
CB57	Concrete Filled	1.0000	0.4194	113.0	0.2	2.38
CB58	Partially Filled Concrete*	1.0000	0.4274	70.0	0.2	2.34
	Gypsum or Plaster Board					
GP01	1/2 inch	0.0417	0.0926	50.0	0.2	0.45
GP02	5/8 inch	0.0521	0.0926	50.0	0.2	0.56
GP03	3/4 inch	0.0625	0.0926	50.0	0.2	0.67
	Gypsum Plaster					
GP04	3/4 inch Light Weight Aggregate	0.0625	0.1330	45.0	0.2	0.47
GP05	1 inch Light Weight Aggregate	0.0833	0.1330	45.0	0.2	0.63
GP06	3/4 inch Sand Aggregate	0.0625	0.4736	105.0	0.2	0.13
GP07	1 inch Sand Aggregate	0.0833	0.4736	105.0	0.2	0.18
	Hard Board 3/4 inch					
HB01	Medium Density Siding	0.0625	0.0544	40.0	0.28	1.15
HB02	Medium Density Others	0.0625	0.0608	50.0	0.31	1.03
HB03	High Density Standard Tempered	0.0625	0.0683	55.0	0.33	0.92
HB04	High Density Service Tempered	0.0625	0.0833	63.0	0.33	0.75
LT01	**Linoleum Tile**				0.30	0.05
	Particle Board					
PB01	Low Density 3/4 inch	0.0625	0.0450	75.0	0.31	1.39
PB02	Medium Density 3/4 inch	0.0625	0.7833	75.0	0.31	0.08
PB03	High Density 3/4 inch	0.0625	0.9833	75.0	0.31	0.06
PB04	Underlayment 5/8 inch	0.0521	0.1796	75.0	0.29	0.29

* One filled and reinforced concrete core every 24 inches of wall length.

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-^{o}F	Lb/ Ft^3	Btu/ Lb-^{o}F	Hr-Ft^2-^{o}F/ Btu
	Plywood					
PW01	1/4 inch	0.0209	0.0667	34.0	0.29	0.31
PW02	3/8 inch	0.0313	0.0667	34.0	0.29	0.47
PW03	1/2 inch	0.0417	0.0667	34.0	0.29	0.63
PW04	5/8 inch	0.0521	0.0667	34.0	0.29	0.78
PW05	3/4 inch	0.0625	0.0667	34.0	0.29	0.94
PW06	1 inch	0.0833	0.0667	34.0	0.29	1.25
	Roof Gravel or Slag					
RG01	1/2 inch	0.0417	0.8340	55.0	0.4	0.05
RG02	1 inch	0.0833	0.8340	55.0	0.4	0.10
RT01	**Rubber Tile**					0.05
SL01	**Slate** 1/2 inch	0.0417	0.8340	100.0	0.35	0.05
ST01	**Stone** 1 inch	0.0833	1.0416	140.0	0.2	0.08
SC01	**Stucco**, 1 inch	0.0833	0.4167	166.0	0.2	0.20
TZ01	**Terrazzo**, 1 inch	0.0833	1.0416	140.0	0.2	0.08
	Wood Soft					
WD01	3/4 inch	0.0625	0.0667	32.0	0.33	0.94
WD02	1.5 inch	0.1250	0.0667	32.0	0.33	1.87
WD03	2.5 inch	0.2083	0.0667	32.0	0.33	3.12
WD04	3.5 inch	0.2917	0.0667	32.0	0.33	4.37
WD05	4 inch	0.3333	0.0667	32.0	0.33	5.00
	Wood Hard					
WD11	3/4 inch	0.0625	0.0916	45.0	0.30	0.68
WD12	1 inch	0.0833	0.0916	45.0	0.30	0.91
	Wood Shingle					
WS01	For Wall	0.0583	0.0667	32.0	0.30	0.87
WS02	For Roof	0.0583	0.0667	32.0	0.30	0.94

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2. Thermal Properties of Insulating Materials

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties: Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-^{o}F	Lb/ Ft^3	Btu/ Lb-^{o}F	Hr-Ft^2-^{o}F/ Btu
	Mineral Wool/Fiber					
IN01	Batt, R-7‡	0.1882	0.0250	0.60	0.2	7.53
IN02	Batt, R-11	0.2957	0.0250	0.60	0.2	11.83
IN03	Batt, R-19	0.5108	0.0250	0.60	0.2	20.43
IN04	Batt, R-24	0.6969	0.0250	0.60	0.2	27.88
IN05	Batt, R-30	0.8065	0.0250	0.60	0.2	32.26
IN11	Fill 3.5 inch, R-11	0.2917	0.0270	0.60	0.2	10.80
IN12	Fill, 5.5 inch, R-19	0.4583	0.0270	0.63	0.2	16.97
	Cellulose					
IN13	Fill, 3.5 inch, R-13	0.2917	0.0225	3.0	0.33	12.96
IN14	Fill 5.5 inch R-20	0.4583	0.0225	3.0	0.33	20.37
	Preformed Mineral Board					
IN21	7/8 inch R-3	0.0729	0.0240	15.0	0.17	3.04
IN22	1 inch R-3.5	0.0833	0.0240	15.0	0.17	3.47
IN23	2 inch R-6.9	0.1667	0.0240	15.0	0.17	6.95
IN24	3 inch R-10.3	0.2500	0.0240	15.0	0.17	10.42
	Polystyrene, Expanded					
IN31	1/2 inch	0.0417	0.0200	1.8	0.29	2.08
IN32	3/4 inch	0.0625	0.0200	1.8	0.29	3.12
IN33	1 inch	0.0833	0.0200	1.8	0.29	4.16
IN34	1.25 inch	0.1042	0.0200	1.8	0.29	5.21
IN35	2 inch	0.1667	0.0200	1.8	0.29	8.33
IN36	3 inch	0.2500	0.0200	1.8	0.29	12.50
IN37	4 inch	0.3333	0.0200	1.8	0.29	16.66
	Polyurethane, Expanded					
IN41	1/2 inch	0.0417	0.0133	1.5	0.38	3.14
IN42	3/4 inch	0.0625	0.0133	1.5	0.38	4.67
IN43	1 inch	0.0833	0.0133	1.5	0.38	6.26
IN44	1.25 inch	0.1042	0.0133	1.5	0.38	7.83
IN45	2 inch	0.1667	0.0133	1.5	0.38	12.53
IN46	3 inch	0.2500	0.0133	1.5	0.38	18.80
IN47	4 inch	0.3333	0.0133	1.5	0.38	25.06

‡ Nominal thickness is 2 inches to 2 3/4 inches. Resistance value is based on a thickness of 2.26 inches.

2. Thermal Properties of Insulating Materials -- continued

DOE-2 Code-word	Description	Thickness Feet	Conductivity Btu-Ft/Hr-Ft²-°F	Density Lb/Ft³	Specific Heat Btu/Lb-°F	Resistance Hr-Ft²-°F/Btu
			Thermal Properties			
	Urea Formaldehyde					
IN51	3.5 inch, R-19	0.2910	0.0200	0.7	0.3	14.55
IN52	5.5 inch, R-30	0.4580	0.0200	0.7	0.3	22.90
	Insulation Board					
IN61	Sheathing, 1/2 inch	0.0417	0.0316	18.0	0.31	1.32
IN62	Sheathing, 3/4 inch	0.0625	0.0316	18.0	0.31	1.98
IN63	Shingle Backer, 3/8 inch	0.0313	0.0331	18.0	0.31	0.95
IN64	Nail Base Sheathing, 1/2 inch	0.0417	0.0366	25.0	0.31	1.14
	Roof Insulation, Preformed					
IN71	1/2 inch	0.0417	0.0300	16.0	0.2	1.39
IN72	1 inch	0.0833	0.0300	16.0	0.2	2.78
IN73	1.5 inch	0.1250	0.0300	16.0	0.2	4.17
IN74	2 inch	0.1667	0.0300	16.0	0.2	5.56
IN75	2.5 inch	0.2083	0.0300	16.0	0.2	6.94
IN76	3 inch	0.2500	0.0300	16.0	0.2	8.33

3. Thermal Properties of Air Spaces

DOE-2 Code-word	Description	Thickness Feet	Conductivity Btu-Ft/Hr-Ft²-°F	Density Lb/Ft³	Specific Heat Btu/Lb-°F	Resistance Hr-Ft²-°F/Btu
			Thermal Properties			
	Air Layer, 3/4 inch or less					
AL11	Vertical Walls					0.90
AL12	Slope 45°					0.84
AL13	Horizontal Roofs					0.82
	Air Layer, 3/4 inch to 4 inches					
AL21	Vertical Walls					0.89
AL22	Slope 45°					0.87
AL23	Horizontal Roofs					0.87
	Air Layer, 4 inches or more					
AL31	Vertical Walls					0.92
AL32	Slope 45°					0.89
AL33	Horizontal Roofs					0.92

Note: A more extensive list of data can be found in the ASHRAE Handbook of Fundamentals, Chap. 23, 1985.

Appendix E

List of Basic Commands and Keywords

This list of commands and keywords applies to the *DOE-2 Basics* manual only. A complete list of all commands and keywords in DOE-2.1E is given in Appendix F of the *Supplement (2.1E)*, and is updated once a year in the summer issue of the "User News".

• COMMAND or Keyword	Abbrev.	Keyword is under this Command	Page Number(s)
EXHAUST-EFF	E-E	ZONE-AIR	3.70,F.12
EXHAUST-KW	E-KW	ZONE-AIR	3.70,F.12
EXHAUST-STATIC	E-S	ZONE-AIR	3.70,F.12
EXT-ELEC-KW	E-E-K	PLANT-ASSIGNMENT	3.93,F.14
EXT-ELEC-SCH	E-E-SCH	PLANT-ASSIGNMENT	3.93,F.14
EXT-FUEL-BTU HR	E-F-BTU	PLANT-ASSIGNMENT	3.93,F.14
EXT-FUEL-SCH	E-FSCH	PLANT-ASSIGNMENT	3.93,F.14
• EXTERIOR-WALL/-ROOF	**E-W/E-R**		2.25,F.8
FAN-CONTROL	F-C	SYSTEM-FANS	3.85,F.13
FAN-SCHEDULE	F-SCH	SYSTEM-FANS	3.85,F.13
FLOOR-MULTIPLIER	F-M	SPACE	2.24,F.8
FLOOR-WEIGHT	F-W	SPACE-CONDITIONS	2.23,F.7
GLASS-CONDUCTANCE	G-C	GLASS-TYPE	2.13,F.4
• GLASS-TYPE	**G-T**		2.13,F.4
GLASS-TYPE	G-T	WINDOW	2.27,F.9
GND-REFLECTANCE	G-R	EXTERIOR WALL or ROOF	2.25,F.8
GROSS-AREA	G-A	BUILDING-LOCATION	2.6,F.4
GROUND-T	G-T	BUILDING-LOCATION	2.6,F.4
HCIRC-DESIGN-T-DROP		PLANT-PARAMETERS	4.13,F.17
HCIRC-HEAD		PLANT-PARAMETERS	4.13,F.17
HCIRC-LOSS		PLANT-PARAMETERS	4.13,F.17
HCIRC-MIN-PLR		PLANT-PARAMETERS	4.14,F.17
HCIRC-PUMP-TYPE		PLANT-PARAMETERS	4.14,F.17
HCIRC-SIZE-OPT		PLANT-PARAMETERS	4.14,F.17
• HEAT-RECOVERY	**HEAT-R**		4.15,F.18
HEATING-CAPACITY	H-CAP	SYSTEM	3.92,F.14
HEATING-SCHEDULE	H-SCH	SYSTEM-CONTROL	3.74,F.13
HEAT-CONTROL	H-C	SYSTEM-CONTROL	3.74,F.13
HEAT-RESET-SCH	H-R-SCH	SYSTEM-CONTROL	3.75,F.13
HEAT-SET-SCH	H-S-SCH	SYSTEM-CONTROL	3.75,F.13
HEAT-SET-T	H-S-T	SYSTEM-CONTROL	3.74,F.13
HEAT-SOURCE	HEAT-S	SYSTEM	3.90,F.14
HEAT-TEMP-SCH	H-T-SCH	ZONE-CONTROL	3.67,F.11
HEIGHT	H	DOOR	2.31,F.10
		EXTERIOR-WALL or ROOF	2.26,F.8
		WINDOW	2.27,F.9
HERM-CENT-COND-TYPE		PLANT-PARAMETERS	4.12,F.17
HERM-REC-COND-TYPE		PLANT-PARAMETERS	4.12,F.17

• COMMAND or Keyword	Abbrev.	Keyword is under this Command	Page Number(s)
HOLIDAY	HOL	BUILDING-LOCATION	1.2,2.5,F.4
HUMIDIFIER-TYPE	H-TYPE	SYSTEM	3.91,F.14
HW-BOILER-HIR		PLANT-PARAMETERS	4.13,F.17
INDUCED-AIR-ZONE	I-A-Z	ZONE	3.71,F.12
INF-CFM/SQFT	I-CFM	SPACE-CONDITIONS	2.23,F.7
INF-METHOD	I-M	SPACE-CONDITIONS	2.22,F.7
INF-SCHEDULE	I-SCH	SPACE-CONDITIONS	2.23,F.7
INSIDE-FILM-RES	I-F-R	LAYERS	2.7,F.6
INSTALLED-NUMBER	I-N	PLANT-EQUIPMENT	4.8,F.16
INT-ELEC-KW	I-E-K	PLANT-ASSIGNMENT	3.93,F.14
INT-ELEC-SCH	I-E-SCH	PLANT-ASSIGNMENT	3.93,F.14
INT-FUEL-BTU/HR	I-F-BTU	PLANT-ASSIGNMENT	3.93,F.14
INT-FUEL-SCH	I-F-SCH	PLANT-ASSIGNMENT	3.93,F.14
• **INTERIOR-WALL**	**I-W**		2.32,F.8
LATITUDE	LAT	BUILDING-LOCATION	1.2,2.4,F.4
• **LAYERS**	**LA**		2.7,F.6
LAYERS	LA	CONSTRUCTION	2.9,F.6
LEFT-FIN-A	L-F-A	DOOR WINDOW	F.10 2.29,F.9
LEFT-FIN-B	L-F-B	DOOR WINDOW	F.10 2.29,F.9
LEFT-FIN-D	L-F-D	DOOR WINDOW	F.10 2.29,F.9
LEFT-FIN-H	L-F-H	DOOR WINDOW	F.10 2.29,F.9
LIGHTING-KW	L-KW	SPACE-CONDITIONS	2.17,F.7
LIGHTING-SCHEDULE	L-SCH	SPACE-CONDITIONS	2.17,F.7
LIGHTING-TYPE	L-T	SPACE-CONDITIONS	2.17,F.7
LIGHTING-W/SQFT	L-W	SPACE-CONDITIONS	2.18,F.7
LIGHT-TO-SPACE	L-T-S	SPACE-CONDITIONS	2.18,F.7
LONGITUDE	LON	BUILDING-LOCATION	1.2,2.4,F.4
MATERIAL	MAT	LAYERS	2.7,F.6
MAX-COND-RCVRY	M-C-R	SYSTEM	3.91,F.14
MAX-HUMIDITY	MAX-H	SYSTEM-CONTROL	3.76,F.13
MAX-SOLAR-SCH	M-S-SCH	WINDOW	2.27,F.9
MAX-SUPPLY-T	MAX-S-T	SYSTEM-CONTROL	3.74,F.13
MIN-AIR-SCH	M-A-SCH	SYSTEM-AIR	3.81,F.13
MIN-CFM-RATIO	M-C-R	SYSTEM ZONE	3.91,F.14 3.72,F.12

• **COMMAND** or Keyword	Abbrev.	Keyword is under this Command	Page Number(s)
MIN-CFM-SCH	M-C-SCH	ZONE	3.73,F.12
MIN-COND-AIR-T		PLANT-PARAMETERS	4.11,F.17
MIN-HUMIDITY	MIN-H	SYSTEM-CONTROL	3.77,F.13
MIN-MON-CHGS	M-M-CHG	UTILITY-RATE	5.4,F.19
MIN-MON-DEM-CHGS	M-D-CHG	UTILITY-RATE	5.4,F.19
MIN-OUTSIDE-AIR	M-O-A	SYSTEM-AIR	3.80,F.13
MIN-SUPPLY-T	MIN-S-T	SYSTEM-CONTROL	3.75,F.13
MIN-TWR-WTR-T		PLANT-PARAMETERS	4.12,F.17
MONTH-CHGS	M-CHG	UTILITY-RATE	5.2,F.19
MULTIPLIER	M	EXTERIOR-WALL or ROOF	2.25,F.8
NATURAL-VENT-AC	N-V-A	SYSTEM-AIR	3.82,F.13
NATURAL-VENT-SCH	N-V-SCH	SYSTEM-AIR	3.82,F.13
NEXT-TO	N-T	INTERIOR-WALL	2.32,F.8
NIGHT-CYCLE-CTRL	N-C-C	SYSTEM-FANS	3.87,F.13
NUMBER-OF-PEOPLE	N-O-P	SPACE-CONDITIONS	2.16,F.7
OA-CFM PER	O-CFM/P	ZONE-AIR	3.69,F.12
OA-CHANGES	O-C	ZONE-AIR	3.69,F.12
OA-CONTROL	O-CTRL	SYSTEM-AIR	3.81,F.13
OUTSIDE-AIR-CFM	O-A-CFM	ZONE-AIR	3.69,F.12
OUTSIDE-HI	O-H	DAY-RESET-SCHED	3.64,F.11
OUTSIDE-LO	O-L	DAY-RESET-SCHED	3.64,F.11
OVERHANG-A	OH-A	DOOR WINDOW	F.10 2.28,F.9
OVERHANG-ANGLE	OH-ANG	DOOR WINDOW	F.10 2.28,F.9
OVERHANG-B	OH-B	DOOR WINDOW	F.10 2.28,F.9
OVERHANG-D	OH-D	DOOR WINDOW	F.10 2.28,F.9
OVERHANG-W	OH-W	DOOR WINDOW	F.10 2.28,F.9
PANES	P	GLASS-TYPE	2.13,F.4
• **PART-LOAD-RATIO**	**P-L-R**		4.9,F.16
PEOPLE-HEAT-GAIN	P-H-G	SPACE-CONDITIONS	2.16,F.7
PEOPLE-HG-LAT	P-H-L	SPACE-CONDITIONS	2.17,F.7
PEOPLE-HG-SENS	P-H-S	SPACE-CONDITIONS	2.17,F.7
PEOPLE-SCHEDULE	P-SCH	SPACE-CONDITIONS	2.16,F.7
• **PLANT-ASSIGNMENT**	**P-A**	in Plant	4.9,F.17
• **PLANT-ASSIGNMENT**	**P-A**	in Systems	3.93,F.14

Appendix F

BASIC BDL SUMMARY

Table of Contents

INTRODUCTION

This *Basic BDL Summary* contains only a partial list of commands and keywords found in the DOE-2 Building Description Language (BDL). Information contained herein is considered appropriate for the beginning DOE-2 user. A complete list of all commands and keywords can be found in the *BDL Summary (2.1E)*. A discussion of commands and keywords can be found in the *Reference Manual (2.1A)*, and the *Supplement (2.1E)*.

COMMAND(abbrev.,max allowed) [comments] • **KEYWORD**(abbrev.)(**default**;range and dimension) KEYWORD(abbrev.)(**default**;range and dimension) KEYWORD(abbrev.)(**default**;range and dimension)

About Commands and Keywords

•	indicates a required keyword
Suggested Inputs	To indicate their relative importance, we have bold-faced certain keywords that are most commonly used.
=	in front of a command means that a u-name is mandatory
(=)	in front of a command means that a u-name is optional Otherwise no u-name is permitted
LIKE	Unless otherwise noted, the **LIKE** keyword is permitted for each command.
Default Values	For easier reference, the default values of all keywords are bold-faced. Some keywords are shown with a long dash (—) as the default instead of a given value; in these cases, the user must define the value.
Terminator	A two-dot terminator, (..), is required to end each input. If a comment is to follow the terminator, put a space between the terminator and the comment.

LOADS SUMMARY

INPUT LOADS Required for Loads input

TITLE(5) LINE-*n* *Up to 40 characters enclosed by asterisks*
where n=1,2,...,5

[Note: In SYSTEMS, PLANT, and ECONOMICS, lines may be replaced, up to an *overall* total of 5. Also, any particular LINE-*n* may be substituted for lines input in LOADS by using TITLE command followed by LINE-*n* *changed text*, where *n* is the line to be changed.]

ABORT(**ERRORS**;ERRORS,WARNINGS,CAUTIONS)

DIAGNOSTIC(LIST) takes up to six optional code-words
WARNINGS:ERRORS,WARNINGS,CAUTIONS,DEFAULTS,COMMENTS
(**default**;options) is as follows:
ECHO:ECHO,NO-ECHO

RUN-PERIOD(1) Required for LOADS input

BUILDING-LOCATION(B-L,1)
LATITUDE(LAT)(*;-66.5 to 66.5°)
LONGITUDE(LON)(*;-180.0 to 180.0°)
ALTITUDE(ALT)(**0.0**;-1000.0 to 20000.0 ft)
TIME-ZONE(T-Z)(*;-12 to (all integers)
GROSS-AREA(G-A)(**;0.0 to 10^7ft^2)
AZIMUTH(AZ)(**0.0**;-360.0 to 360.0°)
HOLIDAY(HOL)(**YES**;YES,NO)
DAYLIGHT-SAVINGS(D-S)(**YES**;YES,NO)
GROUND-T(G-T)(***;-100.0 to 150.0°F)
CLEARNESS-NUMBER(C-N)(***;0.5 to 1.2)

[Note: HOL = YES ~ U.S. Holidays assumed; HOL = NO ~ no holidays assumed]
[Note: D-S = YES ~ Daylight Savings correction; D-S = NO ~ no Daylight Savings correction]
* Default is taken from the weather file
** Defaults to net area, i.e., the sum of areas of all conditioned SPACE's.
*** Takes a list of twelve values: one per month. Default is taken from the weather file.

= **GLASS-TYPE**(G-T,32)
PANES(P)(**1**:1 to 3) (all integers)
• **SHADING-COEF**(S-C)(—;0.0 to 1.0)
GLASS-CONDUCTANCE(G-C)(*;0.0 to 10.0 Btu/hr-ft^2-°F)

* See page 2.14 of this manual for GLASS-CONDUCTANCE defaults.
[For typical values, see Chapter 27 of the *ASHRAE* Handbook of Fundamentals, 1989.]

= **DAY-SCHEDULE**(D-SCH,300)

(see example below)

[Note: All 24 hours must be accounted for]

In its simplest form, the input for DAY-SCHEDULE takes the form:

U-NAME = DAY-SCHEDULE (hours covered) (values for each hour) ..

For example, for weekdays:

LTG-1 = DAY-SCHEDULE (1,24) (0,0,0,0,0,0,0,0,.3,.6,.8,1,1,1,1,1,1,1,0,0,0,0,0,0) ..

Optionally, this can be shortened by writing:

LTG-1 = DAY-SCHEDULE (1,8)(0) (9,11) (.3,.6,.8) (12,18) (1) (19,24) (0) ..

For week-ends and holidays:

LTG-2 = DAY-SCHEDULE (1,24)(0) ..

= **WEEK-SCHEDULE**(W-SCH,200)

(see example below)

[Note: Code-word for days of week and holidays is first three letters of name.

ALL ~ Monday thru Sunday + Holidays; WEH ~ weekends + Holidays; and WD ~ weekdays]

[Note: Must preserve order of Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday, Holiday]

[Note: All days of week + Holiday must be accounted for]

In its simplest form, the input for WEEK-SCHEDULE takes the form:

U-NAME = **WEEK-SCHEDULE** (†) (**U-NAME** of **DAY-SCHEDULE** referenced) ..

† days of week covered

Using the previously defined DAY-SCHEDULEs LTG-1 and LTG-2, the example can be carried forward with:

NORMAL = WEEK-SCHEDULE (MON,FRI) LTG-1
(SAT,HOL) LTG-2 ..

VACATION = WEEK-SCHEDULE (ALL) LTG-2 ..

Optionally, NORMAL can be shortened to:

NORMAL = WEEK-SCHEDULE (WD) LTG-1 (WEH) LTG-2 ..

where (WD) stands for week-days and (WEH) for week-ends and holidays.

If Saturday is considered part of the normal week, you must write

(MON,SAT) LTG-1 (SUN,HOL) LTG-2.

= **SCHEDULE**(SCH,100) [Note: **LIKE** keyword not allowed]

(see example below)

[Note: Every day of run period must be accounted for]

[Note: Code-word for month is first three letters of month name]

[Note: A maximum of 52 THRU's per command]

In its simplest form, the input for SCHEDULE takes the form:

U-NAME =**SCHEDULE**(THRU †)(**U-NAME** of **WEEK-SCHEDULE** referenced) ..

† calendar period covered

To finalize the example:

```
LIGHTS = SCHEDULE    THRU JUN 10 NORMAL
                     THRU SEP 5 VACATION
                     THRU DEC 31 NORMAL ..
```

Alternatively, explicit use of DAY-SCHEDULE and WEEK-SCHEDULE can be bypassed by writing:

```
LIGHTS = SCHEDULE    THRU JUN 10 (WD)(1,8)(0)(9,11)(.3,.6,.8)(12,18)(1)(19,24)(0)(WEH)(1,24)(0)
                     THRU SEP 5 (ALL)(1,24)(0)
                     THRU DEC 31 (WD) (1,8)(0)(9,11)(.3,.6,.8)(12,18)(1)(19,24)(0)(WEH)(1,24)(0) ..
```

= **LAYERS**(LA,16) *
• **MATERIAL**(MAT) **   THICKNESS(TH) ***   INSIDE-FILM-RES(I-F-R)(0.68;0.0 to 40.0 hr-ft^2-°F/Btu)
* LIKE keyword not allowed   ** Value must be a list of either the u-names of MATERIALs or code-words from the Materials Library; see Appendix D. Also, list the materials (a maximum of 9) from outside to inside; don't specify inside or outside air film as a material   *** THICKNESS must be specified if any thickness is different from those specified in MATERIAL commands or Materials Library. Order of list must correspond to list following MATERIALs

= **CONSTRUCTION**(CONS,64)
• **LAYERS**(LA) u-name or code-word   or   • U-VALUE(U)(—:0.0 to 20.0 Btu/hr-ft^2-°F)*   ABSORPTANCE(ABS)(**0.7**;0.0 to 1.0)**   ROUGHNESS(RO)(**3**;1 to 6) (all integers)**
* For interior surfaces, includes resistance of both air films; for exterior surfaces, includes inside film resistance, but not outside film resistance.   ** See pages 2.11-12 for ABSORPTANCE and ROUGHNESS values. Not used for interior walls, underground walls, or underground floors

= **SPACE–CONDITIONS**(S-C,50)
PEOPLE–SCHEDULE(P-SCH) u-name
NUMBER–OF–PEOPLE(N-O-P)(**0.0**;0.0 to 10000.0)
AREA/PERSON(A/P)(**100.0**;0.0 to 10000.0ft^2)[Used only if NUMBER-OF-PEOPLE not specified]
PEOPLE–HEAT–GAIN(P-H-G)(**0.0**;350.0 to 2000.0 Btu/hr-pers)†
or
PEOPLE-HG-LAT(P-H-L)(**0.0**;0.0 to 2000.0 Btu/hr-pers)†
and
PEOPLE-HG-SENS(P-H-S)(**0.0**;0.0 to 2000.0 Btu/hr-pers)†
LIGHTING–SCHEDULE(L-SCH) u-name
LIGHTING–TYPE(L-T)(**SUS–FLUOR**; Options are: SUS-FLUOR, REC-FLUOR-RV, REC-FLUOR-RSV, REC-FLUOR-NV, and INCAND.)
LIGHTING–W/SQFT(L-W)(**0.0**;0.0 to 10.0 W/ft^2) [If both specified, contribution is added]
or
LIGHTING-KW(L-KW)(**0.0**;0.0 to 200.0 kW)[If both specified, contribution is added.]
LIGHT–TO–SPACE(L-T-S)(*;0.0 to 1.0)
TASK–LIGHT–SCH(T-L-SCH) u-name
TASK–LT–W/SQFT(T-L-W)(**0.0**;0.0 to 10.0 W/ft^2)[If both specified, contribution is added.]
or
TASK-LIGHTING-KW(T-L-KW)(**0.0**;0.0 to 200.0 kW)[If both specified, contribution is added.]
EQUIP–SCHEDULE(E-SCH) u-name
EQUIPMENT–W/SQFT(E-W)(**0.0**;0.0 to 100.0 W/ft^2) [If both specified, contribution is added]
or
EQUIPMENT-KW(E-KW)(**0.0**;0.0 to 200.0 kW)[If both specified, contribution is added.]
EQUIP-SENSIBLE(E-S)(**1.0**;0.0 to 1.0)
EQUIP-LATENT(E-L)(**0.0**;0.0 to 1.0)
SOURCE-SCHEDULE(S-SCH) u-name
SOURCE-TYPE(S-T)(**GAS**;GAS,ELECTRIC,HOT-WATER,PROCESS)
SOURCE-BTU/HR(S-B)(**0.0**;-1000000.0 to 1000000.0 Btu/hr)
SOURCE-SENSIBLE(S-S)(**1.0**;-1.0 to 1.0)
SOURCE-LATENT(S-L)(**0.0**;0.0 to 1.0)
TEMPERATURE(T)((**70.0**);0.0 to 120.0°F) (list of 1)
FLOOR-WEIGHT(F-W)(**70.0**;0.0 to 200.0 lb/ft^2)
INF-SCHEDULE(I-SCH) u-name **
INF-METHOD(I-M)(**NONE**;NONE,CRACK,AIR-CHANGE,RESIDENTIAL,S-G) **
AIR-CHANGES/HR(A-C)(**0.0**;0.0 to 30.0) [If both specified, contribution is added.] **
or
INF-CFM/SQFT(I-CFM)(**0.0**;0.0 to 20.0 cfm/ft^2)[If both specified, contribution is added.] **
RES-INF-COEF(R-I-C)((**0.252,0.0251,0.0084**);0.0 to 20.0, mixed units) **

* See the table below, "Default Table for LIGHTING-TYPEs"

** See the table on the next page, "Default Table for INF-METHODs"

† If no value is input, there is no contribution from people. If all are specified, the contribution is cumulative.

Default Table for LIGHTING-TYPEs					
KEYWORD	SUS–FLUOR	REC–FLUOR–RV	REC–FLUOR–RSV	INCAND	REC–FLUOR–NV
LIGHT-TO-SPACE	1.0	0.8	0.8	1.0	1.0

KEYWORD	Default Table for INF-METHODs				
	NONE	AIR-CHANGE		CRACK	RESI-DENTIAL
		With wind correction	Without wind correction		
AIR-CHANGES HR	not used	required	not used	not used	not used
INF-CFM-SQFT	not used	not used	required	not used	not used
INF-SCHEDULE	not used	†	†	†	†
RES-INF-COEF	not used	not used	not used	not used	‡

† If not specified, always on ‡ If not specified, takes default value

* This keyword is input under the EXTERIOR-WALL, DOOR, and WINDOW commands. [Note: For INF-METHOD= RESIDENTIAL, wind and temperature dependence is given through the RES-INF-COEF keyword.]

= **SPACE**(S,128)
- **AREA**(A)(—:0.0– to 100000.0 ft^2)
- **VOLUME**(V)(—:0.0 to 10^6 ft^3)

FLOOR-MULTIPLIER(F-M)(**1.0**:1.0 to 200.0)
SPACE-CONDITIONS(S-C) u-name §

§ Any keyword from this subcommand may be placed in the SPACE command.

(=)**EXTERIOR-WALL**(E-W) or **ROOF**(300)
- **HEIGHT**(H)(—:0.0 to 2000.0 ft)
- **WIDTH**(W)(—:0.0 to 2000.0 ft)
- **CONSTRUCTION**(CONS) u-name

AZIMUTH(AZ)(**0.0**:-360.0 to 360.0°)
TILT(**90.0**:0.0 to 180.0°) [Tilt for ROOF must be input, otherwise it will default to 90°]
MULTIPLIER(M)(**1.0**:0.0 to 99.0)
GND-REFLECTANCE(G-R)(**0.2**:0.0 to 1.0) [See page 2.25 for typical values.]

(=) **INTERIOR-WALL**(I-W,512)
- **AREA**(A)(—:0.0 to 100000.0 ft^2)
- **CONSTRUCTION**(CONS) u-name

NEXT-TO(N-T) u-name of adjacent SPACE

(=) **UNDERGROUND-WALL**(U-W) or **UNDERGROUND-FLOOR**(U-F)(64)
- **AREA**(A)(—:0.0 to 100000.0 ft^2)
- **CONSTRUCTION**(CONS) u-name

(=) **WINDOW**(WI)(200)

- **HEIGHT**(H)(—;0.0 to 40.0 ft)
- **WIDTH**(W)(—;0.0 to 1000.0 ft)
- **GLASS-TYPE**(G-T) u-name

SETBACK(SETB)(**0.0**;0.0 to 10.0 ft) [Unused for interior windows]
SHADING-SCHEDULE(S-SCH) u-name
MAX-SOLAR-SCH(M-S-SCH) u-name
CONDUCT-SCHEDULE(C-SCH) u-name
CONDUCT-TMIN-SCH(C-T-SCH) u-name
OVERHANG-A(OH-A)(**0.0**;no limits - ft) [Unused for interior windows]
OVERHANG-B(OH-B)(**0.0**;no limits - ft) [Unused for interior windows]

OVERHANG-W(OH-W)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*
and*
OVERHANG-D(OH-D)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*

OVERHANG-ANGLE(OH-ANG)(**90.0**;0.0 to 180°) [Unused for interior windows]
LEFT-FIN-A(L-F-A)(**0.0**;no limits - ft) [Unused for interior windows]
LEFT-FIN-B(L-F-B)(**0.0**;no limits - ft) [Unused for interior windows]

LEFT-FIN-H(L-F-H)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*
and*
LEFT-FIN-D(L-F-D)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*

RIGHT-FIN-A(R-F-A)(**0.0**;no limits - ft) [Unused for interior windows]
RIGHT-FIN-B(R-F-B)(**0.0**;no limits - ft) [Unused for interior windows]

RIGHT-FIN-H(R-F-H)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*
and*
RIGHT-FIN-D(R-F-D)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*

* Either both or neither of these should be specified. If not specifed, shading calculation will not be done.

(=) DOOR(64)

- HEIGHT(H)(—;0.0 to 40.0 ft)
- WIDTH(W)(—;0.0 to 1000.0 ft)
- CONSTRUCTION(CONS) u-name of a quick-type (U-value) CONSTRUCTION

SETBACK(SETB)(**0.0**;0.0 to 10.0 ft)
OVERHANG-A(OH-A)(**0.0**;no limits - ft)
OVERHANG-B(OH-B)(**0.0**;no limits - ft)

OVERHANG-W(OH-W)(**0.0**;0.0 to no limits - ft)*
and*
OVERHANG-D(OH-D)(**0.0**;0.0 to no limits - ft)*

OVERHANG-ANGLE(OH-ANG)(**90.0**;0.0 to 180°)
LEFT-FIN-A(L-F-A)(**0.0**;no limits - ft)
LEFT-FIN-B(L-F-B)(**0.0**;no limits - ft)

LEFT-FIN-H(L-F-H)(**0.0**;0.0 to no limits - ft)*
and*
LEFT-FIN-D(L-F-D)(**0.0**;0.0 to no limits - ft)*

RIGHT-FIN-A(R-F-A)(**0.0**;no limits - ft)
RIGHT-FIN-B(R-F-B)(**0.0**;no limits - ft)

RIGHT-FIN-H(R-F-H)(**0.0**;0.0 to no limits - ft)*
and*
RIGHT-FIN-D(R-F-D)(**0.0**;0.0 to no limits - ft)*

* *Either both or neither of these should be specified. If not specified, shading calculation will not be done.*

LOADS-REPORT(L-R.1)
VERIFICATION(V)((—);LV-A,LV-B,...,LV-M)
SUMMARY(S)((**LS-D**);LS-A,LS-B,...,LS-L)

END

Required at end of LOADS input and before FUNCTION command, if specified.

COMPUTE LOADS

Required to do Loads simulation

SYSTEMS SUMMARY

INPUT SYSTEMS Required for Systems input

TITLE(5)
See LOADS

= **DAY-SCHEDULE**(D-SCH,300)
See LOADS

= **WEEK-SCHEDULE**(W-SCH,200)
See LOADS

= **SCHEDULE**(SCH,100) [Note:LIKE keyword not allowed]
See LOADS

= **DAY-RESET-SCH**(D-R-SCH,300 minus the number of D-SCH's)
- **SUPPLY-HI**(S-H)(—;0.0 to 120.0°F) or (—;0.0 to 1.0)
- **SUPPLY-LO**(S-L)(—;0.0 to 120.0°F) or (—;0.0 to 1.0)
- **OUTSIDE-HI**(O-H)(—;-20.0 to 120.0°F)
- **OUTSIDE-LO**(O-L)(—;-20.0 to 120.0°F)

= **RESET-SCHEDULE**(R-SCH,100 minus the number of SCH's)
See LOADS [Note:**LIKE** keyword not allowed]

= **ZONE-CONTROL**(Z-C,50)
- **DESIGN-HEAT-T**(D-H-T)(—;0.0 to 80°F) *
  HEAT-TEMP-SCH(H-T-SCH) u-name **
- **DESIGN-COOL-T**(D-C-T)(—;0.0 to 90°F) *
  COOL-TEMP-SCH(C-T-SCH) u-name **
  BASEBOARD-CTRL(B-C)(**OUTDOOR-RESET**;OUTDOOR-RESET, THERMOSTATIC)
  THERMOSTAT-TYPE(T-TYPE)(**PROPORTIONAL**;PROPORTIONAL, REVERSE-ACTION,TWO-POSITION)
  THROTTLING-RANGE(T-R)(***;0.1 to 10.0°F)

* Required but not used in simulation of SUM system.

** If omitted no heating or cooling, respectively, in zone.

*** Default is 2.0 if THERMOSTAT-TYPE = PROPORTIONAL or REVERSE-ACTION, 0.5 if TWO-POSITION.

= **ZONE-AIR**(Z-A,50)

ASSIGNED-CFM(A-CFM)(—;0.0 to 99999999.0 cfm)
or
CFM/SQFT(—;0.0 to 5.0 cfm/ft^2)
or
AIR-CHANGES/HR(A-C/HR)(—;0.0 to 10.0/hr)

OUTSIDE-AIR-CFM(O-A-CFM)(—;0.0 to 99999999.0 cfm)
or
OA-CFM/PER(O-CFM/P)(—;0.0 to 60.0 cfm/person)
or
OA-CHANGES(O-C)(—;0.0 to 10.0/hr)

EXHAUST-CFM(E-CFM)(—;0.0 to 99999999.0 cfm)
EXHAUST-STATIC(E-S)(—;0.0 to 10.0 in of WG)
EXHAUST-EFF(E-E)(**0.75**;0.1 to 1.0)
EXHAUST-KW(E-KW)(—;0.0 to 0.01)

= **ZONE**(Z,128)

ZONE-CONTROL(Z-C) u-name §
ZONE-AIR(Z-A) u-name §
MIN-CFM-RATIO(M-C-R)(—;0.0 to 1.0)
MIN-CFM-SCH(M-C-SCH) u-name
TERMINAL-TYPE(TER-TYPE)(**SVAV**;SVAV,SERIES-PIU,PARALLEL-PIU)*
INDUCED-AIR-ZONE(I-A-Z) u-name of ZONE*
REHEAT-DELTA-T(R-D-T)(—;0.0 to 100.0)*
BASEBOARD-RATING(B-R)(**0.0**;-99999999.0 to 0.0)

- **ZONE-FAN-RATIO**(Z-F-R)(**;0.0 to 10.0) ***

or

- **ZONE-FAN-CFM**(Z-F-CFM)(**;0.0 to 99999999.0 ft^3/min) ***
- **ZONE-FAN-T-SCH**(Z-F-SCH) u-name [Required if TERMINAL-TYPE = PARALLEL-PIU.] ***

ZONE-FAN-KW(Z-F-KW)(0.00033;0.0 to 0.01 kW/cfm) ***

* Used only for PIU system; I-A-Z required if TERMINAL-TYPE ≠ SVAV

** For series PIU, ZONE-FAN-RATIO defaults to 1.0. However, defaulting is not allowed for parallel PIU; therefore, user must input -RATIO or -CFM.

*** This keyword appears under the ZONE-FANS command in the (unabridged) *BDL Summary (2.1E)*.

§ Any keyword from these subcommands may be placed in the ZONE command

= **SYSTEM-CONTROL**(S-C,50)

MAX-SUPPLY-T(MAX-S-T)(—;50.0 to 200.0°F)
MIN-SUPPLY-T(MIN-S-T)(—;45.0 to 70.0°F)
COOL-CONTROL(C-C)(**CONSTANT**;CONSTANT,WARMEST,
RESET,SCHEDULED)
ECONO-LIMIT-T(E-L-T)(—;45.0 to 80.0°F)
BASEBOARD-SCH(B-SCH) u-name
HEATING-SCHEDULE(H-SCH) u-name
COOLING-SCHEDULE(C-SCH) u-name
HEAT-CONTROL(H-C)(**CONSTANT**;CONSTANT,COLDEST,RESET,SCHEDULED)
HEAT-SET-T(H-S-T)(—;50.0 to 200.0°F)
HEAT-RESET-SCH(H-R-SCH) u-name of RESET-SCHEDULE
HEAT-SET-SCH(H-S-SCH) u-name
COOL-RESET-SCH(C-R-SCH) u-name of RESET-SCHEDULE
COOL-SET-SCH(C-S-SCH) u-name
MAX-HUMIDITY(MAX-H)(**100.0**;30.0 to 80.0%)
MIN-HUMIDITY(MIN-H)(**0.0**;0.0 to 70.0%)
PREHEAT-T(P-T)(**45.0**;-50.0 to 70.0°F)

= **SYSTEM-AIR**(S-A,50)

OA-CONTROL(O-CTRL)(**TEMP**;TEMP,FIXED,ENTHALPY)
SUPPLY-CFM(S-CFM)(*;10.0 to 9999999.0 cfm) [* Calculated from ZONE-AIR input and zone loads.]
MIN-OUTSIDE-AIR(M-O-A)(*;0.0 to 1.0) [* Calculated from ZONE-AIR input and zone loads.]
MIN-AIR-SCH(M-A-SCH) u-name
RECOVERY-EFF(REC-E)(**0.0**;0.2 to 0.8 Btu/Btu)
NATURAL-VENT-AC(N-V-A)(—;0.0 to 100.0 air changes/hr)**
NATURAL-VENT-SCH(N-V-SCH) u-name**
VENT-TEMP-SCH(V-T-SCH) u-name**

** Used only for SYSTEM-TYPE = RESYS.

= **SYSTEM-FANS**(S-FANS,50)

FAN-SCHEDULE(F-SCH) u-name
FAN-CONTROL(F-C)(—;CONSTANT-VOLUME,SPEED,INLET,DISCHARGE,CYCLING,
TWO-SPEED,FAN-EIR-FPLR)

SUPPLY-DELTA-T(SUP-D-T)(—;0.0 to 30.0°F)
and
SUPPLY-KW(S-KW)(—;0.0 to 0.0 kW/cfm)

RETURN-DELTA-T(RET-D-T)(—;0.0 to 30.0°F)
and
RETURN-KW(R-KW)(—;0.0 to 0.01 kW/cfm)

NIGHT-CYCLE-CTRL(N-C-C)(—;STAY-OFF,CYCLE-ON-ANY,
CYCLE-ON-FIRST, ZONE-FANS-ONLY*) [*Used only for PIU systems]

= **SYSTEM**(SYST,100)

SYSTEM-CONTROL(S-C)§
SYSTEM-AIR(S-A)§
SYSTEM-FANS(S-FANS)§
SYSTEM-FLUID(S-FLU)§
• **SYSTEM-TYPE**(S-TYPE)(—)
• **ZONE-NAMES**(Z-N) (list of zones in system,including plenum and unconditioned zones)
HEAT-SOURCE(HEAT-S)(—;HOT-WATER,ELECTRIC FURNACE,OIL-FURNACE,HEAT-PUMP)
ZONE-HEAT-SOURCE(Z-H-S)(—;HOT-WATER,ELECTRIC FURNACE,OIL-FURNACE)
PREHEAT-SOURCE(PREHEAT)(—;HOT-WATER,ELECTRIC FURNACE,OIL-FURNACE)
BASEBOARD-SOURCE(BASEB-S)(—;HOT-WATER,ELECTRIC FURNACE,OIL-FURNACE)
HUMIDIFIER-TYPE(H-TYPE)(—;HOT-WATER,ELECTRIC,FURNACE, OIL-FURNACE)
SIZING-RATIO(S-R)(**1.0**;0.1 to 2.0)
REHEAT-DELTA-T(R-D-T)(—;0.0 to 100.0°F)*
MIN-CFM-RATIO(M-C-R)(—;0.0 to 10.0)*
HEATING-CAPACITY(H-CAP)(—;-99999999.0 to 0.0 Btu/hr)**
MAX-COND-RCVRY(M-C-R)(—;0.0 to 1.0)**

* This keyword appears under the SYSTEM-TERMINAL command in the (unabridged) BDL Summary (2.1E).

** This keyword appears under the SYSTEM-EQUIPMENT command in the (unabridged) *BDL Summary (2.1E)*.

§ Any keyword from these subcommands may be placed in the ZONE command

= PLANT-ASSIGNMENT(P-A,4)+

SYSTEM-NAMES(S-N) (list of system names in this plant)
INT-FUEL-BTU/HR(I-F-BTU) (**0.0**;0.0 to 10,000,000 Btu/hr)
INT-FUEL-SCH(I-F-SCH) (u-name)
EXT-FUEL-BTU/HR(E-F-BTU) (**0.0**;0.0 to 10,000,000 Btu/hr)
EXT-FUEL-SCH(E-F-SCH) (u-name)
INT-ELEC-KW(I-E-K) (**0.0**;0.0 to 1000 kW)
INT-ELEC-SCH(I-E-SCH) (u-name)
EXT-ELEC-KW(E-E-K) (**0.0**;0.0 to 1000 kW)
EXT-ELEC-SCH(E-E-SCH) = (u-name)
DHW-GAL MIN (DHW-GPM)(**0.0**; 0.0 to 10,000 gal/min)
DHW-SCH (u-name)
DHW-SUPPLY-T (**140.0**; 70.0 to 200.0 F)
DHW-INLET-T-SCH (u-name)[defaults to ground temperatures from weather file]
PROCESS-HW-BTU/HR(HW-BTU) (**0.0**;0.0 to 10,000,000 Btu/hr)
PROCESS-HW-SCH(HW-SCH) (u-name)
PROCESS-CHW-BTU/HR(CHW-BTU) (**0.0**;0.0 to 10,000,000 Btu/hr)
PROCESS-CHW-SCH (u-name)

+ If this command is not used, the default PLANT-ASSIGNMENT is all systems described in the input.

SYSTEMS-REPORT(S-R,1) The total number of reports generated may not exceed 200.
SUMMARY(S)((SS-A);SS-A.SS-B,...,SS-O)

END
Required at end of Systems input

COMPUTE SYSTEMS
Required to do Systems simulation

PLANT SUMMARY

INPUT PLANT Required for Plant input

TITLE(5)
See LOADS

= **PLANT-EQUIPMENT**(P-E,60) [Six **PLANT-EQUIPMENT instructions** are allowed for each equipment type, so that up to six different sizes may be specified for each type. Exceptions are cooling towers, and hot and cold water tanks. Only one of each of these may be specified.]

- **TYPE**(—;*)
  SIZE(**0.0**;-1000.0 to 100.0 MBtu/hr)
  INSTALLED-NUMBER(I-N)(**1**;1 to 10) (all integers)
  Note: For a cooling tower, INSTALLED-NUMBER is the number of cells.

Note: At least one PLANT-EQUIPMENT command is required; TYPE must be the first keyword listed]

* Allowed TYPE code-words are:

ABSORG-CHLR	ELEC-HW-BOILER
ABSOR1-CHLR	ELEC-STM-BOILER
ABSOR2-CHLR	ENG-CHLR
COOLING-TWR	HERM-CENT-CHLR
DBUN-CHLR	HERM-REC-CHLR
DHW-HEATER	HW-BOILER
ELEC-DHW-HEATER	STM-BOILER

PART-LOAD-RATIO(P-L-R,25) [One PART-LOAD-RATIO instruction may be used for each equipment type.]

- TYPE(—;*) [* Takes same code-words as TYPE in PLANT-EQUIPMENT.]
  ELEC-INPUT-RATIO(E-I-R)(‡;0.0 to 10.0) ‡

‡ See *Reference Manual (2.1A)*, Chap.V, Table V.4 for default values.

For
DIESEL-GEN
GTURB-GEN
STURB-GEN
ABSORG-CHLR
ENG-CHLR
see the table below for revised default values.

Revised Default Values for PART-LOAD-RATIO			
Plant-Equipment	**MIN**	**MAX**	**OPT**
DIESEL-GEN	0.15	1.1	0.95
GTURB-GEN	0.30	1.1	1.0
STURB-GEN	0.10	1.1	1.0

u-name = PLANT-ASSIGNMENT(P-A,1)

[Note: u-name must be the u-name of the PLANT-ASSIGNMENT in SYSTEMS;
if PLANT-ASSIGNMENT is defined in SYSTEMS, then it must be defined in PLANT also.]

PLANT-PARAMETERS(P-P,1)

Boilers:
STM-BOILER-HIR(**1.3**;0.0 to 3.0)
HW-BOILER-HIR(**1.25**;0.0 to 3.0)

Domestic Hot Water Heaters:
DHW-HIR(**1.39**;0.0 to 3.0)

Chillers:
HERM-CENT-COND-TYPE(**TOWER**;TOWER,AIR)
HERM-REC-COND-TYPE(**TOWER**;TOWER,AIR)
ABSOR1-HIR(**1.6**;0.0 to 3.0)
ABSOR2-HIR(**1.0**;0.0 to 3.0)
ABSORG-HIR(**1.0**; 0.0 to 3.0)
ABSORG-HEAT-XEFF(**0.8**; 0.1 to 1.0)
ENG-CH-COP(**1.4**; 0.1 to 3.0)
ENG-CH-COND-TYPE(**TOWER**;TOWER,AIR)
DBUN-COND-T-REC(**105.0**;80.0 to 120.0°F)
MIN-COND-AIR-T(**65.0**;0.0 to 100.0°F)
CHILL-WTR-T(**44.0**;32.0 to 80.0°F)

Towers:
TWR-CAP-CTRL(**ONE-SPEED-FAN**;ONE-SPEED-FAN, FLUID-BYPASS,
TWO-SPEED-FAN VARIABLE-SPEED-FAN)
TWR-SETPT-CTRL(**FIXED**:FIXED,WETBULB-RESET)
TWR-SETPT-T(**80.0;** 32.0 to 100.0F)
MIN-TWR-WTR-T(**65.0**;32.0 to 100.0°F)
TWR-PUMP-HEAD(**60.0**;0.0 to 100.0 ft)
TWR-DESIGN-WETBULB(**75.0**;32.0 to 100.0°F)

Pumps:
HCIRC-HEAD(**60.0**;0.0 to 100.0 ft)
HCIRC-DESIGN-T-DROP(**30.0**;0.0 to 100.0°F)
HCIRC-LOSS(**0.01**;0.0001 to 1.0)
CCIRC-HEAD(**60.0**;0.0 to 100.0 ft)
CCIRC-DESIGN-T-DROP(**10.0**;0.0 to 20.0°F)
CCIRC-LOSS(**0.01**;0.0001 to 1.0)
CCIRC-SIZE-OPT(**SYSTEM-PEAK**:SYSTEM-PEAK,INST-PLANT-EQUIP)
HCIRC-SIZE-OPT(**SYSTEM-PEAK**;SYSTEM-PEAK,INST-PLANT-EQUIP)
CCIRC-PUMP-TYPE(**FIXED-SPEED**;FIXED-SPEED,VARIABLE-SPEED)
HCIRC-PUMP-TYPE(**FIXED-SPEED**;FIXED-SPEED,VARIABLE-SPEED)
CCIRC-MIN-PLR(**0.5**;0.0001 to 1.0)
HCIRC-MIN-PLR(**0.5**;0.0001 to 1.0)

* The options are: DIESEL-OIL,NATURAL-GAS,FUEL-OIL,LPG,COAL,METHANOL.

HEAT-RECOVERY(HEAT-R,1)
SUPPLY-1(S-1)(**DBUN-CHLR**)
DEMAND-1(D-1)(**SPACE-HEAT**)

ENERGY-RESOURCE(E-R,7)

- RESOURCE(R)(—;ELECTRICITY,DIESEL-OIL,NATURAL-GAS, FUEL-OIL, STEAM,CHILLED-WATER,LPG,COAL,METHANOL)

SOURCE-SITE-EFF(S-S-E)(†;0.0 to 1.0) [† See *Supplement (2.1E)* for default values.]

Default Values for ENERGY-RESOURCE

RESOURCE	SOURCE-SITE-EFF
CHILLED-WATER	1.5*
COAL	1.0
DIESEL-OIL	1.0
ELECTRICITY	0.333***
FUEL-OIL	1.0
LPG	1.0
METHANOL	1.0
NATURAL-GAS	1.0
STEAM	0.60**

* Efficient electrically-driven chillers in a central chilled-water plant.

** Steam produced by heat-only boiler in a central steam generation plant.

*** California Energy Commission conversion factor for electricity: 10,239 Btu/kWh.

PLANT-REPORT(P-R,1)
SUMMARY(S)((**PS-A,PS-B,PS-D**);PS-A,PS-B,PS-C,PS-D,PS-G,BEPS

END
Required at end of Plant input

COMPUTE PLANT
Required to do Plant simulation

ECONOMICS SUMMARY

INPUT ECONOMICS
Required for Economics input

TITLE
See LOADS

= **WEEK-SCHEDULE**(W-SCH,200)
See LOADS

= **SCHEDULE**(SCH,100)
See LOADS

= **BLOCK-CHARGE**(B-C)(30)
BLOCK-SCH(B-SCH) (u-name)
SCH-FLAG(FLAG)(**1.0**;key to hourly value used in a SCHEDULE)
BLOCK1-TYPE(B1-T)(**ENERGY**;ENERGY,KWH/KW,KWH/KW-LIMITSUM,DEMAND)
BLOCK1-DATA(B1-D)(**0.0**;list of up to 10 sets of block-size,cost/unit,limit)
BLOCK2-TYPE(B2-T)(**ENERGY**;ENERGY,KHW/KW,KWH/KW-LIMITSUM,DEMAND)
BLOCK2-DATA(B2-D)(**0.0**;list of up to 10 sets of block-size, cost/unit, limit)
BLOCK3-TYPE(B3-T)(**ENERGY**; ENERGY, KWH/KW, KWH/KW-LIMITSUM, DEMAND)
BLOCK3-DATA(B3-D)(**0.0**; list of up to 10 sets of block-size, cost/unit, limit)
TOU-SEASON-LINKS(TOU-LINK)(accepts list of u-names of BLOCK-CHARGEs)

= **UTILITY-RATE**(U-R)(15)
- **RESOURCE**(R)(—;ELECTRICITY,DIESEL-OIL,NATURAL-GAS,FUEL-OIL, STEAM,CHILLED-WATER,LPG,COAL,METHANOL,OTHER-FUEL, and for cogeneration ELEC-BUY/SELL,ELEC-NET-SALE)

MONTH-CHGS(M-CHG)(**0.0**;0.0 to $100,000/month) list of 1 to 12 values.
ENERGY-CHG(E-CHG)(**0.0**:0.0 to $100,000,000/unit)
ENERGY-CHG-SCH(E-SCH) (u-name)
DEMAND-CHGS(D-CHG)(**0.0**;0.0 to $100,000,000/unit-hr) list of 1 to 12 values
BLOCK-CHARGE(B-C)(-;list of up to ten u-names of BLOCK-CHARGEs)
MIN-MON-CHGS(M-M-CHG)(**0.0**;0.0 to $1,000,000,000/month) list of 1 to 12 values
MIN-MON-DEM-CHGS(M-D-CHG)(**0.0**;0.0 to $1,000/month) list of 1 to 12 values
RATE-LIMITATION(R-LIM)(**0.0**;0.0 to $100,000,000/UNIT)
LIKE (-;accepts u-name of another UTILITY-RATE)
BILLING-DAYS(B-D)(**31 or last day of month**;list of 12 days, one for each month; 1 to 31)

ECONOMICS-REPORT(E-R,1)
VERIFICATION(V)(—;EV-A,EV-B) (list)
SUMMARY(S)(**ES-A**;ES-A,ES-B,ES-C,ES-D,ES-E,ES-F,ALL-SUMMARY) (list)

(See Appendix C of the the *Supplement (2.1E)* for a full description of all reports.)

END

Required at end of Economics input

COMPUTE ECONOMICS

Required for Economics simulation

STOP

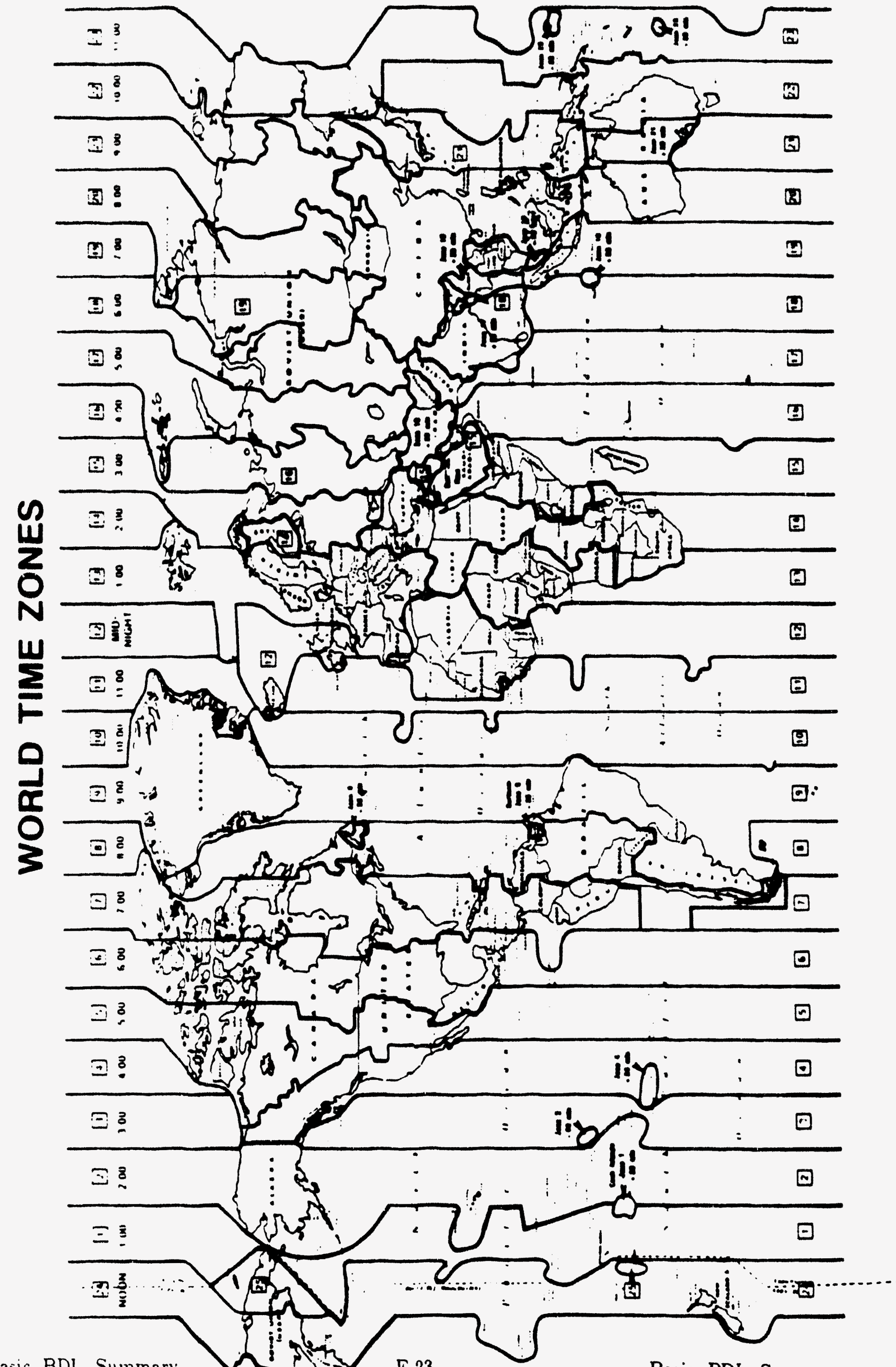
Use only if want BDL and simulation to stop here

Geographical Data for the 50 Largest U.S. Cities

State	City	Lat.	Long.	Time Zone
Arizona	Phoenix	33.45	112.07	7
	Tucson	32.13	110.58	7
California	Fresno	36.43	119.47	8
	Long Beach	33.78	118.18	8
	Los Angeles	34.07	118.25	8
	Oakland	37.82	122.27	8
	Sacramento	38.35	121.29	8
	San Diego	32.72	117.15	8
	San Francisco	37.78	122.42	8
	San Jose	37.33	121.88	8
Colorado	Denver	39.73	104.98	7
Florida	Jacksonville	30.33	81.65	5
	Miami	25.78	80.18	5
Georgia	Atlanta	33.75	84.38	5
Hawaii	Honolulu	21.32	157.87	10
Illinois	Chicago	41.88	87.63	6
Indiana	Indianapolis	39.77	86.15	5
Louisiana	New Orleans	29.97	90.07	6
Maryland	Baltimore	39.28	76.62	5
Massachusetts	Boston	42.37	71.07	5
Michigan	Detroit	42.33	83.00	5
Minnesota	Minneapolis	44.98	93.27	6
Missouri	Kansas City	39.10	94.58	6
	Saint Louis	38.62	90.20	6
Nebraska	Omaha	41.28	96.02	6
New Mexico	Albuquerque	35.05	106.39	6
New York	Buffalo	42.88	78.88	5
	New York	40.72	74.00	5
North Carolina	Charlotte	35.13	80.5	5
Ohio	Cincinnati	39.10	84.52	5
	Cleveland	41.50	81.70	5
	Columbus	39.97	83.00	5
	Toledo	41.65	83.55	5
Oklahoma	Oklahoma City	35.50	97.50	6
	Tulsa	36.17	95.92	6

Oregon	Portland	45.53	122.62	8
Pennsylvania	Philadelphia	39.95	75.17	5
	Pittsburgh	40.43	80.02	5
Tennessee	Memphis	35.13	90.05	6
	Nashville	36.17	86.78	6
Texas	Austin	30.16	97.44	6
	Dallas	32.78	96.82	6
	El Paso	31.75	106.48	7
	Fort Worth	32.75	97.30	6
	Houston	29.77	95.37	6
	San Antonio	29.42	98.50	6
Virginia	Virginia Beach	36.5	75.58	5
Washington	Seattle	47.60	122.33	8
Wisconsin	Milwaukee	43.03	87.92	6
D.C.	Washington	38.90	77.03	5

TIME ZONE CHART



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1778	5	1803	7	1828	10	1853	7	1878	3	1903	5	1928	8	1953	5	1978	1
1779	6	1804	8	1829	5	1854	1	1879	4	1904	13	1929	3	1954	6	1979	2
1780	14	1805	3	1830	6	1855	2	1880	12	1905	1	1930	4	1955	7	1980	10
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1790	6	1815	1	1840	11	1865	1	1890	4	1915	6	1940	9	1965	6	1990	2
1791	7	1816	9	1841	6	1866	2	1891	5	1916	14	1941	4	1966	7	1991	3
1792	8	1817	4	1842	7	1867	3	1892	13	1917	2	1942	5	1967	1	1992	11
1793	3	1818	5	1843	1	1868	11	1893	1	1918	3	1943	6	1968	9	1993	6
1794	4	1819	6	1844	9	1869	6	1894	2	1919	4	1944	14	1969	4	1994	7
1795	5	1820	14	1845	4	1870	7	1895	3	1920	12	1945	2	1970	5	1995	1
1796	13	1821	2	1846	5	1871	1	1896	11	1921	7	1946	3	1971	6	1996	9
1797	1	1822	3	1847	6	1872	9	1897	6	1922	1	1947	4	1972	14	1997	4
1798	2	1823	4	1848	14	1873	4	1898	7	1923	2	1948	12	1973	2	1998	5
1799	3	1824	12	1849	2	1874	5	1899	1	1924	10	1949	7	1974	3	1999	6
1800	4	1825	7	1850	3	1875	6	1900	2	1925	5	1950	1	1975	4	2000	14

Year 1

S	M	Tu	W	Th	F	S
JANUARY						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				
FEBRUARY						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28				
MARCH						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	
APRIL						
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						
MAY						
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			
JUNE						
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	
JULY						
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					
AUGUST						
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		
SEPTEMBER						
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
OCTOBER						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				
NOVEMBER						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		
DECEMBER						
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

Year 2

S	M	Tu	W	Th	F	S
JANUARY						
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			
FEBRUARY						
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28			
MARCH						
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	31
APRIL						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					
MAY						
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		
JUNE						
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
JULY						
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				
AUGUST						
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	
SEPTEMBER						
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						
OCTOBER						
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			
NOVEMBER						
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	
DECEMBER						
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Note: The program and the weather files use a 365 day year even for leap years. Therefore, in leap years, the calendar and the program get one day out of step with regard to days of the week after February 29. When using the perpetual calendar for leap years, shift back one day of the week for dates after February 29.

Year 3

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
		1	2	3	4	5						1	2						1	2
6	7	8	9	10	11	12	3	4	5	6	7	8	9	3	4	5	6	7	8	9
13	14	15	16	17	18	19	10	11	12	13	14	15	16	10	11	12	13	14	15	16
20	21	22	23	24	25	26	17	18	19	20	21	22	23	17	18	19	20	21	22	23
27	28	29	30	31			24	25	26	27	28			24	25	26	27	28	29	30
APRIL							MAY							31	JUNE					
	1	2	3	4	5	6				1	2	3	4							1
7	8	9	10	11	12	13	5	6	7	8	9	10	11	2	3	4	5	6	7	8
14	15	16	17	18	19	20	12	13	14	15	16	17	18	9	10	11	12	13	14	15
21	22	23	24	25	26	27	19	20	21	22	23	24	25	16	17	18	19	20	21	22
28	29	30					26	27	28	29	30	31		23	24	25	26	27	28	29
JULY							AUGUST							30	SEPTEMBER					
	1	2	3	4	5	6					1	2	3	1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	8	9	10	11	12	13	14
14	15	16	17	18	19	20	11	12	13	14	15	16	17	15	16	17	18	19	20	21
21	22	23	24	25	26	27	18	19	20	21	22	23	24	22	23	24	25	26	27	28
28	29	30	31				25	26	27	28	29	30	31	29	30					
OCTOBER							NOVEMBER							DECEMBER						
		1	2	3	4	5						1	2	1	2	3	4	5	6	7
6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14
13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20	21
20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28
27	28	29	30	31			24	25	26	27	28	29	30	29	30	31				

Year 4

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
			1	2	3	4							1							1
5	6	7	8	9	10	11	2	3	4	5	6	7	8	2	3	4	5	6	7	8
12	13	14	15	16	17	18	9	10	11	12	13	14	15	9	10	11	12	13	14	15
19	20	21	22	23	24	25	16	17	18	19	20	21	22	16	17	18	19	20	21	22
26	27	28	29	30	31		23	24	25	26	27	28		23	24	25	26	27	28	29
APRIL							MAY							30	31	JUNE				
		1	2	3	4	5					1	2	3	1	2	3	4	5	6	7
6	7	8	9	10	11	12	4	5	6	7	8	9	10	8	9	10	11	12	13	14
13	14	15	16	17	18	19	11	12	13	14	15	16	17	15	16	17	18	19	20	21
20	21	22	23	24	25	26	18	19	20	21	22	23	24	22	23	24	25	26	27	28
27	28	29	30				25	26	27	28	29	30	31	29	30					
JULY							AUGUST							SEPTEMBER						
		1	2	3	4	5						1	2		1	2	3	4	5	6
6	7	8	9	10	11	12	3	4	5	6	7	8	9	7	8	9	10	11	12	13
13	14	15	16	17	18	19	10	11	12	13	14	15	16	14	15	16	17	18	19	20
20	21	22	23	24	25	26	17	18	19	20	21	22	23	21	22	23	24	25	26	27
27	28	29	30	31			24	25	26	27	28	29	30	28	29	30				
OCTOBER							31	NOVEMBER						DECEMBER						
			1	2	3	4							1		1	2	3	4	5	6
5	6	7	8	9	10	11	2	3	4	5	6	7	8	7	8	9	10	11	12	13
12	13	14	15	16	17	18	9	10	11	12	13	14	15	14	15	16	17	18	19	20
19	20	21	22	23	24	25	16	17	18	19	20	21	22	21	22	23	24	25	26	27
26	27	28	29	30	31		23	24	25	26	27	28	29	28	29	30	31			
							30													

Year 5

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
				1	2	3	1	2	3	4	5	6	7	1	2	3	4	5	6	7
4	5	6	7	8	9	10	8	9	10	11	12	13	14	8	9	10	11	12	13	14
11	12	13	14	15	16	17	15	16	17	18	19	20	21	15	16	17	18	19	20	21
18	19	20	21	22	23	24	22	23	24	25	26	27	28	22	23	24	25	26	27	28
25	26	27	28	29	30	31								29	30	31				
APRIL							MAY							JUNE						
			1	2	3	4						1	2		1	2	3	4	5	6
5	6	7	8	9	10	11	3	4	5	6	7	8	9	7	8	9	10	11	12	13
12	13	14	15	16	17	18	10	11	12	13	14	15	16	14	15	16	17	18	19	20
19	20	21	22	23	24	25	17	18	19	20	21	22	23	21	22	23	24	25	26	27
26	27	28	29	30			24	25	26	27	28	29	30	28	29	30				
JULY							31	AUGUST						SEPTEMBER						
			1	2	3	4							1			1	2	3	4	5
5	6	7	8	9	10	11	2	3	4	5	6	7	8	6	7	8	9	10	11	12
12	13	14	15	16	17	18	9	10	11	12	13	14	15	13	14	15	16	17	18	19
19	20	21	22	23	24	25	16	17	18	19	20	21	22	20	21	22	23	24	25	26
26	27	28	29	30	31		23	24	25	26	27	28	29	27	28	29	30			
							30	31												
OCTOBER							NOVEMBER							DECEMBER						
				1	2	3	1	2	3	4	5	6	7			1	2	3	4	5
4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12
11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19
18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26
25	26	27	28	29	30	31	29	30						27	28	29	30	31		

Year 6

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
					1	2		1	2	3	4	5	6		1	2	3	4	5	6
3	4	5	6	7	8	9	7	8	9	10	11	12	13	7	8	9	10	11	12	13
10	11	12	13	14	15	16	14	15	16	17	18	19	20	14	15	16	17	18	19	20
17	18	19	20	21	22	23	21	22	23	24	25	26	27	21	22	23	24	25	26	27
24	25	26	27	28	29	30	28							28	29	30	31			
31	APRIL						MAY							JUNE						
				1	2	3							1			1	2	3	4	5
4	5	6	7	8	9	10	2	3	4	5	6	7	8	6	7	8	9	10	11	12
11	12	13	14	15	16	17	9	10	11	12	13	14	15	13	14	15	16	17	18	19
18	19	20	21	22	23	24	16	17	18	19	20	21	22	20	21	22	23	24	25	26
25	26	27	28	29	30		23	24	25	26	27	28	29	27	28	29	30			
							30	31												
JULY							AUGUST							SEPTEMBER						
				1	2	3	1	2	3	4	5	6	7				1	2	3	4
4	5	6	7	8	9	10	8	9	10	11	12	13	14	5	6	7	8	9	10	11
11	12	13	14	15	16	17	15	16	17	18	19	20	21	12	13	14	15	16	17	18
18	19	20	21	22	23	24	22	23	24	25	26	27	28	19	20	21	22	23	24	25
25	26	27	28	29	30	31	29	30	31					26	27	28	29	30		
OCTOBER							NOVEMBER							DECEMBER						
					1	2		1	2	3	4	5	6				1	2	3	4
3	4	5	6	7	8	9	7	8	9	10	11	12	13	5	6	7	8	9	10	11
10	11	12	13	14	15	16	14	15	16	17	18	19	20	12	13	14	15	16	17	18
17	18	19	20	21	22	23	21	22	23	24	25	26	27	19	20	21	22	23	24	25
24	25	26	27	28	29	30	28	29	30					26	27	28	29	30	31	
31																				

PERPETUAL CALENDAR

Year 7

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
			JANUARY							FEBRUARY							MARCH			
						1			1	2	3	4	5			1	2	3	4	5
2	3	4	5	6	7	8	6	7	8	9	10	11	12	6	7	8	9	10	11	12
9	10	11	12	13	14	15	13	14	15	16	17	18	19	13	14	15	16	17	18	19
16	17	18	19	20	21	22	20	21	22	23	24	25	26	20	21	22	23	24	25	26
23	24	25	26	27	28	29	27	28						27	28	29	30	31		
30	31																			
30-31			APRIL							MAY							JUNE			
					1	2	1	2	3	4	5	6	7				1	2	3	4
3	4	5	6	7	8	9	8	9	10	11	12	13	14	5	6	7	8	9	10	11
10	11	12	13	14	15	16	15	16	17	18	19	20	21	12	13	14	15	16	17	18
17	18	19	20	21	22	23	22	23	24	25	26	27	28	19	20	21	22	23	24	25
24	25	26	27	28	29	30	29	30	31					26	27	28	29	30		
			JULY							AUGUST							SEPTEMBER			
					1	2		1	2	3	4	5	6					1	2	3
3	4	5	6	7	8	9	7	8	9	10	11	12	13	4	5	6	7	8	9	10
10	11	12	13	14	15	16	14	15	16	17	18	19	20	11	12	13	14	15	16	17
17	18	19	20	21	22	23	21	22	23	24	25	26	27	18	19	20	21	22	23	24
24	25	26	27	28	29	30	28	29	30	31				25	26	27	28	29	30	
31			OCTOBER							NOVEMBER							DECEMBER			
						1			1	2	3	4	5					1	2	3
2	3	4	5	6	7	8	6	7	8	9	10	11	12	4	5	6	7	8	9	10
9	10	11	12	13	14	15	13	14	15	16	17	18	19	11	12	13	14	15	16	17
16	17	18	19	20	21	22	20	21	22	23	24	25	26	18	19	20	21	22	23	24
23	24	25	26	27	28	29	27	28	29	30				25	26	27	28	29	30	31
30	31																			

Year 8

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
			JANUARY							FEBRUARY							MARCH			
1	2	3	4	5	6	7				1	2	3	4					1	2	3
8	9	10	11	12	13	14	5	6	7	8	9	10	11	4	5	6	7	8	9	10
15	16	17	18	19	20	21	12	13	14	15	16	17	18	11	12	13	14	15	16	17
22	23	24	25	26	27	28	19	20	21	22	23	24	25	18	19	20	21	22	23	24
29	30	31					26	27	28	29				25	26	27	28	29	30	31
			APRIL							MAY							JUNE			
1	2	3	4	5	6	7			1	2	3	4	5						1	2
8	9	10	11	12	13	14	6	7	8	9	10	11	12	3	4	5	6	7	8	9
15	16	17	18	19	20	21	13	14	15	16	17	18	19	10	11	12	13	14	15	16
22	23	24	25	26	27	28	20	21	22	23	24	25	26	17	18	19	20	21	22	23
29	30						27	28	29	30	31			24	25	26	27	28	29	30
			JULY							AUGUST							SEPTEMBER			
1	2	3	4	5	6	7				1	2	3	4							1
8	9	10	11	12	13	14	5	6	7	8	9	10	11	2	3	4	5	6	7	8
15	16	17	18	19	20	21	12	13	14	15	16	17	18	9	10	11	12	13	14	15
22	23	24	25	26	27	28	19	20	21	22	23	24	25	16	17	18	19	20	21	22
29	30	31					26	27	28	29	30	31		23	24	25	26	27	28	29
			OCTOBER							NOVEMBER				30			DECEMBER			
	1	2	3	4	5	6					1	2	3							1
7	8	9	10	11	12	13	4	5	6	7	8	9	10	2	3	4	5	6	7	8
14	15	16	17	18	19	20	11	12	13	14	15	16	17	9	10	11	12	13	14	15
21	22	23	24	25	26	27	18	19	20	21	22	23	24	16	17	18	19	20	21	22
28	29	30	31				25	26	27	28	29	30		23	24	25	26	27	28	29
														30_31						

Year 9

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
			JANUARY							FEBRUARY							MARCH			
	1	2	3	4	5	6					1	2	3						1	2
7	8	9	10	11	12	13	4	5	6	7	8	9	10	3	4	5	6	7	8	9
14	15	16	17	18	19	20	11	12	13	14	15	16	17	10	11	12	13	14	15	16
21	22	23	24	25	26	27	18	19	20	21	22	23	24	17	18	19	20	21	22	23
28	29	30	31				25	26	27	28	29			24	25	26	27	28	29	30
			APRIL							MAY				31			JUNE			
	1	2	3	4	5	6				1	2	3	4							1
7	8	9	10	11	12	13	5	6	7	8	9	10	11	2	3	4	5	6	7	8
14	15	16	17	18	19	20	12	13	14	15	16	17	18	9	10	11	12	13	14	15
21	22	23	24	25	26	27	19	20	21	22	23	24	25	16	17	18	19	20	21	22
28	29	30					26	27	28	29	30	31		23	24	25	26	27	28	29
			JULY							AUGUST				30			SEPTEMBER			
	1	2	3	4	5	6					1	2	3	1	2	3	4	5	6	7
7	8	9	10	11	12	13	4	5	6	7	8	9	10	8	9	10	11	12	13	14
14	15	16	17	18	19	20	11	12	13	14	15	16	17	15	16	17	18	19	20	21
21	22	23	24	25	26	27	18	19	20	21	22	23	24	22	23	24	25	26	27	28
28	29	30	31				25	26	27	28	29	30	31	29	30					
			OCTOBER							NOVEMBER							DECEMBER			
		1	2	3	4	5						1	2	1	2	3	4	5	6	7
6	7	8	9	10	11	12	3	4	5	6	7	8	9	8	9	10	11	12	13	14
13	14	15	16	17	18	19	10	11	12	13	14	15	16	15	16	17	18	19	20	21
20	21	22	23	24	25	26	17	18	19	20	21	22	23	22	23	24	25	26	27	28
27	28	29	30	31			24	25	26	27	28	29	30	29	30	31				

Year 10

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
			JANUARY							FEBRUARY							MARCH			
		1	2	3	4	5						1	2							1
6	7	8	9	10	11	12	3	4	5	6	7	8	9	2	3	4	5	6	7	8
13	14	15	16	17	18	19	10	11	12	13	14	15	16	9	10	11	12	13	14	15
20	21	22	23	24	25	26	17	18	19	20	21	22	23	16	17	18	19	20	21	22
27	28	29	30	31			24	25	26	27	28	29		23	24	25	26	27	28	29
														30	31					
			APRIL							MAY							JUNE			
		1	2	3	4	5					1	2	3	1	2	3	4	5	6	7
6	7	8	9	10	11	12	4	5	6	7	8	9	10	8	9	10	11	12	13	14
13	14	15	16	17	18	19	11	12	13	14	15	16	17	15	16	17	18	19	20	21
20	21	22	23	24	25	26	18	19	20	21	22	23	24	22	23	24	25	26	27	28
27	28	29	30				25	26	27	28	29	30	31	29	30					
			JULY							AUGUST							SEPTEMBER			
		1	2	3	4	5						1	2		1	2	3	4	5	6
6	7	8	9	10	11	12	3	4	5	6	7	8	9	7	8	9	10	11	12	13
13	14	15	16	17	18	19	10	11	12	13	14	15	16	14	15	16	17	18	19	20
20	21	22	23	24	25	26	17	18	19	20	21	22	23	21	22	23	24	25	26	27
27	28	29	30	31			24	25	26	27	28	29	30	28	29	30				
			OCTOBER				31			NOVEMBER							DECEMBER			
				1	2	3							1		1	2	3	4	5	6
4	5	6	7	8	9	10	2	3	4	5	6	7	8	7	8	9	10	11	12	13
11	12	13	14	15	16	17	9	10	11	12	13	14	15	14	15	16	17	18	19	20
18	19	20	21	22	23	24	16	17	18	19	20	21	22	21	22	23	24	25	26	27
25	26	27	28	29	30	31	23	24	25	26	27	28	29	28	29	30	31			
							30													

Year 11

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
			1	2	3	4							1	1	2	3	4	5	6	7
5	6	7	8	9	10	11	2	3	4	5	6	7	8	8	9	10	11	12	13	14
12	13	14	15	16	17	18	9	10	11	12	13	14	15	15	16	17	18	19	20	21
19	20	21	22	23	24	25	16	17	18	19	20	21	22	22	23	24	25	26	27	28
26	27	28	29	30	31		23	24	25	26	27	28	29	29	30	31				
APRIL							MAY							JUNE						
			1	2	3	4						1	2		1	2	3	4	5	6
5	6	7	8	9	10	11	3	4	5	6	7	8	9	7	8	9	10	11	12	13
12	13	14	15	16	17	18	10	11	12	13	14	15	16	14	15	16	17	18	19	20
19	20	21	22	23	24	25	17	18	19	20	21	22	23	21	22	23	24	25	26	27
26	27	28	29	30			24	25	26	27	28	29	30	28	29	30				
JULY							31	AUGUST						SEPTEMBER						
			1	2	3	4							1			1	2	3	4	5
5	6	7	8	9	10	11	2	3	4	5	6	7	8	6	7	8	9	10	11	12
12	13	14	15	16	17	18	9	10	11	12	13	14	15	13	14	15	16	17	18	19
19	20	21	22	23	24	25	16	17	18	19	20	21	22	20	21	22	23	24	25	26
26	27	28	29	30	31		23	24	25	26	27	28	29	27	28	29	30			
							30	31												
OCTOBER							NOVEMBER							DECEMBER						
				1	2	3	1	2	3	4	5	6	7			1	2	3	4	5
4	5	6	7	8	9	10	8	9	10	11	12	13	14	6	7	8	9	10	11	12
11	12	13	14	15	16	17	15	16	17	18	19	20	21	13	14	15	16	17	18	19
18	19	20	21	22	23	24	22	23	24	25	26	27	28	20	21	22	23	24	25	26
25	26	27	28	29	30	31	29	30						27	28	29	30	31		

Year 12

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
				1	2	3	1	2	3	4	5	6	7		1	2	3	4	5	6
4	5	6	7	8	9	10	8	9	10	11	12	13	14	7	8	9	10	11	12	13
11	12	13	14	15	16	17	15	16	17	18	19	20	21	14	15	16	17	18	19	20
18	19	20	21	22	23	24	22	23	24	25	26	27	28	21	22	23	24	25	26	27
25	26	27	28	29	30	31	29							28	29	30	31			
APRIL							MAY							JUNE						
				1	2	3							1			1	2	3	4	5
4	5	6	7	8	9	10	2	3	4	5	6	7	8	6	7	8	9	10	11	12
11	12	13	14	15	16	17	9	10	11	12	13	14	15	13	14	15	16	17	18	19
18	19	20	21	22	23	24	16	17	18	19	20	21	22	20	21	22	23	24	25	26
25	26	27	28	29	30		23	24	25	26	27	28	29	27	28	29	30			
							30	31												
JULY							AUGUST							SEPTEMBER						
				1	2	3	1	2	3	4	5	6	7				1	2	3	4
4	5	6	7	8	9	10	8	9	10	11	12	13	14	5	6	7	8	9	10	11
11	12	13	14	15	16	17	15	16	17	18	19	20	21	12	13	14	15	16	17	18
18	19	20	21	22	23	24	22	23	24	25	26	27	28	19	20	21	22	23	24	25
25	26	27	28	29	30	31	29	30	31					26	27	28	29	30		
OCTOBER							NOVEMBER							DECEMBER						
					1	2		1	2	3	4	5	6				1	2	3	4
3	4	5	6	7	8	9	7	8	9	10	11	12	13	5	6	7	8	9	10	11
10	11	12	13	14	15	16	14	15	16	17	18	19	20	12	13	14	15	16	17	18
17	18	19	20	21	22	23	21	22	23	24	25	26	27	19	20	21	22	23	24	25
24	25	26	27	28	29	30	28	29	30					26	27	28	29	30	31	
31																				

Year 13

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
					1	2		1	2	3	4	5	6			1	2	3	4	5
3	4	5	6	7	8	9	7	8	9	10	11	12	13	6	7	8	9	10	11	12
10	11	12	13	14	15	16	14	15	16	17	18	19	20	13	14	15	16	17	18	19
17	18	19	20	21	22	23	21	22	23	24	25	26	27	20	21	22	23	24	25	26
24	25	26	27	28	29	30	28	29						27	28	29	30	31		
31																				
APRIL							MAY							JUNE						
					1	2	1	2	3	4	5	6	7				1	2	3	4
3	4	5	6	7	8	9	8	9	10	11	12	13	14	5	6	7	8	9	10	11
10	11	12	13	14	15	16	15	16	17	18	19	20	21	12	13	14	15	16	17	18
17	18	19	20	21	22	23	22	23	24	25	26	27	28	19	20	21	22	23	24	25
24	25	26	27	28	29	30	29	30	31					26	27	28	29	30		
JULY							AUGUST							SEPTEMBER						
					1	2		1	2	3	4	5	6					1	2	3
3	4	5	6	7	8	9	7	8	9	10	11	12	13	4	5	6	7	8	9	10
10	11	12	13	14	15	16	14	15	16	17	18	19	20	11	12	13	14	15	16	17
17	18	19	20	21	22	23	21	22	23	24	25	26	27	18	19	20	21	22	23	24
24	25	26	27	28	29	30	28	29	30	31				25	26	27	28	29	30	
31	OCTOBER						NOVEMBER							DECEMBER						
						1			1	2	3	4	5					1	2	3
2	3	4	5	6	7	8	6	7	8	9	10	11	12	4	5	6	7	8	9	10
9	10	11	12	13	14	15	13	14	15	16	17	18	19	11	12	13	14	15	16	17
16	17	18	19	20	21	22	20	21	22	23	24	25	26	18	19	20	21	22	23	24
23	24	25	26	27	28	29	27	28	29	30				25	26	27	28	29	30	31
30	31																			

Year 14

S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S	S	M	Tu	W	Th	F	S
JANUARY							FEBRUARY							MARCH						
						1			1	2	3	4	5				1	2	3	4
2	3	4	5	6	7	8	6	7	8	9	10	11	12	5	6	7	8	9	10	11
9	10	11	12	13	14	15	13	14	15	16	17	18	19	12	13	14	15	16	17	18
16	17	18	19	20	21	22	20	21	22	23	24	25	26	19	20	21	22	23	24	25
23	24	25	26	27	28	29	27	28	29					26	27	28	29	30	31	
30	31																			
APRIL							MAY							JUNE						
						1		1	2	3	4	5	6					1	2	3
2	3	4	5	6	7	8	7	8	9	10	11	12	13	4	5	6	7	8	9	10
9	10	11	12	13	14	15	14	15	16	17	18	19	20	11	12	13	14	15	16	17
16	17	18	19	20	21	22	21	22	23	24	25	26	27	18	19	20	21	22	23	24
23	24	25	26	27	28	29	28	29	30	31				25	26	27	28	29	30	
30	JULY						AUGUST							SEPTEMBER						
						1			1	2	3	4	5						1	2
2	3	4	5	6	7	8	6	7	8	9	10	11	12	3	4	5	6	7	8	9
9	10	11	12	13	14	15	13	14	15	16	17	18	19	10	11	12	13	14	15	16
16	17	18	19	20	21	22	20	21	22	23	24	25	26	17	18	19	20	21	22	23
23	24	25	26	27	28	29	27	28	29	30	31			24	25	26	27	28	29	30
30	31																			
OCTOBER							NOVEMBER							DECEMBER						
1	2	3	4	5	6	7				1	2	3	4						1	2
8	9	10	11	12	13	14	5	6	7	8	9	10	11	3	4	5	6	7	8	9
15	16	17	18	19	20	21	12	13	14	15	16	17	18	10	11	12	13	14	15	16
22	23	24	25	26	27	28	19	20	21	22	23	24	25	17	18	19	20	21	22	23
29	30	31					26	27	28	29	30			24	25	26	27	28	29	30
														31						

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END