

Volume

1

DOE-2.2

Building Energy Use and Cost Analysis Program
Volume 1: Basics

LAWRENCE BERKELEY NATIONAL LABORATORY
JAMES J. HIRSCH & ASSOCIATES

DOE-2.2 BUILDING ENERGY USE AND COST ANALYSIS PROGRAM

Volume 1: Basics

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Overview

What Is DOE-2?

DOE-2 is a set of computer programs that provide an up-to-date, unbiased analysis of a building's energy consumption. 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. Using the program, designers can determine the choice of building parameters that improve energy efficiency while maintaining thermal comfort and cost-effectiveness. The purpose of the program 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

This manual helps you learn the program by introducing you to the program's basic features. For users familiar with previous versions of the simulation engine, it helps with the transition to the most recent version. This manual covers approximately 80 percent of usual simulation applications, yet requires you to be familiar with only 20 percent of the input variables available. These variables have been chosen from our long experience of assisting users prepare their inputs.

This manual is organized as follows. First we show the structure of the program. We then briefly describe the subprograms and list some of the program's applications. This is followed by an overview of the basic format of the input language for describing buildings. We then show a simple, annotated example of a run to give you an idea of what the program's input and output look like. Next, we describe the weather file types acceptable to the program and given an overview of the Building Description Language (BDL). Then, we describe the input commands and their associated keywords for the three major program sections in the program: LOADS, HVAC, and ECON. In the HVAC section, we also discuss, and give example inputs for, the different types of air distribution systems that the program can simulate. Finally, there are a number of appendices: Appendix A lists advanced features of the program not covered by this manual. Appendix B describes the basic output reports.

Other Documentation

This manual is the first volume in a set of four volumes. The three other volumes in this set are:

DOE-2.2 Dictionary

This is a dictionary that defines all of the input commands and keywords in the program. It also gives examples of usage. The *DOE-2.2 Dictionary* pulls together all of the information pertaining to

commands and keywords that was previously found in the *Reference Manual, Supplement*, and *BDL Summary*. It is meant to be used with the *DOE-2.2 Topics*.

DOE-2.2 Topics

This is a topic-oriented document with detailed instructions on how to use many features of the program. It contains material that was previously in the *Reference Manual* and *Supplement*, plus new material.

DOE-2.2 Libraries & Reports

This document list all of the components in the program Libraries, such as materials, constructions, glass-types, etc. It also presents all of the output reports, together with explanations of many of the key report items. Finally, it contains tables of all of the user-defineable hourly report variables.

Other program documentation includes:

Engineers Manual (DOE-2.1A)

Describes the engineering and mathematical basis of program calculations in DOE-2.1A, which was released in 1981. The *Engineers Manual, Version 2.1A*, (order No. DE-830-04575) is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; Ph. (703) 487-4650, Fax (703) 321-8547. Contact NTIS for price and delivery information. This manual is now out of date and should be used with caution.

Building Energy Simulation User News

This is a quarterly newsletter, distributed free of charge. It lists program bugs and fixes, offers articles on the effective use of DOE-2; it also contains a directory of program-related software, consultants, services, web sites, etc. To be put on the mailing list, please fax Kathy Ellington at 510-486-4089 or send email to kl Ellington@lbl.gov.

Installing and Running DOE-2

Instructions for installing and running DOE-2 on your computer are not provided in this manual but may be found in separate documentation provided by your program supplier.

Simulation Engine Structure

Figure 1 shows a flowchart of the simulation engine. Basically, the program has one subprogram for translation of your input (BDL Processor), and three simulation subprograms (LOADS, HVAC, and ECON). The LOADS subprogram executes first for the entire simulation period, and its hourly data stored in a disk file for the HVAC simulation. Next the HVAC subprogram executes for the entire simulation period, with its hourly results stored in a disk file for the ECONOMICS calculations. Finally, the ECONOMICS subprogram executes. Each of the simulation subprograms also produces printed reports of the results of its calculations.

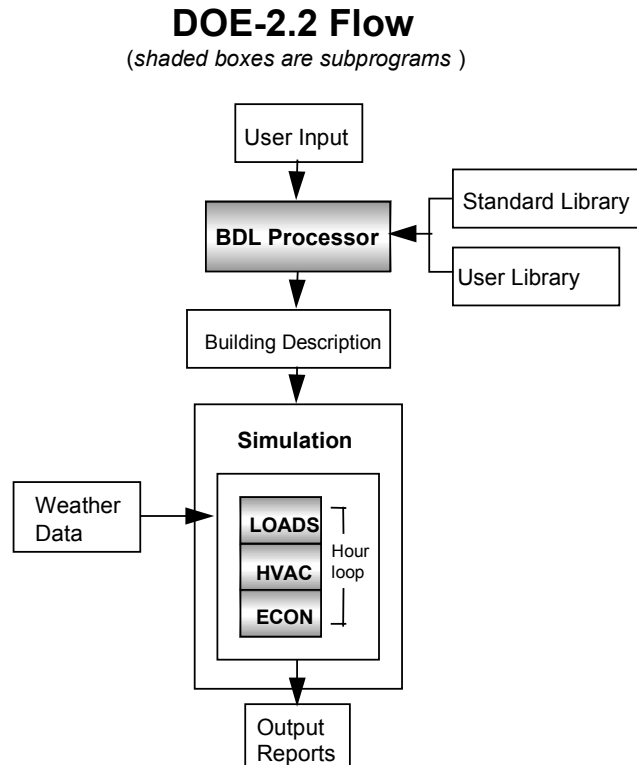


Figure 1 Simulation Engine Structure

The elements of the program shown in Figure 1 are as follows:

BDL Processor

The Building Description Language (BDL) processor reads the flexibly formatted input data that you supply 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.

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 user-specified temperature. LOADS is responsive to weather and solar conditions, to schedules of people, lighting and equipment, to infiltration, to heat transfer through walls, roofs, and windows and to the effect of building shades on solar radiation.

HVAC

The HVAC simulation subprogram is divided into a secondary systems simulation (SYSTEMS) and a primary systems simulation (PLANT). The secondary HVAC systems simulation calculates the performance of air-side equipment (fans, coils, and ducts). It corrects the constant-temperature loads calculated by the LOADS subprogram by taking into account outside air requirements, hours of equipment operation, equipment control strategies, and thermostat set points. The output of the secondary HVAC system simulation is air flow and coil loads. The primary HVAC system simulation calculates the behavior of boilers, chillers, cooling towers, storage tanks, etc., in satisfying the secondary systems heating and cooling coil loads. It takes into account the part-load characteristics of the primary equipment in order to calculate the fuel and electrical demands of the building.

ECON

The economic analysis subprogram calculates the cost of energy. It can also be used to compare the cost-benefits of different building designs or to calculate savings for retrofits to an existing building.

Weather Data

The weather data for a location consists of hourly values of outside dry-bulb temperature, wet-bulb temperature, atmospheric pressure, wind speed and direction, cloud cover, and (in some cases) solar radiation. Weather data suitable for use in the program is produced by running the weather processor on raw weather files provided by the U.S. National Weather Service and other organizations. See “Weather Files” below.

Standard Library

The program comes with a library of input components. The elements in this library relevant to this document are wall materials, layered wall constructions, and windows. Other elements include HVAC performance curves, glass layers, between-glass gas fills, window blinds, pull-down shades, lamps, and luminaires.

User Library

The User Library contains building elements such as walls, windows, schedules, HVAC systems, etc., that you create.

Uses for the program

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

Energy Conservation Studies

- Effect of the thickness, order, type of materials, and orientation of exterior walls and roofs;
- Effect of thermal storage in walls and floors, and in energy storage tanks coupled to HVAC systems;
- Effect of occupant, lighting, and equipment schedules;
- Effect of intermittent operation, such as the shutdown of HVAC systems during the night, on weekends, holidays, or for any hour;
- Effect of reduction in minimum outside air requirements and the scheduled use of outside air for cooling;
- Effect of internal and external shading, tinted and reflective glass, and use of daylighting.

Building Design Studies

- Initial design selection of the basic elements of the building, primary and secondary HVAC systems, and energy source;
- During the design stage, evaluating specific design concepts such as system zoning, control strategies, and systems selection;

- During construction, evaluating contractor proposals for deviations from the construction plans and specifications;
- A base of comparison for monitoring the operation and maintenance of the finished building and systems;
- Analysis of existing buildings for cost-effective retrofits.

Validation of DOE-2

DOE-2 has been validated by comparing its results with thermal and energy use measurements on actual buildings and with calculations. Detailed information on some of the DOE-2 program validation efforts may be found in the following reports (available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161):

- *Comparison of DOE-2 with Measurements in the Pala Test Houses.* Lawrence Berkeley National Laboratory, Report No. LBL-37979, 1995.
- *DOE-2 Verification Project, Phase 1, Final Report.* Los Alamos National Laboratory, Report No. LA-10649-MS, 1986.
- *DOE-2 Verification Project, Phase 1, Interim Report.* Los Alamos National Laboratory, Report No. LA-8295-MS, 1981.

Input Hierarchy

The following flowchart shows schematically the recommended sequence in which the basic program commands should be entered. The chart also indicates the general flow of the hourly calculation loops performed by the programs.

Loads
TITLE RUN PERIOD DESIGN-DAY (for advanced users) SITE-PARAMETERS BUILD-PARAMETERS BUILDING-SHADES (for advanced users) MATERIALS, LAYERS and CONSTRUCTIONS GLASS-TYPES SCHEDULEs (people, lighting, fans, temperatures, etc.) FLOOR (specifies different floor heights and geometries) SPACES Lighting, people, equipment, infiltration data EXTERIOR-WALLS WINDOWS INTERIOR-WALLS UNDERGROUND-WALLS

There are very few changes in the LOADS input from previous program versions, except for the FLOOR command, the specification of lighting systems, and the specification of shapes for floors, spaces, and walls using polygons.

Meters
ELEC-METER, FUEL-METER, etc

The program defaults to a main electric meter and a natural gas fuel meter. You may use sub-meters if desired.

Pumps	
CHW-PUMP-1 = PUMP	\$CHW pump
CAP-CTRL	= VAR-SPEED-PUMP
TWR-PUMP-1 = PUMP	\$CW pump
CAP-CTRL	= ONE-SPEED-PUMP
HW-PUMP-1 = PUMP	\$HW pump
CAP-CTRL	= ONE-SPEED-PUMP ..

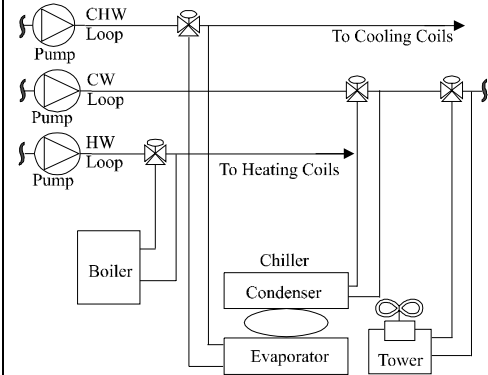
This shows one possible assignment of circulation loop pumps.

Circulation Loops

```

COOLING-WATER-1 = CIRCULATION-LOOP
  TYPE           = CHW
  LOOP-PUMP      = CHW-PUMP-1 ..
TOWER-WATER-1 = CIRCULATION-LOOP
  TYPE           = CW
  LOOP-PUMP      = CW-PUMP-1 ..
HOT-WATER-1 = CIRCULATION-LOOP
  TYPE           = HW
  LOOP-PUMP      = HW-PUMP-1 ..
  
```

As an example, input a chilled water, a condenser water, and a hot water circulation loop, with a pump for each loop.



Plant Equipment

```

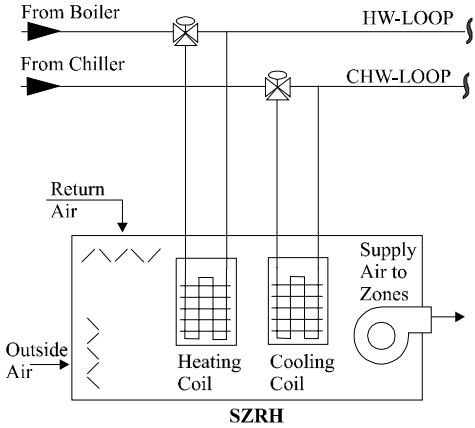
CHILLER-1 = CHILLER
  TYPE           = ELEC-HERM-CENT
  CONDENSER-TYPE = WATER-COOLED
  CHW-LOOP       = COOLING-WATER-1
  CW-LOOP        = TOWER-WATER-1
TOWER-1 = HEAT-REJECTION
  TYPE           = COOLING-TWR
  CW-LOOP        = TOWER-WATER-1
BOILER-1 = BOILER
  TYPE           = HW-BOILER
  HW-LOOP        = HOT-WATER-1 ..
  
```

Attach a chiller to both the CHW and CW loops and provide a cooling tower. For heating, attach a boiler to the HW loop.

Since the plant equipment capacities are not specified, the program will size the boiler, chiller, and tower based on non-coincident design coil capacities.

Air Systems		
SYS1 = SYSTEM		
TYPE	=	SZRH
CHW-LOOP	=	COOLING WTR-1
HEAT-SOURCE	=	HOT-WATER
HW-LOOP	=	HEATING-WTR-1
MAX-SUPPLY-T	=	105
MIN-SUPPLY-T	=	55
OA-CONTROL	=	TEMP
ECONO-LIMIT-T	=	70
FAN-SCHEDULE	=	FAN-SCH-1
CONTROL-ZONE	=	ZONE-1 ..

Air systems are defined after the plant equipment. They are also attached to the previously-defined circulation loops.



Zones		
ZONE-1 = ZONE		
DESIGN-HEAT-T	=	72
DESIGN-COOL-T	=	74
HEAT-TEMP-SCH	=	HT-SCH-1
COOL-TEMP-SCH	=	CT-SCH-1
OA-FLOW/PER	=	15
SPACE	=	(Loads space U-name)
ZONE-2 = ZONE		
LIKE		ZONE-1
etc...		

All of the zones that follow the input for a system are automatically attached to that system.

Additional Systems and Zones		
SYS-2 = SYSTEM		
etc.		
ZONE-3 = ZONE		

Additional systems followed by their zones can be inserted here. If a system is served by a dedicated chiller, a separate CHW circulation loop should be defined.

Economics
BLOCK-CHARGE _s SCHEULE _s UTILITY-RATE _s

The ECONOMICS input is the same as in previous versions with the exception of a few keywords.

Reports
LOADS-REPORT SYSTEMS-REPORT PLANT-REPORT ECONOMICS-REPORT

END ..
COMPUTE ..
STOP ..

A Simple Input/Output Example

As a quick introduction the following pages give the input and output for the simple, one-zone building shown in Figure 2. We recommend that you look at this example before proceeding with the rest of the manual.

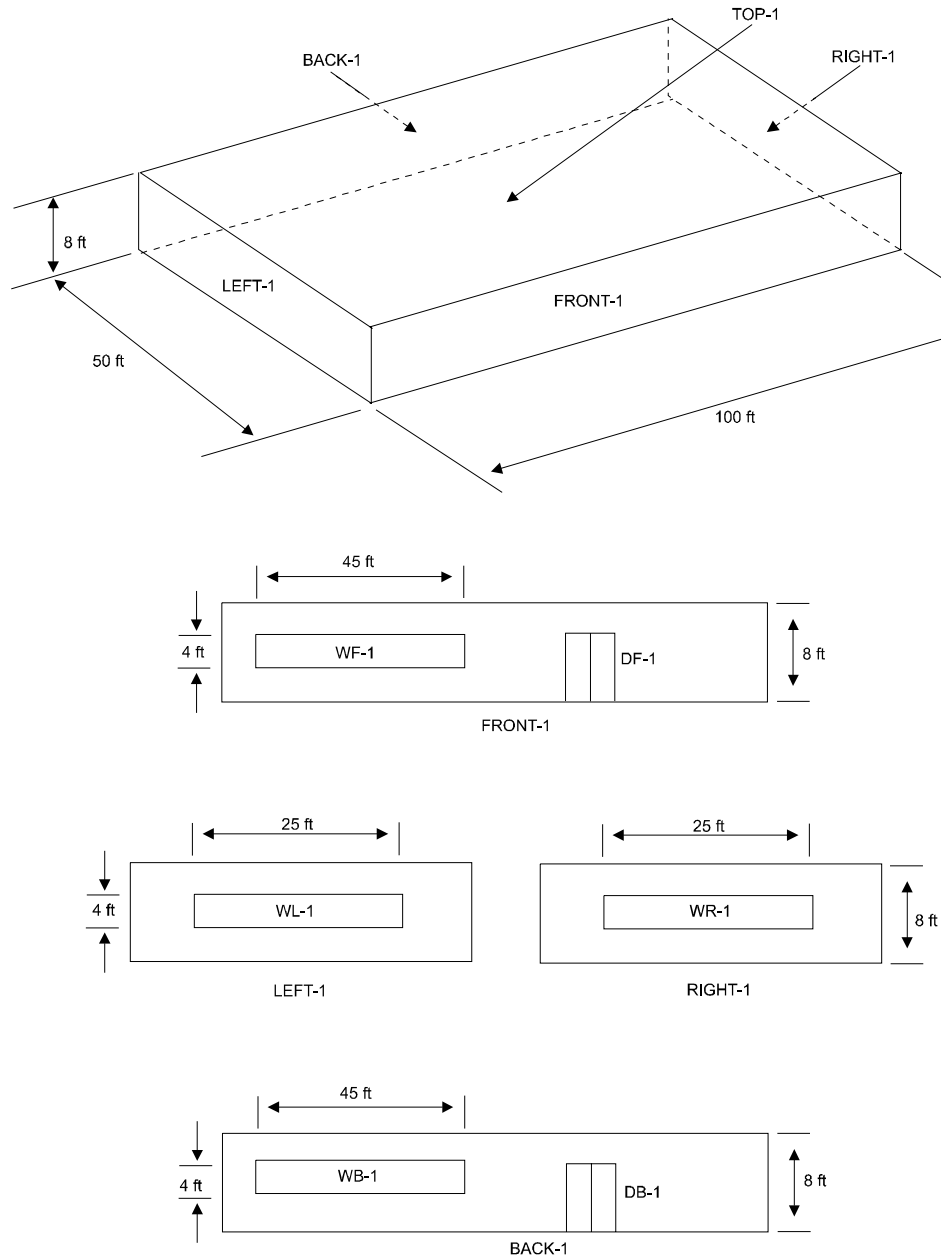


Figure 2 One zone example building
LEFT-1, FRONT-1, etc., are user-defined names

Sample Input (U-names are italicized)

INPUT ..


```

TITLE          LINE-1 = ONE-ZONE EXAMPLE FOR BASICS MANUAL* ..
RUN-PERIOD     JAN 1 1974 THRU DEC 31 1974 ..

ABORT          ERRORS   ..
DIAGNOSTIC     WARNINGS ..

SITE-PARAMETERS  $ CHICAGO ALTITUDE
                  ALTITUDE = 610 ..

                  $-----$
                  $   LOADS input   $
                  $-----$

                  $ CONSTRUCTIONS, USING MATERIALS FROM LIBRARY:

                  $ Exterior wall construction --
                  $ Wood, plywood, insulation, gypsum board

WA-1           =LAYERS    MATERIAL = ( "Wood Sft 3/4in (WD01)",
                                      "Plywd 1/2in (PW03)",
                                      "MinWool Batt R11 (IN02)",
                                      "GypBd 1/2in (GP01)" ) ..

WALL-1         =CONSTRUCTION  TYPE    = LAYERS
                  LAYERS    = WA-1 ..

                  $ Roof construction --
                  $ Gravel, built-up roofing, insulation, wood

RF-1         =LAYERS    MATERIAL = ( "Gravel 1/2in (RG01)",
                                      "Blt-Up Roof 3/8in (BR01)",
                                      "MinBd 1in R-3.5 (IN22)",
                                      "Wood Sft 3/4in (WD01)" )
                  INSIDE-FILM-RES = .76 ..

ROOF-1         =CONSTRUCTION  TYPE    = LAYERS
                  LAYERS    = RF-1 ..

                  $ Slab-on-grade construction --
                  $ fictitious insulation layer, soil, concrete.
                  $ See "Underground Surfaces" in the DOE-2.2 Topics
                  $ for instructions on how to choose the resistance
                  $ of the fictitious insulation layer, here called
                  $ INSUL-1.

INSUL-1        =MATERIAL  TYPE = RESISTANCE
                  RESISTANCE = 22.3 ..

"Soil 12in"    =MATERIAL  TYPE = PROPERTIES
                  THICKNESS    = 1.0
                  CONDUCTIVITY  = 0.5
                  DENSITY       = 100
                  SPECIFIC-HEAT = 0.25 ..

FL-1          =LAYERS    MATERIAL = ( INSUL-1,
                                      "Soil 12in",
                                      "Conc HW 140lb 4in (CC03)" )
                  INSIDE-FILM-RES = 0.77 ..

FLOOR-1       =CONSTRUCTION  TYPE    = LAYERS
                  LAYERS    = FL-1 ..

```

Used to label most pages of output

Comment lines start with \$. They are ignored by the program.

A building material code word selected from the DOE2 library

A user-chosen name (U-name) that is assigned, then referenced.

"Layers" type Constructions account for time lag due to the mass of the materials

```

$ Door construction

DOOR-1      =CONSTRUCTION      TYPE = U-VALUE
                                U-VALUE = .5 ..

$ GLASS TYPES, USING WINDOW CODES FROM LIBRARY:

$ Clear double glazing

WINDOW-1    =GLASS-TYPE        TYPE = GLASS-TYPE-CODE
                                GLASS-TYPE-CODE = 2000 ..

$ Tinted single glazing

G-DOOR      =GLASS-TYPE        TYPE = GLASS-TYPE-CODE
                                GLASS-TYPE-CODE = 1200 ..

$ LOADS SCHEDULES:

$ Occupancy schedule

OCCUPY-1    =SCHEDULE          TYPE = MULTIPLIER
                                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          TYPE = MULTIPLIER
                                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) (0.05) ..

$ Office equipment schedule

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

```

“U-Value” type Constructions ignore any time lag due to mass, i.e., treat all heat transfer as instantaneous

A glass type chosen from the DOE-2 library

Hours 1 to 8 (midnight to 8 am) are at zero occupancy

Hours 15 to 18 (2 pm to 6 pm) are at full occupancy

Monday through Friday

Weekends and holidays

There is infiltration only during the winter

BASICS

```

$ FLOOR DEFINITION:

OFFICE-FLOOR  =FLOOR ..

$ SPACE DEFINITION:

OFFSPACE-1    =SPACE          AREA = 5000          VOLUME = 40000
                                PEOPLE-SCHEDULE = OCCUPY-1
                                LIGHTING-SCHEDULE = LIGHTS-1
                                EQUIP-SCHEDULE   = EQUIP-1
                                LIGHTING-TYPE    = REC-FLUOR-RV
                                LIGHTING-W/AREA  = 1.5
                                EQUIPMENT-W/AREA = 1
                                AREA/PERSON     = 110
                                PEOPLE-HEAT-GAIN = 450
                                INF-METHOD      = AIR-CHANGE
                                INF-SCHEDULE     = INFIL-1
                                AIR-CHANGES/HR  = 0.6 ..

```

OVERVIEW

The hourly values in these schedules are used as multipliers for the lighting and equipment density inputs. DOE-2.2 can now accept lists for lighting and equipment schedules, up to 5 per zone, in which case, the schedule u-names are listed within parentheses.

Lighting type is Recessed Fluorescent, Return-Vented, selected from a list of lighting type options

Maximum lighting power density; multiplied each hour by the LIGHTS-1 schedule value. DOE-2.2 now accepts a list for lighting and equipment power densities (up to 5 per zone).

The previously-defined infiltration schedule is referenced here

Note the input hierarchy: space, then wall in that space, then window in that wall.

```

$ Walls, windows and doors

FRONT-1  =EXTERIOR-WALL  HEIGHT = 8          WIDTH = 100
                                AZIMUTH=180          TILT = 90
                                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          TILT = 90
                                CONSTRUCTION = WALL-1 ..

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

BACK-1   =EXTERIOR-WALL  HEIGHT = 8          WIDTH = 100
                                AZIMUTH = 0           TILT = 90
                                CONSTRUCTION = WALL-1 ..

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

DB-1     =DOOR           WIDTH = 8           HEIGHT = 7
                                CONSTRUCTION = DOOR-1 .. $ Wood door

LEFT-1   =EXTERIOR-WALL  HEIGHT = 8          WIDTH = 50
                                AZIMUTH = 270         TILT = 90
                                CONSTRUCTION = WALL-1 ..

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

TOP-1    =ROOF           HEIGHT = 50         WIDTH = 100
                                AZIMUTH = 180         TILT = 0
                                CONSTRUCTION = ROOF-1 ..

```

Clockwise angle between space Y-axis and horizontal projection of surface outward normal

Angle between surface outward normal and vertical

Copies the data from WF-1, except for width, and applies it to WB-1.

References a Construction defined previously

BASICS

OVERVIEW

```

BOTTOM-1      =UNDERGROUND-FLOOR  HEIGHT = 50          WIDTH = 100
                  TILT = 180
                  CONSTRUCTION = FLOOR-1  ..

LOADS-REPORT   SUMMARY = (LS-C) ..

$-----$
$   HVAC input   $
$-----$

$ METERS:

EM-1           =ELEC-METER          TYPE = UTILITY ..
FM-1           =FUEL-METER          TYPE = NATURAL-GAS ..

MASTER-METERS  MSTR-ELEC-METER = EM-1
                  MSTR-FUEL-METER = FM-1 ..

$ PUMPS AND CIRCULATION LOOPS:

CHWPUMP-1      =PUMP ..
CHWLOOP-1      =CIRCULATION-LOOP    TYPE           = CHW
                  LOOP-OPERATION = DEMAND
                  LOOP-PUMP       = CHWPUMP-1 ..

HWPUMP-1      =PUMP ..
HWLOOP-1      =CIRCULATION-LOOP    TYPE           = HW
                  LOOP-OPERATION = DEMAND
                  LOOP-PUMP       = HWPUMP-1 ..

DHWLOOP-1      =CIRCULATION-LOOP    TYPE           = DHW
                  PROCESS-FLOW = 0.222 $ GAL/MIN
                  PROCESS-SCH  = DHW-1
                  HEAT-SETPT-T = 120 ..

$ PRIMARY EQUIPMENT:

DHW-HEATER-1   =DW-HEATER  TYPE           = GAS
                  DHW-LOOP   = DHWLOOP-1 ..

BOILER-1       =BOILER     TYPE           = HW-BOILER
                  HW-LOOP    = HWLOOP-1 ..

CHILLER-1      =CHILLER    TYPE           = ELEC-HERM-REC
                  CHW-LOOP   = CHWLOOP-1
                  ELEC-INPUT-RATIO = 0.27
                  CONDENSER-TYPE = AIR-COOLED
                  AIR-COND-KW  = 0.04 .. $ Condenser fan kW per
                                      $ chiller output kW

PLANT-REPORT   VERIFICATION = (PV-A) SUMMARY = (BEPS) ..

$ HVAC SCHEDULES:

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

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

```

Selects one of several available LOADS summary reports for printing. LS-C is "Building Peak Load Components" See Appendix C for a complete list of these.

Note the HVAC input order: first meters, then pumps and circulation loops, then primary equipment (boilers, chillers, etc.), then secondary systems and zones.

Circulation loops connect HVAC components like chillers and cooling coils, boilers and heating coils

There is flow in the chilled-water circulation loop only when there is a cooling demand

In general, if no capacity is given, an HVAC component like a pump, coil, circulation loop, chiller, boiler, storage tank, cooling tower, etc. is automatically sized based on heating and cooling peaks calculated by the LOADS program.

Selects a PLANT verification report for printing. PV-A is "Plant Design Parameters"

BASICS

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```

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

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

$ AIR DISTRIBUTION SYSTEM:

AC-SYST        =SYSTEM      TYPE = SZRH
                CHW-LOOP    = CHWLOOP-1
                HW-LOOP     = HWLOOP-1
                HEAT-SOURCE = HOT-WATER
                MAX-SUPPLY-T = 110
                MIN-SUPPLY-T = 55
                NIGHT-CYCLE-CTRL = CYCLE-ON-FIRST
                FAN-SCHEDULE = FANS-ON-1
                DRY-BULB-LIMIT = 68
                OA-CONTROL   = TEMP
                CONTROL-ZONE = OFFZONE-1 ..

$ THERMAL ZONE SERVED BY THE SYSTEM:

OFFZONE-1      =ZONE        TYPE = CONDITIONED
                SPACE        = OFFSPACE-1
                DESIGN-HEAT-T = 72
                DESIGN-COOL-T = 74
                HEAT-TEMP-SCH = HEATSETPT-1
                COOL-TEMP-SCH = COOLSETPT-1
                OA-FLOW/PER   = 20 ..

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

$-----$
$    ECONOMICS input    $
$-----$

BLC            =BLOCK-CHARGE    BLOCK1-TYPE = ENERGY
                BLOCKS-1      = (800,1200,1)
                COSTS-1       = (0.075,0.095,0.10)
                LIMITS-1      = (0,0,0) ..

ELEC-RATE      =UTILITY-RATE    TYPE = ELECTRICITY
                ELEC-METERS   = EM-1
                BLOCK-CHARGES = BLC ..

GAS-RATE       =UTILITY-RATE    TYPE = NATURAL-GAS
                FUEL-METERS    = FM-1
                ENERGY-CHG    = 0.62 ..

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

END ..
COMPUTE ..
STOP ..

```

The thermostat setpoint for heating is 72F during the day and 55F at night

Note the input hierarchy: system followed by one or more zones attached to that

The circulation loops to which the coils in this system are attached.

Establishes a correspondence between this zone and a space defined in the LOADS input

Not the same as thermostat setpoints, rather, used as HVAC indoor design temperatures

The minimum ventilation rate expressed as CFM per person

Electricity costs \$0.075/kWh for first block of 800 kWh, \$0.095/kWh for second block of 400 kWh, and \$0.10/kWh above that

Natural gas has a flat rate of \$0.62/therm

Sample Output

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

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- LV-D Details of Exterior Surfaces in the Project

WEATHER FILE- TRY CHICAGO

NUMBER OF EXTERIOR SURFACES 5
(U-VALUE INCLUDES OUTSIDE AIR FILM; WINDOW INCLUDES FRAME, IF DEFINED)

“LV”=LOADS Verification report; “D” uniquely identifies this

SURFACE	- - - W I N D O W S - - -		- - - W A L L - - -		- W A L L + W I N D O W S -		AZIMUTH
	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	
BACK-1	0.518	100.00	0.067	700.00	0.123	800.00	NORTH
in space: OFFSPACE-1							
RIGHT-1	0.518	100.00	0.067	300.00	0.180	400.00	EAST
in space: OFFSPACE-1							
FRONT-1	0.611	236.00	0.067	564.00	0.228	800.00	SOUTH
in space: OFFSPACE-1							
LEFT-1	0.518	100.00	0.067	300.00	0.180	400.00	WEST
in space: OFFSPACE-1							
TOP-1	0.000	0.00	0.168	5000.00	0.168	5000.00	ROOF
in space: OFFSPACE-1							
BOTTOM-1	0.000	0.00	0.453	5000.00	0.453	5000.00	UNDERGRND
in space: OFFSPACE-1							
	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	0.518	0.067	0.123	100.00	700.00	800.00	
EAST	0.518	0.067	0.180	100.00	300.00	400.00	
SOUTH	0.611	0.067	0.228	236.00	564.00	800.00	
WEST	0.518	0.067	0.180	100.00	300.00	400.00	
ROOF	0.000	0.168	0.168	0.00	5000.00	5000.00	
ALL WALLS	0.559	0.067	0.177	536.00	1864.00	2400.00	
WALLS+ROOFS	0.559	0.141	0.171	536.00	6864.00	7400.00	
UNDERGRND	0.000	0.453	0.453	0.00	5000.00	5000.00	
BUILDING	0.559	0.272	0.284	536.00	11864.00	12400.00	

A verification report that summarizes your input for walls and windows

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- LS-C Building Peak Load Components

WEATHER FILE- TRY CHICAGO

*** BUILDING ***

"LS"=LOADS Summary report; reports LOADS simulation results

Building total conditioned area

FLOOR	AREA				
	5000	SQFT	465	M2	
VOLUME	40000	CUFT	1133	M3	

Date and time of peak

COOLING LOAD				HEATING LOAD			
JUL 9 4PM				JAN 12 8AM			
DRY-BULB TEMP	94 F	34 C		-7 F	-22 C		
WET-BULB TEMP	74 F	23 C		-7 F	-22 C		
TOT HORIZONTAL SOLAR RAD	227 BTU/H.SQFT	716 W/M2		3 BTU/H.SQFT	9 W/M2		
WINDSPEED AT SPACE	5.1 KTS	2.6 M/S		5.1 KTS	2.6 M/S		
CLOUD AMOUNT 0 (CLEAR) -10	4			0			

Ambient conditions at peak

	SENSIBLE (KBTU/H) (KW)		LATENT (KBTU/H) (KW)		SENSIBLE (KBTU/H) (KW)	
WALL CONDUCTION	3.636	1.065	0.000	0.000	-7.214	-2.114
ROOF CONDUCTION	45.768	13.410	0.000	0.000	-53.234	-15.598
WINDOW GLASS+FRM COND	7.424	2.175	0.000	0.000	-17.920	-5.250
WINDOW GLASS SOLAR	16.418	4.811	0.000	0.000	2.751	0.806
DOOR CONDUCTION	0.779	0.228	0.000	0.000	-1.425	-0.418
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-1.012	-0.297	0.000	0.000	-5.062	-1.483
OCCUPANTS TO SPACE	8.223	2.409	8.056	2.360	0.729	0.214
LIGHT TO SPACE	15.367	4.503	0.000	0.000	1.913	0.560
EQUIPMENT TO SPACE	8.889	2.604	0.000	0.000	1.060	0.311
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	105.492	30.909	8.056	2.360	-97.598	-28.596
TOTAL / AREA	0.021	0.067	0.002	0.005	-0.020	-0.062
TOTAL LOAD	113.549 KBTU/H	33.270 KW			-97.598 KBTU/H	-28.596 KW
TOTAL LOAD / AREA	22.71 BTU/H.SQFT	71.622 W/M2			19.520 BTU/H.SQFT	61.561 W/M2

**Building peak
sensible cooling
space load**

* NOTE 1) THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR *
 * --- LOADS *
 * 2) TIMES GIVEN IN STANDARD TIME FOR THE LOCATION *
 * IN CONSIDERATION *
 * 3) THE ABOVE LOADS ARE CALCULATED ASSUMING A *
 * CONSTANT INDOOR SPACE TEMPERATURE *
 * *****

**Roof conduction is
biggest contributor to
both peak cooling and
peak heating space
load**

Note that the LOADS portion of the simulation calculates space loads that

- 1) assume a single indoor space temperature (same for both heating and cooling), and
- 2) excludes other loads such as outside ventilation air, duct losses, and fan heat.

Systems reports include these additional air-side load components and reflect actual thermostat setpoints.

“SV”=SYSTEMS Verification report; verifies air-side inputs and design calculations

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- SV-A System Design Parameters for AC-SYST												WEATHER FILE- TRY CHICAGO	
SYSTEM TYPE	ALTITUDE FACTOR	FLOOR AREA (SQFT)	MAX PEOPLE	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)	HEAT PUMP SUPP-HEAT (KBTU/HR)			
SZRH	1.020	5000.0	45.	0.177	199.550	0.692	-287.667	0.000	0.000	0.000			
FAN TYPE	CAPACITY (CFM)	DIVERSITY FACTOR (FRAC)	POWER DEMAND (KW)	FAN DELTA-T (F)	STATIC PRESSURE (IN-WATER)	TOTAL EFF (FRAC)	MECH EFF (FRAC)	FAN PLACEMENT	FAN CONTROL	MAX FAN RATIO (FRAC)	MIN FAN RATIO (FRAC)		
SUPPLY	5244.	1.00	4.025	2.37	0.0	0.00	0.00	DRAW-THRU	CONSTANT	1.10	0.30		
ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW (FRAC)	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (FRAC)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	ZONE MULT		
OFFZONE-1	5244.	0.	0.000	1.000	927.	0.00	0.00	105.49	0.00	-210.98	1.		

System design
air flow

Zone design
air flow

Air handling unit
cooling coil capacity

ONE-ZONE EXAMPLE FOR BASICS MANUAL DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- SS-A System Loads Summary for AC-SYST WEATHER FILE- TRY CHICAGO

“SS”=SYSTEMS Summary report; reports air-side (Systems) simulation results

	- - 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	31 24	22.F	19.F	0.000	-38.085	7 8	-1.F	-1.F	-171.516	5526.	15.525		
FEB	0.00000	28 24	31.F	28.F	0.000	-31.332	4 8	7.F	6.F	-161.222	4797.	15.525		
MAR	0.00003	6 18	59.F	55.F	0.034	-17.482	25 8	14.F	12.F	-147.870	4698.	15.525		
APR	1.65997	26 15	78.F	61.F	91.920	-2.985	8 8	30.F	27.F	-91.055	3989.	15.525		
MAY	4.17762	21 14	85.F	75.F	141.416	-0.739	7 8	36.F	32.F	-65.882	3799.	15.525		
JUN	13.39427	20 16	90.F	77.F	164.142	-0.087	24 8	55.F	50.F	-18.831	3495.	15.525		
JUL	24.56191	9 16	94.F	74.F	165.977	-0.001	20 16	78.F	67.F	-1.046	4005.	15.525		
AUG	21.03436	19 16	90.F	71.F	149.108	-0.020	5 8	57.F	54.F	-10.296	3828.	15.525		
SEP	9.01822	11 15	87.F	72.F	135.076	-0.550	23 8	36.F	34.F	-77.973	3491.	15.525		
OCT	2.72604	30 14	76.F	67.F	75.208	-2.351	21 8	30.F	29.F	-96.362	3920.	15.525		
NOV	0.41117	1 15	71.F	59.F	66.998	-14.443	26 8	25.F	22.F	-114.633	4341.	15.525		
DEC	0.00000	31 24	33.F	33.F	0.000	-29.343	9 8	13.F	12.F	-144.856	5418.	15.525		
TOTAL	76.984					-137.418					51307.			
MAX					165.977					-171.516		15.525		

Total coiling coil load to be met by the chiller - includes all air-side loads (space loads plus outside ventilation air, duct losses, and fan heat) but excludes Plant loads such as piping losses and pump work

Maximum coiling coil load to be met by the chiller

Includes lights, plug loads, and fans

BASICS

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ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- SS-J Peak Heating and Cooling for AC-SYST

WEATHER FILE- TRY CHICAGO

- - - - C O O L I N G - - - -					- - - H E A T I N G - - -			D A Y C O O L I N G P E A K			
JUL 9					JAN 7			JUL 9			
HOURLY COOLING LOAD (KBTU)	SENSIBLE HEAT RATIO	DRY- BULB TEMP	WET- BULB TEMP		HOURLY HEATING LOAD (KBTU)	DRY- BULB TEMP	WET- BULB TEMP	HOURLY COOLING LOAD (KBTU)	SENSIBLE HEAT RATIO	DRY- BULB TEMP	WET- BULB TEMP
1	0.000	0.000	78.F	68.F	-97.017	6.F	6.F	0.000	0.000	78.F	68.F
2	0.000	0.000	76.F	68.F	-103.916	4.F	4.F	0.000	0.000	76.F	68.F
3	0.000	0.000	75.F	68.F	-108.002	2.F	2.F	0.000	0.000	75.F	68.F
4	0.000	0.000	73.F	67.F	-107.719	2.F	2.F	0.000	0.000	73.F	67.F
5	0.000	0.000	72.F	66.F	-113.506	2.F	2.F	0.000	0.000	72.F	66.F
6	0.000	0.000	71.F	65.F	-114.137	1.F	1.F	0.000	0.000	71.F	65.F
7	40.203	0.838	75.F	68.F	-113.388	0.F	0.F	40.203	0.838	75.F	68.F
8	96.682	0.764	77.F	69.F	-171.516	-1.F	-1.F	96.682	0.764	77.F	69.F
9	118.116	0.749	82.F	72.F	-138.170	0.F	0.F	118.116	0.749	82.F	72.F
10	135.985	0.747	85.F	74.F	-129.339	2.F	1.F	135.985	0.747	85.F	74.F
11	146.606	0.765	88.F	75.F	-110.646	4.F	3.F	146.606	0.765	88.F	75.F
12	151.564	0.781	91.F	76.F	-91.458	6.F	5.F	151.564	0.781	91.F	76.F
13	160.420	0.801	92.F	75.F	-85.622	8.F	6.F	160.420	0.801	92.F	75.F
14	156.704	0.847	91.F	72.F	-78.846	9.F	7.F	156.704	0.847	91.F	72.F
15	165.977	0.823	94.F	74.F	-70.706	10.F	8.F	165.977	0.823	94.F	74.F
16	157.163	0.844	95.F	73.F	-75.965	9.F	7.F	157.163	0.844	95.F	73.F
17	152.887	0.852	97.F	73.F	-92.928	8.F	6.F	152.887	0.852	97.F	73.F
18	0.000	0.000	96.F	73.F	-106.690	5.F	4.F	0.000	0.000	96.F	73.F
19	0.000	0.000	94.F	73.F	0.000	4.F	3.F	0.000	0.000	94.F	73.F
20	0.000	0.000	84.F	70.F	-62.976	2.F	1.F	0.000	0.000	84.F	70.F
21	0.000	0.000	78.F	70.F	-68.064	3.F	2.F	0.000	0.000	78.F	70.F
22	0.000	0.000	76.F	71.F	-74.240	4.F	3.F	0.000	0.000	76.F	71.F
23	0.000	0.000	70.F	67.F	-77.416	4.F	3.F	0.000	0.000	70.F	67.F
24	0.000	0.000	70.F	67.F	-78.468	5.F	4.F	0.000	0.000	70.F	67.F
SUM								1482.307			
MAX	165.977				-171.516						
SYSTEM-TYPE SZRH					SQFT/TON			361.5			
COOLING PEAK 33.20 (BTU/HR- SQFT)					HEATING PEAK -34.30 (BTU/HR- SQFT)						
SUPPLY AIR PEAK FLOW 1.05 (CFM/SQFT)					MIN-OA/PERSON 20.40 (CFM)						
OA FRAC AT CLG PEAK 0.177					OA FRAC AT HTG PEAK 0.177						

* ASTERISKS INDICATE HOURS LOADS NOT MET

Shows hourly profile for days with highest cooling demand, highest heating demand and highest integrated cooling load

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- PV-A Plant Design Parameters

WEATHER FILE- TRY CHICAGO

*** CIRCULATION LOOPS *** "PV"=PLANT Verification report; verifies water-side inputs and design calculations

HEATING CAPACITY (MBTU/HR)	COOLING CAPACITY (MBTU/HR)	LOOP FLOW (GAL/MIN)	TOTAL HEAD (FT)	SUPPLY UA PRODUCT (BTU/HR-F)	SUPPLY LOSS DT (F)	RETURN UA PRODUCT (BTU/HR-F)	RETURN LOSS DT (F)	LOOP VOLUME (GAL)	FLUID HEAT CAPACITY (BTU/LB-F)
CHWLOOP-1 0.000	0.202	39.9	56.6	0.0	0.00	0.0	0.00	59.8	1.00
HWLOOP-1 -0.287	0.000	14.4	36.6	0.0	0.00	0.0	0.00	21.6	1.00
DHWLOOP-1 -0.009	0.000	0.2	0.0	0.0	0.00	0.0	0.00	0.3	1.00

*** PUMPS ***

ATTACHED TO	FLOW (GAL/MIN)	HEAD (FT)	HEAD SETPOINT (FT)	CAPACITY CONTROL	POWER (KW)	MECHANICAL EFFICIENCY (FRAC)	MOTOR EFFICIENCY (FRAC)
CHWPUMP-1 CHWLOOP-1 PRIMARY LOOP	1 PUMP (s) 39.9	67.9	0.0	ONE-SPEED	0.828	0.770	0.800
HWPUMP-1 HWLOOP-1 PRIMARY LOOP	1 PUMP (s) 14.4	43.9	0.0	ONE-SPEED	0.234	0.770	0.660

*** PRIMARY EQUIPMENT ***

EQUIPMENT TYPE	ATTACHED TO	CAPACITY (MBTU/HR)	FLOW (GAL/MIN)	EIR (FRAC)	HIR (FRAC)	AUXILIARY (KW)
BOILER-1 HW-BOILER	HWLOOP-1	-0.287	14.3	0.000	1.250	0.000
CHILLER-1 ELEC-HERM-REC	CHWLOOP-1	0.202	40.3	0.270	0.000	0.000

*** DW-HEATERS ***

EQUIPMENT TYPE	ATTACHED TO	CAPACITY (MBTU/HR)	FLOW (GAL/MIN)	EIR (FRAC)	HIR (FRAC)	AUXILIARY (KW)	TANK (GAL)	TANK UA (BTU/HR-F)
GAS DW-HEATER	DHWLOOP-1	-0.009	0.2	0.000	1.370	0.000	30.0	9.00

Boiler capacity

Chiller capacity

Domestic hot water heater
capacity

BASICS

OVERVIEW

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- PS-B Utility and Fuel Use Summary

WEATHER FILE- TRY CHICAGO

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EM-1 ELECTRICITY													
KWH	5681.	4930.	4808.	4204.	4266.	4881.	6546.	5958.	4449.	4263.	4489.	5574.	60051.
MAX KW	15.8	15.8	15.8	24.8	28.0	30.4	31.1	29.9	28.6	23.4	23.0	15.8	31.1
DAY/HR	2/11	1/11	1/11	26/15	21/14	20/16	9/16	19/15	11/15	31/15	1/12	2/11	7/ 9
FM-1 NATURAL-GAS													
THERM	672.	561.	361.	99.	48.	27.	22.	23.	36.	80.	306.	557.	2792.
MAX THERM/HR	2.4	2.3	2.2	1.5	1.4	0.8	0.4	0.6	1.3	1.6	1.8	2.1	2.4
DAY/HR	7/ 8	4/ 8	25/ 8	8/ 8	6/ 8	24/ 8	20/16	5/ 8	23/ 8	21/ 8	26/ 8	9/ 8	1/ 7

Master fuel
meter

Master
electric meter

BASICS

OVERVIEW

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- BEPS Building Energy Performance

WEATHER FILE- TRY CHICAGO

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM-1 ELECTRICITY MBTU	74.7	0.0	35.9	0.0	24.8	0.0	5.0	64.4	0.0	0.0	0.0	0.0	205.0
FM-1 NATURAL-GAS MBTU	0.0	0.0	0.0	248.5	0.0	0.0	0.0	0.0	0.0	0.0	30.7	0.0	279.2
MBTU	74.7	0.0	35.9	248.5	24.8	0.0	5.0	64.4	0.0	0.0	30.7	0.0	484.1
TOTAL SITE ENERGY				484.11 MBTU	96.8 KBTU/SQFT-YR GROSS-AREA				96.8 KBTU/SQFT-YR NET-AREA				
TOTAL SOURCE ENERGY				894.01 MBTU	178.8 KBTU/SQFT-YR GROSS-AREA				178.8 KBTU/SQFT-YR NET-AREA				
PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.0													
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0													
NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.													

Lighting is highest
electrical end use

Space heating is highest
fuel end use

“ES-D”=ECONOMICS Summary report; reports Economics simulation results

ONE-ZONE EXAMPLE FOR BASICS MANUAL

DOE-2.2b-027 Tue Feb 3 13:07:01 1998BDL RUN 1

REPORT- ES-D Energy Cost Summary

WEATHER FILE- TRY CHICAGO

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE (\$)	VIRTUAL RATE (\$/UNIT)	RATE USED ALL YEAR?
ELEC-RATE	ELECTRICITY	EM-1	60051. KWH	5693.	0.0948	YES
GAS-RATE	NATURAL-GAS	FM-1	2792. THERM	1731.	0.6200	YES
				7424.		

ENERGY COST/GROSS BLDG AREA: 1.48
ENERGY COST/NET BLDG AREA: 1.48

Annual energy cost per unit
floor area

Energy charge divided by
metered energy use

Weather Files

Vendors of the program generally provide weather files for various locations. If your vendor cannot provide the weather file you need for a particular location, you can run the weather processor utility, which is provided with the program, to convert raw weather data into compatible weather files. Using the weather processor is described in the *DOE-2.2 Topics*. Weather data can be obtained from the following organizations:

Via website: The http://www.DOE2.com website offers a comprehensive set of weather files in most of the DOE-2 supported formats. These files can be downloaded at no cost.	
TMY data sets - download from the World Wide Web	TMY: http://oipea-www.rutgers.edu/TMY/tmy.html
TMY2 data sets and TMY2 User Manual - download from the World Wide Web	TMY2: http://redc.nrel.gov/solar/old_data/nsrdb/tmy2
TMY (Typical Meteorological Year) TRY (Test Reference Year)	National Climatic Data Center 151 Patton Avenue, #120 Asheville, NC 28801 Phone: (704) 271-4871 order / Fax 271-4876
CTZ (California Thermal Climate Zones)	California Energy Commission Bruce Maeda, MS- 251516-9th Street Sacramento, CA 95814-55121- 800-772-3300 Energy Hotline
WYEC (Weather Year for Energy Calculation)	ASHRAE 1791 Tullie Circle N.E. Atlanta, GA 30329 Phone: (404) 636-8400 / Fax: (404) 321-5478
Comprehensive collection of TRY, TMY and CTZ weather file libraries, from NCDC, which can be used on all PC versions of the program. Includes original source data and pre-formatted packed versions on a single IBM format CD. Individual sites available.	Jenny Latham or Martyn Dodd EnergySoft 100 Galli Drive, Suite 1 Novato, CA 94949 Phone: (800) 467-4738 Fax: (415) 883-5970
European Weather Files	Andre Dewint Alpha Pi, s.a. rue de Livourne 103/12B-1050 BRUXELLES, Belgium Phone: 32-2-649-8359 / Fax: 32-2-649-9437
Canadian Weather Files in WYEC2 Format [Note: the original long-term data sets, up to 40 years of data, from which the CWEC files were derived can also be obtained directly from Environment Canada. Contact Mr. Robert Morris at (416) 739-4361.]	Dr. Didier Thevenard Watsun Simulation Lab University of Waterloo Waterloo, Ont., N2L-3G1 Canada Phone: (519) 888-4904 / Fax: (519) 888-6197 watsun@helix.watstar.uwaterloo.ca

Building Description Language

In this section we describe the basic rules of the Building Description Language (BDL)¹, which is the language you use to input information about a building so that the program can simulate it. To help understand what follows, we recommend that you refer to the one-zone input example in the Introduction section.

The BDL Instruction

The primary element of BDL is the instruction, which corresponds roughly to a sentence. An instruction always includes a command that specifies the subject matter, generally a building component like EXTERIOR-WALL or CHILLER. It usually contains keywords and their values, and always ends with a terminator. It may contain a user-defined name for identification. An example is the BDL instruction that defines a window:

```
WIN-1 = WINDOW
      X           = 10
      Y           = 4
      HEIGHT      = 5
      WIDTH       = 15
      GLASS-TYPE   = GT-1 ..
```

Here, the command is WINDOW, the user-defined name is WIN-1, and the keywords are X, Y, HEIGHT, WIDTH, and GLASS-TYPE.

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 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 in almost 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 will result.

¹ In this manual, “BDL” refers to the input language itself as well as the processor that reads your input and translates it into a form that is usable by the simulation subprograms.

INPUT Command

Your first line of input should be the INPUT instruction, which tells BDL that input data follow. For example:

```
INPUT  ..
```

END Command

END tells BDL that the input data is complete. The lines between INPUT and END must contain all data needed to perform the simulation.

COMPUTE Command

COMPUTE requests that a simulation be performed using input data between the previous INPUT and END commands.

Keywords

The data for an instruction is entered using keywords. Keywords always appear in the form keyword=value or keyword=(a list of values), where you specify a value or list of values. For example, the SITE-PARAMETERS command tells BDL that the data to follow give the building's location, time zone, and orientation:

```
SITE-PARAMETERS
  LATITUDE           = 42
  LONGITUDE          = 88
  ALTITUDE           = 610
  TIME-ZONE          = 6
  AZIMUTH            = 0
  DAYLIGHT-SAVINGS   = YES
  ..
```

In this example there are six keyword=value pairs: LATITUDE=42, LONGITUDE=88, ALTITUDE=610, TIME-ZONE=6, AZIMUTH=0, and DAYLIGHT-SAVINGS=YES. Most keywords, like LATITUDE, accept numeric values. Other keywords, like DAYLIGHT-SAVINGS, accept code-words, such as YES or NO, as values.

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.

U-names and Referenced Commands

Some keywords take values that are user-defined names, called U-names. U-names allow previously-defined commands to be referenced, allowing data from one instruction to be used in one or more subsequent instructions. U-names are also used to identify building elements in output reports.

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,
                          "Stucco 1in (SC01)",
                          "Plywd 1/2in (PW03)",
                          "MinWool Batt R11 (IN02)",
                          "GypBd 1/2in (GP01)" ..
```

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

```
WALL-1 = CONSTRUCTION
      TYPE          = LAYERS
      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
      ..
```

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). However, there are some commands, like `SITE-PARAMETERS`, that cannot have U-names.

Choosing U-names

In the example above, the command `EXTERIOR-WALL` has been given a U-name, `FRONT-1`. The U-name is optional for this command. However, there are reasons for U-naming specific walls, windows and the like. The first is that many of the output reports refer to specific building components. Unless the various components have U-names, it is difficult to tell which wall, for example, is being described. Another reason to assign U-names is to use 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 32 or fewer characters that are different from all commands, keywords and code-words or their corresponding abbreviations. If the U-name has embedded spaces, it should be enclosed in quotes. Thus, FRONT-1 and "FRONT 1" are both valid U-names. U-names may contain a mixture of upper and lower case letters. Thus, FRONT-1, Front-1, and front-1 are allowed, but will be considered by BDL to be different U-names.

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. The LIKE 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, that has the same height and glass type as WF-1:

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

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 your input after an absence, in which case you 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
      TYPE           = LAYERS
      LAYERS         = RB-1-1   $BUILT-UP ROOF$
      ..
```

A comment that spans several lines must have \$ at the beginning of each line of comment.

Input Styles

The program allows you to format your input with a text editor in a way that makes it most readable to you and others. Following are examples of different ways of formatting the input for a SPACE command.

```

OFFICE = SPACE
  AREA                = 1000.
  PEOPLE-SCHEDULE     = OCCUPY-1
  AREA/PERSON         = 110
  LIGHTING-SCHEDULE   = LIGHTS-1
  LIGHTING-W/AREA     = 1.5
  ..

OFFICE = SPACE  AREA                1000
                PEOPLE-SCHEDULE     OCCUPY-1
                AREA/PERSON         110
                LIGHTING-SCHEDULE   LIGHTS-1
                LIGHTING-W/AREA     1.5  ..

OFFIC=SPACE
  AREA=1000
  PEOPLE-SCHEDULE=OCCUPY-1  AREA/PERSON=110
  LIGHTING-SCHEDULE=LIGHTS-1  LIGHTING-W/AREA=1.5  ..

```

This manual most commonly uses the first structure, as this is similar to the BDL generated by PowerDOE and eQUEST.

INPUT COMMAND

The input data for the program begins with the instruction:

```
INPUT  . .
```

or

```
INPUT FOR DOE-2  . .
```

The INPUT command has two keywords, INPUT-UNITS and OUTPUT-UNITS, that specify the units for input and output, respectively. The default is English input and output. For metric input and output, specify INPUT-UNITS=METRIC and OUTPUT-UNITS=METRIC. It is also possible to have English input and metric output and vice-versa. For example, INPUT-UNITS=ENGLISH, OUTPUT-UNITS=METRIC.

TITLE COMMAND

Used to describe up to five lines of title information to be placed at the top of each output report page.

The instruction has the form

```
TITLE
  LINE-1      = *text for first line*
  LINE-2      = *text for second line*
  LINE-3      = *text for second line*
  LINE-4      = *text for second line*
  LINE-5      = *text for fifth line*
  ..
```

The text between the asterisks can be anything you want but must be 40 characters or less.

Example input:

```
TITLE
  LINE-1      = *30-story office building*
  LINE-2      = *Chicago, IL* ..
```

DIAGNOSTIC COMMAND

Used to choose options for printing diagnostic messages. The instruction has the form

```
DIAGNOSTIC option ..
```

where option is one or more code-words, as follows.

ERRORS	Only error messages are printed
WARNINGS	Only warning and error messages are printed.
CAUTIONS	Error, warning, and caution messages are printed.
DEFAULTS	Same as CAUTIONS, plus all default values used by the program are printed.
COMMENTS	Same as DEFAULTS, plus additional information such as conduction response factors or curve-fit coefficients calculated by the program.

Example input:

To print only error messages, use

```
DIAGNOSTIC ERRORS ..
```

To print error, warning, and caution messages, and also print default values for unspecified keyword inputs, use

```
DIAGNOSTIC DEFAULTS ..
```

ABORT COMMAND

Specifies what level of diagnostic is fatal enough to prevent execution of the simulation. The instruction has the form

```
ABORT    level    ..
```

Where level is one of the following code-words

ERRORS	Error messages are fatal.
WARNINGS	Error and warning messages are fatal.
CAUTIONS	Error, warning, and caution messages are fatal.

Example input:

To prevent execution when there are input errors, but not if there are warning or caution messages, use

```
ABORT  ERRORS  ..
```

RUN-PERIOD COMMAND

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 code-words that specify the names of the months are given below. The final date is the last simulation date, specified in the same manner as the initial date. U-name is not allowed.

The code-words for the months are:

JAN FEB MAR APR MAY JUN

JUL AUG SEP OCT NOV DEC

Example input: This instruction would run the program for one year:

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

Rules

1. The initial and final dates specified in any one run must all be in the same year. The final date must be equal to or later than the initial date.
2. The day number cannot be greater than the number of days in the month associated with that date. For example, SEP 31 1978 is not valid.
3. 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 file assume a 365 day year; for leap years, February 29 is ignored.

SCHEDULES

Describes schedules, which are hourly profiles of such quantities as lighting power, occupancy, and thermostat setpoint. The format of schedules is the same in LOADS, HVAC, and ECON input.

The SCHEDULE command references two related commands, DAY-SCHEDULE, which defines the hourly profile for a particular type of day (such as weekday, weekend day, or holiday), and WEEK-SCHEDULE, which defines what day schedules make up a weekly schedule. The following describes DAY-SCHEDULE and WEEK-SCHEDULE, then shows how SCHEDULEs are built up from WEEK-SCHEDULEs and how WEEK-SCHEDULEs are built up from DAY SCHEDULEs.

DAY-SCHEDULE

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

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

Example input:

```
LTG-1 = DAY-SCHEDULE
      TYPE = FRACTION
      (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) ..
```

which is representative of a week-day daily profile. Optionally, clarity can be improved by writing

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

Hour 1 is midnight to 1 am, hour 2 is 1 am to 2 am, etc. For example, (12,18) (1) (19,24) (0), above, means that the lights are fully on from 11 am to 6 pm and fully off from 6 pm to midnight.

In these examples, TYPE=FRACTION indicates that the schedule value is a fraction of design value, some quantity, such as design lighting power density. Other schedule types are possible, e.g. TYPE=TEMPERATURE, ON/OFF, etc.

In the following, let's assume that the day schedule for week-ends and holidays looks like:

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

Next we show how day schedules can be combined into week schedules.

WEEK-SCHEDULE

So far we have two DAY-SCHEDULEs -- LTG-1 represents week-days and LTG-2 represents week-ends and holidays. The form of the WEEK-SCHEDULE is:

```
U-NAME = WEEK-SCHEDULE
      (days of week covered) (U-name of DAY-SCHEDULE) .
```

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
      TYPE = FRACTION
      (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.

Next we combine different WEEK-SCHEDULEs into a schedule that covers the entire year.

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
      TYPE = FRACTION
      (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:

```
U-NAME = SCHEDULE
      TYPE = FRACTION
      THRU (calendar period covered) (U-name of WEEK-SCHEDULE)
```

To finalize the example:

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

Nesting of Schedules

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
      TYPE              = FRACTION
      THRU JUN 10      (WD)  LTG-1  (WEH)  LTG-2
      THRU SEP  5      (ALL) LTG-2
      THRU DEC 31      (WD)  LTG-1  (WEH)  LTG-2  ..

```

Envelope Components

The LOADS section of the simulation engine calculates the heating and cooling loads of each space in a building. 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.

In the LOADS 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 amount of heat that must be added to or removed from the space's air to maintain a constant air temperature.

The 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.

SITE-PARAMETERS

This command specifies information about the site on which the building is located.

Rules

1. One, and only one, SITE-PARAMETERS instruction must be entered. 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 input: The data entry below describes a building in Los Alamos, New Mexico. Daylight saving time and national holidays are in effect.

```

SITE-PARAMETERS
  LATITUDE           = 35.8
  LONGITUDE          = 106.3
  ALTITUDE           = 7200
  TIME-ZONE          = 7
  GROUND-T           = (45, 45, 45, 50, 50, 55, 55, 55, 55, 50, 50, 45)
  ..

```

LATITUDE

Angular distance in degrees from the plane of the equator to the origin of the building coordinate system.

Latitudes in the northern hemisphere are specified as positive degrees, and in the southern hemisphere as negative degrees. The default value is taken from the weather file.

LONGITUDE

Angular distance in degrees from the prime (Greenwich) meridian to the origin of the building coordinate system. Longitudes between Greenwich and International date lines are positive for the Americas and negative for Europe and Asia degrees. The default value is taken from the weather file.

ALTITUDE

Distance of the origin of the building coordinate system above mean sea level. If you want to input air flow rates instead of having the program adjust them for altitude, ALTITUDE should be set to zero, although this is not recommended.

TIME-ZONE

Specifies the time zone for a building location as the number of time zones, each one hour from the next, starting at Greenwich. 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. The default value is taken from the weather file.

The TIME-ZONE values for the United States are listed in Table 1:

Table 1 United States Times Zones

Region	TIME-ZONE
Atlantic	4
Eastern	5
Central	6
Mountain	7
Pacific	8
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. In the program, the clock time is moved forward on the first Sunday of April, and back again the last Sunday of October. Note that times shown on the output reports are always in local standard time, regardless of the input for this keyword.

YES Invokes a clock adjustment of one hour in the spring and again in the fall.

NO Disables daylight savings.

GROUND-T

Takes a list of 12 local mean ground temperatures, one for each month. Default values are taken from weather file. It is recommended that the weather file values be used; i.e., that GROUND-T not be specified.

BUILD-PARAMETERS

Specifies the location, orientation, and other miscellaneous information about the building.

At most, one BUILD-PARAMETERS instruction should be entered. It should be input before any commands that describe the building or anything associated with it (e.g., SPACE or CONSTRUCTION).

Example input: The following describes a building facing southeast with a gross area of 10500 ft².

```
BUILD-PARAMETER
  AZIMUTH           = -45          (or 315)
  GROSS-AREA        = 10500       (optional)
  ..
```

AZIMUTH

Orients the building relative to true north. This entry is the angle between true north and the y-axis of the building (see Figure 3). The azimuth is expressed in degrees from 0 to 360 (clock-wise as seen from above) or 0 to -360 (counterclockwise as seen from above). Changing this angle has the effect of rotating the building about its z-axis (vertical axis).

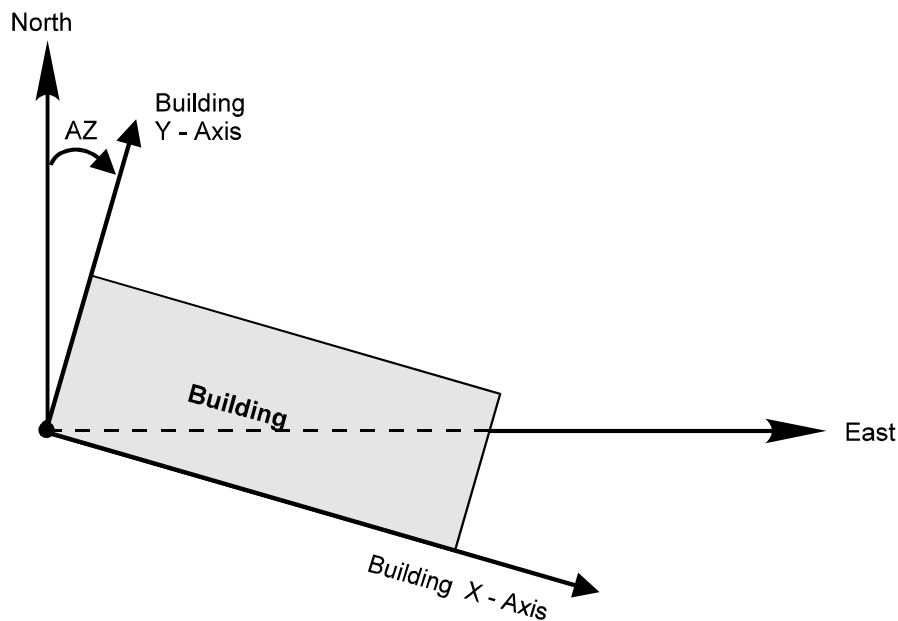


Figure 3 Orienting the Building

GROSS-AREA

Gross floor area (outside dimensions) of all of the spaces in the building. This keyword is used only for the BEPS (Building Energy Performance Summary) Report. Defaults to net area; i.e., the sum of areas of all conditioned SPACES.

HOLIDAYS

Accepts the U-name of a HOLIDAYS command.

HOLIDAYS = US references a library entry giving official United States holidays. This is also the default.

Table 2 Official United States National Holidays

Holiday Name	Holiday is Celebrated on this Day
New Years Day	December 31 if a Friday January 1 (unless on Saturday or Sunday) January 2 if a Monday
M.L. King Birthday	Third Monday in January
Washington's Birthday	Third Monday in February
Memorial Day	Last Monday in May
Fourth of July	July 3 if a Friday July 4 (unless on Saturday or Sunday) July 5 if a Monday
Labor Day	First Monday in September
Columbus Day	Second Monday in October
Veterans Day	November 10 if a Friday November 11 (unless on Saturday or Sunday) November 12 if a Monday
Thanksgiving	Fourth Thursday in November
Christmas	December 24 if a Friday December 25 (unless on Saturday or Sunday) December 26 if a Monday

LAYERS

Specifies the layers of material that are in a construction, the order of the layers, and the layer thicknesses. It initiates the calculation of response factors for the wall. The LIKE keyword is not allowed. U-name must be used so that LAYERS may be referenced in a CONSTRUCTION instruction. The program's Library contains pre-assembled layers for exterior walls, roofs, and interior walls (see Appendix B, "Constructions" in the *DOE-2.2 Libraries & Reports*).

Example input: One-ft-thick concrete block with a 1-inch-thick stucco exterior

```
CBLOCK = LAYERS      $from the library$
      MATERIAL      = "Stucco 1in (SC01) ",
                    "CMU HW 12in ConcFill CB17) "
      THICKNESS      = (0.0625, 1.00) ..
```

MATERIAL

Takes a list of material code-words from the Library. The number of elements in the list is the number of layers in the construction. For an exterior wall, the elements in the list start with the exterior layer and end with the interior layer. Reversing this sequence can notably affect the thermal performance of a wall. Do not specify inside or outside air film as a material. See Appendix A, "Materials Library" in the *DOE-2.2 Libraries & Reports*.

THICKNESS

Takes a list of the thickness of each material in the construction; overrides the thickness in the immediately preceding MATERIAL list. The order of the THICKNESS list must correspond to the order of the MATERIAL list. THICKNESS is required only if one or more of the materials has a thickness that is different from the library value.

INSIDE-FILM-RES

Specifies the combined convective and radiative air film resistance for the inside wall surface. The default of 0.68 hr-ft²-F/Btu (0.1198 m²-K/W) 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.

For radiant barriers having a low-emissivity surface (for example, aluminum foil, aluminum coated paper or insulation with aluminum coating) facing the interior of the space, an INSIDE-FILM-RES value in the E = 0.50 column of the table should be chosen.

If you cannot decide which is more important, cooling or heating, you can use the average of the heating and cooling values. For exterior walls and roofs, the outside-film-resistance is calculated by the program depending on wind speed. 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 of an INTERIOR-WALL, the INSIDE-FILM-RES is duplicated on the other surface (opposite side).

Table 3
 INSIDE-FILM-RES values for position of surface, direction of heat flow and insidesurface emissivity.

Position of surface	Direction of heat flow	Surface emissivity		
		0.90*	0.20**	0.05***
<i>Ceiling in the heating mode or Floor in the cooling mode</i>				
Horizontal	Up	0.61 (0.11)	1.10 (0.19)	1.32 (0.23)
45(slope	Up	0.62 (0.11)	1.14 (0.20)	1.37 (0.24)
Vertical	Horizontal	0.68 (0.12)	1.35 (0.24)	1.70 (0.30)
45(slope	Down	0.76 (0.13)	1.67 (0.29)	2.22 (0.39)
<i>Ceiling in the cooling mode or Floor in the heating mode</i>				
Horizontal	Down	0.92 (0.16)	2.70 (0.48)	4.55 (0.80)
*Regular building materials: wood, masonry, non-metallic paints, paper				
**Polished aluminum coated paper, for example				
***Bright aluminum foil, for example				
From 1997 ASHRAE Fundamentals, p.24.2				

Table 4 IR Emissivity of Different Interior Surfaces

Surface	Emissivity
Aluminum foil, bright	0.05
Aluminum sheet	0.12
Aluminum coated paper, polished	0.20
Steel, galvanized, bright	0.25
Aluminum paint	0.50
Regular glass	0.84
Building materials (wood, masonry, non-metallic paints)	0.90
<i>From 1997 ASHRAE Fundamentals, p.24.2</i>	

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 wind speed.
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. For an UNDERGROUND-FLOOR or UNDERGROUND-WALL, the lists start with the layer in contact with the ground. For an INTERIOR-WALL, the lists start with the layer in contact with the air of the space adjacent to the space in which the INTERIOR-WALL is defined.
6. Maximum list length for MATERIAL and THICKNESS is 9 elements each. Not all LAYERS can be specified by RESISTANCE (for MATERIAL) only. At least one must be specified as a transient type layer.

CONSTRUCTION

Specifies 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 used so that the CONSTRUCTION may be referenced in a subsequent EXTERIOR-WALL, ROOF, INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR, or DOOR. LIKE may be used to copy a similar CONSTRUCTION.

Example inputs:

1. An exterior wall is constructed of heavyweight concrete block with stucco exterior. Here, CBLOCK is the U-name of a previously defined LAYERS instruction (see "LAYERS Command").

```
HEAVY = CONSTRUCTION
  TYPE           = LAYERS
  LAYERS          = CBLOCK
  ABSORPTANCE    = 0.65
  ROUGHNESS      = 1 ..
```

2. An interior wall is light wood framing with drywall finish.

```
LIGHT = CONSTRUCTION
  TYPE           = U-VALUE
  U-VALUE        = 0.306 ..
```

3. Concrete with interior insulation from the Library (originally from ASHRAE).

```
WALL-1 = CONSTRUCTION
  LAYERS          = "ASH Wall-74 lay"
  ABSORPTANCE    = 0.88
  ROUGHNESS      = 2 ..
```

TYPE

Specifies the type of construction.

LAYERS	Indicates that the LAYERS keyword will be used to specify a layered construction. The program will calculate response factors for this construction. The response factors will be used in the hourly simulation to calculate the dynamic, time-delayed heat flow through the construction. Recommended for all but lightweight (low heat capacity) constructions.
U-VALUE	Indicates that the U-VALUE keyword will be used to specify the conductance of the construction. In this case, the heat flow through the construction will be considered to be instantaneous, i.e., without time delay. Recommended only for lightweight (low heat capacity) constructions.

LAYERS

Required when TYPE=LAYERS. Takes the U-name of a previously defined LAYERS instruction or a layers code-word from the Library (see Appendix B, "Constructions" in the *DOE-2.2 Libraries & Reports*).

U-VALUE

Required when TYPE=U-VALUE. For exterior surfaces, equals the overall conductance of the surface including the inside air film but excluding the outside air film. For INTERIOR-WALLS, includes the air film on both sides of the wall. For UNDERGROUND-WALLS and UNDERGROUND-FLOORS, includes the inside air film. The following table shows typical U-Values for some lightweight walls.

Table 5 Example U-Values for Lightweight Construction

Construction	U-value	
	Btu/h-ft ² -F	W/m ² -K
Exterior Walls (includes inside surface air film)		
Wood sheathing, 1/2" on studs, 1/2" gypsum board	0.35	1.99
Metal siding on 1/2" plywood studs, 1/2" gypsum board	0.38	2.16
Stucco on 3/4" pine studs, 1/2" gypsum board	0.34	1.93
Roofs (includes inside surface air film)		
Wood shingles on 1/2" plywood, 2"x8" studs, 1/2" gypsum board	0.28	1.59
Built-up roof on plywood deck, 2"x8" studs, 1/2" gypsum board with acoustical tile	0.27	1.53
Interior Walls and Floors (includes air film on both sides)		
Gypsum board, 1/2", on either side of metal studs	0.32	1.82
Hardwood floor on 1/2" deck, 2" x 8" floor joists, subfloor, tile (ceiling to space below)	0.20	1.13

Slab doors are also defined as a CONSTRUCTION with TYPE = U-VALUE. The table below gives some typical U-values for doors.

Table 6 Example U-Values for Lightweight Construction
 U-values shown in Btu/h-ft²-F and, in parentheses, W/m²-K

	No Storm Door	Storm Door with Wood	Storm Door with Metal
Solid Wood Door			
1.0 in (2.5 cm)	0.64 (3.63)	0.30 (1.70)	0.39 (2.21)
1.25 in (3.2 cm)	0.55 (3.12)	0.28 (1.59)	0.34 (1.93)
1.5 in (3.8 cm)	0.49 (2.78)	0.27 (1.53)	0.33 (1.87)
2.0 in (5.1 cm)	0.43 (2.44)	0.24 (1.36)	0.29 (1.65)
Steel Door [1.75 in (4.4 cm) thick]			
Mineral fiber core	0.59 (3.35)		
Urethane core	0.19 (1.08)		
Polystyrene core	0.47 (2.67)		

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 for INTERIOR-WALL, UNDERGROUND-WALL, or UNDERGROUND-FLOOR. Typical ABSORPTANCE values are given in the following table.

Table 7 Solar Absorptance of Exterior Surfaces*

Material	Absorptance	Paint	Absorptance
Aluminum, polished refl 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

*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

Takes a code-number that indicates the relative roughness of the exterior surface finish of an EXTERIOR-WALL or ROOF. This keyword is not appropriate for INTERIOR-WALL, UNDERGROUND-WALL, or UNDERGROUND-FLOOR. The code-numbers are given below.

Table 8 Roughness Codes

Wall Finish	Roof Finish	Code number
Stucco	Wood shingles or built-up roof with stones	1
Brick or Plaster		2
Concrete (poured)	Asphalt shingles	3 (default)
Clear pine		4
Smooth plaster	Metal	5
Glass or Paint on Pine		6

GLASS-TYPE

Specifies the type of glass in a window. U-name must be used so that GLASS-TYPE may be referenced in a WINDOW instruction. LIKE may be used to copy a previously defined GLASS-TYPE.

Example input:

```
GT-1 = GLASS-TYPE
      TYPE           = GLASS-TYPE-CODE
      GLASS-TYPE-CODE = 2000 ..
```

The program's Library has about 200 window entries. The choices are shown in Appendix C, "Windows" in the *DOE-2.2 Libraries & Reports*. Included are single-, double-, triple- and quadruple-pane glazings with different tints, coatings, gas fills, glass thicknesses, and gap widths.

You select a window from the library by specifying GLASS-TYPE-CODE to be one of the values indicated by G-T-C in Appendix C in the *DOE-2.2 Libraries & Reports*. In the following example we have selected low-E clear double-pane glazing with 6mm glass and 12mm gap filled with argon (G-T-C number 2635).

```
GT-2 = GLASS-TYPE
      TYPE           = GLASS-TYPE-CODE
      GLASS-TYPE-CODE = 2635 ..

WIN-1 = WINDOW
      X              = 12
      Y              = 3
      HEIGHT         = 4
      WIDTH          = 5
      GLASS-TYPE     = GT-2 ..
```

TYPE

You can find the best GLASS-TYPE-CODE for a particular glazing product by matching the number of panes, glass thickness, gap width, tint, coating, and gas fill from the manufacturer's data sheet with the corresponding information in Appendix C. in the *DOE-2.2 Libraries & Reports*. Manufacturer's values for shading coefficient, transmittance, and reflectance can be used to check your selection.

SPACE

Specifies information associated with a space. U-name must be used to identify the space so that it can be referenced by the SPACE keyword in the ZONE command, and for use in output reports. LIKE may be used to copy data from a previously U-named SPACE instruction. LIKE only copies the SPACE instruction and does not carry with it walls, roof, or floors.

This component defines the internal loads such as people, lighting, equipment and process loads, infiltration, zone type and loads calculation temperatures for the space. 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.

Example input:

```
OFFICE = SPACE
  AZIMUTH           = 0.
  AREA              = 800.
  VOLUME            = 6400.
  PEOPLE-SCHEDULE   = MANHR-1
  NUMBER-OF-PEOPLE  = 6
  PEOPLE-HG-LAT     = 200
  PEOPLE-HG-SENS    = 250
  LIGHTING-SCHEDULE = HILITE
  LIGHTING-TYPE     = SUS-FLUOR
  LIGHTING-W/AREA   = 2
  LIGHT-TO-SPACE    = 1.0
  TASK-LIGHT-SCHED  = LOLITE-1
  TASK-LIGHTING-KW  = 0.3
  EQUIP-SCHEDULE    = MOTOR-1
  EQUIPMENT-KW      = 0.75
  EQUIP-SENSIBLE    = 0.2
  INF-METHOD       = AIR-CHANGE
  AIR-CHANGES/HR   = 2.
  ZONE-TYPE         = CONDITIONED ..
```

Space Coordinates

The following keywords define the shape and orientation of the space within the building

AREA

Floor area of the space. This keyword is required.

VOLUME

Space air volume, used to calculate the infiltration rate by the air-change method. This keyword is required.

X

Y

Z

X, Y, and Z are the coordinates of the origin of the space in the building coordinate system. See Figure 4.

AZIMUTH

The clockwise angle between the building Y-axis and the SPACE Y-axis. See Figure 4

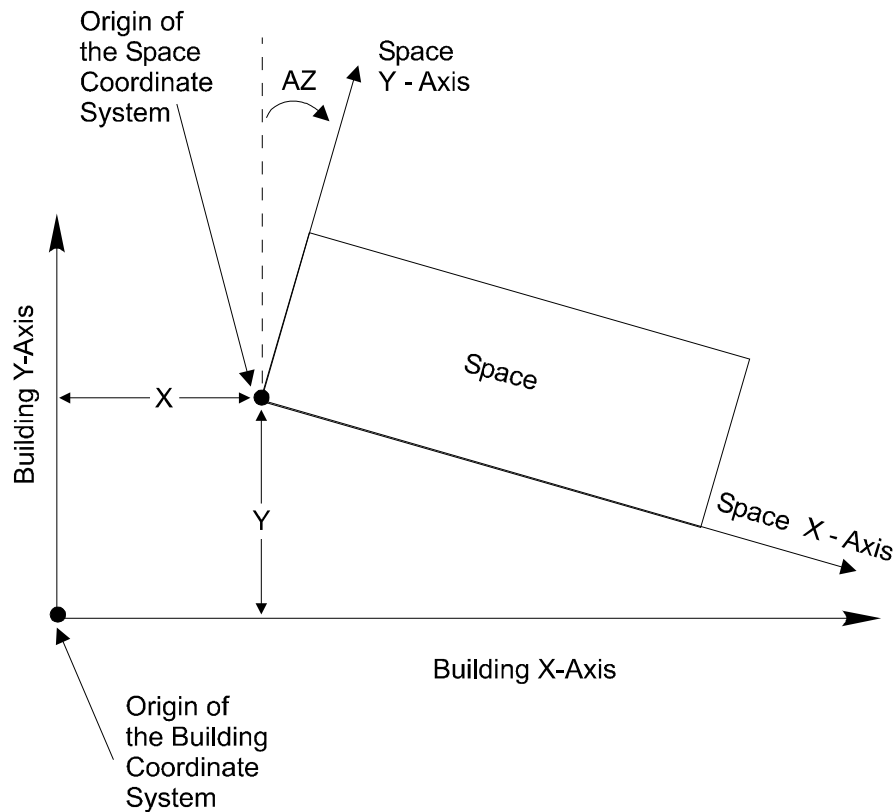


Figure 4 Example of a space coordinate system located in a building coordinate system

MULTIPLIER

Specifies the number of identical spaces. MULTIPLIER multiplies space loads. It also multiplies the heat transfer to adjacent spaces through interior walls in this space.

FLOOR-MULTIPLIER

Used to simplify the input for a multistory building. Equals the number of floors that are thermodynamically identical and where there is negligible heat transfer from floor to floor. FLOOR-MULTIPLIER multiplies space loads but does not multiply heat transfer through the SPACE's interior walls. The overall multiplier on the space load is (MULTIPLIER) x (FLOOR-MULTIPLIER).

Internal Loads

Before specifying the input data for SPACE, you should understand some of the logic built into the program. All of the heat sources associated with a particular space do not necessarily affect the heating and cooling loads of that space. Some sources contribute all of their heat to the space and others only part of their heat.

1. All of the heat associated with people, task lighting, and infiltration is assumed to enter the space.
2. Only part of the heat associated with the other sources (overhead lighting, process equipment, and process utilities) enters the space.

You control the fraction of heat that enters the space with the LIGHT-TO-SPACE keyword for overhead lighting and the sensible and latent keywords for process loads.

The heat 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. This portion of the heat has no effect on the subsequent sizing of HVAC equipment. The corresponding energy demand is, however, added to the demands made on the equipment, or purchased utilities, in the primary systems simulator. It is not charged to the secondary HVAC system.

When the program sizes equipment in the primary systems 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 instruction. This includes process equipment and process utilities. If any loads are omitted, the secondary HVAC equipment may be properly sized but the primary 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 (i.e., thermostat).

You should pay close attention when specifying SCHEDULEs. All the SCHEDULEs associated with a space, 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.

Occupancy Loads

The following five keywords specify space occupancy.

TEMPERATURE

The space air temperature used for the LOADS calculation. For conditioned spaces, this value should be between the heating and cooling indoor design temperatures (ZONE: DESIGN-HEAT-T and ZONE: DESIGN-COOL-T, respectively) in the HVAC input; it is best set equal to the design cooling temperature or design heating temperature, whichever will most probably be used to set the HVAC equipment size (air flow rate for air systems). For an unconditioned space, the TEMPERATURE value should be roughly equal to the average space temperature.

PEOPLE-SCHEDULE

Takes the U-name of a schedule (with TYPE=MULTIPLIER) for space occupancy as a function of time. Schedule inputs are fractions of maximum occupancy (as determined by NUMBER-OF-PEOPLE or AREA/PERSON). If PEOPLE-SCHEDULE is not entered the schedule value will default to zero and the space will be simulated with no people.

NUMBER-OF-PEOPLE

Maximum number of people occupying a space during the run period. 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 for that hour as given by PEOPLE-SCHEDULE. The number of people times the heat gain per

person (see PEOPLE-HEAT-GAIN, PEOPLE-HG-LAT and PEOPLE-HG-SENS) determines the hourly sensible and latent heat gain from occupants.

AREA/PERSON

Sets the peak occupancy based on area per person. This is an alternative keyword to NUMBER-OF-PEOPLE.

PEOPLE-HEAT-GAIN W/person)

The maximum combined latent and sensible heat gain per person to the space. Table 9 gives typical values for different activity levels. The program calculates the split between sensible and latent components using a fixed air temperature of 75F (23.9C). The program determines the hourly heat gain from occupants from PEOPLE-HEAT-GAIN, PEOPLE-SCHEDULE and NUMBER-OF-PEOPLE or AREA/PERSON. If PEOPLE-SCHEDULE is specified PEOPLE-HEAT-GAIN defaults to 450, otherwise PEOPLE-HEAT-GAIN is not used.

Table 9 PEOPLE-HEAT-GAIN Values for Different Activity Levels^a

Degree of Activity	Typical Application	PEOPLE-HEAT-GAIN ^b	
		Btu/hr	W
Seated at Theater	Theater	350	103
Seated/Very Light Work	Offices, Motels, Apts	400	117
Moderately Active Office Work	Offices, Hotels, Apts	450	132
Standing, Light Work, Walking	Department/Retail Store	450	132
Walking, Standing	Drugstore, Bank	500	147
Sedentary Work	Restaurant	550	161
Light Bench Work	Factory	750	220
Light Machine Work	Factory	1000	293
Heavy Work	Factory	1450	425
Athletics	Gymnasium	1800	527
^a From 1997 ASHRAE Handbook of Fundamentals, Table 3, Chapter 28			
^b Based on a normal percentage of men, women, and children for the application listed			

Lighting Loads

The following eight keywords specify space lighting. Many of these keywords accept lists of up to 5 entries, so that multiple lighting systems can be defined in the same space.

LIGHTING-SCHEDULE

Accepts a list of up to 5 U-names of a space overhead lighting schedule (with TYPE=MULTIPLIER). Schedule inputs are fractions of maximum lighting energy input (see LIGHTING-KW or LIGHTING-W/AREA; see also LIGHTING-TYPE and LIGHT-TO-SPACE). If not specified, the LIGHTING-SCHEDULE value defaults to zero and results in a simulation with no lighting, even if lighting is specified by keywords LIGHTING-KW or LIGHTING-W/AREA.

LIGHTING-TYPE

Takes a list of up to 5 code-words that specify the type of overhead lighting used in the space. For mixed types of lighting within the same space, select the dominant type and then use the LIGHT-TO-SPACE keyword to adjust the percentage of heat produced by the lighting. The following table shows the meaning of the code-words; see also Figure 5.

SUS-FLUOR	Suspended fluorescent
REC-FLUOR-NV	Recessed fluorescent - not vented
REC-FLUOR-RV	Recessed fluorescent - vented to return air
REC-FLUOR-RSV	Recessed fluorescent - vented to supply and return air
INCAND	Incandescent

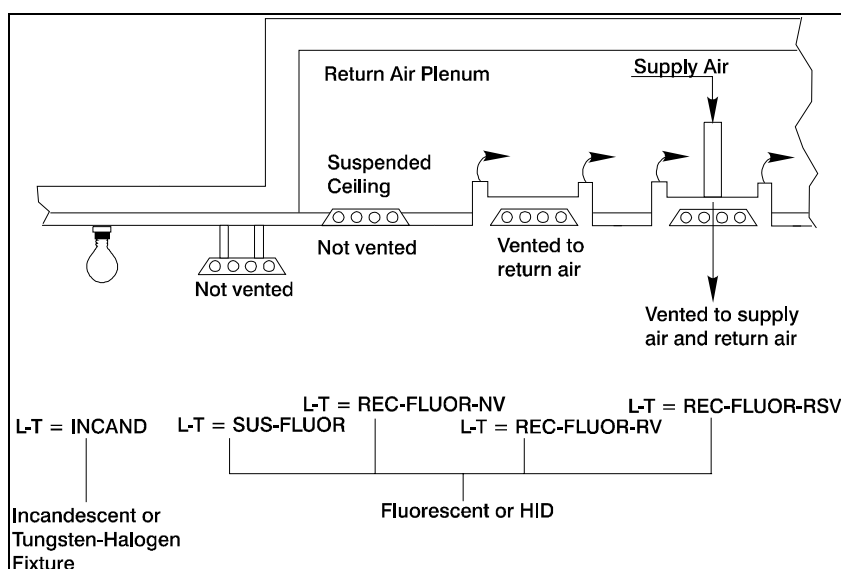


Figure 5 Examples of LIGHTING-TYPEs

LIGHTING-KW

Takes a list of up to 5 of the maximum electrical power required to operate the main or overhead lights within the SPACE. It is not necessarily the heat added by the lights to the space (see LIGHT-TO-SPACE). The actual space lighting power required by the space during any given hour is the value assigned to this keyword multiplied by the fractional value for that hour of LIGHTING-SCHEDULE. If both LIGHTING-KW and LIGHTING-W/AREA are specified, the values are added. Note that the values for LIGHTING-KW and LIGHTING-W/AREA are amounts consumed by lamps and ballasts, if present.

LIGHTING-W/AREA

An alternative to LIGHTING-KW for specifying the maximum overhead, or general, lighting power. The dimensions are watts of lighting power per unit space floor area. The actual overhead lighting energy required by the space during any given hour is the value assigned to this keyword multiplied by the area of the space multiplied by the fractional value that hour of LIGHTING-SCHEDULE. Accepts a list of up to 5 entries, one for each lighting system.

The following table compares the approximate percentages by type of energy produced by incandescent and fluorescent lighting. Thus, if the same values of LIGHTING-KW or LIGHTING-W/AREA 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.

Table 10
Distribution of Energy from LIGHTING-KW or LIGHTING-W/AREA

Type of Energy	Approximate percent for	
	Fluorescent	Incandescent
Visible Light	19	10
Infrared	31	72
Convection, Conduction	36	18
Ballast	14	0
(Eventually all the energy gets converted into SPACE load.)		

LIGHT-TO-SPACE

Fraction of the overhead lighting energy added to the space as a sensible heat gain. The remaining energy is added to the ductwork if RETURN-AIR-PATH=DUCT for the system serving this space. For zonal systems, SYSTEM:TYPE=UHT, UVT, HP, FC, UI or PTAC, the value of LIGHT-TO-SPACE is automatically set to 1.0. The default is 1.0 for LIGHTING-TYPE = SUS-FLUOR, REC-FLUOR-NV and INCAND and to 0.8 for LIGHTING-TYPE=REC-FLUOR-RV and REC-FLUOR-RSV.

TASK-LIGHT-SCH

Takes the U-name of a SCHEDULE (with TYPE=MULTIPLIER) for task lighting in the space. A task light is any small lamp, such as a desk lamp, that has a different schedule of use than the main space overhead lighting. Schedule inputs are fractions of maximum task lighting power (see TASK-LIGHTING-KW and TASK-LT-W/AREA). If TASK-LIGHT-SCH is not input, the schedule value defaults to zero and no task lights are simulated.

TASK-LIGHTING-KW

The maximum electrical power required for task lighting. All of the heat from task lights is added to the space. The actual task lighting power required during any given hour is the value assigned to this keyword multiplied by TASK-LIGHT-SCH value for that hour. If both TASK-LIGHTING-KW and TASK-LT-W/AREA are specified, the program adds the values.

TASK-LT-W/AREA

Watts of task lighting per unit of floor area of the space. An alternative to TASK-LIGHTING-KW. If both TASK-LT-W/AREA and TASK-LIGHTING-KW are specified, the contributions are added.

Equipment Loads

The following five keywords specify space equipment (plug loads). The keywords accepts lists of up to five inputs per space, for spaces having more than one type (sensible/latent split) or schedule of equipment use.

EQUIP-SCHEDULE

Takes the U-name of the operation of a schedule (with TYPE=MULTIPLIER) for space equipment, such as computers, printers, and copy machines. Schedule values are fractions of maximum equipment power

input (see EQUIPMENT-KW or EQUIPMENT-W/AREA). If the EQUIP-SCHEDULE is not input, the schedule value defaults to zero and no space equipment loads are simulated.

EQUIPMENT-W/AREA

An alternative to EQUIPMENT-KW, this keyword gives the maximum equipment power per unit floor area of the space. If both EQUIPMENT-W/AREA and EQUIPMENT-KW are specified, the contributions are added.

EQUIPMENT-KW

Maximum amount of power required to operate electrical equipment in the space. The equipment power required by the space during any given hour is the value of this keyword multiplied by the EQUIP-SCHEDULE value that hour. If both EQUIPMENT-KW and EQUIPMENT-W/AREA are specified, the program adds the values. Before specifying a value for EQUIPMENT-KW, review SOURCE-TYPE=ELECTRIC below (with EQUIPMENT-KW you specify equipment; with SOURCE-TYPE you specify a utility demand).

EQUIP-LATENT

Fraction of EQUIPMENT-KW or EQUIPMENT-W/AREA added to the space as latent heat. The sum of EQUIP-LATENT and EQUIP-SENSIBLE must not exceed 1.0. If neither EQUIP-SENSIBLE nor EQUIP-LATENT is specified, all heat from equipment is considered sensible.

EQUIP-SENSIBLE

Fraction of EQUIPMENT-KW or EQUIPMENT-W/AREA added to the space as sensible heat. The sum of EQUIP-SENSIBLE and EQUIP-LATENT must not exceed 1.0.

Source Energy

The following five keywords specify space sources. A source corresponds to a utility demand, not equipment. Depending on how the source is specified, it may or may not result in a space heating or cooling load. Also, a source may or may not result in a utility load. Only one source per space may be specified.

SOURCE-POWER

The maximum power supplied by the source defined by SOURCE-TYPE. This is the maximum power required to operate devices, other than lighting or equipment, in the space. A negative value represents heat removed from the space. The source power during any given hour is SOURCE-POWER times the value of SOURCE-SCHEDULE that hour. The fraction of SOURCE-POWER that contributes to the space load is given by the sum of SOURCE-LATENT and SOURCE-SENSIBLE (which can be < 1.0).

SOURCE-SCHEDULE

Takes the U-name of the schedule (with TYPE=MULTIPLIER) for any source of internal energy (such as process equipment within a space) other than people, lights, or electrical equipment. Schedule values are fractions of SOURCE-POWER. If SOURCE-SCHEDULE is not entered, the schedule values will default to zero and no source loads are simulated.

SOURCE-TYPE

Used when there are internal heating or cooling loads caused by a source other than people, lights, or equipment. Associated code-words represent space heating (e.g., ovens) or cooling loads (e.g., ice rink). See note under keyword SOURCE-BTU/HR.

GAS

The load contributes to natural gas use. Examples include natural gas for ovens, kilns, or dryers. Do not use the code-word GAS to specify gas

heated hot water; instead, specify SOURCE-TYPE=HOT-WATER. This will pass a demand for hot water to the HVAC program, where the hot water heater is specified along with its fuel type.

ELECTRIC

The load contributes to electricity use. Examples include electricity for electroplating or battery charging. Do not use the code-word ELECTRIC for specifying electrically heated hot water; instead, specify SOURCE-TYPE=HOT-WATER. This will pass a demand for hot water to the HVAC program, where the hot water heater is specified along with its fuel type.

PROCESS

The load will not contribute a utility load. Examples of this type of load are gasoline-powered fork trucks, oxyacetylene welders, wood stoves, and bottled gas equipment. Sum all the process loads in the space and express the total with the keyword SOURCE-POWER. The portion of the total process load that enters as a heating or cooling load is specified with the SOURCE-LATENT and SOURCE-SENSIBLE keywords.

SOURCE-SENSIBLE

Fraction of SOURCE-POWER added to the space as 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.

SOURCE-LATENT

The fraction of SOURCE-POWER added to the space as 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.

Air Infiltration

The following five keywords specify the infiltration rate.

INF-METHOD

Takes a code-word that identifies the method used to calculate the infiltration rate for the space. Air-change method calculations are made with and/or without wind velocity correction, depending upon code-word chosen here and the keyword used to enter the value for infiltration.

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-FLOW/AREA. One of these keywords should be specified if INF-METHOD=AIR-CHANGE. AIR-CHANGES/HR will give an infiltration rate that depends on wind speed. INF-FLOW/AREA will give an infiltration rate that does not depend on wind speed.

RESIDENTIAL

The infiltration rate will depend on both wind speed and inside-outside temperature difference as described below for keyword RES-INF-COEF.

RES-INF-COEFF

Used when INF-METHOD=RESIDENTIAL. Takes a list of three values for the coefficients A,B, and C in the expression

$$\text{Infiltration rate} = A + (B \times \text{windspeed}) + (C \times (T))$$

where Infiltration rate is in air changes per hour, windspeed is in knots or m/s (taken from the weather file), and (T is the absolute value of the outdoor-indoor temperature difference in F or K. The default coefficients are 0.252, 0.251 knot-1 (0.0488 (m/s)-1) and 0.0084 F-1 (0.0151 K-1)

AIR-CHANGES/HR

The number of infiltration-caused air changes per hour at a wind speed of 10 mph (4.47 m/s) for a space with INF-METHOD=AIR-CHANGE. When this keyword is specified, the program will calculate the hourly air change rate as (AIR-CHANGES/HR) x (windspeed)/(10 mph).

INF-FLOW/AREA

Used when INF-METHOD=AIR-CHANGE. Equals the space's infiltration air flow (cfm or m3/hr) divided by the floor area (ft2 or m2). There is no correction for wind speed.

INF-SCHEDULE

Takes the U-name of a schedule (with TYPE=MULTIPLIER) that specifies the multiplier of the maximum air infiltration rate into a space as a function of time. 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 defaults to 1.0 for all hours, and the full infiltration rate will be simulated for all hours. Ordinarily, INF-SCHEDULE should not be used with the RESIDENTIAL method of infiltration because the schedule will distort wind information from the weather tape.

Alternative methods of describing spaces

The preceding discussion of the basic SPACE keywords assumes user input for the space AREA and VOLUME keywords. There are two alternative methods to describe the shape of a space whereby the program calculates the space AREA and VOLUME. Both alternatives employ the SHAPE keyword: SHAPE=BOX and SHAPE=POLYGON. See the SPACE command in the DOE-2.2 Dictionary for more detailed information.

EXTERIOR-WALL OR ROOF

Specifies the size and construction of an exterior surface of a space such as an exterior wall, roof, or exterior floor. EXTERIOR-WALL and ROOF are synonymous except that the default TILT for EXTERIOR-WALL is 90(, and for ROOF is 0(. Each EXTERIOR-WALL or ROOF applies to the SPACE instruction preceding it and describes one of the exterior surfaces of that space.

Example input:

```
SP-1 = SPACE

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

HEIGHT

Height of the wall. This is the dimension of the exterior wall parallel to the y-axis in the surface coordinate system.

WIDTH

Width of the wall. This is the dimension of the exterior wall parallel to the x-axis in the surface coordinate system.

AZIMUTH

Clockwise angle between the parent space's Y-axis and the horizontal projection of the wall's outward normal. For example, if the Y-axis of the parent space points north, then a north-facing wall has AZIMUTH=0, an east-facing wall has AZIMUTH=90, a south-facing wall has AZIMUTH=180, and a west-facing wall has AZIMUTH=270 (see Figure 6).

TILT

Angle between vertical and the surface outward normal. For EXTERIOR-WALL, the default is 90((vertical surface). For ROOF, the default is 0((upward-facing horizontal surface). A downward-facing exterior surface has TILT=180((see Figure 6).

X Y Z

X, Y, and Z are the coordinates of the lower left-hand corner of the wall (as viewed from the outside) in the space coordinate system (see Figure 6).

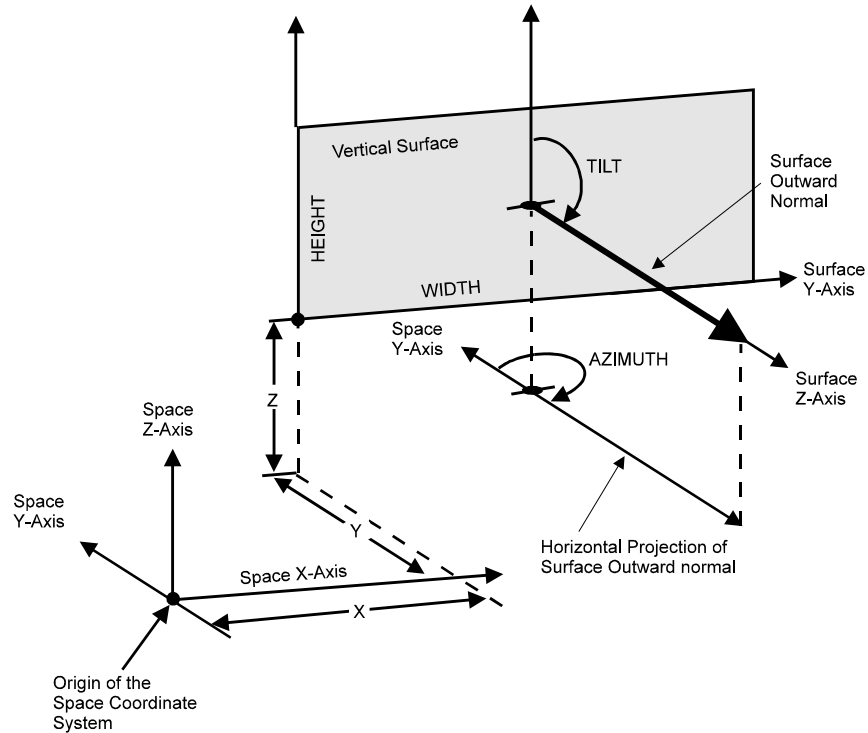


Figure 6 Positioning a wall in the space coordinate system

CONSTRUCTION

Takes the U-name of a previously-defined CONSTRUCTION instruction. This is a required keyword.

MULTIPLIER

Specifies the number of identical exterior surfaces located in the same plane. MULTIPLIER multiplies the net area of the surface (surface area minus window area minus door area). It also multiplies any WINDOW and DOOR area associated with this surface.

GND-REFLECTANCE

Solar reflectance of the ground in the vicinity of the EXTERIOR-WALL. Typical values are given in Table 11.

Table 11 Typical Ground Reflectance Values

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

Alternative method for locating and sizing exterior walls or roofs

The preceding discussion of the basic keywords for Exterior Walls and Roofs assumes user input for the HEIGHT, WIDTH, AZIMUTH, and X, Y, Z keywords. If the SHAPE keyword is used for the space containing an exterior wall or roof (i.e., SHAPE=BOX or SHAPE=POLYGON), then the LOCATION keyword can be used to both locate and size the Exterior Wall or Roof (i.e., LOCATION=FRONT or LOCATION=V2). See the EXTERIOR-WALL (or ROOF) command in the DOE-2.2 Dictionary for more detailed information.

WINDOW

Specifies the size, position, number, and glazing properties of a window. Each WINDOW command applies to the EXTERIOR-WALL or ROOF instruction preceding it and describes a window on that exterior wall or roof. Both a GLASS-TYPE and an EXTERIOR-WALL or ROOF instruction must precede a WINDOW instruction. U-name may be specified. LIKE may be used to copy data from a previously entered and U-named WINDOW.

Example input:

```

GT-1 = GLASS-TYPE
      TYPE                = GLASS-TYPE-CODE
      GLASS-TYPE-CODE     = 2200
      ..

EW-1 = EXTERIOR-WALL
      . . .
      ..

WIN-1 = WINDOW
      GLASS-TYPE          = GT-1
      MULTIPLIER          = 2
      WIDTH               = 10
      HEIGHT              = 4
      SETBACK             = 0.5 ..

```

HEIGHT

Height of the glazed portion of the window. This is a required keyword. Note that the window area (HEIGHT times WIDTH) is automatically removed from the associated wall area.

WIDTH

Width of the glazed portion of the window. This is a required keyword. Note that the WINDOW area (HEIGHT times WIDTH) is automatically removed from the associated wall area.

X

Y

X and Y are the coordinates of the lower left-hand corner of the window in the wall coordinate system (see Figure 7). If X is not specified, the program will center the window on the wall X-axis. If Y is not specified, the program will center the window on the wall Y-axis.

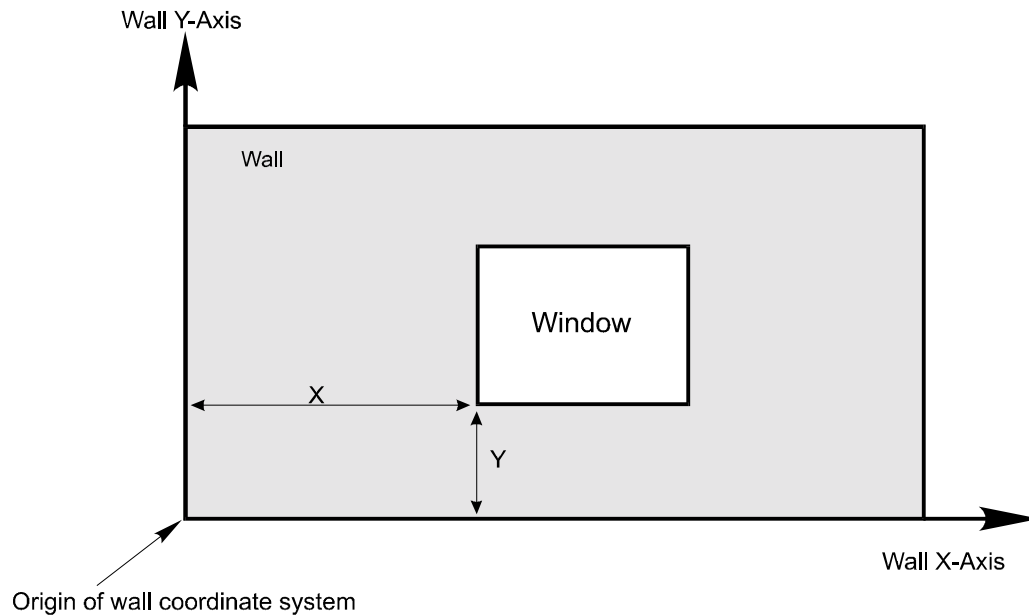


Figure 7 Locating a window on a wall

SETBACK

Distance that the window is recessed from the outside surface of the wall.

GLASS-TYPE

Takes the U-name of the GLASS-TYPE instruction that describes the glass in the window. This is a required keyword.

MULTIPLIER

Specifies the number of identical windows. Multiplies the window area.

SHADING-SCHEDULE

Takes the U-name of a SCHEDULE (with TYPE=MULTIPLIER) that defines hourly values of a multiplier on the solar gain through the window. This represents the shading effect of movable devices such as blinds, drapes, or shutters. The multiplier values in the SCHEDULE should be (1.0 Items that change solar transmission may also affect heat conduction. If so, a matching CONDUCT-SCHEDULE should be used. If the SHADING-SCHEDULE is not input, the schedule will default to 1.0 for all hours.

CONDUCT-SCHEDULE

Takes the U-name of a SCHEDULE (with TYPE=MULTIPLIER) that defines hourly values of a multiplier on the heat conduction through the window. The multiplier values in the SCHEDULE should be (1.0. This represents the effect of movable devices such as blinds, insulating drapes, or shutters. If these devices are present, a matching SHADING-SCHEDULE should be specified. If CONDUCT-SCHEDULE is not input, the schedule value will default to 1.0 for all hours.

CONDUCT-TMIN-SCH

Takes the U-name of a SCHEDULE (of TYPE=TEMPERATURE) of values of outside dry-bulb temperature below which movable insulation is deployed on a window. If CONDUCT-TMIN-SCH is specified, a corresponding SHADING-SCHEDULE and CONDUCT-SCHEDULE should be assigned to the window.

MAX-SOLAR-SCH

Takes the U-name of a SCHEDULE (of TYPE=RADIATION) of values of incident solar radiation (in Btu/ft²-hr or W/m²) on the window. The program will automatically deploy a shading device whenever the actual direct-plus-diffuse solar radiation on the window exceeds the schedule value. The shading device will be retracted if the incident solar falls below the schedule value. For example, the shades will be deployed if the incident solar is 50 Btu/ft²-hr and the schedule value is 20 Btu/ft²-hr. 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.

Overhangs and Fins

Overhangs and fins are specified and positioned with respect to the window with the following keywords. The keywords refer to Figure 8

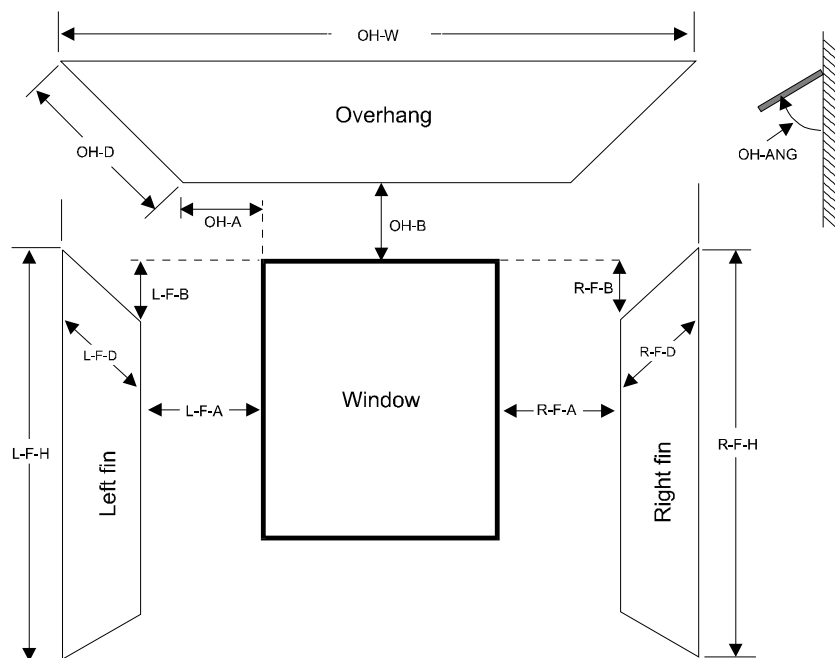


Figure 8 Positioning of overhang and fins with respect to a window
(The values in this figure are all positive. If the value of L-F-B is input as a negative, the left fin will originate at a point above the top edge of the window; similarly for R-F-B. If OH-A is input as negative, the overhang will originate to the right of the left side of the window)

OVERHANG-A
OVERHANG-B
OVERHANG-W
OVERHANG-D

OVERHANG-ANGLE

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.

LEFT-FIN-A**LEFT-FIN-B****LEFT-FIN-H****LEFT-FIN-D****RIGHT-FIN-A****RIGHT-FIN-B****RIGHT-FIN-H****RIGHT-FIN-D****Rules**

1. 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.
2. For fin shading calculations to be performed, the pairs LEFT-FIN-H and LEFT-FIN-D or RIGHT-FIN-H and RIGHT-FIN-D must be specified. If one of the pair is specified, but not both, a warning message is printed and fin shading is not performed.
3. 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.

DOOR

This instruction is used to specify the size and position of a door and its heat-transfer characteristics. Each DOOR instruction applies to the EXTERIOR-WALL instruction preceding it and describes a door on that exterior wall. Glass doors should be treated as windows rather than doors. Overhangs and fins can be applied to doors in the same way as described under the WINDOW command. U-name may be specified. LIKE may be used to copy data from a previously entered and U-named DOOR instruction.

Example input:

```
D1 = CONSTRUCTION
    TYPE                = U-VALUE
    U-VALUE              = 0.5 ..

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

HEIGHT

Door height. Height times width must not be greater than the area of the parent wall. This is a required keyword.

WIDTH

Door width. Height times width must not be greater than the area of the parent wall. This is a required keyword.

X

Y

X and Y are the coordinates of the lower left-hand corner of the door in the coordinate system of the parent wall. If X is not specified, the program will center the door horizontally on the wall.

CONSTRUCTION

Takes the U-name of a previously defined CONSTRUCTION that specifies the U-value of the door. This is a required keyword.

SETBACK

Distance that the door is recessed from the outside surface of the parent wall.

INTERIOR-WALL

Specifies the size, construction, and adjacent space for an interior wall, interior ceiling, or interior floor. Each INTERIOR-WALL applies to the SPACE instruction preceding it and describes one of the interior walls, interior ceilings, or interior floors of that space. It is important not to input INTERIOR-WALLs twice. This is usually done by accidentally specifying the same interior wall under two adjacent SPACES. U-name may be used to identify each wall. LIKE may be used to copy a previously U-named INTERIOR-WALL.

Example input:

```
P1 = CONSTRUCTION
    TYPE                = U-VALUE
    U-VALUE              = 0.2 ..

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

SURFACE-TYPE

Takes a code-word that specifies whether the surface is a ceiling, roof, floor or wall in the space in which it is defined. SURFACE-TYPE is a required keyword.

HEIGHT

Height of the wall.

WIDTH

Width of the wall.

X Y Z

X, Y, and Z are the coordinates of the lower left-hand corner of the wall (when viewed from the adjacent space) in the coordinate system of the space in which the wall is defined (see Figure 6).

AZIMUTH

Clockwise angle between the Y-axis of the space in which the wall is defined and the horizontal projection of the wall's outward normal (see Figure 6).

TILT

Angle between vertical and the wall's outward normal (see Figure 64).

NEXT-TO

Takes the U-name of the adjacent space that shares this wall. This is a required keyword.

CONSTRUCTION

Takes the U-name of a previously defined CONSTRUCTION that describes the LAYERS or the U-value of this interior wall. For interior walls with openings, a CONSTRUCTION with TYPE=U-VALUE

should be used with an effective U-value, U_{eff} , calculated as follows. If U_{solid} is the U-value of the solid part of the wall, U_{open} is the U-value of the opening, A is the area of the wall and A_{open} is the area of the opening, then

$$U_{\text{eff}} = \boxed{}$$

As an approximate value of U_{open} we recommend $U_{open}=2.7 \text{ Btu/ft}^2\text{-hr}$ (15.3 W/m^2). If the INTERIOR-WALL has no solid portion (i.e., is completely open), then $U_{eff}=U_{open}=2.7 \text{ Btu/ft}^2\text{-hr}$ (15.3 W/m^2).

Alternative method for locating and sizing interior walls

The preceding discussion of the basic keywords for Interior Walls assumes user input for the HEIGHT, WIDTH, AZIMUTH, and X, Y, Z keywords. If the SHAPE keyword is used for the space containing an Interior Wall (i.e., SHAPE=BOX or SHAPE=POLYGON), then the LOCATION keyword can be used to both locate and size the Interior Wall (i.e., LOCATION=FRONT or LOCATION=V2). In all cases, NEXT-TO is required input. See the INTERIOR-WALL command in the DOE-2.2 Dictionary for more detailed information.

UNDERGROUND-WALL

UNDERGROUND-FLOOR

These equivalent commands specify the size and construction of a wall (such as a basement wall) or a floor (such as a slab-on-grade) that is in contact with the ground. 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. LIKE may be used to copy a previously defined wall or floor.

Example input:

Concrete slab-on-grade entered as an UNDERGROUND-FLOOR. See "Underground Surfaces" in the DOE-2.2 Topics for a description of how to input the floor's layers and how to choose the perimeter conductance (PERIM-CONDUCT) and perimeter exposed to outside air (PERIM-EXPOSED). Note that the construction should always contain a 12-in layer of soil on the ground side of the underground surface.

```
LAY-SLAB-1 = LAYERS
  MATERIAL          = ("Soil 12in",
                      "Conc HW 140lb 4in (CC03)")
  INSIDE-FILM-RES   = 0.77
  ..

CON-SLAB-1 = CONSTRUCTION
  TYPE              = LAYERS
  LAYERS             = LAY-SLAB-1 ..
  ..

SLAB-1 = UNDERGROUND-FLOOR
  AREA              = 5000
  PERIM-CONDUCT     = 0.68
  PERIM-EXPOSED     = 300
  CONSTRUCTION      = CON-SLAB-1
  ..
```

AREA

Area of the UNDERGROUND-WALL or UNDERGROUND-FLOOR

CONSTRUCTION

Takes the U-name of a previously-defined CONSTRUCTION command that describes the layer-by-layer construction of the wall or floor. This is a required keyword.

One of these layers in the construction should be a 1-ft (0.305-m) layer of soil on the ground side of the wall or floor. This layer can be chosen from the library; it is "Soil 12in".

PERIM-EXPOSED

The length of the perimeter portion of the surface exposed to outside air. See "Underground Surfaces" in the DOE-2.2 Topics for examples of how to choose a value for this keyword. This is a required keyword.

PERIM-CONDUCT

This is a required keyword, equal to the conductance of the surface per unit length of exposed perimeter. A value can be chosen from the tables in the section "Underground Surfaces" in the DOE-2.2 Topics. The value depends on several factors, including:

- The type of surface: slab on grade, basement wall or crawl space wall.
- The placement and amount of foundation insulation.
- If slab on grade, whether it is bare or carpeted.

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.

Example Input:

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

Descriptions and examples of the basic LOADS reports are given in Appendix B. This appendix also has a table that shows in which Loads reports to look for various load-related quantities, like monthly loads, peak loads, and load components. (There are similar tables in the appendix for SYSTEMS, PLANT and ECONOMIC quantities.)

VERIFICATION

Verifies the input.

LV-A	General project and building input
LV-B	Summary of spaces occurring in the project
LV-C	Details of space <space name>
LV-D	Details of exteriorsSurfaces in the project
LV-E	Details of underground surfaces in the project
LV-F	Details of interior surfaces in the project
LV-G	Details of schedules occurring in the project
LV-H	Details of windows occurring in the project
LV-I	Details of constructions occurring in the project
LV-K	Weighting factor summary
LV-L	Daylight factor summary
LV-M	English/metric conversion table
ALL-VERIFICATION	All verification reports

SUMMARY

Displays the calculated results.

LS-A	SPACE PEAK LOADS SUMMARY Gives monthly values of peak heating and cooling loads for a space.
------	---

LS-B	<p>SPACE PEAK LOAD COMPONENTS</p> <p>Gives a breakdown of cooling and heating peak loads according to the source of the load for each space.</p>
LS-C	<p>BUILDING PEAK LOAD COMPONENTS</p> <p>Similar in format to LS-B; however, 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 in this report.</p>
LS-D	<p>BUILDING MONTHLY LOADS SUMMARY</p> <p>Gives a summary of monthly cooling, heating, and electrical requirements plus annual total energy requirements and maximum monthly peak loads for conditioned spaces.</p>
LS-E	<p>SPACE MONTHLY LOAD COMPONENTS <space name></p> <p>Gives a breakdown of loads for each space on a monthly basis, according to the source of the load.</p>
LS-F	<p>BUILDING MONTHLY LOAD COMPONENTS</p> <p>Gives a breakdown of loads on a monthly basis for the entire building, according to the source of the load. Only conditioned spaces are included.</p>
LS-G	<p>SPACE DAYLIGHTING SUMMARY</p> <p>Gives monthly-average overhead lighting energy reduction, illuminance, and glare for each daylit space.</p>
LS-H	<p>LIGHTING ENERGY REDUCTION BY DAYLIGHT</p> <p>For each daylit space, gives the monthly lighting energy reduction due to daylighting for each hour of the day, and for all hours of the day combined (including night time hours).</p>
LS-I	<p>PERCENT LIGHTING ENERGY REDUCTION BY DAYLIGHT, BUILDING</p> <p>For the building as a whole, gives the monthly lighting energy reduction due to daylighting for each hour of the day and for all hours of the day combined (including night time hours).</p>
LS-J	<p>DAYLIGHT ILLUMINANCE FREQUENCY</p> <p>For each daylit space, gives the monthly daylight-illuminance frequency-of-occurrence distribution at each lighting reference point.</p>
LS-K	<p>SPACE INPUT FUELS SUMMARY</p> <p>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.</p>

LS-L

MANAGEMENT AND SOLAR SUMMARY

Gives monthly summaries of window shade management and solar radiation into space.

Air-side Components

INTRODUCTION

The HVAC module models the performance of the building's heating, cooling, and ventilation systems. These systems are divided into air systems which consist of fans, ducts, dampers, coils, etc., that provide conditioned air and ventilation to the building's spaces, and primary systems, which consist of boilers, chillers, cooling towers, storage tanks, generators, etc., that provide hot water, chilled water, and electricity to the distribution systems. Air systems are also called "secondary systems," "air distribution systems," "distribution systems," "fan systems," and often just "systems." The primary system is also called the "plant" or "waterside." In larger buildings the primary and secondary systems are connected by circulation loops that bring hot or cold water from the boilers and chillers to the heating and cooling coils.

This section describes the modeling of the air-side, or secondary, HVAC systems. The following section describes the central plant, or primary, systems.

The program requires a fair amount of understanding of how HVAC systems operate. A general description of types of systems is given in this manual. Once you have understood the structure of the LOADS input, there should be little difficulty in learning to assemble an HVAC input. The major problem most users have is that the program offers a high degree of flexibility and a large choice of options for HVAC input. In some programs you can simply assign the name of the desired system and the program will pull from its file all of the necessary input. To a degree this can be done by relying on default values and pre-stored 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 HVAC commands and keywords.

Air Systems

In this section we describe the general properties of air systems for users whose knowledge in this area is limited. It is important to know what systems do and not simply know their names. First we discuss the common features and heritage of various systems. Then we describe specific system types modeled by the program.

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 (mixture of Systems (1) through (4))

Each of these categories are discussed in the following sections

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 control zone.

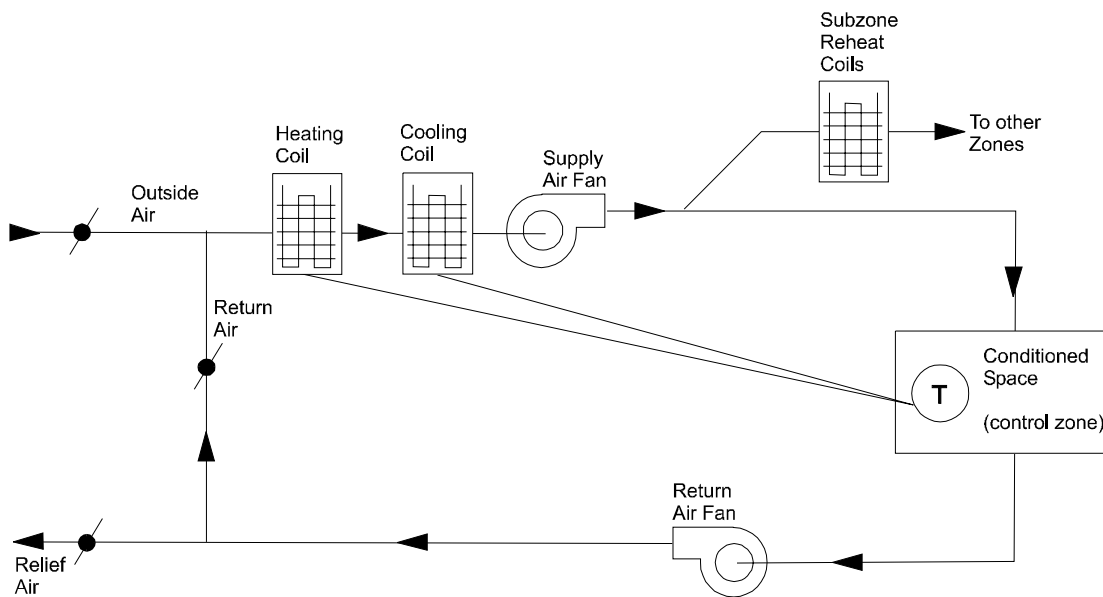


Figure 9 Variable air-temperature system

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.

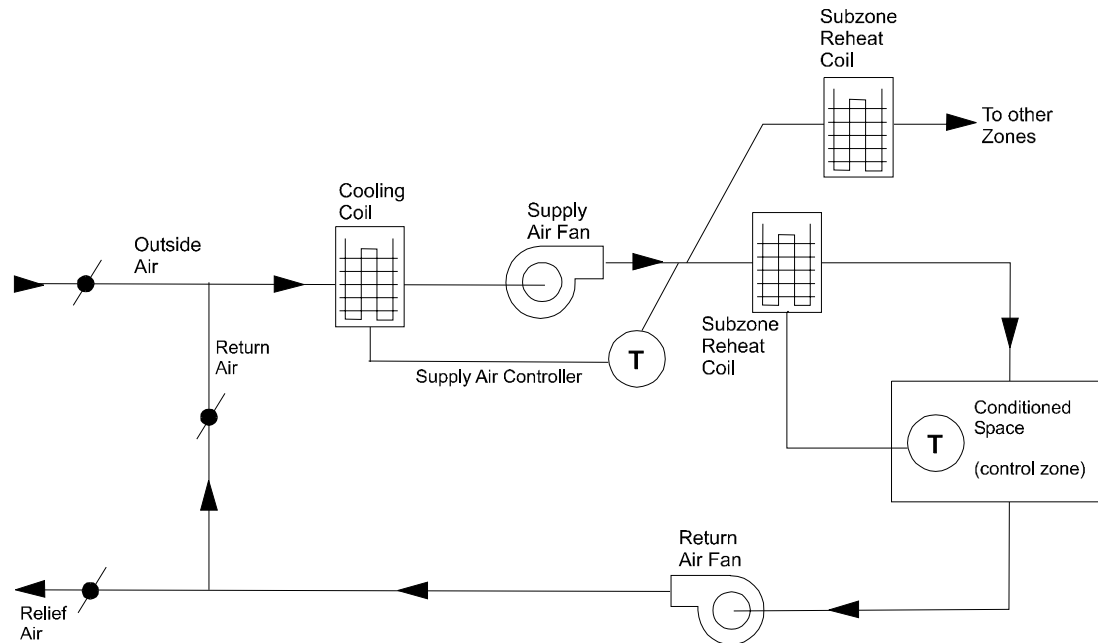


Figure 10 Reheat system

Air Mixing Systems (Constant-volume) (DDS, MZS, PMZS)

These systems are commonly referred to as Dual-Duct and Multizone 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 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. Therefore, 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 55F (12.8C), the space temperature 75F (23.9C), and the hot deck 95F (35C), the two air streams will mix in equal parts. However, if the hot deck is 155F (68.3C) and all other criteria remain unchanged, then the cold deck will pass four parts, and the hot deck one part. 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.

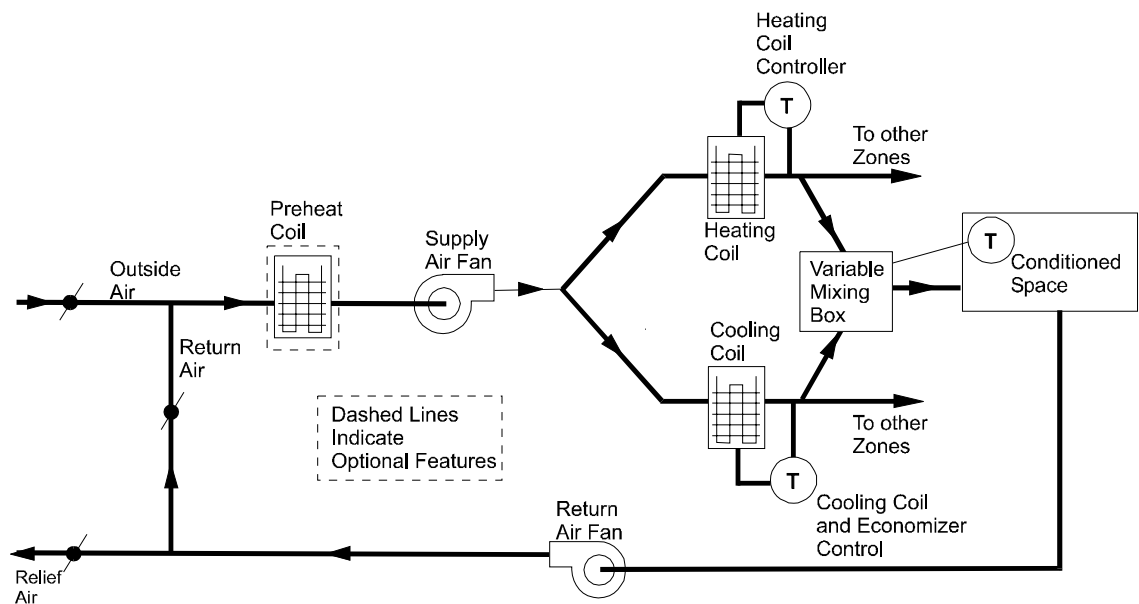


Figure 11 Air mixing (constant-volume) system

Variable Air Volume (Constant Temperature) Systems (VAVS, PAVS)

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 the minimum flow 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 minimum flow ratio to provide sufficient ventilation air. 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.

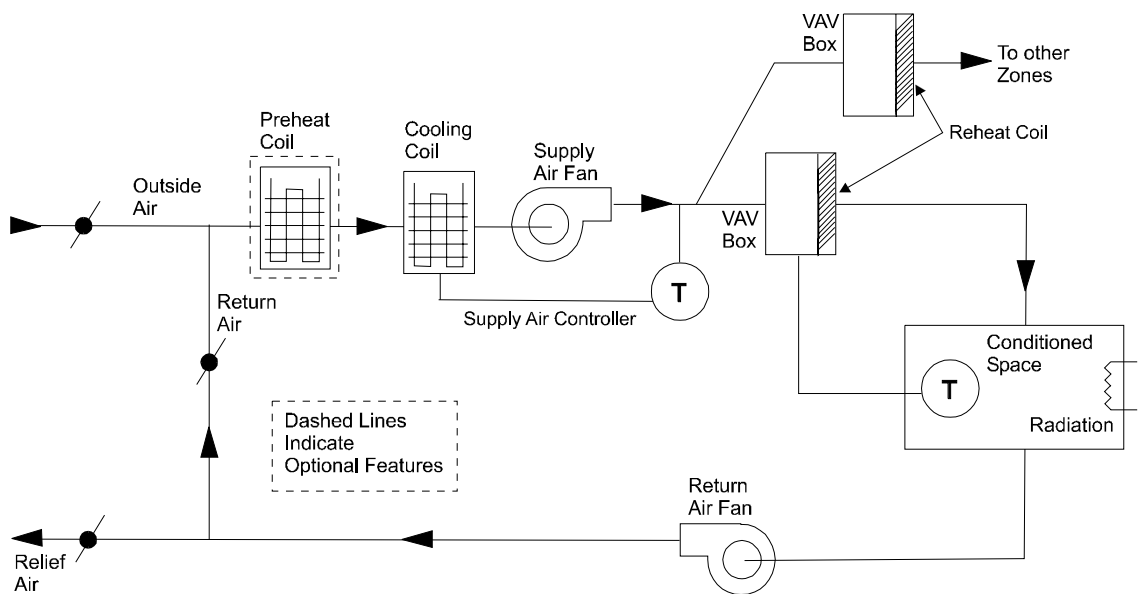


Figure 12 Variable-air volume (constant temperature) system

Hybrid Systems

Hybrid systems are defined here as a combination of any of the above systems. For example, consider a VAV-Reheat System with a minimum stop on the supply box specified by minimum flow ratio. Typically, this system acts as a VAV system if the total air supply is above the minimum flow ratio setting. Whenever the system supply air needed is less than that allowed by the minimum flow ratio, the system becomes a standard reheat system.

Another hybrid system is the VAV-Dual-Duct System. Again, only when the total supply air requirement is less than that allowed by the minimum flow ratio, does the system act as a typical Dual-Duct System that mixes two air streams to satisfy the space thermostat.

The Powered Induction Unit (PIU) is also a hybrid system. It is a variation of the VAV System in which a small fan pulls air from the ceiling plenum and mixes it with air from the central system.

Other Air Distribution System Categories

In addition to the above, the program models many additional system types. .

Fan Coil (FC)

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 is 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. Note that the program does not simulate a separate ventilation system; all outside air is drawn through the fan coil.

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 encased in a single unit). They perform cooling with direct expansion coils, which require data about ambient wet-bulb and dry-bulb temperatures. As a result, the entire cooling calculation is done in SYSTEMS and only the resulting electrical load is reported, as there is no primary equipment (i.e., boilers or chillers).

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. A fluid cooler (closed circuit cooling tower) is used to reject heat to the atmosphere when the majority of units are cooling.

Residential System (RESYS2)

It is possible to simulate the following combination of systems for residential conditioning. Cooling may be provided by 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.

Heating Only Systems

The program can simulate a number of heating-only systems. They are:

- Unit Heaters (UHT)
- Unit Ventilators (UVT)
- 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

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

Recovery Systems.

The program allows you to simulate either a coil run-around recovery cycle or a wheel that exchanges heat between the outside air and the return air. This heat exchange can be modeled in either heating or cooling mode.

Another Way of Classifying Air Systems

Air systems can also be classified by dividing them into built-up vs. packaged systems, or into central vs. zonal systems:

Built-Up Systems

Depending upon the system type 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.

Packaged Systems

These units are usually self-contained, produced as one or more modular pieces of pre-matched equipment that only require installation. They possess all the necessary equipment for energy conversion and distribution. Packaged systems are simulated entirely in the secondary systems subprogram.

Zonal vs. Central Systems

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

SYSTEM

Specifies 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. U-name is required so that the SYSTEM is identified in reports.

A SYSTEM command must precede the input of any ZONE that belongs to that system. The ZONEs following a system command are assumed to belong to that system. For example, in the following, ZONE-1 and ZONE-2 belong to SYS-1 and ZONE-3 belongs to SYS-2:

```
SYS-1 =  SYSTEM

ZONE-1 =  ZONE

ZONE-2 =  ZONE

SYS-2 =  SYSTEM

ZONE-3 =  ZONE

SYS-3 =  SYSTEM

. . . .
```

Example input:

```
"System 1" = SYSTEM
  TYPE                =  VAVS
  MAX-SUPPLY-T         =  110
  MIN-SUPPLY-T         =  55
  HEAT-SET-T           =  70
  REHEAT-DELTA-T       =  55

  FAN-SCHEDULE         =  FANS-ON
  NIGHT-CYCLE-CTRL     =  CYCLE-ON-FIRST
  FAN-CONTROL          =  SPEED
  SUPPLY-KW            =  0.0010
  RETURN-KW            =  0.0008 ..OA-CONTROL  =  TEMP

  ECONO-LIMIT-T        =  68
  MIN-FLOW-RATIO       =  0.3

  HEAT-SOURCE          =  HOT-WATER
  HW-LOOP              =  HOT-WATER-1
  CHW-LOOP             =  COOLING-WATER-1  ..
  HEAT-SOURCE=HOT-WATER ..

Z-1 = ZONE              $first zone on this system$
. . . .

Z-2 = ZONE              $second zone on this system$
. . . .
```

TYPE

Takes a code-word, chosen from Table 12 that identifies the type of system to be simulated. This keyword is required and should be the first keyword entered for the SYSTEM command.

Table 12 Airside system types

Category	Code-word	Description
Single Supply Duct	SZRH	Variable Temperature
	PSZ	Packaged Single-zone
	SZCI	Ceiling Induction
	RHFS	Constant-volume Reheat Fan
	VAVS	Variable-volume Fan
	PIU	Powered Induction Unit
	PVAVS	Packaged Variable Air Volume
	PVVT	Packaged Variable-Volume, Variable-Temperature
	CBVAV	Ceiling Bypass
	EVAP-COOL	Evaporative Cooling
Air Mixing	MZS	Multizone Fan
	PMZS	Packaged Multizone
	DDS	Dual-duct Fan
	FC	Fan Coil
Terminal Unit	IU	Induction Unit
	PTAC	Packaged Terminal Air Conditioner
	HP	Water Loop Heat Pump
Residential	RESYS	Residential with cycling furnace and cycling air-conditioner
	RESYS2	Residential with cycling furnace and cycling air-conditioner
	RESVVT	Residential Variable-Volume, Variable-Temperature
Heating Only	FPH	Floor Panel Heating
	HVSY	Heating and Ventilating
	UHT	Unit Heater
	UVT	Unit Ventilator
Diagnostics	SUM	Sum Zone Loads
User-Defined	FNSYS1	Defined using Input Functions

Airflow Parameters

This set of keywords provide information on system supply air and outside air flow rate. 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.

SUPPLY-FLOW

SUPPLY-FLOW 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-FLOW. The program proportions the specified total supply air into zone air quantities as follows:

$$\text{Adjusted Zone Air CFM} = \left(\frac{\text{< Supply - CFM >}}{\text{(SUM Calculated Zone Air CFMs)}} \right) * \text{(Calculated Zone Air)}$$

Note that user-inputs of zone-level ASSIGNED-FLOW and EXHAUST-FLOW replace the "Calculated Zone Air CFM" in the summation (but only when the latter exceeds calculated zone CFM).

MIN-OUTSIDE-AIR

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-FLOW/PER, or OUTSIDE-AIR-FLOW in the ZONE command). If a value is specified for this keyword and values are also specified for the zone level keywords OUTSIDE-AIR-FLOW, OA-CHANGES, OA-FLOW/PER, or EXHAUST-FLOW, 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-FLOWs 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	specifies that a fixed amount of outside air is used whenever the fans are running.
-------	---

OA-TEMP	specifies that the economizer is enabled whenever the outside air temperature is below the maximum allowed temperature, as specified by DRYBULB-LIMIT.
OA-ENTHALPY	specifies that the economizer is enabled whenever the outside air enthalpy is below the maximum allowed enthalpy, as specified by ENTHALPY-LIMIT.
DUAL-TEMP	specifies that the economizer is enabled whenever the outside air temperature is less than the return air temperature.
DUAL-ENTHALPY	specifies that the economizer is enabled whenever the outside air enthalpy is less than the return air enthalpy.

DRYBULB-LIMIT

for OA-CONTROL=TEMP, specifies the maximum allowable outside air temperature for which the economizer is enabled. The outside air dampers return to their minimum position above this value. The default is 65°F.

ENTHALPY-LIMIT

for OA-CONTROL=ENTHALPY, specifies the maximum allowable outside air enthalpy for which the economizer is enabled. The outside air dampers return to their minimum position above this value. The default is 30.0 Btu/lb.

VENT-TEMP-SCH

U-name of a schedule giving the hourly minimum temperature setpoint for the natural venting algorithm. This keyword is appropriate to system types RESYS, PSZ, and EVAP-COOL. The hourly values that should be specified in the SCHEDULE referenced by VENT-TEMP-SCH are the indoor drybulbdry-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

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. Keyword is appropriate only to system types RESYS, PSZ, and EVAP-COOL.

NATURAL-VENT-SCH

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 types RESYS, PSZ, and EVAP-COOL.

A schedule value of 0 indicates that the windows are always closed for this hour.

A schedule value of 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 -1 indicates that the windows will be opened, for part or all of this hour, only if the condition for the value of 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, let's 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 would be:

```
VENT-DAY = DAY-SCHEDULE
  TYPE                      = ON/OFF
                           ( 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 command would be:

```
HOME-AIR = SYSTEM
.
.
.
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. Should the user wish to specify "temperature limits" for cooling by natural ventilation, he should specify VENT-TEMP-SCH in the SYSTEM command. For example, suppose the schedule

```
COOL-DAY = DAY-SCHEDULE
  TYPE                      = TEMPERATURE
                           ( 1, 8) (78)
                           ( 9,17) (90)
                           (18,24) (78) ..
```

```
MECH-COOL-TEMP = SCHEDULE
  THRU DEC 31              (ALL) COOL-DAY ..
```

describes the cooling setpoint of the mechanical system; while the schedule

```
MIN-VENT = DAY-SCHEDULE
                           ( 1, 6) (60)
                           ( 7,22) (68)
                           (23,24) (60) ..
```

```
MIN-VENT-TEMP = SCHEDULE
                THRU DEC 31          (ALL) MIN-VENT  . .
```

describes the minimum below which the windows will be closed. Then under ZONE, you should specify COOL-TEMP-SCH = MECH-COOL-TEMP, while under SYSTEM, VENT-TEMP-SCH should be set equal to MIN-VENT-TEMP. The preceding example states the following:

Schedule Hours	Temperature Range*
1,6 (midnight to 6 am)	78F max (provided by mechanical cooling)
7,8 (6 am to 8 am)	78F max (provided by mechanical cooling) 68F min (provided by occupant operating windows)
9,17 (8 am to 5 pm)	85F max (provided by mechanical cooling)
18,22 (5 pm to 10 pm)	78F max (provided by mechanical cooling) 68F min (provided by occupant operating windows)
23,24 (10 pm to midnight)	78F max (provided by mechanical cooling)
* Note that during the hours when the windows are constantly closed (10 pm to 6 am and 8 am to 5 pm), the temperatures referenced by VENT-TEMP-SCH are meaningless. Note also that VENT-TEMP-SCH does not necessarily say that cooling by natural ventilation will be done (that is accomplished by NATURAL-VENT-SCH). 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.	

MAX-VENT-RATE

The maximum air change rate for VENT-METHOD = S-G. For high wind speeds, the Sherman-Grimsrud model can give unrealistically large ventilation rates; MAX-VENT-RATE eliminates this problem.

System Control

The following keywords provide information on supply air temperature (setpoint, control strategy, and limits) and humidity limits, and identifies the appropriate equipment operating schedules.

MAX-SUPPLY-T

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

U-name of the SCHEDULE 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

HEAT-SET-T has two main functions depending upon the type of system being specified.

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.

For variable volumevariable-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

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

U-name of the 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 (i.e., entry for the keyword HEAT-CONTROL is the code-word RESET).

The following example shows a schedule that linearly reduces the hot deck temperature from 120F at 0F outside temperature to 70F at 70F outside temperature.

```
HOT-DECK-1 = DAY-SCHEDULE
    TYPE                = RESET-TEMP
    SUPPLY-HI           = 120
    SUPPLY-LO           = 70
    OUTSIDE-HI          = 70
    OUTSIDE-LO          = 0 ..

HOT-RESET-1 = SCHEDULE
    TYPE                = RESET-TEMP
    THRU DEC 31         (ALL) HOT-DECK-1 ..
```

```

"The Airhandler" = SYSTEM
.
.
HEAT-CONTROL      = RESET
HEAT-RESET-SCH    = HOT-RESET-1

```

MIN-SUPPLY-T

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

COOLING-SCHEDULE

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, the program 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.
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 on outdoor air temperature.
SCHEDULED	Specifies use of COOL-SET-SCH for control of heating and/or cooling air supply temperature.

COOL-RESET-SCH

U-name of the SCHEDULE 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 is COOL-CONTROL = RESET.

COOL-SET-SCH

U-name used to identify the schedule for controlling cooling air supply temperature when COOL-CONTROL = SCHEDULED.

The following example shows a COOL-SET-SCH that gives a cooling supply air temperature of 60F in the winter and 55F in the summer.


```

CC-SCH-1=SCHEDULE
  TYPE                = TEMPERATURE
  THRU APR 30         (ALL) (1,24) (60)
  THRU SEP 30         (ALL) (1,24) (55)
  THRU DEC 30         (ALL) (1,24) (60) ..

SC-SCH-1=SYSTEM
  COOL-CONTROL        = SCHEDULED
  COOL-SET-SCH        = CC-SCH-1

```

MAX-HUMIDITY

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 exist. The default value of 100 per cent is intended to specify no upper limit on humidity, that is, no humidity control.

The program 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. Figure 13 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 control zone. 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. For SZRH, PSZ and PVAVS. MIN-SUPPLY-T should be entered.

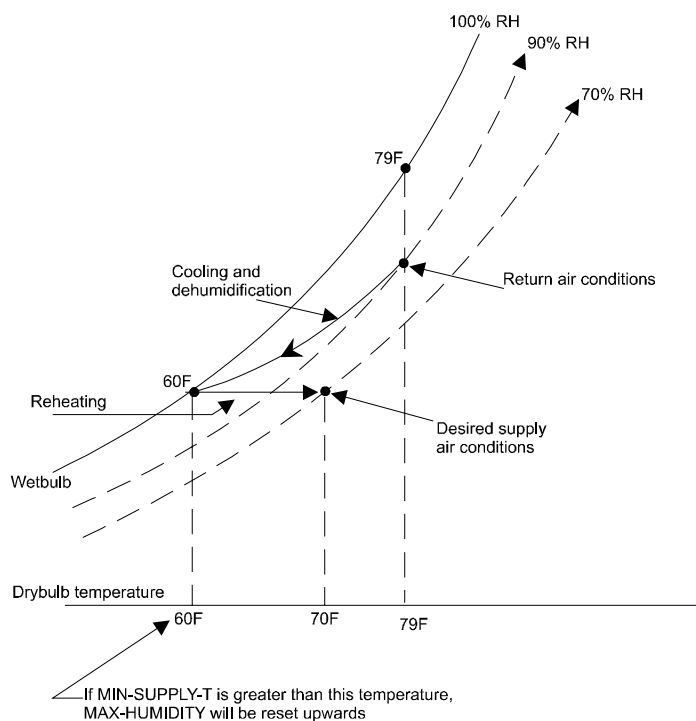


Figure 13 Relationship of MAX-HUMIDITY to MIN-SUPPLY-T

MIN-HUMIDITY

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). Don't set MIN-HUMIDITY so high that the ductwork condenses the humidity out of the supply air. 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.

BASEBOARD-SCH

U-name of the 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 ZONE keyword BASEBOARD-CTRL=OUTDOOR-RESET and the capacity is defined using BASEBOARD-RATING = value (negative) at the zone level.

Following is an example input for BASEBOARD-SCH and the associated reset schedule instructions DAY-SCHEDULE and SCHEDULE. This reset schedule reduces the fractional baseboard output linearly from 1.0 when the outside temperature is 0F to 0.0 when the outside temperature is 70F.

```

BASE-DAY-1 = DAY-SCHEDULE
  TYPE                = RESET-TEMP
  SUPPLY-HI            = 1.0
  SUPPLY-LO            = 0.0
  OUTSIDE-HI           = 70.0
  OUTSIDE-LO           = 0.0 ..

BASE-SCHED-1 = SCHEDULE
  TYPE                = RESET-TEMP
  THRU DEC 31          (ALL) BASE-DAY-1 ..

```

```

"The Airhandler" = SYSTEM
.
.
BASEBOARD-SCH      = BASE-SCHED-1
. . .

```

PREHEAT-T

Minimum temperature of air leaving the preheat coil. The SYSTEMS program calculates the necessary preheat coil energy input to maintain this temperature.

System Fans

The next set of keywords provide information on supply and return fan operating schedules, control modes, static pressures, and efficiencies. In short, 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 via the keywords ZONE:EXHAUST-FLOW, ZONE:EXHAUST-STATIC

FAN-SCHEDULE

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

Code-word specifies the kind of flow reduction or control methods to be simulated. 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 Figure 14). The program assumes that both supply and return fans have the same kind of flow control.

SPEED	Control of the motor speed (Curve 1 in Figure 14), variable pitch of axial vanes, or adjustable V-pulley (for systems that have variable flow central air-handlers only.) Note, the PTGSD system defaults to SPEED control.
INLET	Variable position inlet vanes (Curve 2 in Figure 14). (For systems that have variable flow central air-handlers only.)
DISCHARGE	Variable position discharge dampers or allowing the duct pressure to build behind the VAV box (Curve 3 in Figure 14). [For systems that have variable flow central air-handlers only.]
CYCLING	Fan cycles on and off (RESYS) (Curve 4 in Figure 14).
TWO-SPEED	High or low speed (for PTAC only - represented as 100 percent and another point lower on Curve 1)
CONSTANT-VOLUME	Indicates no control (the default for all systems other than variable volumevariable-volume systems)

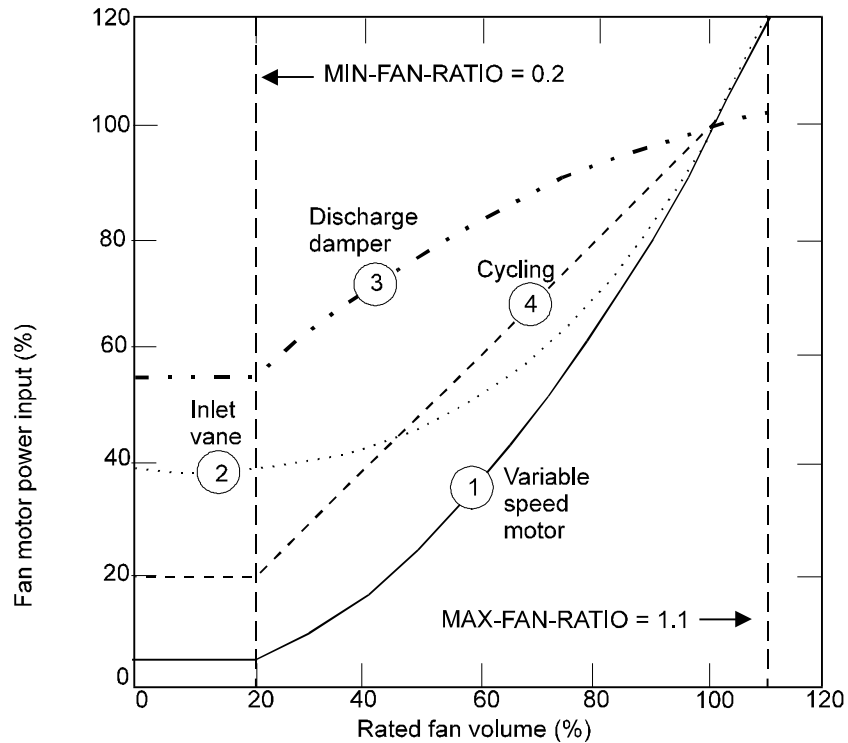


Figure 14 Typical power requirements at part-load operation for four different methods of air flow control. Note that for FAN-CONTROL = CYCLING, MIN-FAN-RATIO is meaningless when the fan is off.

SUPPLY-DELTA-T

Used in conjunction with SUPPLY-KW. It is the temperature rise in the air stream across the supply fan. It is expressed in °F.

SUPPLY-KW

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)

RETURN-DELTA-T

Used in conjunction with RETURN-KW. It is the temperature rise in the air stream across the return air fan.

RETURN-KW

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	(the default) Indicates that regardless of conditions, fans stay off.
CYCLE-ON-ANY	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	If the temperature in the first, or control, ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, 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.

Additional input

REHEAT-DELTA-T

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. This keyword is required in order to simulate heating the air as it passes through the terminal reheat coil. Note that when very little air is passed (see MIN-FLOW-RATIO) there may be insufficient reheating.

HEAT-SOURCE

Takes a code-word that specifies the heat source for the SYSTEM's main heating coils. This keyword can also be used for the UHT, UVT, FC and PTAC zone heating coils since these coils are served by a central distribution system. Allowed values of HEAT-SOURCE are:

ELECTRIC	The heat source is an electric resistance element.
HOT-WATER	The heat source is hot water provided by equipment specified in the PLANT input.
FURNACE	The heat source is a furnace (simulated in SYSTEMS).
HEAT-PUMP	The source of heat is an electric air-to-air heat pump. Used only for the RESYS, PSZ and PTAC systems.
GAS-HEAT-PUMP	The heat source is a natural-gas engine-driven heat pump. Used only with the PSZ, PVVT, PTAC, RESYS and PVAVS system types.
GAS-HYDRONIC	For the PTGSD system type, specifies that the heat source is a gas-fired hot water generator.

ZONE-HEAT-SOURCE

Takes a code-word that specifies the heat source for the zone heating coils (reheat coils) in central air handler systems. Allowed values are:

ELECTRIC	The heat source is an electric resistance element.
HOT-WATER	The source of heat is hot water provided by equipment specified in the PLANT input.
FURNACE	The heat source is a furnace (simulated in SYSTEMS).
HEAT-PUMP	The source of heat is an electric air-to-air heat pump. Used only for the RESYS, PSZ and PTAC systems.
GAS-HEAT-PUMP	The heat source is a natural-gas engine-driven heat pump. Used only with the PSZ, PVVT, PTAC, RESYS and PVAVS system types.
GAS-HYDRONIC	For the PTGSD system type, specifies that the heat source is a gas-fired hot water generator.

PREHEAT-SOURCE

Takes a code-word that specifies the heat source for the preheat coil, when applicable.

ELECTRIC	The heat source is an electric resistance element.
HOT-WATER	The source of heat is hot water provided by equipment specified in the PLANT input.
FURNACE	The heat source is a furnace (simulated in SYSTEMS).
HEAT-PUMP	The source of heat is an electric air-to-air heat pump. Used only for the RESYS, PSZ and PTAC systems.
GAS-HEAT-PUMP	The heat source is a natural-gas engine-driven heat pump. Used only with the PSZ, PVVT, PTAC, RESYS and PVAVS system types.
GAS-HYDRONIC	For the PTGSD system type, specifies that the heat source is a gas-fired hot water generator.

BASEBOARD-SOURCE

Takes a code-word that specifies the heat source for baseboard heating. Allowed values are:

ELECTRIC	The heat source is an electric resistance element.
HOT-WATER	The heat source is hot water provided by equipment specified in the PLANT input.
FURNACE	The heat source is a furnace (simulated in SYSTEMS).
HEAT-PUMP	The source of heat is an electric air-to-air heat pump. Used only for the RESYS, PSZ and PTAC systems.

GAS-HEAT-PUMP	The heat source is a natural-gas engine-driven heat pump. Used only with the PSZ, PVVT, PTAC, RESYS and PVAVS systems.
GAS-HYDRONIC	For the PTGSD system type, specifies that the heat source is a gas-fired hot water generator

HUMIDIFIER-TYPE

Takes a code-word that determines the type and source of heating energy used to vaporize water for humidification of supply air. The heating energy is reported with the main heating coil. Allowed code-words are:

ELECTRIC	The heat source is an electric resistance element.
HOT-WATER	The heat source is hot water provided by equipment specified in the PLANT input.
FURNACE	The heat source is a furnace (simulated in SYSTEMS).
HEAT-PUMP	The source of heat is an electric air-to-air heat pump. Used only for the RESYS, PSZ and PTAC systems.
GAS-HEAT-PUMP	The heat source is a natural-gas engine-driven heat pump. Used only with the PSZ, PVVT, PTAC, RESYS and PVAVS systems.

SIZING-RATIO

Multiplier on the program-calculated values of air flow rate and coil size. This keyword is used to deliberately oversize or undersize the equipment in the system. The input for this keyword is the desired capacity of the system divided by either (1) the capacity you assign in the input or (2) the capacity calculated by the program from peak loads. The ratio can be more than, equal to, or less than unity. SIZING-RATIO modifies the secondary HVAC equipment sizes only, not the primary equipment sizes. Using SIZING-RATIO will probably change the responsiveness of the system, either faster or slower depending upon whether the equipment is being oversized or undersized. Likewise, the alteration of equipment size can change the demands, placed by the system, on the primary equipment. The latter change may render the primary equipment inadequate in size (if assigned) or may result in excessively large equipment.

CONTROL-ZONE

Takes the U-name of the zone whose thermostat controls the system supply air flow and/or temperature. This keyword is required by the following system types: SZRH, RESYS, PSZ, EVAP-COOL, and RESVVT. It is unused by other system types.

ZONE

Gives information on secondary HVAC distribution system characteristics specific to a thermal zone. This includes air flow rate (supply air, exhaust air, and outside air), zone air temperature setpoint, thermostat characteristics, and maximum heating and/or cooling capacity. U-name is required. A ZONE is assumed to belong to the immediately-preceding SYSTEM. For example, in the following, ZONE-1 and ZONE-2 belong to SYS-1 and ZONE-3 belongs to SYS-2:

Example input:

```

SYS-1 = SYSTEM

ZONE-1 = ZONE
    SPACE                = SPACE-1

    ASSIGNED-FLOW        = 1000
    OA-FLOW/PER           = 20

    DESIGN-HEAT-T         = 72
    DESIGN-COOL-T         = 78
    HEAT-TEMP-SCH         = HT-SCH-1
    COOL-TEMP-SCH         = CT-SCH-1
    BASEBOARD-CTRL        = THERMOSTATIC
    THERMOSTAT-TYPE       = PROPORTIONAL
    THROTTLING-RANGE      = 3    ..

ZONE-2 = ZONE
    LIKE                  = ZONE-1
    SPACE                 = SPACE-2    ..

SYS-2 = SYSTEM
    . . .

ZONE-3 = ZONE
    LIKE                  = ZONE-1
    SPACE                 = SPACE-3    ..

```

SPACE

Required keyword that takes the U-name of the SPACE command (in the LOADS input) that corresponds to this zone.

Zone Airflow

The next set of keywords provide information on zone air flow quantities. All air quantities should be 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.

ASSIGNED-FLOW

Allows you to set (in standard cfm) the design supply air flow rate (sometimes referred to as the recirculated air rate) for the zone. Two other keywords, AIR-CHANGES/HR and FLOW/AREA, may be used as alternative methods of assigning this design parameter; however, any entry for ASSIGNED-FLOW will take precedence and be used by the program. If data entry is omitted for ASSIGNED-FLOW (and for AIR-CHANGES/HR and FLOW/AREA) 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. The flow rates so calculated don't account for interzone heat transfer unless explicitly requested. 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 given to the zone. It is expressed in terms of the number of times per hour that the flow rate replaces the total volume of air in the zone. ASSIGNED-FLOW takes precedence over this input.

FLOW/AREA

Sets the minimum design supply air flow rate 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-FLOW takes precedence over this input.

Ventilation Air Keywords

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-FLOW

Use either OUTSIDE-AIR-FLOW or OA-FLOW/PER or OA-CHANGES Sets or specifies the minimum flow rate of outside air (in standard, or sea level, cfm) for the zone. Alternatively, or additionally, outside air flow rate may be specified by the keywords OA-FLOW/PER and OA-CHANGES (or by MIN-OUTSIDE-AIR in the SYSTEM command). The program calculates outside air flow rate based on each entry and normally uses the larger value except if it sees data entry for OUTSIDE-AIR-FLOW, which overrides other values. Note that the specification of outside ventilation air at the zone level takes precedence over the specification of outside ventilation air at the system level. This keyword is 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. The outside ventilation air quantity is not determined by the design space heating or cooling demands except when an economizer is specified.

OA-CHANGES

Use either OUTSIDE-AIR-FLOW or OA-FLOW/PER or OA-CHANGES 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-FLOW takes precedence over this input. This keyword is 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. The outside ventilation air quantity is not determined by the design space heating or cooling demands except when an economizer is specified.

OA-FLOW/PER

Minimum flow rate of outside air (in standard, or sea level, cfm) per zone occupant at peak occupancy. OUTSIDE-AIR-FLOW takes precedence over this input. The minimum outside air flow rate can be scheduled using the MIN-AIR-SCH keyword in the SYSTEM command.

EXHAUST-FLOW

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. The

SYSTEMS program does not simulate heat recovery from zone exhaust, but only from central exhaust. If heat is to be recovered, zone exhaust should not be entered but rather allowed to default to the central system. Return fan static should be adjusted, on a weighted average basis, to reflect zone exhaust fan conditions. The program will not allow MIN-OUTSIDE-AIR to be less than the sum of EXHAUST-FLOWs 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

Total pressure (in inches of water) produced by the exhaust fan serving the zone. See the keyword SUPPLY-EFF in the SYSTEM command. EXHAUST-STATIC applies only if a data entry is made for the keyword EXHAUST-FLOW.

EXHAUST-EFF

Combined efficiency of the zone exhaust fan and motor at design conditions. EXHAUST-EFF applies only the keyword EXHAUST-FLOW is used. The program calculates exhaust fan horsepower on the basis of the value of this data entry and the entries for the keywords EXHAUST-FLOW 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 SYSTEM).

EXHAUST-KW

An alternative to 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 Control

This set of keywords provides information on zone temperature control characteristics such as setpoint, thermostat type, and throttling range.

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.

HEAT-TEMP-SCH

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 that the program uses to calculate the supply air flow rate required to meet peak (or design day) cooling loads for the zone

COOL-TEMP-SCH

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 baseboard heating element in the zone. Applicable code-words are:

THERMOSTATIC

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 will assume 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 first in response to a drop in space temperature.

THERMOSTAT-TYPE

Identifies the type of thermostat action to be simulated. The program assumes the same type of thermostat action for both cooling and heating. Applicable code-words are:

PROPORTIONAL	Thermostat throttles heat addition rate (or heat extraction rate) in linear proportion to the difference between zone setpoint temperature and actual zone temperature; thermostat modulates its signal to proportion the amount of zone cooling or heating. You set 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 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-FLOW-RATIO. Otherwise, the effect is the same as for THERMOSTAT-TYPE=PROPORTIONAL.

THROTTLING-RANGE

Specifies the number of degrees that room temperature must change in order 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.

Additional input

BASEBOARD-RATING

Baseboard heating element capacity for the zone; input for this keyword should be a negative number

DAY-RESET-SCH AND RESET-SCHEDULE

Note: DAY-RESET-SCH and RESET-SCHEDULE still exist, but they are just synonyms for DAY-SCHEDULE and SCHEDULE

These commands define the relationship between a system control parameter and the outside air temperature for each hour of the RUN-PERIOD. On the air side, they apply to control of hot deck temperature, cold deck temperature, and baseboard heating. They also apply to CIRCULATION-LOOP temperatures on the water side.

RESET-SCHEDULE is similar to SCHEDULE. DAY-RESET-SCH is analogous to DAY-SCHEDULE but, instead of entering 24 hourly values, the four required keywords SUPPLY-HI, SUPPLY-LO, OUTSIDE-HI, and OUTSIDE-LO are specified.

A DAY-RESET-SCH requires a U-name so it can be referenced by RESET-SCHEDULE. LIKE may be used with DAY-RESET-SCH but not with RESET-SCHEDULE.

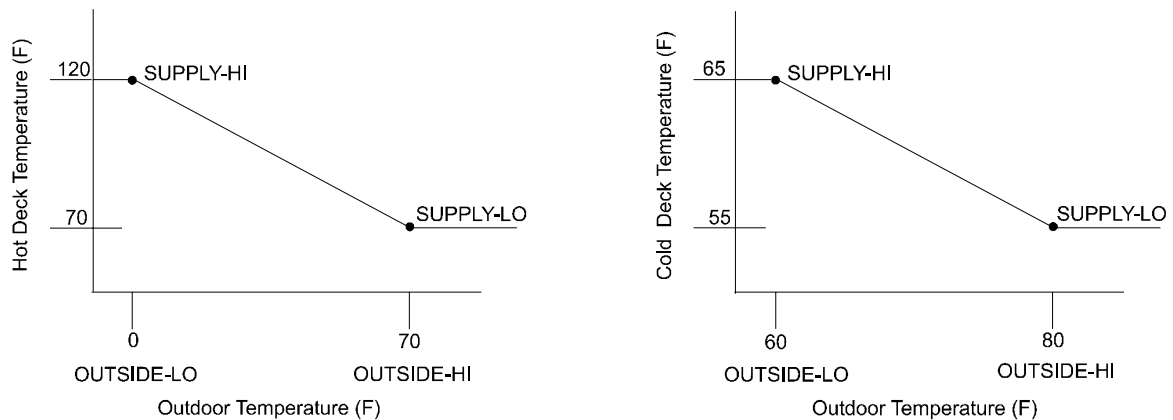


Figure 15 Typical reset control for hot-deck or cold-deck temperature

Example input:

For the hot deck reset control in Figure 15 the input would look like:

```
DRS-1 = DAY-RESET-SCH
  TYPE                = RESET-TEMP
  SUPPLY-HI            = 120
  OUTSIDE-LO           = 0
  SUPPLY-LO            = 70
  OUTSIDE-HI           = 70
  ..

RS-1 = RESET-SCHEDULE
  TYPE                = RESET-TEMP
  THRU DEC 31          (ALL) DRS-1
  ..
```

Caution: DAY-RESET-SCH cannot be nested; the following is *not* permitted:

```

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

```

TYPE

Takes a code-word that specifies the type of reset.

RESET-TEMP	applies to supply air temperature reset.
RESET-RATIO	applies to baseboard output reset.

OUTSIDE-HI

Outside drybulbdry-bulb temperature that corresponds to SUPPLY-LO. OUTSIDE-HI should be greater than OUTSIDE-LO.

OUTSIDE-LO

Outside drybulbdry-bulb temperature that corresponds to SUPPLY-HI. OUTSIDE-LO should be less than OUTSIDE-HI.

SUPPLY-HI

Upper supply air setpoint temperature (or output ratio) corresponding to the value you input for OUTSIDE-LO. For reset of cooling air or heating air temperature (Figure 15), your input is a temperature. See keywords HEAT-RESET-SCH and COOL-RESET-SCH in the SYSTEM command. For baseboard heating (Figure 16), your input is a heating output ratio. See keyword BASEBOARD-SCH in the SYSTEM command. The heating output is expressed as a decimal fraction of the maximum zone baseboard heating capacity (see keyword BASEBOARD-RATING in the ZONE command).

SUPPLY-LO

Lower supply air setpoint temperature (or output ratio) corresponding to the input value for the OUTSIDE-HI. See the discussion for SUPPLY-HI.

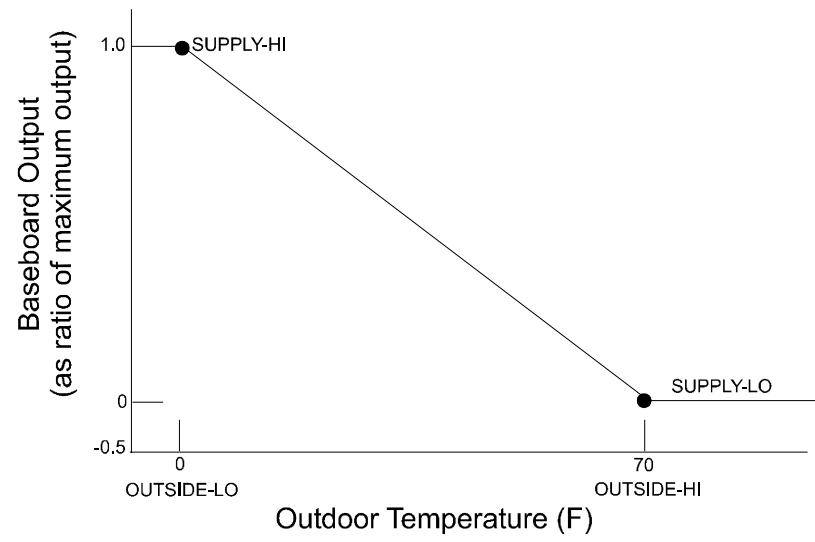


Figure 16 Typical reset control for baseboard heating output

SPECIFIC AIR SYSTEM TYPES

Table 13 lists all of the air system types that can be simulated in the program. The first group of 15 systems in this table, labeled as "basic," are the most familiar types of systems; they are described in more detail in the following section of this manual. The second group of 8 systems, labeled as "other," are less commonly used or more difficult to input; they are described elsewhere (see, for example, the *DOE-2.2 Dictionary* and the *DOE-2.2 Topics*).

Table 13 Specific Air System Types

Basic Systems	
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 (single or dual fan)
VAVS	Variable-volume air-handling unit
PIU	Powered Induction unit variable air volume air-handling unit
FC	Two- and four- pipe fan coil
RESYS	Residential furnace and packaged condensing unit (heat pump is an option)
PSZ	Packaged single-zone variable temperature DX unit
PMZS	Packaged multizone DX unit
PVAVS	Packaged variable-volume DX unit
PTAC	Packaged terminal air conditioner with heat pump option (e.g., window units)
UHT	Unit heater
UVT	Unit ventilator (heating only)
Other Systems Not Covered In This Manual	
EVAP-COOL	Evaporative cooling unit
PVVT	Packaged variable-volume, variable-temperature unit
RESVVT	Residential variable-volume, variable-temperature unit
HP	Heat pumps on a common water loop (with ground source option)
CBVAV	Ceiling bypass unit
IU	Two- and four- pipe induction unit
SZCI	Ceiling induction unit
HVSYS	Heating and ventilating system
FPH	Floor panel heating system

In the material that follows, you will find

1. A full description of each basic 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 primary system input is also given.
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. 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.

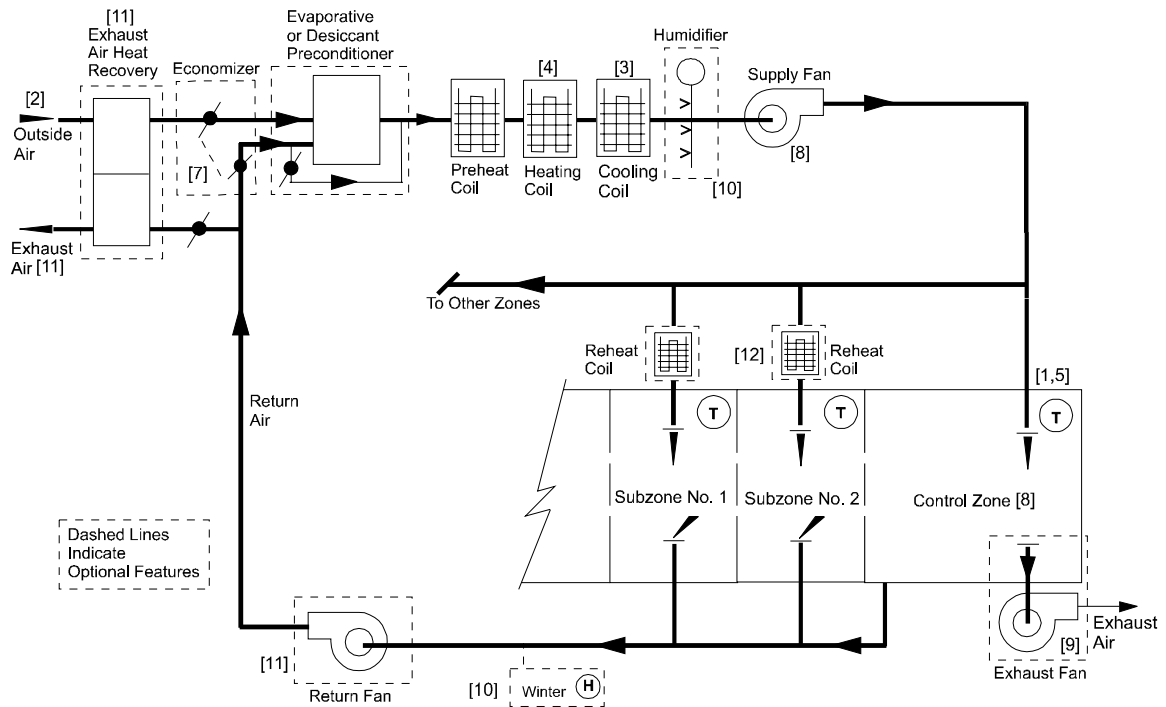


Figure 17 Single-zone fan system with optional subzone reheat

Suggested minimal input for SZRH system with an economizer:

```

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

$ SYSTEMS SCHEDULES

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

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

```

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                  $pump $is not required as the chiller
                  $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.25                      $gpm$
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..
  LOOP-PUMP            = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
  TYPE                = CHW
  LOOP-PUMP            = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
  TYPE                = HW
  LOOP-PUMP            = HW-PUMP-1 ..

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE       = AIR-COOLED
  CHW-LOOP             = COOLING-WATER-1 ..

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP              = HOT-WATER-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP             = DHW-LOOP-1 ..

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

```

```

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

```

```
$THIS MAY BE FOLLOWED BY AN ECON INPUT$
```

```
END ..
```

```
COMPUTE ..
```

```
STOP ..
```

Additional capabilities for SZRH system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [9]
2. To enable a humidifier that requires heat to evaporate water into the air add MIN-HUMIDITY (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 (0.6 is typical) and RETURN-KW (0.0003 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 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
  TYPE                = ON/OFF
  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 energy equivalent of moisture added to the air stream to maintain a minimum humidity is passed to the PLANT program as a heating load.

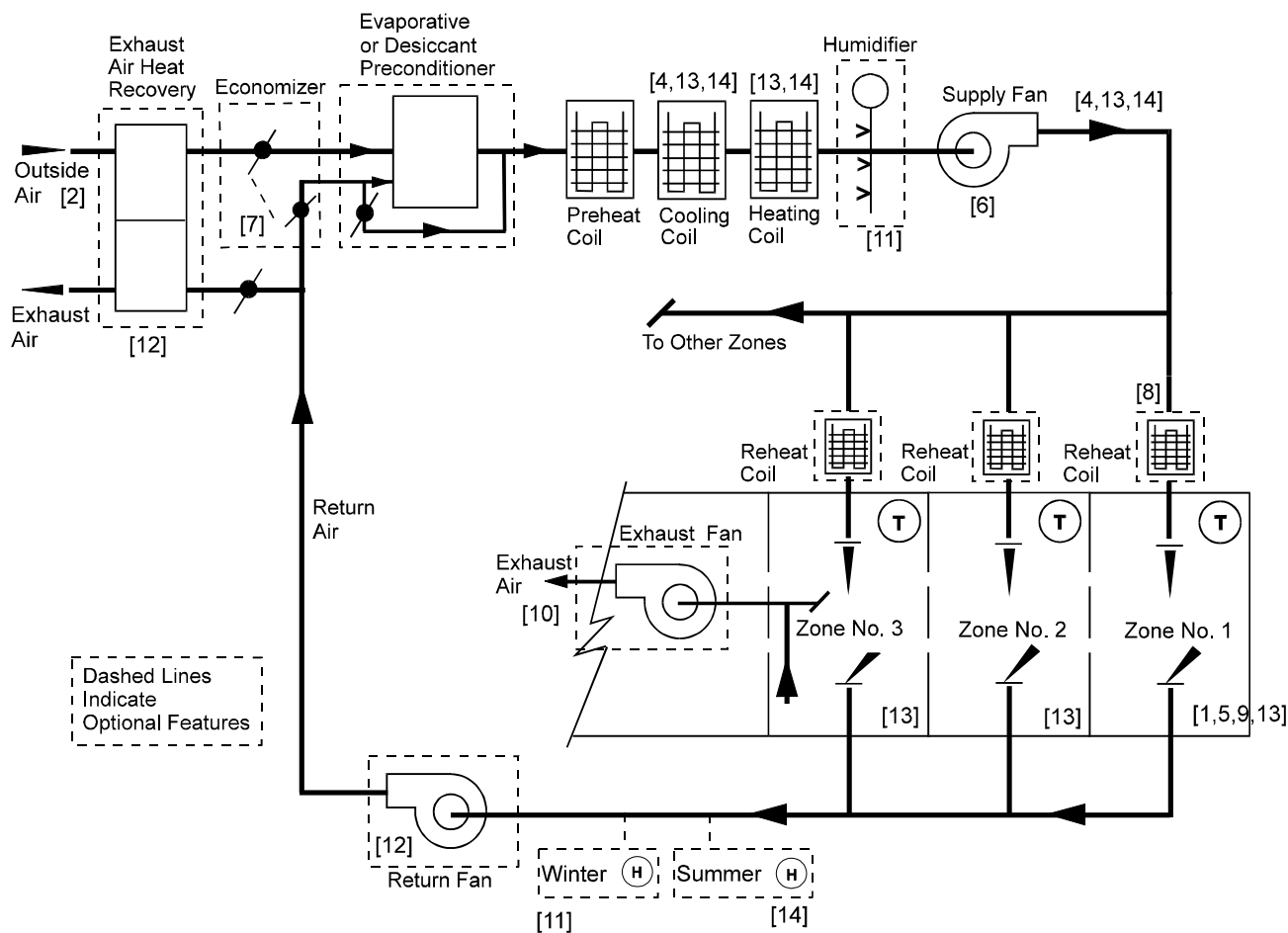


Figure 18 Constant-volume reheat fan system (RHFS)

Suggested minimal input for RHFS system with an economizer:

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                $pump $is not required as the chiller
                $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW              = 0.25                      $gpm$
PROCESS-SCH               = DHW-1
HEAT-SETPT-T              = 120 ..
LOOP-PUMP                 = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
TYPE                      = CHW
LOOP-PUMP                 = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
TYPE                      = HW
LOOP-PUMP                 = HW-PUMP-1 ..

CHILLER-1 = CHILLER-1
TYPE                      = ELEC-HERM-REC
CONDENSER-TYPE            = AIR-COOLED
CHW-LOOP                  = COOLING-WATER-1 ..

```

```

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP              = HOT-WATER-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP            = DHW-LOOP-1 ..

AC-SYST = 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]
  HEAT-SOURCE         = HOT-WATER
  HW-LOOP              = HOT-WATER-1
  CHW-LOOP            = COOLING-WATER-1 ..

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

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for RHFS system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [10]
2. To enable a humidifier that requires heat to evaporate water into the air add MIN-HUMIDITY (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 (0.6 is typical) and RETURN-KW (.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 Runs.
7. To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY (60% is allowed in the 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.

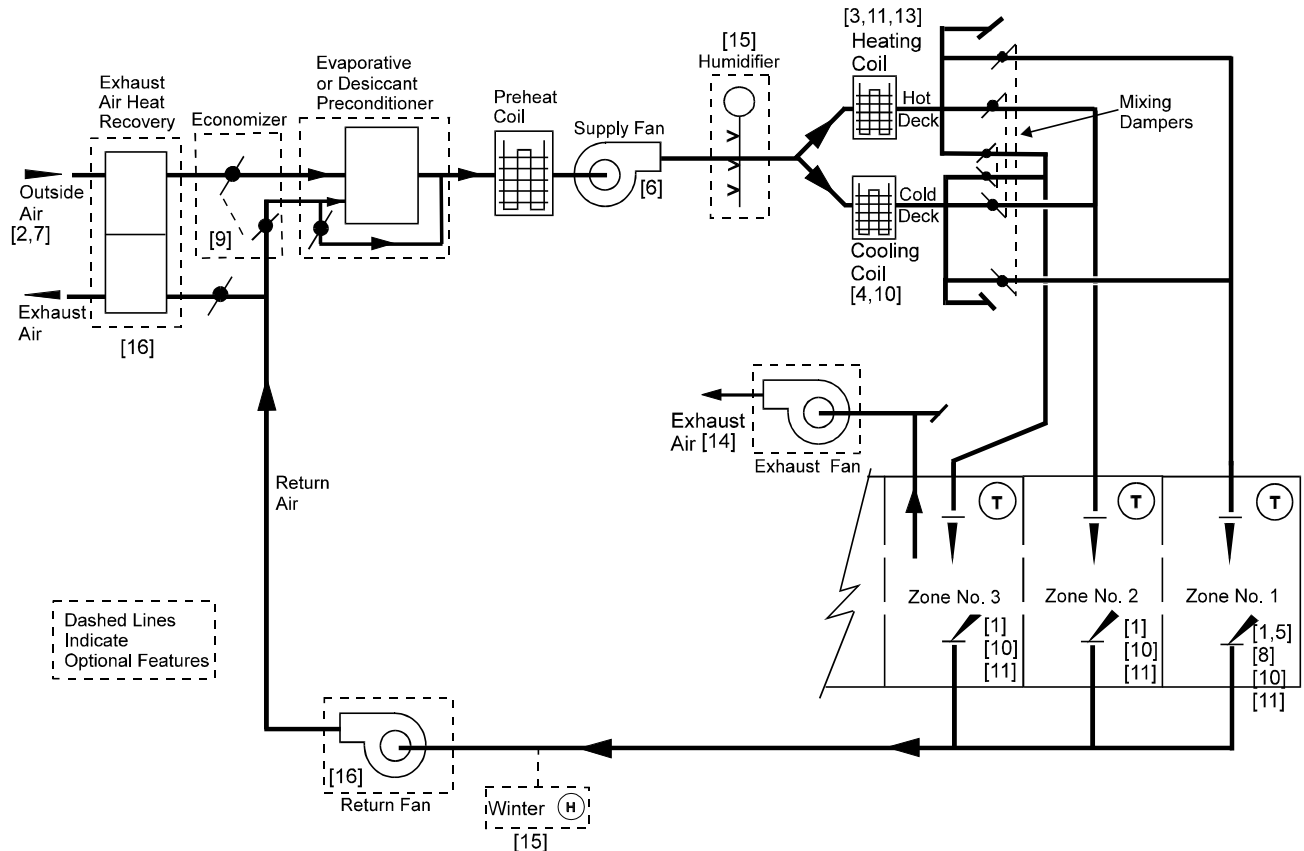


Figure 19 Multizone fan system (MZS)

Suggested minimal input for MZS system:

```

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

$ SYSTEMS SCHEDULES

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



```

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                  $pump $is not required as the chiller
                  $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.25                      $gpm$
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..
  LOOP-PUMP            = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
  TYPE                = CHW
  LOOP-PUMP            = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
  TYPE                = HW
  LOOP-PUMP            = HW-PUMP-1 ..

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE       = AIR-COOLED
  CHW-LOOP             = COOLING-WATER-1 ..

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP              = HOT-WATER-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP             = DHW-LOOP-1 ..

```

```

AC-SYST = 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]
  HEAT-SOURCE        = HOT-WATER
  HW-LOOP             = HOT-WATER-1
  CHW-LOOP            = COOLING-WATER-1 ..

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

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for MZS system:

1. To enable an economizer, add OA-CONTROL=TEMP and ECONO-LIMIT-T (typically 60F) 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 (2) and (3) above are reset of cold and hot deck supply air temperature. An example of this control is covered in the Sample Runs.
5. To simulate turning off the hot deck whenever the outside temperature is above 65F, insert a new schedule like this: [13]

```

HEAT-OFF = SCHEDULE
  TYPE                = TEMPERATURE
  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 and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [14]
7. To enable a humidifier that requires heat to evaporate water into the air add MIN-HUMIDITY (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 (0.6 is typical) and RETURN-KW (0.0003 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. The program assumes there is a preheat coil and calculates the preheat load, if and when the mixed air temperature falls below the required PREHEAT-T.

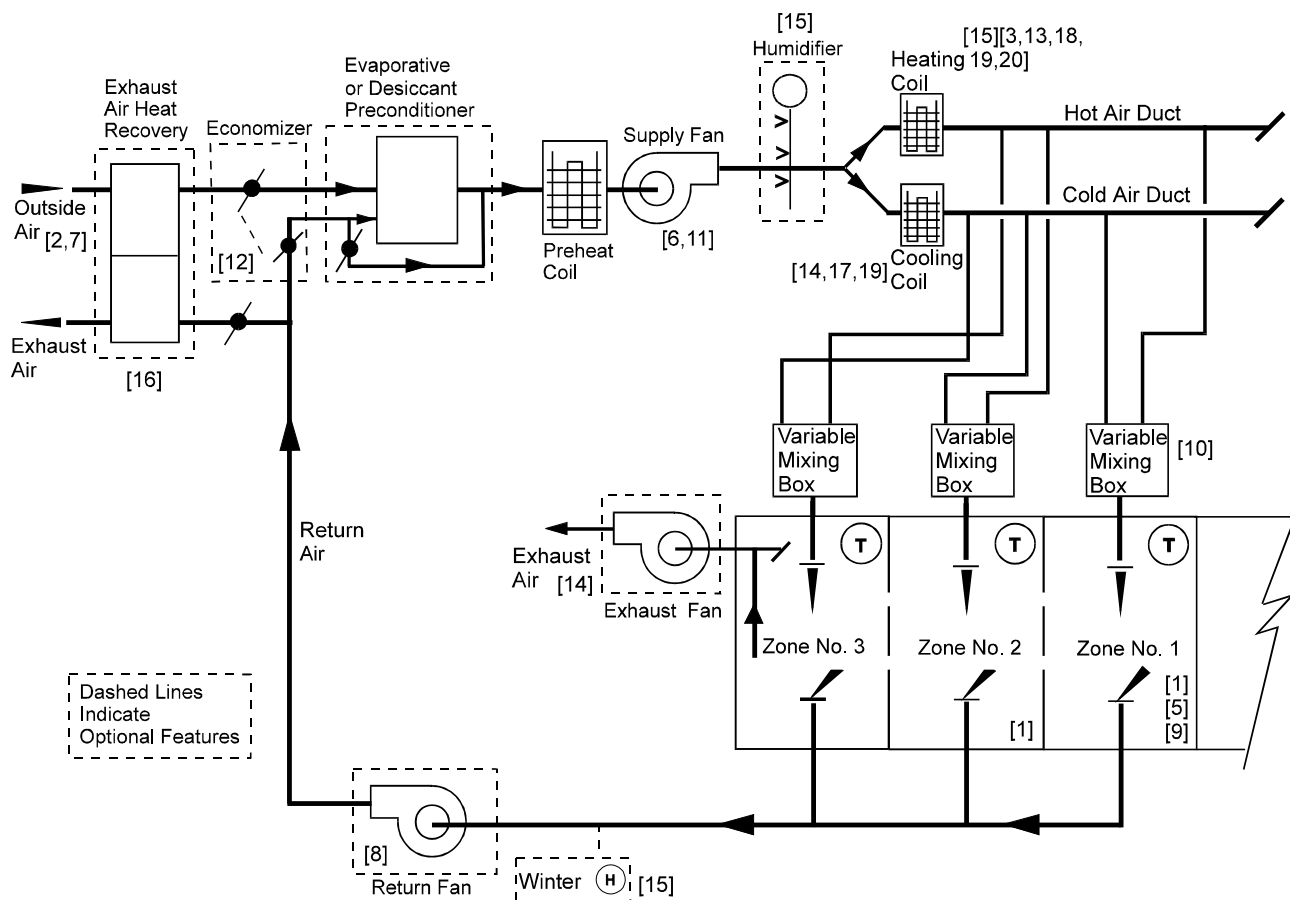


Figure 20 Dual-duct fan system (DDS)

Suggested minimal input for DDS system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                $pump $is not required as the chiller
                $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW              = 0.25                      $gpm$
PROCESS-SCH              = DHW-1
HEAT-SETPT-T             = 120 ..
LOOP-PUMP                = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
TYPE                      = CHW
LOOP-PUMP                = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
TYPE                      = HW
LOOP-PUMP                = HW-PUMP-1 ..

CHILLER-1 = CHILLER-1
TYPE                      = ELEC-HERM-REC
CONDENSER-TYPE           = AIR-COOLED
CHW-LOOP                 = COOLING-WATER-1 ..

```

```

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP              = HOT-WATER-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP             = DHW-LOOP-1 ..

AC-SYST = 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           = 0.55 [8]
  HEAT-SOURCE          = HOT-WATER
  HW-LOOP              = HOT-WATER-1
  CHW-LOOP             = COOLING-WATER-1 ..

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

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for DDS system:

1. To simulate a variable-volume Dual-Duct air system add MIN-FLOW-RATIO=0.5 (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 typically 60F 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 to 70F [12]
4. To simulate turning off the hot deck whenever the outside temperature is above 65F and always during the summer months of JULY 1 through AUGUST 30, insert a new schedule like this: [13]

```

HEAT-OFF-SCHEDULE
  TYPE                = TEMPERATURE
  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 and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [14]
6. To enable a humidifier that requires heat to evaporate water into the air add MIN-HUMIDITY (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 (0.6 is typical) and RETURN-KW (0.0003 is typical) to the SYSTEM keyword list. [16]
8. To simulate discriminator control of the cold deck supply air temperature add COOL-CONTROL=WARMEST to the SYSTEM keyword list. [17]
9. To simulate 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 covered in the Sample Runs. [19]

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.

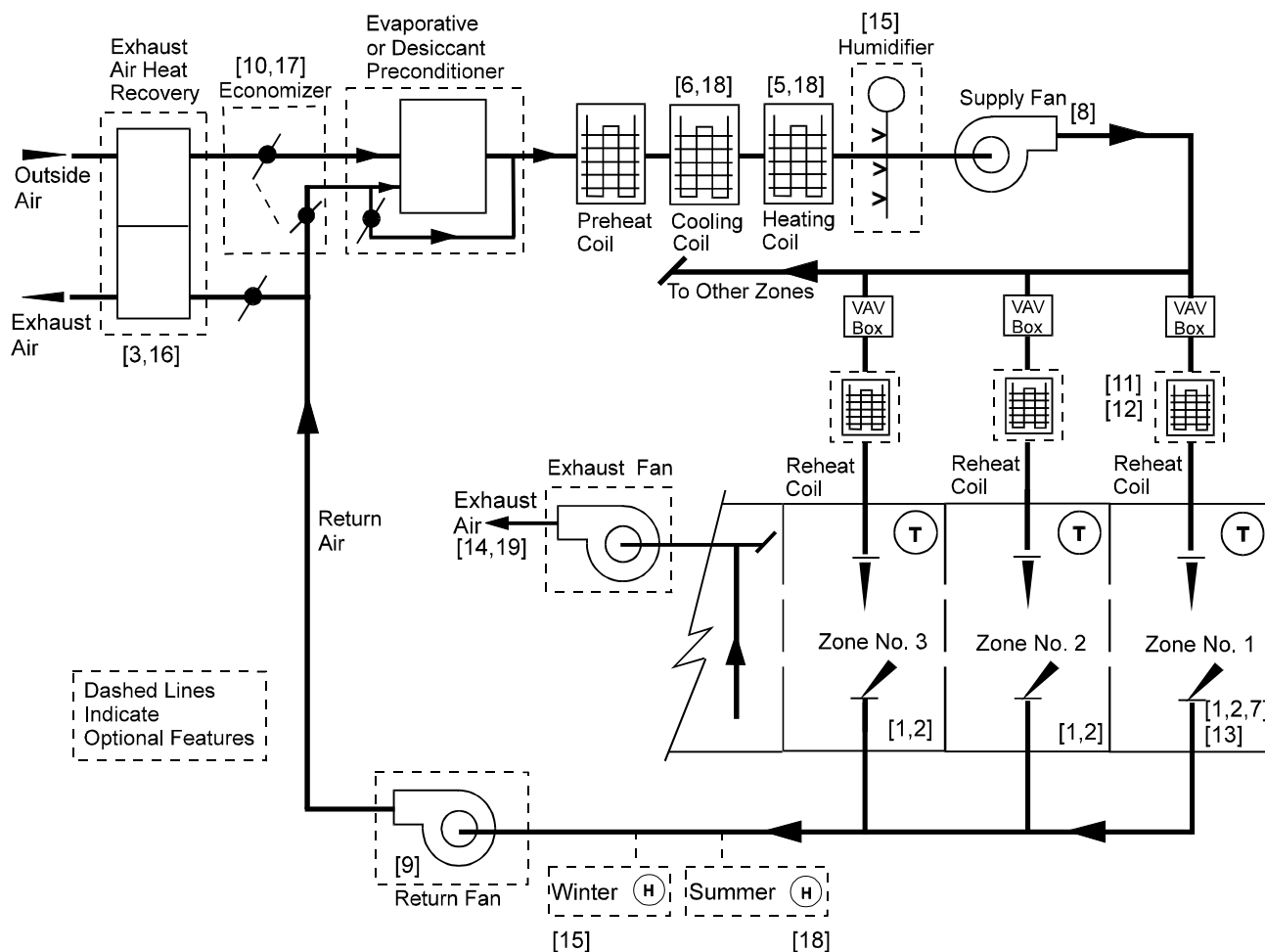


Figure 21 Variable-volume fan system with optional reheat (VAVS)

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-FLOW-RATIO. The supply air flow rate will rise above the MIN-FLOW-RATIO only if you have set THERMOSTAT-TYPE=REVERSE-ACTION. The energy 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.

Suggested minimal input for VAVS system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                  $pump $is not required as the chiller
                  $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW              = 0.25                      $gpm$
PROCESS-SCH               = DHW-1
HEAT-SETPT-T              = 120 ..
LOOP-PUMP                 = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
TYPE                      = CHW
LOOP-PUMP                 = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
TYPE                      = HW
LOOP-PUMP                 = HW-PUMP-1 ..

```

```

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE      = AIR-COOLED
  CHW-LOOP            = COOLING-WATER-1 ..

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP            = HOT-WATER-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP            = DHW-LOOP-1 ..

AC-SYST = 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]
  OA-CONTROL          = TEMP                [7]
  ECONO-LIMIT-T       = 68                  [10]
  MIN-FLOW-RATIO      = 0.3                 [11]
  REHEAT-DELTA-T      = 55                  [12]
  HEAT-SOURCE         = HOT-WATER
  HW-LOOP            = HOT-WATER-1
  CHW-LOOP            = COOLING-WATER-1 ..

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

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for VAVS system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 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 (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 (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 Runs.
6. To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY (60% is allowed in the 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 Runs.
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. In PIU systems one or more zones are served by VAV terminal boxes with small fans that pull air from another zone (called the induced air zone) via a ceiling plenum. These boxes are labeled "PIU box with fan" in the schematic.

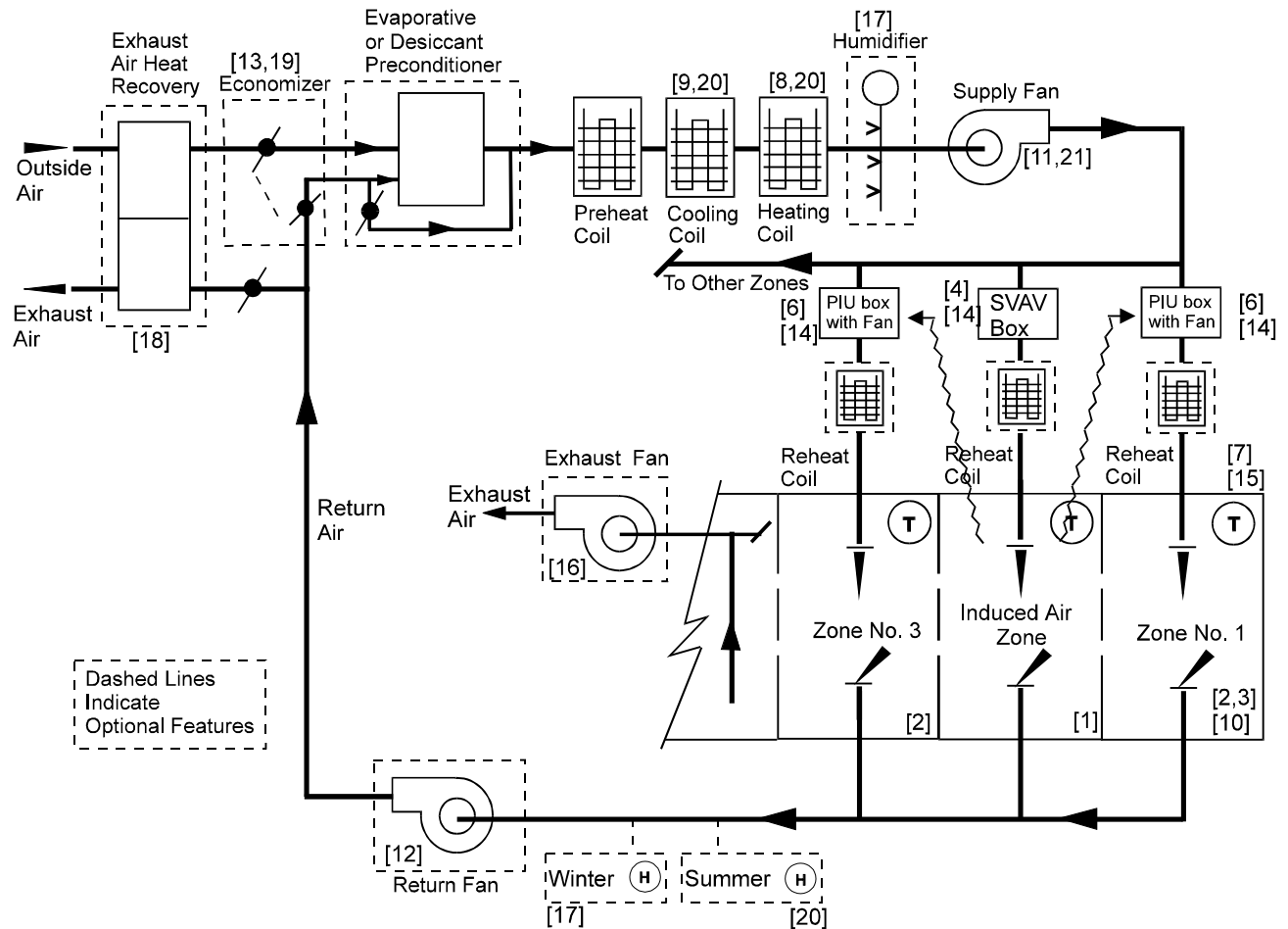


Figure 22 Powered induction unit system with optional reheat

PIU systems have two functions:

1. To move warm air from a core area through the plenum to exterior zones requiring heat, thus conserving heating energy.
2. To provide increased air movement in zones that are normally served by VAV terminals but which suffer from stagnant air when the primary damper is at minimum flow.

The powered induction boxes are available in two configurations: series and parallel. Suggested minimal input for series-type PIU units:

The following input for a PIU system with an economizer has series-type PIU boxes as illustrated in Figure 23. In this type of box, the fan draws air from both the primary and secondary air streams.

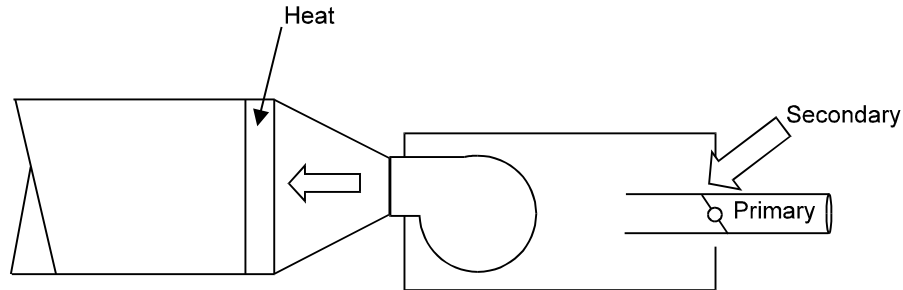


Figure 23 Series PIU

There must be at least two zones in a PIU system. One of the zones (called "CORE" in the example) is the "induced air zone." This zone has a standard (non-induction) VAV box, indicated by `TERMINAL-TYPE = SVAV`. In this example, a second zone, called "OFFICE," has a series PIU box indicated by `TERMINAL-TYPE = SERIES-PIU`. For this zone, `INDUCED-AIR-ZONE=CORE` indicates that the PIU box is drawing secondary air from the zone named "CORE."

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

```

```

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                    $pump $is not required as the chiller
                    $is AIR-COOLED

```

```

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.25                $gpm$
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..
  LOOP-PUMP            = DHW-PUMP-1 ..

```

```

COOLING-WATER-1 = CIRCULATION-LOOP
  TYPE                = CHW
  LOOP-PUMP            = CHW-PUMP-1 ..

```

```

HOT-WATER-1 = CIRCULATION-LOOP
  TYPE                = HW
  LOOP-PUMP            = HW-PUMP-1 ..

```

```

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE       = AIR-COOLED
  CHW-LOOP              = COOLING-WATER-1 ..

```

```

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP              = HOT-WATER-1 ..

```

```

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP              = DHW-LOOP-1 ..

```

```

AC-SYST = 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           = 0.55              [12]
  OA-CONTROL           = TEMP              [13]
  ECONO-LIMIT-T        = 68                [13]
  MIN-FLOW-RATIO       = 0.3               [4]
  HEAT-SOURCE          = HOT-WATER
  HW-LOOP              = HOT-WATER-1
  CHW-LOOP              = COOLING-WATER-1 ..

```

```

CORE = ZONE
  TYPE                = CONDITIONED
  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            = 0.7
  OA-FLOW/PER         = 15 ..                             [5]

OFFICE = ZONE
  LIKE                CORE                                [2]
  TERMINAL-TYPE       = SERIES-PIU
  ZONE-FAN-KW         = 0.00033                          [6]
  INDUCED-AIR-ZONE    = CORE                             [1]
  REHEAT-DELTA-T      = 55 ..                             [15]

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Suggested minimal input for parallel-type PIU units:

In parallel-type PIU boxes, shown in Figure 24, the fan draws air only from the secondary air stream. For zones with parallel-type PIU boxes, ZONE-FAN-T-SCH gives the zone air temperature below which the PIU box fan turns on.

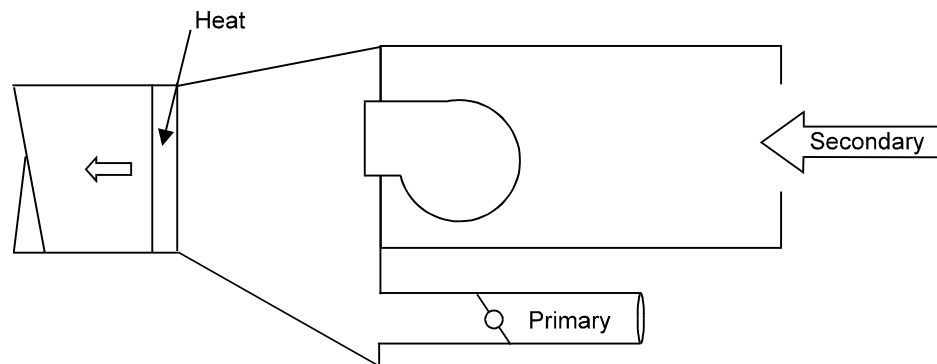


Figure 24 Parallel PIU

```

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

$ SYSTEMS SCHEDULES

```

```

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

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                  $pump $is not required as the chiller
                  $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW        = 0.25                                $gpm$
  PROCESS-SCH         = DHW-1
  HEAT-SETPT-T        = 120 ..
  LOOP-PUMP           = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
  TYPE                = CHW
  LOOP-PUMP           = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
  TYPE                = HW
  LOOP-PUMP           = HW-PUMP-1 ..

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE      = AIR-COOLED
  CHW-LOOP            = COOLING-WATER-1 ..

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP             = HOT-WATER-1 ..

```



```

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP            = DHW-LOOP-1 ..

AC-SYST = 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          = 0.55 [12]
  OA-CONTROL          = TEMP [13]
  ECONO-LIMIT-T       = 68 [13]
  MIN-FLOW-RATIO      = 0.3 [4]
  HEAT-SOURCE         = HOT-WATER
  HW-LOOP             = HOT-WATER-1
  CHW-LOOP            = COOLING-WATER-1 ..

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

OFFICE = ZONE
  LIKE                CORE [2]
  TERMINAL-TYPE       = PARALLEL-PIU
  ZONE-FAN-RATIO      = 0.8 [6]
  ZONE-FAN-KW         = 0.00033 [6]
  ZONE-FAN-T-SCH      = START-Z-FAN [3]
  INDUCED-AIR-ZONE    = CORE [1]
  REHEAT-DELTA-T      = 55 .. [15]

$ THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for PIU system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [16]
2. To enable a humidifier that requires heat to evaporate water into the air add MIN-HUMIDITY (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 (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 Runs.
6. To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY (60% is allowed in the 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 Runs.
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 (FC)

The two-pipe FC system provides both heating and cooling to individually controlled zones. However, all zones served by the system must be operating in the same mode (i.e., either heating or cooling) at any given time. A fan coil unit consists of a filter (not shown), combination heating/cooling coil, and fan. The coil is connected to a CIRCULATION-LOOP with TYPE=PIPE2 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 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.

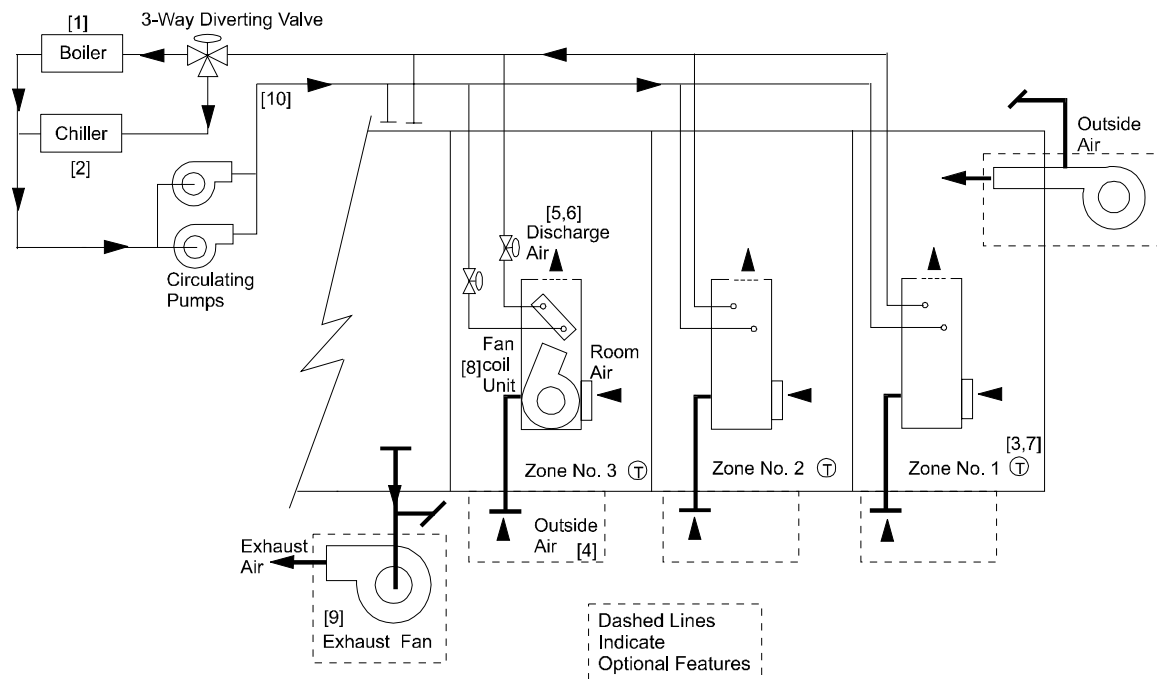


Figure 25 Two-pipe fan coil system (FC)

Suggested minimal input for two-pipe FC system:

Note that the input for a two-pipe FC system requires that you specify a CIRCULATION-LOOP of TYPE=PIPE-2 to which the fan-coil units, chiller, and boiler are attached. In the following, this loop is called FCLOOP-1. The fan-coil unit's cooling coil is attached to this loop by entering CHW-LOOP=FCLOOP-1 under SYSTEM. Similarly, the fan-coil unit's heating coil is attached to source loop by entering HW-LOOP-FCLOOP-1 under SYSTEM. On the PLANT side, the BOILER, called HW-GEN, is attached to this loop by entering HW-LOOP-FCLOOP-1; and the chiller is attached by entering CHW-LOOP-FCLOOP-1.

SYSTEMS-REPORT
SUMMARY

$$= (SS-A, SS-O) \dots$$

\$ SYSTEMS SCHEDULES

FANS-ON = SCHEDULE

TYPE = ON/OFF
 THRU DEC 31 (WD) (1,7) (0) (8,18) (1) (19,24) (0)
 (WEH) (1,24) (0) ..

COOLSETPT = SCHEDULE

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

HEATSETPT = SCHEDULE

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

DHW-1 = SCHEDULE

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

HEAT-ON = SCHEDULE

TYPE = ON/OFF/TEMP
 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

TYPE = ON/OFF/TEMP
 THRU MAY 15 (ALL) (1,24) (1) [2]
 THRU SEP 15 (ALL) (1,24) (0)
 THRU DEC 31 (ALL) (1,24) (1) ..

DHW-PUMP-1 = PUMP .. \$ basic domestic hot water recirc pump

FCLOOP-PUMP-1 = PUMP \$ basic chilled and hot water pump
 \$ for fan coils

DHW-LOOP-1 = CIRCULATION-LOOP

TYPE = DHW
 PROCESS-FLOW = 0.25 \$gpm\$
 PROCESS-SCH = DHW-1
 HEAT-SETPT-T = 120 ..
 LOOP-PUMP = DHW-PUMP-1 ..

FCLOOP-1 = CIRCULATION-LOOP

TYPE = PIPE-2
 LOOP-PUMP = FCLOOP-PUMP-1
 LOOP-OPERATION = SCHEDULED
 HEATING-SCHEDULE = HEAT-ON
 COOLING-SCHEDULE = COOL-ON ..

```

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE      = AIR-COOLED
  CHW-LOOP            = FCLOOP-1 ..

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP            = FCLOOP-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP            = DHW-LOOP-1 ..

AC-SYST = SYSTEM
  TYPE                = FC
  MAX-SUPPLY-T        = 110                [5]
  MIN-SUPPLY-T        = 55                 [6]
  NIGHT-CYCLE-CTRL    = CYCLE-ON-ANY       [7]
  FAN-SCHEDULE        = FANS-ON           [8]
  CHW-LOOP            = FCLOOP-1          [10]
  HW-LOOP            = FCLOOP-1 ..        [10]

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

$ THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capability for two-pipe FC system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [9]

Four-Pipe Fan Coil System (FC)

The four-pipe FC system is identical to the two-pipe FC with the following exceptions. Instead of a combined heating/cooling coil, the fan coil units have separate heating and cooling coils. Each coil is connected to a separate piping system, one circulating cooled fluid and one circulating heated fluid. Thus, the fan coil unit in one zone can cool at the same time that that in another zone is 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 input for two-pipe FC also applies to four-pipe FC.

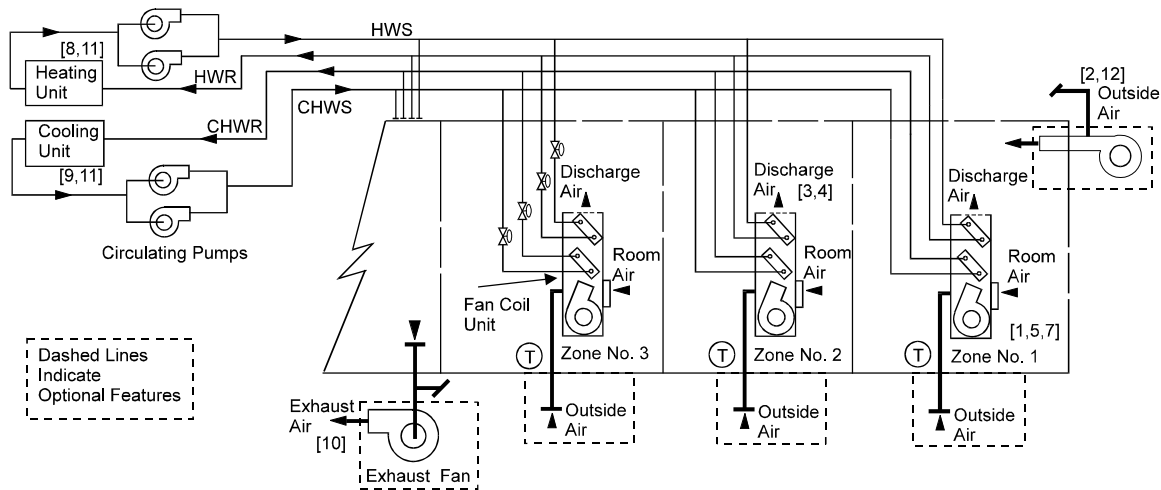


Figure 26 Four-pipe fan coil system (FC)

Suggested minimal input for four-pipe FC system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

```

```

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

CHW-PUMP-1 = PUMP .. $basic chilled water pump

HW-PUMP-1 = PUMP . . $basic hot water pump. Note that a tower
                  $pump $is not required as the chiller
                  $is AIR-COOLED

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.25                                $gpm$
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..
  LOOP-PUMP            = DHW-PUMP-1 ..

COOLING-WATER-1 = CIRCULATION-LOOP
  TYPE                = CHW
  LOOP-PUMP           = CHW-PUMP-1 ..

HOT-WATER-1 = CIRCULATION-LOOP
  TYPE                = HW
  LOOP-PUMP           = HW-PUMP-1 ..

CHILLER-1 = CHILLER-1
  TYPE                = ELEC-HERM-REC
  CONDENSER-TYPE      = AIR-COOLED
  CHW-LOOP            = COOLING-WATER-1 ..

HWGEN-1 = BOILER
  TYPE                = HW-BOILER
  HW-LOOP             = HOT-WATER-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP            = DHW-LOOP-1 ..

AC-SYST = SYSTEM
  TYPE                = FC
  MAX-SUPPLY-T        = 110                                [3]
  MIN-SUPPLY-T        = 55                                [4]
  NIGHT-CYCLE-CTRL    = CYCLE-ON-ANY                      [5]
  FAN-SCHEDULE        = FANS-ON                          [6]
  HW-LOOP             = HOT-WATER-1
  CHW-LOOP            = COOLING-WATER-1 ..

```

```

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

$ THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for this system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [10]
2. To disable the availability of either cooling or heating, insert schedules like that shown for two-pipe FC; 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
  TYPE                = TEMPERATURE
  THRU MAY 15          (ALL) (1,24) (70)
  THRU SEP 15          (ALL) (1,24) (0)
  THRU DEC 31          (ALL) (1,24) (70) ..

COOL-ON = SCHEDULE
  TYPE                = TEMPERATURE
  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 the program does not allow two air systems to be assigned to the same zone. See the example in the Sample Runs. [12]

Residential System (RESYS)

RESYS is a residential heating and cooling system. It can be run with a heating coil plus a DX cooling-only condensing unit or with a cooling/heating heat pump unit. In either case, heating and cooling are distributed by forced air. RESYS also allows cooling by natural ventilation through open windows by using the keywords NATURAL-VENT-SCH, VENT-TEMP-SCH, and NATURAL-VENT-AC.

A multizone residential system may be modeled with RESYS. The zone specified by the SYSTEM CONTROL-ZONE keyword is assumed to have the thermostat and to control the system. The other (conditioned) zones receive air at the times and at the temperature determined by the thermostat action in the control zone.

Residential System with DX Cooling and Heating Coil: This version of RESYS, shown in Figure 27 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.

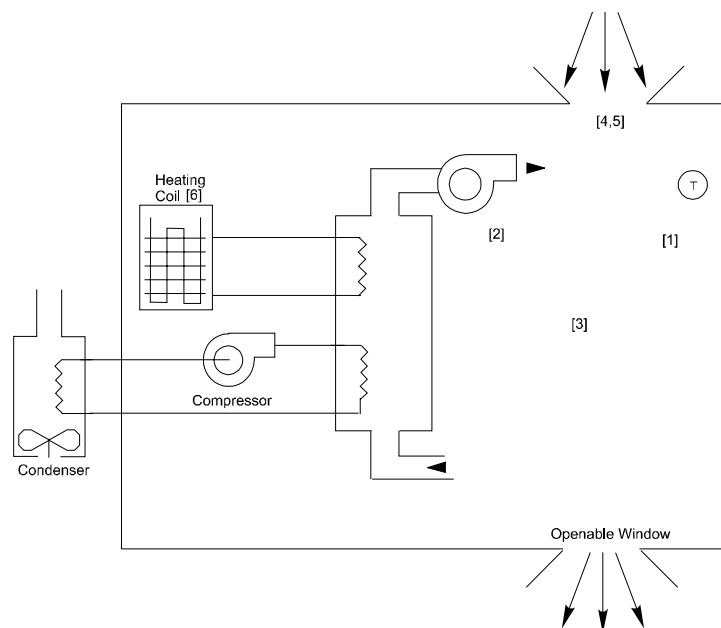


Figure 27 Residential system with DX cooling and heating coil

Residential System with Air-to-Air Heat Pump:

In this version of RESYS (Figure 27), heating and cooling is provided by an air-to-air heat pump. In its basic configuration the system 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.

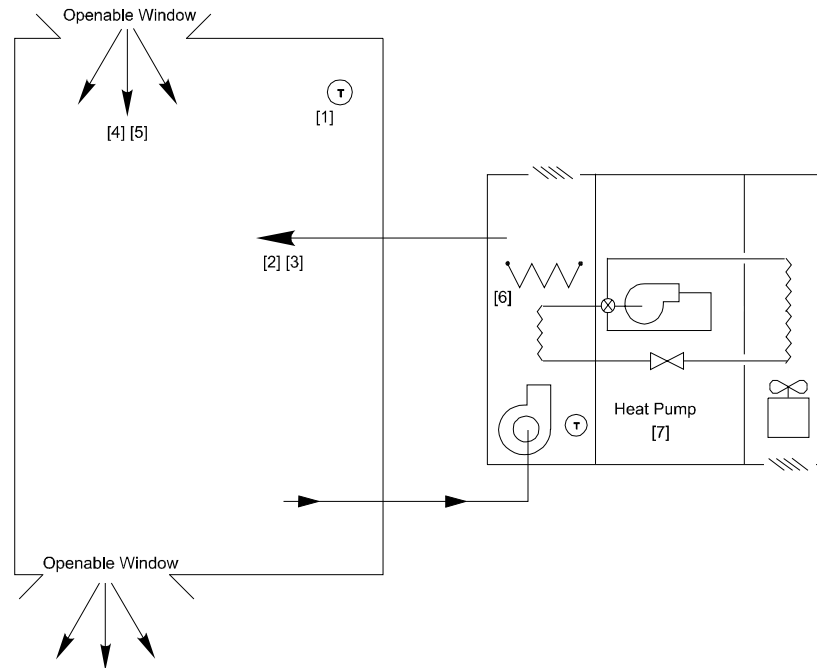


Figure 28 Residential system with air-to-air heat pump

Suggested minimal input for RESYS system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

```

```

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

DHWLOOP-1 = CIRCULATION-LOOP
  TYPE              = DHW
  PROCESS-FLOW      = .222 $gpm$
  PROCESS-SCH       = DHW-1
  HEAT-SETPT-T      = 120 ..

DHW-HEATER-1 = DW-HEATER
  TYPE              = GAS
  DHW-LOOP          = DHWLOOP-1 ..

AC-SYST = 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]
  CONTROL-ZONE      = (HOUSE) ..

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

$ THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capability for RESYS system:

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

```

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

```

```
COOL-ON = SCHEDULE
  TYPE          = TEMPERATURE
  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 (PSZ)

This hybrid system/plant, usually larger than a Packaged Terminal Air Conditioner (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. (Variable-volume air to all zones can be modeled by using the PVAVS system.)

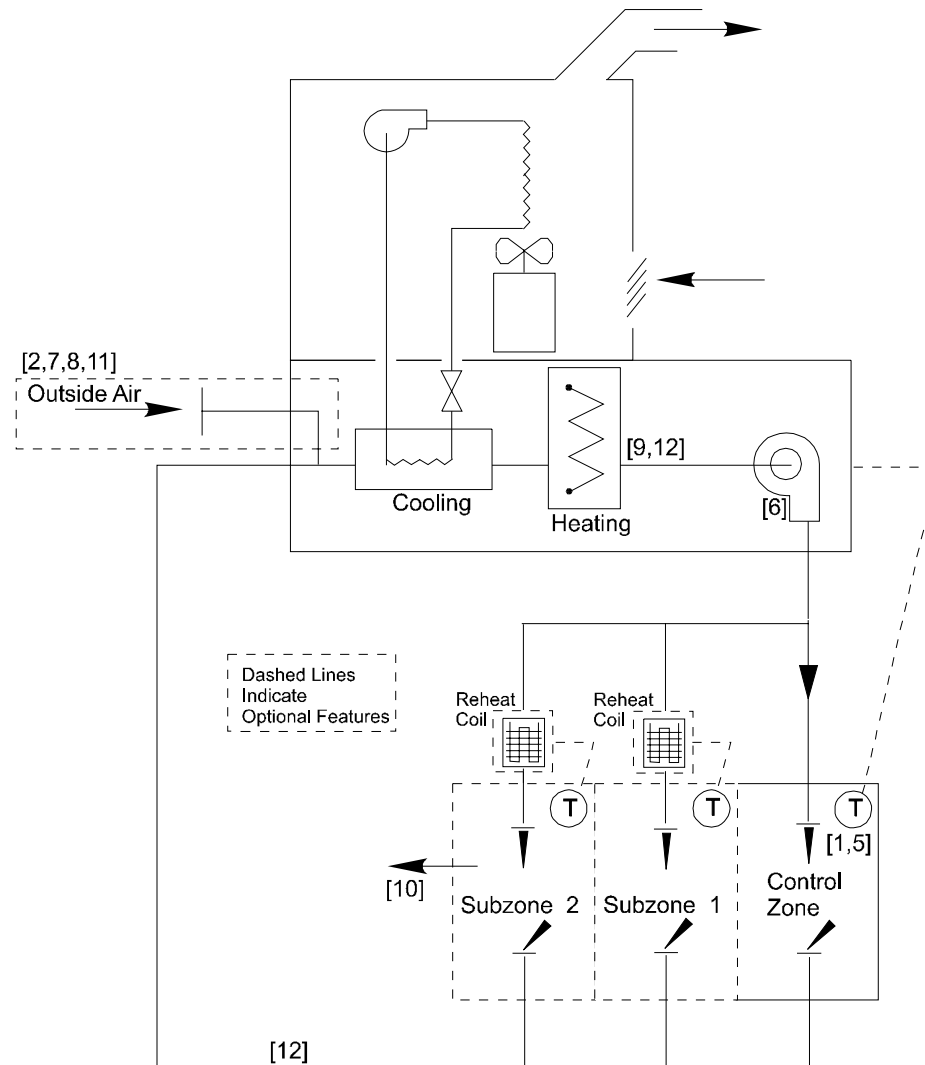


Figure 29 Packaged single zone air conditioner with heating and subzone reheating options (PSZ)

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.

Suggested minimal input for PSZ system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

DHW-LOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW              = 0.25                      $gpm$
PROCESS-SCH               = DHW-1
HEAT-SETPT-T              = 120 ..
LOOP-PUMP                 = DHW-PUMP-1 ..

DHW-HEATER = DW-HEATER
TYPE                      = GAS
DHW-LOOP                  = DHW-LOOP-1 ..

AC-SYST = 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
                           $ or ELECTRIC
                           $ or HOT-WATER
CONTROL-ZONE              = OFFICE ..

```

```

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

```

```
$THIS MAY BE FOLLOWED BY AN ECON INPUT$
```

```
END ..
```

```
COMPUTE ..
```

```
STOP ..
```

Additional capabilities for PSZ system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 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 (60% is allowed) and also MAX-COND-RCVRY (0.5 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. In the *DOE-2.2 Dictionary* see the description of the CONDENSER-TYPE, WS-ECONO and WS-ECONO-MIN-DT keywords in the SYSTEM command.

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.

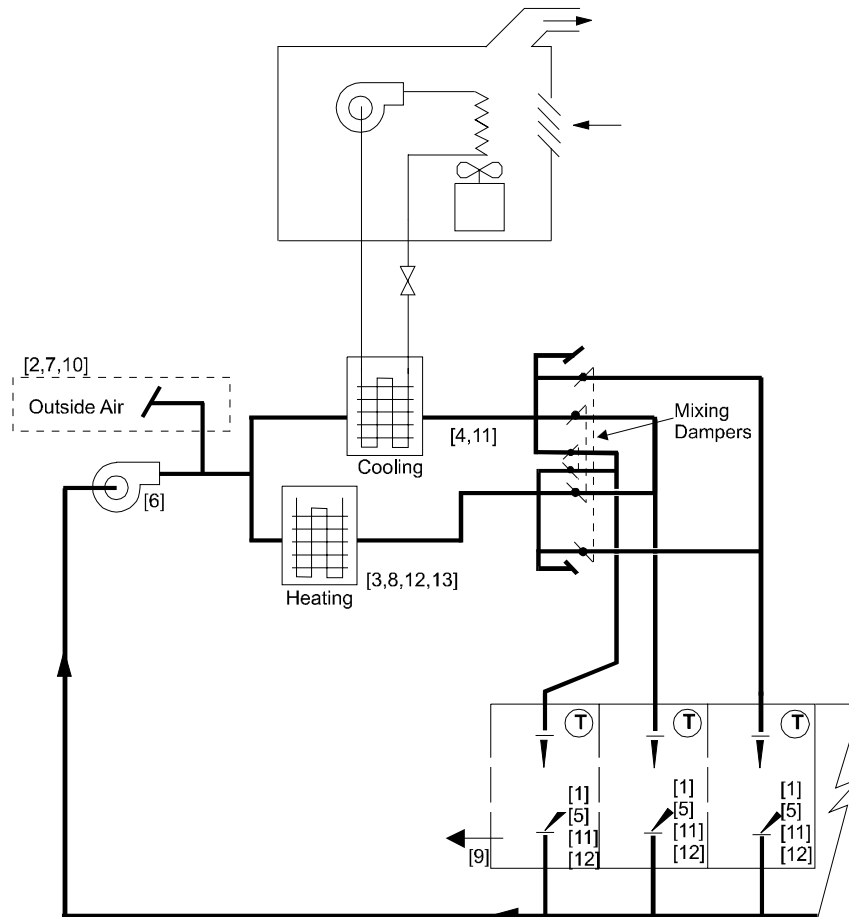


Figure 30 Packaged multizone fan system (PMZS)

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 air stream. The condenser fan operates automatically on demand. The thermostat may be specified with night setback and night cycle control. In the simulation of PMZS there is individual control of temperature in the different zones with no preconditioning of outside ventilation air.

Suggested minimal input for PMZS system:


```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

DHW-LOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW              = 0.25                      $gpm$
PROCESS-SCH               = DHW-1
HEAT-SETPT-T              = 120 ..
LOOP-PUMP                 = DHW-PUMP-1 ..

DHW-HEATER = DW-HEATER
TYPE                      = GAS
DHW-LOOP                  = DHW-LOOP-1 ..

AC-SYST = 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]

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

```

```

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capabilities for PMZS system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 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 covered in the Sample Runs 31-Story Office Building, Run 1.
6. To simulate turning off the hot deck whenever the outside temperature is above 65F, insert a new schedule like this: [13]

```

HEAT-OFF = SCHEDULE
  TYPE           = TEMPERATURE
  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 air stream. The thermostat may be specified with night setback and night cycle control.

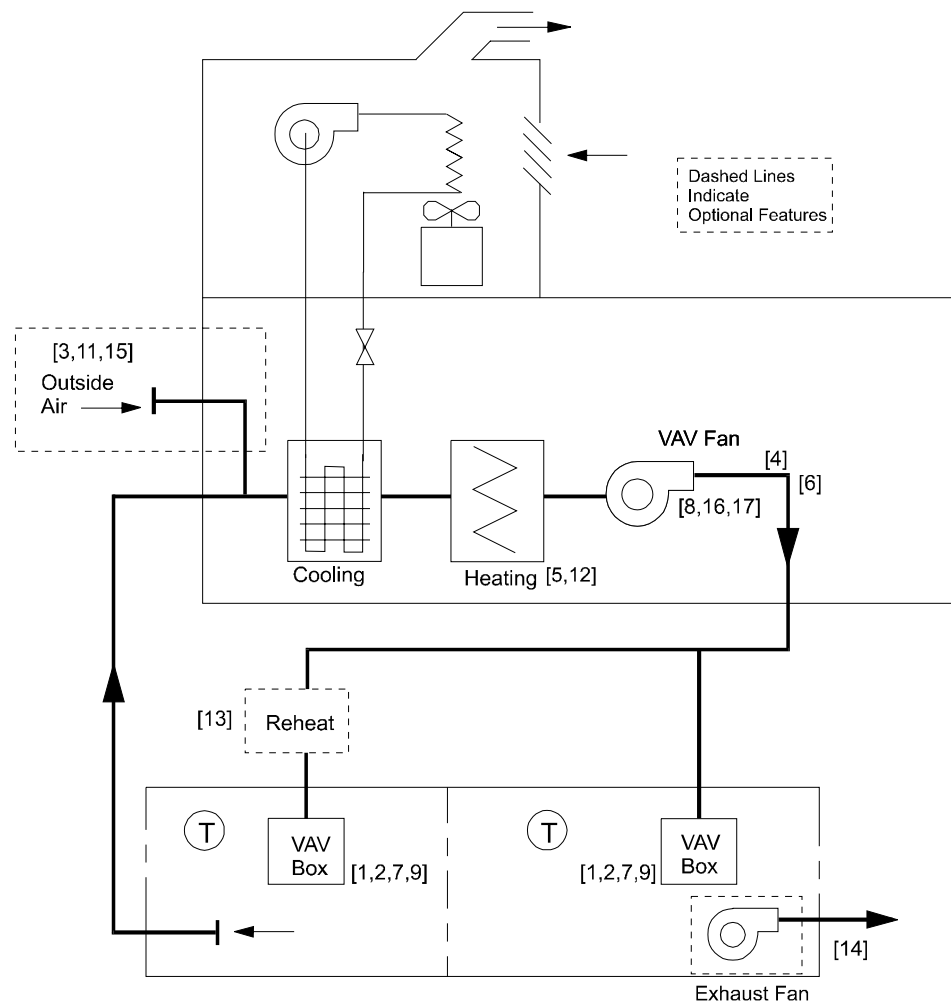


Figure 31 Packaged variable-air-volume system (PVAVS)

Suggested minimal input for PVAVS system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

DHW-LOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW                = 0.25                      $gpm$
PROCESS-SCH                  = DHW-1
HEAT-SETPT-T                 = 120 ..
LOOP-PUMP                    = DHW-PUMP-1 ..

DHW-HEATER = DW-HEATER
TYPE                      = GAS
DHW-LOOP                    = DHW-LOOP-1 ..

AC-SYST = 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-FLOW-RATIO               = 0.3                     [9]
REHEAT-DELTA-T              = 55                      [10]
OA-CONTROL                   = TEMP                   [11]
ECONO-LIMIT-T               = 60                      [11]
HEAT-SOURCE                 = ELECTRIC                 [12]
ZONE-HEAT-SOURCE            = ELECTRIC ..              [13]

```

```

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

```

```
$THIS MAY BE FOLLOWED BY AN ECON INPUT$
```

```
END ..
```

```
COMPUTE ..
```

```
STOP ..
```

Additional capabilities for PVAVS system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 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 (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 (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. In the *DOE-2.2 Dictionary* see the description of the CONDENSER-TYPE, WS-ECONO and WS-ECONO-MIN-DT keywords in the SYSTEM command.

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 often 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 air stream.

Optionally, the unit may be specified with a thermostat with night setback.

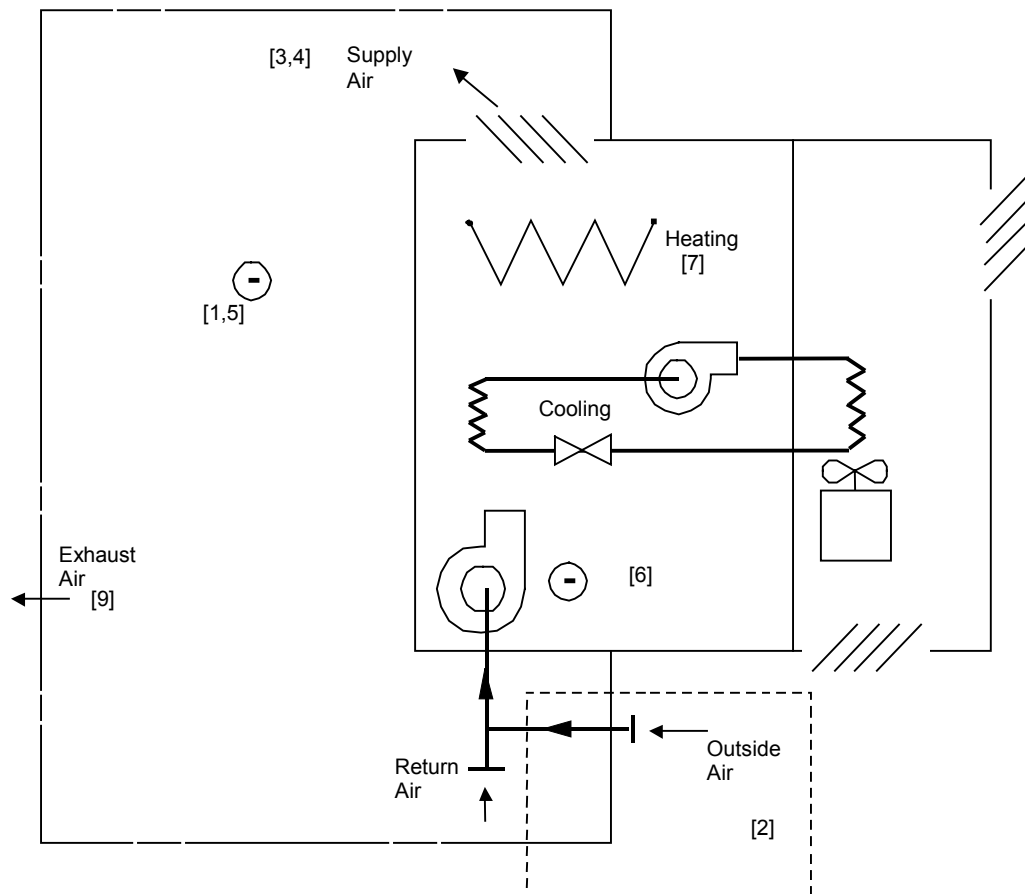


Figure 32 PTAC with DX cooling and electric resistance heating

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 air stream. Optionally, the unit may be specified with a thermostat with night setback.

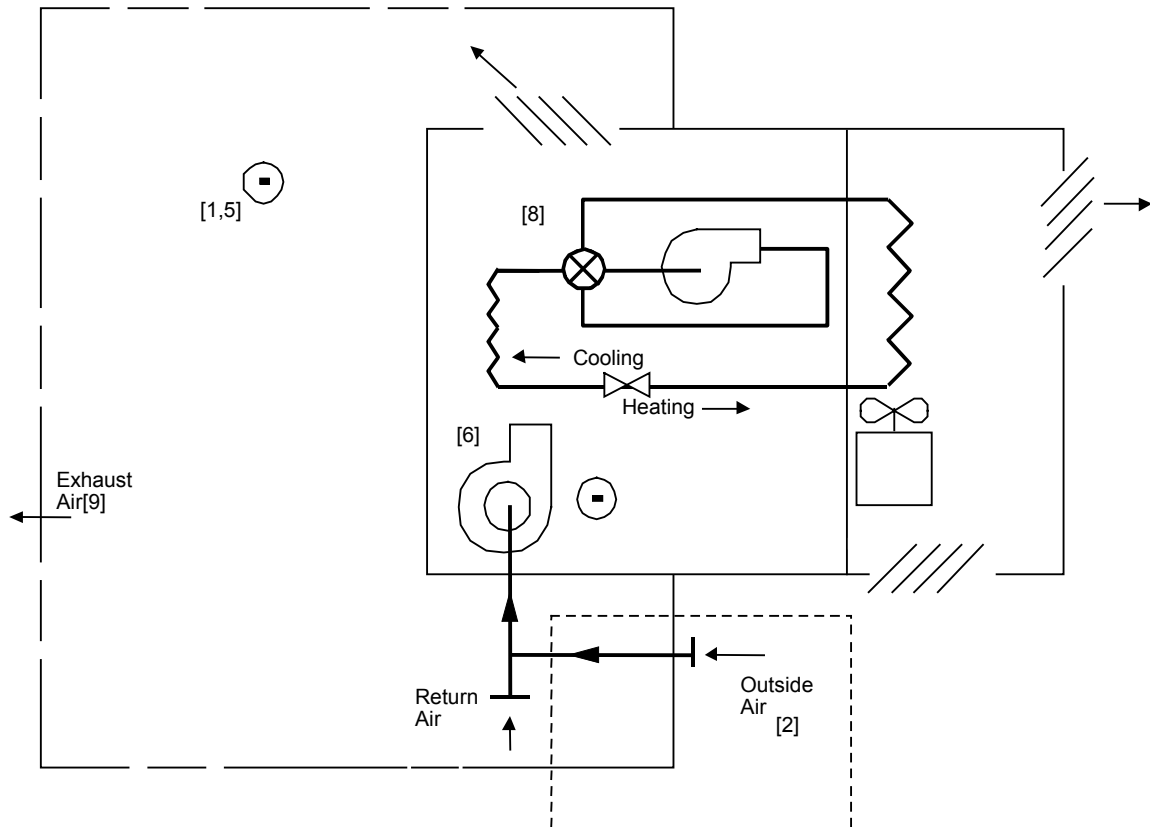


Figure 33 PTAC with air-to-air heat pump

Suggested minimal input for PTAC system:

```

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

$ SYSTEMS SCHEDULES

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

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

```

```

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.25                                $gpm$
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..
  LOOP-PUMP            = DHW-PUMP-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP             = DHW-LOOP-1 ..

AC-SYST = 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]
                      $or HEAT-PUMP                         [8]

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

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Additional capability for PTAC system:

1. To enable an exhaust fan add the keywords EXHAUST-CFM and EXHAUST-KW (0.0001 is typical) to the ZONE keyword list. [9]

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.

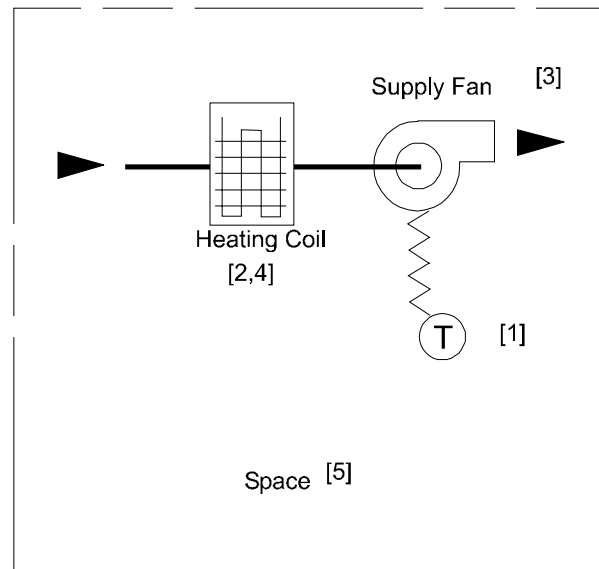


Figure 34 Unit Heater

Suggested minimal input for UHT system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

DHW-PUMP-1 = PUMP .. $basic domestic hot water recirc pump

```

```

DHW-LOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.25                $gpm$
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..
  LOOP-PUMP            = DHW-PUMP-1 ..

DHW-HEATER = DW-HEATER
  TYPE                = GAS
  DHW-LOOP             = DHW-LOOP-1 ..

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

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

$THIS MAY BE FOLLOWED BY AN ECON INPUT$

END ..

COMPUTE ..

STOP ..

```

Unit Ventilator (UVT)

This is the same system as the Unit Heater (UHT), but with the additional capability of introducing a fixed amount of outside air during heating and operating an outside air damper for cooling.

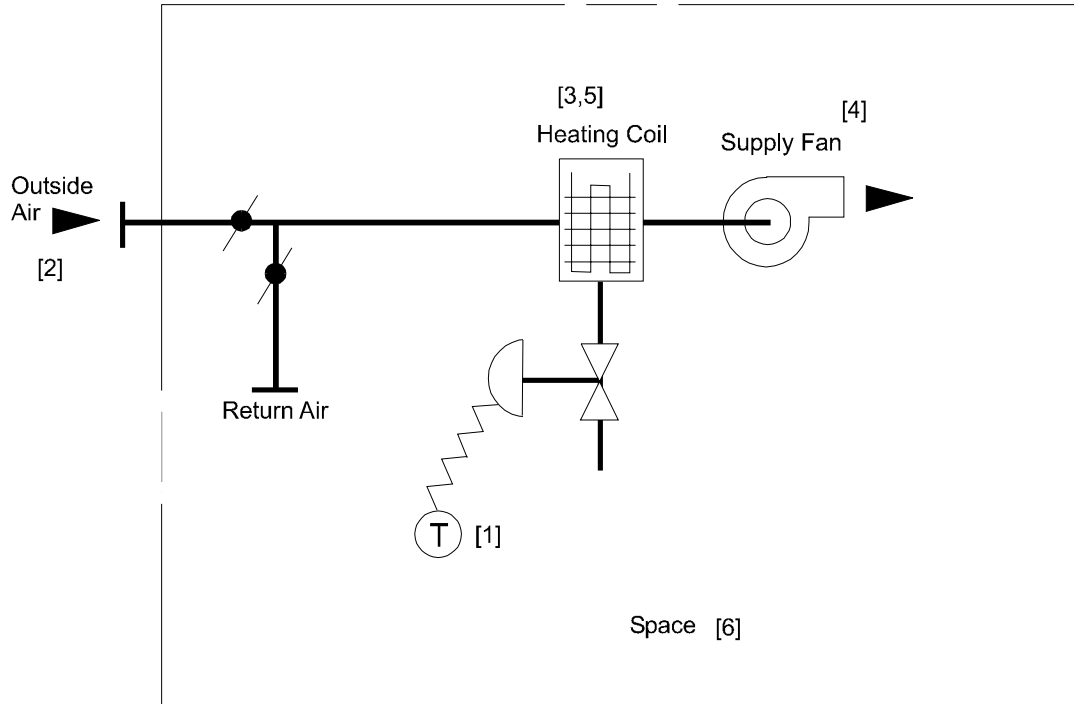


Figure 35 Unit ventilator (UVT)

Suggested minimal input for UVT system:

```

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

$ SYSTEMS SCHEDULES

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

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

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

```

DHW-PUMP-1 = PUMP .. \$basic domestic hot water recirc pump

DHW-LOOP-1 = CIRCULATION-LOOP

TYPE	=	DHW	
PROCESS-FLOW	=	0.25	\$gpm\$
PROCESS-SCH	=	DHW-1	
HEAT-SETPT-T	=	120 ..	
LOOP-PUMP	=	DHW-PUMP-1 ..	

DHW-HEATER = DW-HEATER

TYPE	=	GAS
DHW-LOOP	=	DHW-LOOP-1 ..

AC-SYST = SYSTEM

TYPE	=	UVT	
MAX-SUPPLY-T	=	110	[3]
FAN-SCHEDULE	=	FANS-ON	[4]
HEAT-SOURCE	=	ELECTRIC ..	[5]
		\$ or FURNACE	
		\$ or HOT-WATER (with	
		\$ a hot water generator	
		\$ and pump)	

OFFICE = ZONE

TYPE	=	CONDITIONED	
DESIGN-HEAT-T	=	72	
DESIGN-COOL-T	=	74	
HEAT-TEMP-SCH	=	HEATSETPT	[1]
COOL-TEMP-SCH	=	COOLSETPT	[1]
OA-FLOW/PER	=	15 ..	[2]

\$THIS MAY BE FOLLOWED BY AN ECON INPUT\$

END ..

COMPUTE ..

STOP ..

SYSTEMS-REPORT

Specifies which of the air distribution systems verification and summary reports to print. Examples of these reports along with a detailed description of each are given in Appendix B. Verification reports echo your input in a reorganized form. Summary reports show calculation results, usually monthly and annually.

Example input:

Print summary reports SS-A (System Monthly Loads Summary) and SS-O (Temperature Scatter Plot).

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

VERIFICATION

Takes a list of code-words that identify the verification reports to be printed.

SV-A	SYSTEM DESIGN PARAMETERS FOR <system name>. Always printed by the program for each air distribution system. Shows design quantities such as air flow and heating/cooling capacity for the system and the zones attached to the system.
------	---

SUMMARY

Displays the calculated results.

SS-A	SYSTEM LOADS SUMMARY FOR <system name>. Always printed by the program for each distribution system. Shows monthly cooling, heating, and electrical loads.
SS-D	BUILDING HVAC LOAD SUMMARY Shows the cooling, heating, and electrical energy required by the building's combined air distribution systems and zones.
SS-H	SYSTEM UTILITY ENERGY USE FOR <system name>. For an air distribution system, gives monthly values of fan electrical energy, fuel energy for heating and cooling, and electrical energy for heating and cooling.
SS-L	FAN ELECTRIC ENERGY USE FOR <system name>. For an air distribution system, gives monthly electricity use for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours. Also shows fan part load ratio.
SS-M	BUILDING HVAC FAN ELECTRIC ENERGY For all building fans combined, shows monthly fanelectric energy for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours.

Central Plant Components

As described in the previous section's introduction, HVAC equipment can be divided into equipment directly involved with conditioning air, (air-side or secondary equipment), and equipment that supports the airside functions (water-side, plant, or primary equipment). The previous section described the modeling of the air-side equipment. This section describes the central plant equipment. Included in this category are:

- Boilers - gas and electric
- Chillers - electric, hot-water absorption, gas-absorption, and engine-driven
- Heat-rejection equipment - cooling towers, fluid coolers, dry coolers, and ground-loop heat-exchangers
- Domestic water heaters - gas, electric, and heat-pump
- Circulation loops and pumps - hot-water, chilled-water, condenser water, domestic water, and water-loop heat pumps
- Electric generators – engine and turbine
- Utility meters – electric, fuel, steam, and chilled water

ELEC-METER

This component allows you to assign names to meters that will record electricity usage, and to which rate schedules may be assigned using the UTILITY-RATE command in the ECONOMICS input. The names should be no more than four characters long.

The ELEC-METER and FUEL-METER commands, and the associated MASTER-METERS command, should precede all other HVAC input commands

Example input:

```

EM-1 = ELEC-METER
      TYPE                = UTILITY ..

FM-1 = FUEL-METER
      TYPE                = NATURAL-GAS ..

MASTER-METERS
  MSTR-ELEC-METER        = EM-1
  MSTR-FUEL-METER        = FM-1 ..
  . . .

ERATE-1 = UTILITY-RATE
        TYPE              = ELECTRICITY
        ELECTRIC-METERS   = EM-1
        . . . .

FRATE-1 = UTILITY-RATE
        TYPE              =NATURAL-GAS
        FUEL-METERS       = FM-1
        . . . .

```

TYPE

Specifies whether the meter is fed directly by the utility, or is a submeter to another meter on-site.

UTILITY	The meter is intended to be connected to a UTILITY-RATE. Its children are connected by use of the BLDG/SUB-METERS keyword. This type of meter is intended to be the main meter for a site (although you may define several meters of this type).
BUILDING	The meter is a submeter to a UTILITY meter. All power logged by this meter is also logged on its parent UTILITY meter
SUB-METER	The meter is a sub-submeter to a BUILDING submeter. All power logged by this meter is also logged on its parent BUILDING meter, and grand-parent UTILITY meter.

A UTILITY's submeters are associated with the meter via the BLDG/SUBMETERS keyword. Likewise, a BUILDING's submeters are associated with the meter via the SUBMETERS keyword. Please refer to the *Dictionary* for more information.

FUEL-METER

This component allows you to assign names to meters that will record fuel usage, and to which rate schedules may be assigned using the UTILITY-RATE command in the ECONOMICS input. The names should be no more than four characters long.

The ELEC-METER and FUEL-METER commands, and the associated MASTER-METERS command, should precede all other HVAC input commands

Example input:

```

EM-1 = ELEC-METER
      TYPE                = UTILITY ..

FM-1 = FUEL-METER
      TYPE                = NATURAL-GAS ..

MASTER-METERS
  MSTR-ELEC-METER        = EM-1
  MSTR-FUEL-METER        = FM-1 ..
  . . .

ERATE-1 = UTILITY-RATE
        TYPE              = ELECTRICITY
        ELECTRIC-METERS    = EM-1
        . . . .

FRATE-1 = UTILITY-RATE
        TYPE              =NATURAL-GAS
        FUEL-METERS        = FM-1
        . . . .

```

TYPE

Specifies the type of fuel this meter records. Unlike the ELEC-METER, fuel meters do not support submetering. Acceptable entries are NATURAL-GAS, LPG, FUEL-OIL, DIESEL-OIL, COAL, METHANOL, and OTHER-FUEL). OTHER-FUEL allows you to define the characteristics of a less common fuel, such as wood chips or biomass.

MASTER-METERS

This is a required command that allows you to assign master electricity and fuel meters. It has two basic keywords, MSTR-ELEC-METER, which takes the U-name of a previously-defined ELEC-METER command, and MSTR-FUEL-METER, which takes the U-name of a previously defined FUEL-METER command.

The MASTER-METERS command, as its associated ELEC-METER and FUEL-METER commands, should precede all other HVAC input commands.

Example input:

```
EM-1 = ELEC-METER
      TYPE                = UTILITY ..

FM-1 = FUEL-METER
      TYPE                = NATURAL-GAS ..

MASTER-METERS
  MSTR-ELEC-METER        = EM-1
  MSTR-FUEL-METER        = FM-1 ..
  . . . .
```

MSTR-ELEC-METER

Accepts the U-name of the electric meter to be used as the master electric meter. All electric meter attachments in all components will default to this meter unless specified otherwise within the component command, or unless the appropriate master end-use meter is specified (see following).

MSTR-FUEL-METER

Accepts the U-name of the fuel meter to be used as the master fuel meter. All fuel meter attachments in all components will default to this meter, unless specified otherwise within the component command, or unless the appropriate master end-use meter is specified (see following).

PUMP

Defines the operating parameters of a pump. A U-name is required. The pump attaches to a CIRCULATION-LOOP or a primary equipment unit (such as a chiller) by referencing the pump's U-name in the CIRCULATION-LOOP or primary equipment command. A unique pump must be defined for each application. In other words, a pump U-name can be referenced by only one CIRCULATION-LOOP or by one piece of primary equipment. Multiple references to the same pump will result in an error.

Example input:

```
"CHW pump" = PUMP
  HEAD-RATIO      = 1.2
  FLOW-RATIO      = 1.2
  CAP-CTRL        = VAR-SPEED-PUMP..
```

HEAD-RATIO

The head defaults to the required loop head, adjusted by this value.

FLOW-RATIO

The flow will default to the design loop flow, adjusted by this value.

CAP-CTRL

Accepts a code-word that defines how the pump modulates as the load varies. When you specify NUMBER to be more than one, then the pumps will first stage according to the load and then modulate capacity according to the CAP-CTRL mode.

ONE-SPEED-PUMP	The pump rides its curve as the load varies (2-way valves in at least one system are necessary for this to happen).
TWO-SPEED-PUMP	The pump can operate at two speeds. The low-speed is determined by MIN-SPEED. You should choose MIN-SPEED to match the actual low speed ratio of the pump, typically 0.67 or 0.5.
VAR-SPEED-PUMP	The pump has a variable frequency drive. The minimum pump speed is specified by MIN-SPEED.

CIRCULATION-LOOP

Defines the operating parameters of a circulation loop of hot or cold fluid. A U-name is required. This U-name will be referenced by any pumps or primary equipment attached to this loop. It is also used as the identifier in the heading of the loop report.

A CIRCULATION-LOOP command must precede the input of any element (such as a zone, system or plant component) that is attached to the loop.

Circulation loops are considered an advanced concept in the program. However, we describe the CIRCULATION-LOOP command here (with a small subset of its keywords) to allow you to define a domestic hot water heater and a two-pipe fan coil system, both of which are considered basic. In other cases the program will automatically generate default circulation loops in a way that is transparent to the beginning user.

Example input:

The input for a domestic hot water circulation loop that has an inlet temperature of 55F and that delivers 120F water at a peak flow of 0.222 gal/min is as follows:

```
DHWLOOP-1 = CIRCULATION-LOOP
TYPE                      = DHW
PROCESS-FLOW              = 0.222
PROCESS-SCH               = DHW-1
DHW-INLET-T              = 55
HEAT-SETPT-T             = 120 ..
```

TYPE

Takes a code-word that specifies the type of the loop. This is a required keyword. Allowed values for basic simulation are:

CHW	A chilled-water loop. On the demand side a CHW loop attaches to cooling coils or to process cooling loads defined within a space. On the supply side this loop attaches to chillers and/or a chilled-water utility.
HW	A hot-water loop. On the demand side a hot-water loop attaches to heating coils, preheat coils, reheat coils, baseboard heaters, floor panels, supplementary heating loads (from a heat pump), or to process heating loads defined within a space. On the supply side this loop attaches to boilers, heat-recovery loops, and/or a hot-water/steam utility.
PIPE2	A 2-pipe heating and cooling loop. A 2-pipe loop supplies both chilled water and hot water to coils, but never during the same hour. When the loop is in the heating mode, any cooling loads which may coexist will not be met, and the temperature of the zones that demand cooling will float accordingly. The same is true for heating loads once the loop has switched over to cooling. The loop may switch from heating to cooling on the basis of an indoor or outdoor temperature, or according to a schedule. You specify the switching parameters using the LOOP-OPERATION keyword. The demand and supply connections are any of the connections defined for the HW and CHW loop types.

DHW	A domestic hot water loop that supplies potable heated water to kitchens, bathrooms, etc. You cannot attach heating coils to this type of loop; however you can attach process loads defined in the SPACE command. On the supply side this loop attaches to DHW heaters, boilers, or to a hot-water/steam utility.
CW	A condenser water loop. A CW loop accepts the heat rejection loads of chillers, packaged direct expansion (DX) HVAC systems with water-cooled condensers, water-side economizers, and electrical generators. The loop rejects the condenser heat to one or more cooling towers.

LOOP-OPERATION

Takes a code-word that describes when or how the loop is activated. When activated, the loop pump, if any, runs and the specified primary equipment operates to deliver fluid at the specified temperature setpoint. When deactivated, the pump and all primary equipment are off. This keyword does not apply to the DHW loop. A deactivated loop will override the heating/cooling schedules of any secondary HVAC system coils that are attached. In other words, when a loop is active, an attached coil can draw energy from the loop according to the coil's heating/cooling schedules and temperature setpoint. However, when the loop is inactive, all attached coils are deactivated as well, regardless of their heating/cooling schedules.

STANDBY	Causes the loop to be active whenever an attached system is running (fan on) and the system's heating/cooling schedule allows the coil to operate. Note that, in this mode, the system's coil may not actually be calling on the loop for the loop to be active.
DEMAND-ONLY	Causes the loop to be active only when a coil or process load actually exists. This is the most energy-efficient mode of operation. For example, if an attached system is running and the system's cooling schedule allows for cooling, the CHW loop will not activate until there is actually a cooling load (the system could be using economizer cooling so that there is no cooling load that hour).
SCHEDULED	Causes the loop to activate according to a schedule. Heating-type loops refer to the HEATING-SCH and cooling-type loops refer to the COOLING-SCH. A PIPE2 loop refers to both schedules, as it will have both heating and cooling equipment attached.

The schedules use the standard schedule values of 0 to indicate an OFF condition, and a 1 to indicate an ON condition. In addition, a value other than 0 or 1 is assumed to be an outdoor air lockout temperature. For a HEATING-SCH, an outdoor temperature below the schedule value will activate the loop. For a COOLING-SCH, an outdoor temperature above the schedule value will activate the loop. For the PIPE2 loop, the HEATING-SCH will activate the heating equipment and loop pump and COOLING-SCH will activate the cooling equipment and loop pump. If outdoor temperatures are put into both schedules, there may be an outdoor temperature range where both the heating equipment, cooling equipment, and pump are off. If the schedules conflict, the HEATING-SCH will take precedence.

HEATING-SCHEDULE

When LOOP-OPERATION = SCHEDULED, accepts the U-name of a schedule with TYPE = ON/OFF/TEMP that enables the primary heating equipment attached to a loop. If not defined, the primary equipment is enabled whenever the loop is active. A schedule value of 0 disables the heating equipment, and a value of 1 enables it. A value other than 0 or 1 indicates that the outdoor air temperature is to be used to enable the heating equipment. The equipment will be enabled whenever the outdoor temperature is below the schedule value.

COOLING-SCHEDULE

When LOOP-OPERATION = SCHEDULED, accepts the U-name of a schedule with TYPE = ON/OFF/TEMP that enables the primary cooling or heat-rejection equipment attached to a loop. If not defined, the primary equipment is enabled whenever the loop is active. A value of 0 turns disables the equipment, and a value of 1 enables it. A value other than 0 or 1 indicates that the outdoor air temperature is to be used to enable the equipment. The equipment will be enabled whenever the outdoor air temperature is above the schedule value.

HEAT-SETPT-T

The setpoint temperature of the fluid in a heating loop.

PROCESS-FLOW

For a DHW loop, the flow associated with the process load.

PROCESS-SCH

Accepts PROCESS-FLOW. If not specified, the process flow is constant all hours.

DHW-INLET-T

For DHW loops, the inlet temperature of the water supply to the heaters. The default is the hourly value of DHW-INLET-T-SCH, if defined, or the monthly ground temperature if not.

DHW-INLET-T-SCH

For DHW loops, takes the U-name of a schedule of TYPE = TEMPERATURE that gives the hourly inlet temperature of the water supply to the heaters. The default is DHW-INLET-T, if defined, or the monthly ground temperature if not.

BOILER

Defines the operating parameters of a boiler. A U-name is required.

Example input:

The input for a hot water boiler whose capacity is determined by the program from the peak heating load is as follows:

```
BOILER-1 = BOILER
      TYPE           = HW-BOILER
      HW-LOOP        = "The Hot Water Loop" ..
```

TYPE

Takes a code-word that specifies the type of boiler. This required keyword should be the first keyword entered. Allowed values of TYPE are:

HW-BOILER	Hot water boiler.
HW-BOILER-W/DRAFT	Hot water boiler with draft fan.
ELEC-HW-BOILER	Electric hot water boiler.
STM-BOILER	Steam boiler.
STM-BOILER-W/DRAFT	Stream boiler with draft fan.
ELEC-STM-BOILER	Electric steam boiler.

Note that the steam boilers are modeled identically to the hot water boilers, except that their efficiencies are lower.

CAPACITY

The nominal (or rated) heating capacity of the boiler. If you do not specify CAPACITY, it defaults to the heating loop capacity times CAPACITY-RATIO. If no CAPACITY-RATIO is input, the capacity will default to the loop capacity divided by the number of boilers attached to the loop. If neither the boiler capacity or loop capacity is specified, the program sizes both to meet the non-coincident design day peak loads.

The following keywords define the energy consumption of the boiler. Note that an electric boiler does not consume fuel and so does not use HEAT-INPUT-RATIO. However, a fuel-fired boiler may have electrical usage, such as for a draft fan, and the electrical consumption of this fan may vary with load. Consequently, the fuel-fired boilers may use both HEAT-INPUT-RATIO and ELEC-INPUT-RATIO.

HEAT-INPUT-RATIO

The ratio of fuel heat input to boiler heating capacity at full load (i.e., at the rated conditions). Used only for fuel-consuming boilers. Note that this is a dimensionless ratio, so you must convert heat input and heating capacity to the same units before dividing.

ELEC-INPUT-RATIO

The ratio of electric input power to nominal boiler capacity. The EIR is dimensionless, so the same units for input and capacity should be used when calculating it. .

CHILLER

The CHILLER command defines all of the operating parameters of a chiller. In previous versions of the program, all chillers of the same type (such as open centrifugal) had identical performance characteristics; only the size could be varied from one chiller to the next. Now, the program treats each chiller as a completely separate entity from all others, and you may specify the efficiency, off-design performance characteristics, etc. for each individual chiller.

Because each chiller is a completely separate entity, you no longer define the number of chillers of a given type and size; you define each chiller separately even when they are identical.

U-name must be specified for each chiller. This U-name will be used in the heading of the chiller report to identify the chiller.

Example input:

The input for an electric chiller with an air-cooled condenser:

```
CHILLER-1 = CHILLER
      TYPE           = ELEC-HERM-REC
      CHW-LOOP        = "The Chilled-Water Loop"
      CONDENSER-TYPE  = AIR-COOLED ..
```

TYPE

Takes a code-word that specifies the type of chiller. This keyword is required. It should be the first keyword entered for the CHILLER command. The next keyword entered should be CONDENSER-TYPE, described below. Allowed values of TYPE are:

ELEC-OPEN-CENT	Open centrifugal chiller.
ELEC-OPEN-REC	Open reciprocating chiller.
ELEC-HERM-CENT	Hermetic centrifugal chiller.
ELEC-HERM-REC	Hermetic reciprocating chiller.
ABSOR-1	One-stage absorption chiller.
ABSOR-2	Two-stage absorption chiller.
GAS-ABSOR	Gas-fired absorption chiller
ENGINE	Engine-driven chiller

Chiller Design and Operating Capacity

The next set of keywords describes the chiller's design and operating capacity.

CAPACITY

The nominal (or rated) cooling capacity of the chiller. If you do not specify CAPACITY, it defaults to the chilled water loop capacity times CAPACITY-RATIO. If no CAPACITY-RATIO is input, the capacity

will default to the loop capacity divided by the number of chillers attached to the loop. If neither the chiller capacity or the loop capacity is specified, the program sizes both to meet design day peak loads.

CAPACITY-RATIO

The fraction of the design loop capacity that the chiller will be sized to meet. Used only if CAPACITY is not specified. If you are defining two chillers of identical size that exactly meet the design loop load, set each chiller's CAPACITY-RATIO to 0.5. To include a 20% safety factor, set each chiller's CAPACITY-RATIO to 0.6. If neither CAPACITY nor CAPACITY-RATIO is specified, the chiller capacity will default to the loop capacity divided by the number of chillers attached to the loop.

MIN-RATIO

The minimum fraction of rated load at which the chiller can operate continuously. If the load is between zero and MIN-RATIO the chiller will cycle on and off.

MAX-RATIO

The maximum fraction of rated load the chiller is allowed to handle. If the chiller is allowed to overload, MAX-RATIO may be greater than 1.0.

HGB-RATIO

The fraction of design capacity below which the chiller uses hot-gas bypass. Used only for electric chillers and engine chillers.

Chiller Energy Consumption

The following keywords define the energy consumption of the chiller. Not all keywords are used for every chiller type. For example, an electric chiller does not consume any heat or fuel and so does not have an HIR. However, an absorption chiller may have electrical usage, such as for a spray pump, and the electrical consumption of this pump may vary with load. Consequently, the heat- and fuel-chillers use both the EIR and HIR set of keywords

ELEC-INPUT-RATIO

The ratio of electric input power to nominal capacity (i.e., the inverse of the coefficient of performance (COP)). The EIR is dimensionless, so the same units for input and capacity should be used when calculating it.

For absorption chillers (TYPE = ABSOR-1, ABSOR-2 or GAS-ABSOR), ELEC-INPUT-RATIO includes the primary power consumption of the chiller and the electrical power consumption of the solution pumps. For these chillers, the program will override ELEC-INPUT-RATIO if you specify either SOLUTION-PUMP-KW and/or GAS-COMB-FAN-KW. In this case, the program will recalculate the ELEC-INPUT-RATIO as $(\text{SOLUTION-PUMP-KW} + \text{GAS-COMB-FAN-KW}) * 3413 \text{ Btu/kW} / (\text{CAPACITY} * 106)$. Note that GAS-COMB-FAN-KW is the combustion blower power for the gas-fired chiller, and applies only to that chiller type.

HEAT-INPUT-RATIO

The ratio of fuel heat input to chiller cooling capacity at full load (i.e., at the rated conditions). Used only for fuel-consuming chillers. Note that this is a dimensionless ratio, so you must convert heat input and cooling capacity to the same units before dividing.

START-UP-TIME

It takes the equivalent of 15 minutes of full load fuel consumption to bring an absorption chiller on-line, then this entry should be 0.25 (hours).

If a chiller is to be used in the current hour, but did not operate the previous hour, then a start-up load is assumed to exist. The equivalent full-load run time added to the current hour's load varies according to how many hours the chiller has been shut down:

1 hour	50% of this value
2 hours	80% of this value
3 or more hours	100% of this value

ELEC-METER

Takes the U-name of the ELEC-METER to which the electricity consumption of the chiller is assigned.

FUEL-METER

Takes the U-name of the FUEL-METER to which the fuel consumption of the chiller is assigned.

Chilled-Water Loop Attachment

The following keywords describe how the chiller is attached to a chilled-water loop. If the chiller has a dedicated pump in a equipment-recirculation loop, the pump is attached to the chiller from within the pump command.

CHW-LOOP

Takes the U-name of the primary CHW loop to which this chiller is attached.

CHW-PUMP

Takes the U-name of a PUMP directly attached to the chiller's evaporator. Usually, this pump will be a equipment-recirculation pump and will act to de-couple the flow of the chiller from the loop. In this case, the pump may have CHW-FLOW-CTRL = CONSTANT-FLOW or VARIABLE-FLOW, and will remove the chiller evaporator head requirement from the primary loop. If the loop does not have its own pumps, then this pump will also power the loop. In this case, the head of this pump will be the sum of the maximum coil head, the loop distribution head (including static head), and the chiller's evaporator head. The hourly flow of the pump (and chiller) will be determined based on the loop flow and the number of other chillers running.

Attachment to Hot-Water or Steam Loop

For absorption chillers, the next set of keywords describe how this chiller is attached to a hot-water or steam loop. If the chiller has a dedicated hot-water pump in a equipment-recirculation loop, the pump is attached to the chiller using the PUMP command.

HW-LOOP

Takes the U-name of the HW or STM loop to which this chiller is attached. This is a mandatory entry for absorption chillers.

HW-PUMP

Similar to CHW-PUMP. For a hot-water absorption chiller, this pump will overcome the head of the chiller's generator only; it cannot be used to power the hot water loop. If not specified, the head of the generator will be passed onto the loop. For a chiller/heater, the chiller is a supplier to the heating loop and is functionally identical to a boiler. A pump attached through this keyword may act either as a equipment-recirculation pump (assuming the loop has its own pumps), or may power the loop (if the loop does not have its own pumps).

Attachment to Condenser Water Loop

The following set of keywords describes how the chiller is attached to a condenser water loop. If the chiller has a dedicated condenser-water pump in a equipment-recirculation loop, the pump is attached to the chiller from within the PUMP command.

CONDENSER-TYPE

Takes a code-word that defines the type of the chiller's condenser. This keyword should immediately follow the TYPE keyword

WATER-COOLED Water-cooled condenser.

AIR-COOLED Air-cooled condenser.

CW-LOOP

When CONDENSER-TYPE = WATER-COOLED, takes the U-name of the CW loop to which this chiller is attached. This is a required keyword for all chillers.

CW-PUMP

Takes the U-name of a PUMP directly attached to the chiller's condenser. This pump may be either a equipment-recirculation pump, or may power the loop.

AIR-COND-KW

For air-cooled condensers, the dimensionless ratio of condenser fan electricity consumption to the nominal capacity of the chiller. You can modify the fan electricity consumption based on operating conditions using the following keywords, AIR-PWR-FPLR and AIR-PWR-FT.

MIN-AIR-T

For air-cooled condensers, specifies the minimum drybulbdry-bulb temperature entering the condenser. The program will limit the drybulbdry-bulb temperature by this value.

EQUIPMENT-REPORTS (YES; YES, NO)

Takes the code-words YES or NO. When report PS-H of the PLANT-REPORTS is enabled, a report will print for the chiller unless this keyword is set to NO.

ABSOR-1, ABSOR-2, and GAS-ABSOR Chiller

SOLUTION-PUMP-KW

The electric consumption of the solution pump. The default assumes that the solution pump kW is included in the ELEC-INPUT-RATIO. The program overrides the ELEC-INPUT-RATIO if you specify the SOLUTION-PUMP-KW. In this case, the program will recalculate the ELEC-INPUT-RATIO as $\text{SOLUTION-PUMP-KW} * 3413 \text{ Btu/kW} / (\text{CAPACITY} * 106)$.

For a gas-fired chiller, the program also includes the GAS-COMB-FAN-KW in the recalculated ELEC-INPUT-RATIO.

HEAT-REJECTION

Defines the operating parameters of heat-rejection devices such as cooling towers.

Cooling towers may be directly attached to a loop (open tower), or may include an intermediate heat exchanger. The algorithms model the performance of a tower for wetbulbwet-bulbs ranging from 20F to 82F (-6.6C to 27.8C), leaving temperatures from 40F to 95F (4.4C to 35C), and temperature drops from 1F to 20F (0.55K to 11.1K). For this range of conditions, the algorithms will predict the leaving tower temperature within less than 1F (0.55K) for most common operating conditions, and a maximum error of 2F (1.1K) for the more extreme conditions (very large or very small temperature drops, and very close approaches to the wetbulbwet-bulb).

The algorithm for the open tower is similar to the algorithm in DOE-2.1E, except for the form of the performance curves. The open tower with heat exchanger, fluid cooler, and dry cooler are new.

A U-name is mandatory. It will be used in the heading of the equipment report to identify the device.

TYPE

The mandatory code-word specifies the type of heat-rejection device. This keyword is required and should be the first entered. In this manual, we discuss the OPEN-TWR code-word:

OPEN-TWR

A cooling tower that directly exposes the fluid in the condenser loop to the air flowing through the tower. This type of tower is commonly used with chillers or other devices having cleanable condensers. It is not normally used with devices such as water-loop heat pumps where the oxygen and other contaminants introduced into the loop from the tower's air flow is unacceptable.

The default data is based on a cross-flow configuration, with an induced draft propeller discharging at the top of the tower. This is typically the most energy-efficient configuration. Other configurations may be fetched from the library (if available), or created using the keywords associated with this component.

ELEC-INPUT-RATIO

The ratio of electric input to nominal capacity for the cell fan expressed as

$$(\text{fan electric power}) / (\text{cell capacity})$$

where “cell capacity” is the heat rejection capacity of the cell (see CAPACITY keyword, below) and where “fan electric power” and “cell capacity” are expressed in the same units. The program ignores ELEC-INPUT-RATIO if FAN-KW/CELL is specified.

The default ELEC-INPUT-RATIO for open towers is 0.0105, which corresponds to approximately 0.0154 hp/gpm (0.0030 kW/(l/min)) at the CTI rating conditions. For a fluid cooler, the default EIR is substantially higher, 0.054. This value is representative of a fluid cooler having a centrifugal fan. To simulate an axial fan, you can cut this value in half.

CAPACITY-CTRL

Takes a code-word that indicates the control method for regulating the fluid exit temperature. The basic code-word is:

ONE-SPEED-FAN

A one-speed fan cycles on and off to maintain the tower setpoint. The program assumes that the fan can cycle as often as required to maintain the setpoint. In actual practice, fan cycling is usually limited to no more than 4-8 cycles per hour to protect the motor against burnout. This can cause wide fluctuations in the condenser loop temperature, which the program does not model.

Tower Circulation Loop and Condenser Pump

The next two keywords specifies the CIRCULATION-LOOP that is attached to the tower, and any condenser pumps dedicated to this tower.

CW-LOOP

Takes the U-name of the CW or WLHP loop to which this unit is attached.

CW-PUMP

Takes-recirculation pump or it may power the loop. As with the other pumps, you should refer to “Circulation Loops” under the HVAC topic in the *DOE-2.2 Topics* for a more detailed discussion of how this pump may be configured.

AUX-KW

Auxiliary electrical consumption. For a tower having a filtration system, AUX-KW can represent the power consumption of the filter pump. If the filter runs only when the tower is running, then AUX-MODE should be set to WHEN-ON.

AUX-MODE

Accepts a code-word that specifies when the AUX-KW is consumed.

ALWAYS	Auxiliary power is consumed all hours.
WHEN-ON	Auxiliary power is consumed only during the hours the tower is operating.
WHEN-OFF	Auxiliary power is consumed only during the hours the tower is off.
SCHEDULED	The power consumption is scheduled (see AUX-SCH).

AUX-SCHEDULE

When AUX-MODE = SCHEDULED, takes the U-name of a schedule of TYPE = MULTIPLIER that varies the AUX-KW on an hourly basis.

AUX-METER

Takes the U-name of the AUX-METER to which the auxiliary electricity consumption of the tower is assigned.

OPEN-TWR, OPEN-TWR&HX and FLUID-COOLER

For open cooling towers and fluid coolers, the following set of keywords defines the unit capacity and how the capacity varies with load, ambient conditions, and loop temperature setpoint. Cooling towers and fluid coolers differ from other types of primary equipment in that manufacturers commonly rate their equipment in terms of how much water the unit can cool (gpm or l/min) rather than the actual heat rejection capacity (Btu/hr or W), although the two are equivalent. the program compromises between the

two approaches. If you specify a capacity, it is in Btu/hr or W. The design routine then calculates the fluid flow rate that corresponds to this capacity at your design conditions, and determines the equivalent size tower normalized to the CTI design condition. This condition is 95F (35C) tower water entering temperature and 85F (29.4C) tower water leaving temperature when the wetbulbwet-bulb is 78F (25.6C). This corresponds to a range of 10F (5.6K) and an approach of 7F (3.9K).

CAPACITY

The size of the heat-rejection device. If you do not specify this keyword, the capacity will default to the loop capacity, adjusted by the CAPACITY-RATIO. If no CAPACITY-RATIO is input, then the capacity will default to the loop capacity divided by the number of heat-rejection devices attached to the loop.

CAPACITY-RATIO

If CAPACITY is not specified, this is the fraction of the design loop capacity that this component will be sized to meet. If you are defining two components of identical size that should just meet the design loop load, then CAPACITY-RATIO should be set to 0.5 for each component. If you want to include a 20% safety factor in each component, then set the CAPACITY-RATIO of each component to 0.6.

If you don't specify CAPACITY or CAPACITY-RATIO, then the capacity will default to the loop capacity divided by the number of heat-rejection devices attached to the loop.

DESIGN-WETBULB

The wetbulbwet-bulb temperature used in the cooling tower design calculations. The default (78F or 25.6C) corresponds to the point at which towers are rated by CTI. Specifying a lower design wetbulbwet-bulb when other conditions are fixed (including design approach) will cause the program to size a larger tower (in terms of flow capacity at CTI conditions, not heat rejection capacity). Energy consumption may then either increase or decrease depending on CAPACITY-CTRL and the temperature setpoint.

DESIGN-APPROACH

The approach (difference between tower water leaving temperature and wetbulbwet-bulb) used in the cooling tower design calculations. The default (7F or 3.9K) corresponds to the CTI rating point (95F (35C) tower water entering temperature and 85F (29.4C) tower water leaving temperature when the wetbulbwet-bulb is 78F (25.6C)). Specifying a higher approach when other conditions are fixed (including design wetbulbwet-bulb) will cause the program to size a smaller tower (in terms of flow capacity at CTI conditions, not heat rejection capacity). Energy consumption may then either increase or decrease depending on CAPACITY-CTRL and the temperature setpoint.

DW-HEATER

Defines the operating parameters of a domestic hot water heater. The heater attaches to a CIRCULATION-LOOP of TYPE = DHW. U-name is required.

Example input:

The input for a domestic hot water heater that delivers 120F water at a peak flow of 0.222 gal/min looks like the following:

```
DHWLOOP-1 = CIRCULATION-LOOP
  TYPE                = DHW
  PROCESS-FLOW         = 0.222
  PROCESS-SCH          = DHW-1
  HEAT-SETPT-T         = 120 ..

DHWHTR-1 = DW-HEATER
  TYPE                = GAS
  DHW-LOOP             = DHWLOOP-1 ..
```

TYPE

Takes a code-word that specifies the type of water heater. Available types are:

GAS	A gas-fired water heater.
ELEC	An electric resistance water heater.
HEAT-PUMP	A heat pump water heater with electric resistance backup.

DHW-LOOP

Accepts the U-name of the DHW loop to which this heater is attached.

CAPACITY

The heating capacity of the burner, immersion heater, or heat pump used to meet the DHW load and charge the tank. If you do not specify this keyword, the capacity will default to the design DHW loop load (see CIRCULATION-LOOP command).

The following keywords define the energy consumption of the water heater. Note that an electric water heater does not consume any fuel and so does not use HEAT-INPUT-RATIO. However, a gas-fired heater may have electrical usage, such as for a draft fan. Consequently, gas-fired heaters may use both ELEC-INPUT-RATIO and HEAT-INPUT-RATIO.

ELEC-INPUT-RATIO

The ratio of electric input power to nominal heater capacity. The EIR is dimensionless, so the same units for input and capacity should be used when calculating it. Defaults to 1.0 for TYPE = ELEC and 0.37 for TYPE = HEAT-PUMP.

HEAT-INPUT-RATIO

For GAS heaters only, this is the ratio of fuel heat input to heater capacity at full load (i.e., at the rated conditions). This is a dimensionless ratio, so you must convert heat input and heating capacity to the same units before dividing.

Economic Components

The ECONOMICS sub-program calculates energy costs according to tariffs that you specify using three basic commands: 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 describes energy or demand charges that vary according to the amount used.

The SCHEDULE command coordinates the operation of UTILITY-RATEs and BLOCK-CHARGEs.

Example 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. The following example shows tariffs for electricity and natural gas. In the electricity tariff, for each month the first 500 kWh costs 5.35¢/kWh, the next 400 kWh costs 7.25¢/kWh, and the remaining electricity use costs 12.45¢/kWh. The gas tariff has a flat monthly rate of 75¢/therm and a fixed monthly charge of \$15.

```

INVBLK = BLOCK-CHARGE
  BLOCK1-TYPE      = ENERGY
  BLOCKS1          = (500,400,1)
  COSTS1           = (.0535,0.725,.1245) ..

ELEC-TARIFF = UTILITY-RATE
  TYPE            = ELECTRICITY
  ELEC-METERS     = EM-1
  BLOCK-CHARGE    = (INVBLK) ..

GAS-TARIFF = UTILITY-RATE
  TYPE            = NATURAL-GAS
  FUEL-MTERS      = FM-1
  MONTH-CHGS      = (15.)
  ENERGY-CHG     = 0.75 ..

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

```

UTILITY-RATE

Defines the most basic features of a tariff: units, uniform energy and demand cost rates, reactive demands, monthly charges, minimum charges, taxes, etc. One UTILITY-RATE command is entered for each type of energy or fuel used in the primary systems input. UTILITY-RATE also allows costs to be defined that vary 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 by time of use the ENERGY-CHG-SCH keyword accepts the U-name of a schedule that 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 sums the energy into total and peak values for each billing period. For time of use tariffs, 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, 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 is required. Up to 15 different UTILITY-RATEs may be defined.

TYPE

This is a required keyword that takes a code-word specifying the type of fuel or energy being costed. Allowed values are ELECTRICITY, NATURAL-GAS, FUEL-OIL, DIESEL-OIL, STEAM, CHILLED-WATER, LPG, COAL, METHANOL, and OTHER-FUEL.

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.” 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 UNIT value is the unit as defined or defaulted in the ELEC-METER, FUEL-METER, STEAM-METER or CHW-METER command of the HVAC simulation module.

ENERGY-CHG-SCH

Takes the U-name of a schedule (of TYPE=FRACTION) that specifies an energy charge that varies by time of day, week and/or season. The values 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

Takes a list of up to 12 values that specifies a demand charge that is constant with quantity but may vary by month. As few as one value may be entered in the list; the last value will be used for the remaining months.

BLOCK-CHARGE

Takes a list 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. Energy costs that vary by time-of-use and quantity are calculated using the BLOCK-CHARGE format.

MIN-MON-CHGS

Accepts a list of up to 12 values that places a floor on the cost of a fuel or utility for each billing period in which costs are calculated. 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 of up to 12 values that specifies a variable minimum monthly charge calculated on the basis of billing demand. 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

The value that places a ceiling on the maximum effective rate that will be assessed on a utility or fuel for any month. RATE-LIMITATION excludes MONTH-CHGs. In addition, 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 of up to 12 billing day numbers, one for each month. If you input less than 12, the last value entered will apply for all un-entered values. All costs, etc. 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. This keyword allows you to enter the billing day for each month in order to match existing utility bills. This may be important if the meter is not 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, and energy charges that vary both by time of use and amount consumed. Up to 30 BLOCK-CHARGES may be defined, and up to 10 may be referenced by each UTILITY-RATE. U-name is required.

BLOCK-SCH

Takes the U-name of a schedule (of TYPE=FLAG) that defines the period over which energy or demand from the METERS 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 keyword. 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 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 on a seasonal basis.

SCH-FLAG

Specifies the flag value in the BLOCK-SCH that indicates when this BLOCK-CHARGE is active.

BLOCKS-ARE

Takes a code-word that determines how block sizes are entered.

INCREMENTAL Block sizes are entered as increments.

CUMULATIVE Block sizes are entered cumulatively.

Example input:

Say that electricity costs 10¢/kWh for the first 400 kWh consumed in a month, and 8¢/kWh for the next 800 kWh, and 6¢/kWh for higher usage above 1200 kWh. Then you could enter either

```
BLOCKS-ARE      = INCREMENTAL
BLOCKS-1         = (400,800,1)
COSTS-1          = (0.10,0.08,0.06)
```

or

```
BLOCKS-ARE      = CUMULATIVE
BLOCKS-1         = (400,1200,100000)
COSTS-1          = (0.10,0.08,0.06)
```

Note that in the INCREMENTAL example, all energy above 1200 kWh goes in the third block. Therefore, the entry for this block is arbitrary; we have chosen “1”. In the CUMULATIVE case we have chosen a value, 100000, that exceeds the highest total expected, although an entry of “1” would have exactly the same meaning.

BLOCK1-TYPE

Takes a code-word that defines the type of block calculation. Allowed code-words are:

ENERGY	The cost calculation is based on energy consumption.
KWH/KW	Specifies 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 keyword BLOCK1-DATA or BLOCK2-DATA).
KWH/KW-LIMITSUM	Used when the sum of the kWh in a series of blocks is limited by a kWh/kW value. The maximum value is specified in the BLOCK1-DATA and/or BLOCK2-DATA.
DEMAND	The cost calculation is based on peak demand charges.

BLOCKS-1

Takes a list of up to 10 block sizes of energy or demand to which the cost/unit values given by the corresponding COSTS-1 keyword apply. This is a required keyword.

COSTS-1

Takes a list of up to 10 cost/unit values. Each entry applies to the corresponding block in the BLOCKS-1 list of block sizes.

LIMITS-1

Takes a list of up to 10 values of limits that apply to the corresponding block sizes given by BLOCKS-1. Used only when BLOCK1-TYPE=KWH/KW or KWH/KW-LIMITSUM.

When BLOCK1-TYPE=KWH/KW, the limit has units of kWh and is the maximum quantity of energy that can be charged in the block.

When BLOCK1-TYPE=KWH/KW-LIMITSUM, the limit has units of kWh/kW and, when multiplied by demand, is the maximum sum of all energy that can be charged in that block and in all previous blocks. In this case, the same limit should be entered for each of the blocks.

Example input:

A utility charges 5¢ for the first 5000 kWh, 4¢/kWh for the next 10,000 kWh, and 3.5¢/kWh for the remainder. Then the input would look like

```
BLOCK1-TYPE      = ENERGY
BLOCKS-ARE       = INCREMENTAL $the default$
BLOCKS-1         = (5000,10000,1)
COSTS-1          = (0.05,0.04,0.035)
```

Assuming that BLOCKS-1 is not followed by an entry for BLOCKS-2, all remaining energy will go into the last block; therefore, its size does not matter and we have used "1" as a place holder.

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. Allowed code-words are the same as those for BLOCK1-TYPE.

BLOCKS-2, COSTS-2, and LIMITS-2

These keywords are used in the same way as BLOCKS-1, COSTS-1, and LIMITS-1. When BLOCK2-TYPE is the same as BLOCK1-TYPE, these keywords allow an additional 10 sets of data to be entered.

Example input:

If the previous example also contained kWh/kW blocks, input might be as follows.

```

BLOCK1-TYPE      = ENERGY
BLOCKS-1         = (5000,10000,30000)
COSTS-1          = (.05,.04,.035)

BLOCK2-TYPE      = KWH/KW
BLOCKS-2         = (100,200,1)
COSTS-2          = (.03,.02,.015)
LIMITS-2         = (40000,0,0)

```

Note that the limit must be specified, even if it is zero (no limit).

TOU-SEASON-LINK

This keyword is used only with a time of use rate where different BLOCK-CHARGE_s 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-CHARGE_s 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-CHARGE_s 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-CHARGE_s 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-CHARGE_s. For example, a BLOCK-CHARGE representing spring will overlap with both winter and summer

Yearly, Seasonal, and Time of Use BLOCK-CHARGE_s

BLOCK-CHARGE_s 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-CHARGE_s 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
TYPE        = ELECTRICITY
BLOCK-CHARGE = (INVBLK) ..

```

```

INVBLK = BLOCK-CHARGE
  BLOCK1-TYPE      = ENERGY
  BLOCKS-1         = (500,400,1)
  COSTS-1          = (.0535,.0725,0.1245) ..

```

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
  TYPE              = ELECTRICITY
  BILLING-DAYS      = (31)
  BLOCK-CHARGE      = (WINTER-BLK, SUMMER-BLK) ..

SEASONS-SCH = SCHEDULE
  TYPE              = FLAG
  THRU MAY 15       (ALL) (1,24) (1)
  THRU SEP 15       (ALL) (1,24) (2)
  THRU DEC 31       (ALL) (1,24) (1) ..

WINTER-BLK = BLOCK-CHARGE
  BLOCK-SCH         = SEASONS-SCH
  SCH-FLAG          = 1
  BLOCK1-TYPE       = ENERGY
  BLOCKS-1          = (1000,1)
  COSTS-1           = (0.07,0.10) ..

SUMMER-BLK = BLOCK-CHARGE
  BLOCK-SCH         = SEASONS-SCH
  SCH-FLAG          = 1
  BLOCK1-TYPE       = ENERGY
  BLOCKS-1          = (500,1)
  COSTS-1           = (0.06,0.09) ..

```

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, the program prorates the costs between the two block-charges in the same way that most utilities do:

1. 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.
2. 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. DEMAND type blocks are handled similarly:

1. The cost for each DEMAND type BLOCK-CHARGE is computed using the maximum demand found in the entire billing period.
2. The costs are then prorated based on the number of hours each BLOCK-CHARGE was active.

Both the program 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-CHARGE's 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
  TYPE                = ELECTRICITY
  BILLING-DAYS         = (31)
  BLOCK-CHARGE         = (WIN-PK, WIN-OFFPK, SUM-PK, SUM-OFFPK)
  ..

SCH-BLOCK = SCHEDULE
  TYPE                = FLAG
  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)
  ..

WIN-PK = BLOCK-CHARGE
  BLOCK-SCH            = SCH-BLOCK
  SCH-FLAG             = 1.2
  BLOCK1-TYPE          = KWH/KW
  BLOCKS-1             = (100,1)
  COSTS-1              = (0.05,0.04)
  LIMITS-1             = (0,0)
  ..

```

```

WIN-OFFPK = BLOCK-CHARGE
  BLOCK-SCH          = SCH-BLOCK
  SCH-FLAG           = 1.1
  BLOCK1-TYPE        = KWH/KW
  BLOCKS-1           = (100,1)
  COSTS-1            = (0.04,0.03)
  LIMITS-1           = (0,0)
  ..

SUM-PK = BLOCK-CHARGE
  BLOCK-SCH          = SCH-BLOCK
  SCH-FLAG           = 2.2
  BLOCK1-TYPE        = KWH/KW
  BLOCKS-1           = (100,1)
  COSTS-1            = (0.09,0.08)
  LIMITS-1           = (0,0)
  ..

SUM-OFFPK = BLOCK-CHARGE
  BLOCK-SCH          = SCH-BLOCK
  SCH-FLAG           = 2.1
  BLOCK1-TYPE        = KWH/KW
  BLOCKS-1           = (100,1)
  COSTS-1            = (0.05,0.04)
  LIMITS-1           = (0,0)
  ..

```

For a customer to utilize a time of use rate, the utility must provide a meter that is capable of recording the distribution of energy (and demand) consumption, not just the total amount used in the billing period. the program 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-CHARGE_s as described previously.

Using TOU-SEASON-LINK

For the above seasonal change to computed properly, how does the program 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 shown in *italics*:

```

TIME-OF-USE = UTILITY-RATE
TYPE = ELECTRICITY
BILLING-DAYS = (15)
BLOCK-CHARGE = (WIN-PK,WIN-OFFPK,SUM-PK,SUM-FFPK)
..

SCH-BLOCK = SCHEDULE
TYPE = FLAG
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)
..

WIN-PK = BLOCK-CHARGE
BLOCK-SCH = SCH-BLOCK
SCH-FLAG = 1.2
TOU-SEASON-LINKS = (SUM-PK)
BLOCK1-TYPE = KWH/KW
BLOCKS-1 = (100,1)
COSTS-1 = (0.05,0.04)
LIMITS-1 = (0,0)
..

WIN-OFFPK = BLOCK-CHARGE
BLOCK-SCH = SCH-BLOCK
SCH-FLAG = 1.1
TOU-SEASON-LINKS = (SUM-OFFPK)
BLOCK1-TYPE = KWH/KW
BLOCKS-1 = (100,1)
COSTS-1 = (0.04,0.03)
LIMITS-1 = (0,0)
..

SUM-PK = BLOCK-CHARGE
BLOCK-SCH = SCH-BLOCK
SCH-FLAG = 2.2
TOU-SEASON-LINKS = (WIN-PK)
BLOCK1-TYPE = KWH/KW
BLOCKS-1 = (100,1)
COSTS-1 = (0.09,0.08)
LIMITS-1 = (0,0)
..

```



```

SUM-OFFPK = BLOCK-CHARGE
BLOCK-SCH          = SCH-BLOCK
SCH-FLAG           = 2.1
TOU-SEASON-LINKS   = (WIN-OFFPK)
BLOCK1-TYPE        = KWH/KW
BLOCKS-1           = (100,1)
COSTS-1            = (0.05,0.04)
LIMITS-1           = (0,0)
. .

```

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 the program 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 that 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 air distribution 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-BLOCK = SCHEDULE
  TYPE                = FLAG
  THRU MAR 30          (WD)  ( 1, 6) (1.3)  $ Winter Off-peak
                        ( 7,13) (1.1)  $      Peak
                        (14,20) (1.2)  $      Mid-peak
                        (21,24) (1.3)  $      Off-peak
                        (WEH) ( 1,24) (1.3)  $      Off-peak
  THRU OCT 15          (WD)  ( 1, 6) (2.3)  $ Summer Off-peak
                        ( 7,12) (2.2)  $      Mid-peak
                        (13,18) (2.1)  $      Peak
                        (19,24) (2.3)  $      Off-Peak
                        (WEH) ( 1,24) (2.3)  $      Off-peak
  THRU DEC 31          (WD)  ( 1, 6) (1.3)  $ Winter Off-peak
                        ( 7,13) (1.1)  $      Peak
                        (14,20) (1.2)  $      Mid-peak
                        (21,24) (1.3)  $      Off-peak
                        (WEH) ( 1,24) (1.3)  $      Off-peak
  ..

```

Each BLOCK-CHARGE associated with one of these periods references both the schedule and 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.

TARIFF EXAMPLES

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
  TYPE                = ELECTRICITY
  MONTH-CHGS          = (15.)
  ENERGY-COST        = 0.05
  MIN-MON-CHGS        = (17.)
  ..
```

Note that 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
  TYPE                = ELECTRICITY
  BLOCK-CHARGES       = (INVBLK)
  ..

INVBLK = BLOCK-CHARGE
  BLOCK1-TYPE         = ENERGY
  BLOCKS-1             = ( 500, 400, 1)
  COSTS-1             = ((0.0535, 0.0725, 0.1245)
  ..
```

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.

```
SEASONS-SCH = SCHEDULE
    TYPE                = FLAG
    THRU MAY 31          (ALL) (1,24) (1)  $ Winter
    THRU SEP 30          (ALL) (1,24) (2)  $ Summer
    THRU DEC 31          (ALL) (1,24) (1)  $ Winter
    ..

WINTER-BLK = BLOCK-CHARGE
    BLOCK-SCH            = SEASONS-SCH
    SCH-FLAG             = 1
    BLOCK1-TYPE          = ENERGY
    BLOCKS-1             = (1000, 1)
    COSTS-1              = (0.07,0.10)
    ..

SUMMER-BLK = BLOCK-CHARGE
    BLOCK-SCH            = SEASONS-SCH
    SCH-FLAG             = 2
    BLOCK1-TYPE          = ENERGY
    BLOCKS-1             = ( 500, 1)
    COSTS-1              = (0.06,0.09)
    ..

ELEC-TARIFF = UTILITY-RATE
    TYPE                = ELECTRICITY
    BLOCK-CHARGES        = (WINTER-BLK, SUMMER-BLK) ..
```

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
    TYPE                = ELECTRICITY
    ENERGY-CHGS        = (0.05)
    DEMAND-CHGS         = (12.00)
    RATE-LIMITATION     = 0.07
    ..
```

Example 5: Time of Use and Demand Charges

An 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.

```

ENERGY-SCH = SCHEDULE
  TYPE      = MULTIPLIER
  THRU  MAR 31      (WD)  ( 1, 8) (0.04)  $ Winter
                   ( 9,22) (0.06)
                   (23,24) (0.04)
                   (WEH) ( 1,24) (0.04)
  THRU  SEP 31      (WD)  ( 1, 8) (0.05)  $ Summer
                   ( 9,20) (0.07)
                   (21,24) (0.05)
                   (WEH) ( 1,24) (0.05)
  THRU  DEC 31      (WD)  ( 1, 8) (0.04)  $ Winter
                   ( 9,22) (0.06)
                   (23,24) (0.04)
                   (WEH) ( 1,24) (0.04)
  ..

TIME-OF-USE = UTILITY-RATE
  TYPE      = ELECTRICITY
  ENERGY-CHG-SCH = ENERGY-SCH
  DEMAND-CHGS    = (5,5,5,8,8,8,8,8,8,5,5,5)
  ..

```

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

Selects VERIFICATION and/or SUMMARY reports for the ECONOMICS program.

Format:

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

Example input:

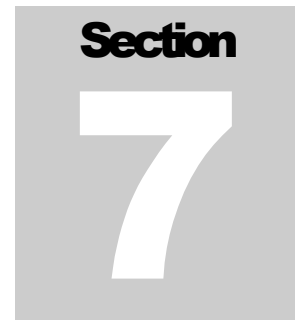
```
ECONOMICS-REPORT
  VERIFICATION      = ( none required )
  SUMMARY           = (ES-D, ES-E) ..
```

will print summary reports ES-D, Summary of Fuel and Utility Use and Costs , and ES-E, Summary of Electricity Charges.

SUMMARY

Accepts a list of code-words specifying the reports to be printed. The reports presenting rate tariffs are:

ES-D:	ENERGY COST SUMMARY Summarizes the yearly energy consumption and cost for all UTILITY-RATEs defined.
ES-E:	SUMMARY OF UTILITY-RATE: <U-name of UTILITY-RATE> Gives the key monthly and annual costs associated with a UTILITY-RATE, including metered energy and demand, and energy and demand charges.
ES-F:	BLOCK-CHARGE AND RATCHET SUMMARY FOR < U-name of UTILITY-RATE > Gives the monthly and annual cost associated with each BLOCK-CHARGE.



Appendices

A. ADDITIONAL CAPABILITIES

The program has many capabilities in addition to those covered in the main text of this document. Following is a list of some of these capabilities. Items in the list point to other pieces of documentation where you will find the capability described in more detail. In some cases we refer you to one of the sample runs provided with the program to illustrate the input method for a feature.

Because there may be different terms to indicate a capability, we use cross referencing where appropriate. For example, under “Lighting Fixtures” we say “See Luminaires.”

The items in the list appear alphabetically and are not organized according to the LOADS, HVAC and ECONOMICS subprograms.

Air Handling Units (AHU)Assign AHU to specific boilers/chillers	See the topic on Circulation Loops
ASHRAE Constructions for Walls and Roofs	Instead of entering a LAYERS command, you can use prespecified ASHRAE material layers. See “Construction Library,” in the <i>DOE-2.2 Libraries & Reports</i> .
ASHRAE Materials Library	Instead of using the materials library described in this manual you can use ASHRAE prespecified materials. See “Materials Library,” in the <i>DOE-2.2 Libraries & Reports</i> .
ASHRAE Weather Design Criteria	See Design Day
Atrium	See Sunspace
Blinds	Interior, between-glass and exterior slatted sun-control devices, such as venetian blinds, can be specified and controlled in various ways. In the DOE-2.2 Dictionary see “WINDOW-LAYER Command.” In the same place, see also the WINDOW-LAYERS keyword and “Window Blind Control” under “WINDOW Command.”
Building Coordinate System	An X-Y-Z three-dimensional description of the building and shading surfaces can be entered. See “Geometry” in the DOE-2.2 Topics. Specifying surface coordinates is generally only necessary in three cases: (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 the simstr1 sample run.
Casework Heat Recovery	See Refrigerated Casework
Chilled-Water Loops	See Circulation Loops
Chilled Water Storage	See Energy Storage
Circulation Loops	You can specify loops of hot or chilled water that connect primary equipment (boilers, chillers, etc.) and coils. You can also specify

	<p>condenser water loops that connect condenser and heat rejection device like a cooling tower. The program calculates the temperature and flow of the fluid in these loops and associated pumping energy. You can specify the characteristics of the pumps on these loops. See “Circulation Loops” in the DOE-2.2 Topics. See also “CIRCULATION-LOOP Command” and “PUMP Command” in the <i>DOE-2.2 Dictionary</i>.</p>
Cogeneration	<p>Cogeneration of electricity and heat using either gas turbine, diesel, or natural gas engines can be modeled. See “Electric Generators and Cogeneration” in the <i>DOE-2.2 Topics</i>.</p>
Curve Fit	<p>The curve fit feature allows you to input your own 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 default curves stored in the program. See “CURVE-FIT Command” in the <i>DOE-2.2 Dictionary</i>.</p>
Custom Weighting Factors	<p>These allow you to tailor the weighting factors used in the load calculations to the construction of the building being modeled. This improves the accuracy of the calculation. Custom Weighting Factors are calculated when FLOOR-WEIGHT = 0 (the default) for a space. See “Weighting Factors” in the <i>DOE-2.2 Topics</i>.</p>
Daily Reports	<p>See Hourly Reports</p>
Daylighting	<p>The program can simulate control of overhead lighting in response to the level of natural lighting (“daylighting”) entering windows from the sun, sky and ground. Reflection of daylight from the inside surfaces of the space is accounted for. Both dimming and step control can be modeled. Window shade management to control solar gain and/or glare can be also be modeled. See “Daylighting” in the <i>DOE-2.2 Topics</i>. See also the dayltg sample run.</p>
Demand Ratchets	<p>allow you to adjust energy demand charges. See “RATCHET Command” under ECONOMICS in the <i>DOE-2.2 Dictionary</i>.</p>
Desiccant Cooling	<p>See System Type PTGSD in this manual and the PTGSD writeup in “System Types” in the <i>DOE-2.2 Topics</i>.</p>
Desiccant Add-On Units	<p>See “Add-On Desiccant Cooling” under the “SYSTEM Command” in the <i>DOE-2.2 Dictionary</i>. The add-on systems can use either solid or liquid desiccants.</p>
Design Day	<p>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 file. 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 “DESIGN-DAY Command” in the <i>DOE-2.2 Dictionary</i> and sample run simstr3.</p>

Dual-Fan Dual-Duct System	See "System Types" in the <i>DOE-2.2 Topics</i>
Energy Storage	The program can simulate storage of hot water, cold water and ice. See "THERMAL-STORAGE Command" in the <i>DOE-2.2 Dictionary</i> and "Thermal Energy Storage" in the <i>DOE-2.2 Topics</i> .
Energy Meters	allow you to meter different energy end uses and attach utility rates to them. See "ELEC-METER Command" in the <i>DOE-2.2 Dictionary</i> and "Building Submetering and ELEC-METER Command" in the <i>DOE-2.2 Topics</i> .
Equipment Control	See Load Assignment in the <i>DOE-2.2 Topics</i> .
Evaporative Cooling	See the material following the EVAP-CL-TYPE keyword (under SYSTEM) in the <i>DOE-2.2 Dictionary</i> for a description of add-on and stand-alone evaporative cooling systems.
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/flow to determine limits for fan power and the program defaults to these approximate values. However, the alternative capability is often preferred by design engineers. See "ZONE" in the <i>DOE-2.2 Dictionary</i> .
Functions	See Input Functions
Gas Heat Pumps	Gas-engine-driven heat pumps are specified by entering HEAT-SOURCE = GAS-HEAT-PUMP in the SYSTEM command. See the keywords starting with HEAT-CAP-FRM under "SYSTEM Command" in the <i>DOE-2.2 Dictionary</i> for details on specifying a gas heat pump.
Glass Coefficients	Specifying coefficients of solar transmission and absorption for windows is an alternative, and more accurate, method of calculating solar gains through glazings than the ASHRAE shading coefficient method. In the <i>DOE-2.2 Topics</i> , see "Windows". Also refer to Appendixes C "Windows" and Appendix D "Window Layers" in the <i>DOE-2.2 Libraries & Reports</i> .
Grocery Store Heat Recovery Systems	See Refrigerated Casework
Ground Source Heat Pumps	See "GROUND-LOOP-HX Command" in the <i>DOE-2.2 Dictionary</i>
Heat Pumps	For a heat pump, you can specify the type of defrost control and the type of supplemental heat in lieu of electric resistance heat. See HP-SUPP-SOURCE and following keywords under "SYSTEM Command" in the <i>DOE-2.2 Dictionary</i> .

Hot-Water Loops	See Circulation Loops
Hot Water Storage	See Energy Storage
Hourly Reports	Allow you to display selected hourly values of quantities like temperatures, flows and energy use calculated by the program. Hourly reports also give daily sums, maxima, minima, and averages. See the “HOURLY-REPORT Command” in the <i>DOE-2.2 Dictionary</i> . For an example, see the simstr3sample run.
Ice Rink Modeling	See Refrigerated Casework
Ice Storage	See Energy Storage
Infiltration Modeling	See “Infiltration” in “SPACE Command” in the <i>DOE-2.2 Dictionary</i> . For crack-method infiltration, see the INF-COEF keyword in “WALL Command” and “DOOR Command” in the <i>DOE-2.2 Dictionary</i> .
Input Functions	In LOADS, allow you to replace program code with your own algorithms to model options like non-linear dimming controls, complex window management, etc. In HVAC, allow you to replace program code with your own algorithms to model things like non-standard economizer controls, control of supply air with a return air controller, custom control for chillers, etc. See “Input Functions” in the <i>DOE-2.2 Topics</i> .
Input Macros	allow keywords to be set equal to the result of adding, subtracting, multiplying and/or dividing other values. Also allows predefined input sections to be brought into your input from a file. See “Input Macros” in the <i>DOE-2.2 Topics</i> .
Interior Walls	The different types of interior walls that can be specified (STANDARD, AIR, ADIABATIC, and INTERNAL) are described under “INTERIOR-WALL Command” in the <i>DOE-2.2 Dictionary</i> . For information related to conduction, thermal mass, daylighting, etc., as applied to interior walls, see “Interior Surfaces” in the <i>DOE-2.2 Topics</i> . For windows in interior walls see “Sunspaces” in the <i>DOE-2.2 Topics</i> .
Layer-by-Layer Window Input	You can specify windows by entering them layer by layer much as you would a wall. A double-pane window, for example, would be entered with three layers – an outer glass layer, a gas layer and an inner glass layer. Blinds can also be entered as a layer. See “Windows” in the <i>DOE-2.2 Topics</i> . See also “WINDOW-LAYER Command” in the <i>DOE-2.2 Dictionary</i> .
Life-Cycle Cost Analysis	See “Life-Cycle Costing” in the <i>DOE-2.2 Topics</i> .
Lighting Control	See Daylighting

Lighting Fixtures	See Luminaires
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 “Load Management and Equipment Control” in the <i>DOE-2.2 Topics</i> .
Load Management	is used in combination with load assignment to control the operation of plant equipment based on scheduling requirements, etc. See “Load Management and Equipment Control” in the <i>DOE-2.2 Topics</i> .
Luminaires	Rather than simply giving watts per unit floor area, overhead electric lighting may be specified by entering specific types of luminaires, lamps and ballasts. See “Electric Lighting” in the <i>DOE-2.2 Topics</i> .
Management of Plant Equipment Operation	See Equipment Control
Manufacturer’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 “Metric Input/Output Option” in the <i>DOE-2.2 Topics</i> .
Meters	Different energy end uses can be assigned to separate meters for energy cost calculations and for reporting. See “Building Submetering and the ELEC-METER Command” in the <i>DOE-2.2 Topics</i> .
Monthly Reports	See Hourly Reports
Motorized Blinds	See Blinds.
Natural Ventilation	The program can simulate the amount of air movement through the space due to open windows as a function of wind speed and other factors.
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 “SYSTEM Command” in the <i>DOE-2.2 Dictionary</i> .
Optimum Fan Start	simulates advancing the system start time to bring a building to comfort conditions at start of occupancy. See the FAN-SCHEDULE keyword under “SYSTEM Command” in the <i>DOE-2.2 Dictionary</i> .
Outside Air Economizers (nonstandard)	See Input Functions
Parametric Runs	allow you to make several runs from a single input file by varying a keyword value. Convenient for doing sensitivity analyses See the

	<i>DOE-2.2 Topics.</i>
Peak Shaving	See Load Management
Plenums	Note that it is unnecessary to define plenums in both LOADS and SYSTEMS if you request RETURN-AIR-PATH = DUCT in the SYSTEM command. This input is sufficient to simulate light heat from return-air-vented lighting fixtures. Otherwise, plenum spaces can be entered with the SPACE command (ZONE-TYPE = PLENUM) in LOADS and the ZONE command (TYPE = PLENUM) in SYSTEMS.
Polygons	Allow you to define non-rectangular walls, floors and ceilings. See “POLYGON Command” in the <i>DOE-2.2 Dictionary</i> ” and “Building Geometry” in the in the <i>DOE-2.2 Topics</i> . See also the sm-off sample run.
Predefined Input Segments	See Input Macros
Pumps	See "Circulation Loops" in the <i>DOE-2.2 Topics</i>
Primary/Secondary Pumping	See "Circulation Loops" in the <i>DOE-2.2 Topics</i>
Refrigerated Casework	applies primarily to food stores where there is 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 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 “Casework Refrigeration” in “SYSTEM Command” in the <i>DOE-2.2 Dictionary</i> .
Replacing program Code	See Input Functions.
Reports	See the <i>DOE-2.2 Libraries & Reports</i> for a description of all verification and summary reports.
Self Shading	When one surface of a building shades another (as happens in L-shaped buildings, for example), see “Self Shades” under “Building Shades” in the <i>DOE-2.2 Topics</i> .
Shading	The program models local solar shading (by fins and overhangs associated with a window or door) and global solar shading (by neighboring buildings, for example). See “Building Shades” in the <i>DOE-2.2 Topics</i> . Global shading requires you to input the building surfaces that are involved into a three-dimensional coordinate system (see “Geometry” in the <i>DOE-2.2 Topics</i>).
Sunspace	is a feature that is used to simulate atria for large buildings and 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 “Sunspaces” in the <i>DOE-2.2 Topics</i> .
Sun Control Shading	See Shading. See also 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 Types	A variety of different secondary system types can be modeled. See “System Types” in the <i>DOE-2.2 Topics</i> .
Thermal Energy Storage	See Energy Storage.
Three-Dimensional Building Input	See Building Coordinate System
Trees	Trees entered as detached shading surfaces can shade a building. A transmittance schedule can be used to model deciduous trees. See Shading.
Trombe Walls	Unvented Trombe walls can be modeled. See “TROMBE-WALL-NV Command” in the <i>DOE-2.2 Dictionary</i> .
Supply Air Reset	See keywords HEAT-CONTROL and COOL-CONTROL under “SYSTEM” in the <i>DOE-2.2 Dictionary</i> .
Venetian Blinds	See Blinds
Venting of Sunspaces	See Sunspace
Water-Cooled Condensers/Water-Side Economizers	may be applied to system types PSZ and PVAVS. See WS-ECONO keyword under “SYSTEM” in the <i>DOE-2.2 Dictionary</i> .
Window Management	with drapes, blinds, etc. can be simulated to control solar gain or to reduce daylight glare. See “Windows” in the <i>DOE-2.2 Topics</i> .

B. BASIC OUTPUT REPORTS

This appendix shows examples of some of the verification and summary reports printed by the LOADS, HVAC (SYSTEMS and PLANT) and ECONOMICS programs. A description of the contents of each summary report and selected verification reports is given. The sample reports in this appendix are in English units. For metric runs the corresponding units can be determined from the Units Table (see “Metric Option” in the *DOE-2.2 Topics*).

REPORT LV-A: GENERAL PROJECT AND BUILDING INPUT

```
Simple Structure Run 3, Chicago          Divide into zones; add plenum          DOE-2.2b-027  Fri Jan  9 15:25:08 1998BDL RUN  1
Design-day sizing of VAV system          Show All Reports
REPORT- LV-A  General Project and Building Input          WEATHER FILE- TRY  CHICAGO
-----
```

PERIOD OF STUDY

STARTING DATE	ENDING DATE	NUMBER OF DAYS
7 JAN 1997	7 JAN 1997	1
5 AUG 1997	5 AUG 1997	1
1 JAN 1997	31 DEC 1997	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

REPORT LV-D: DETAILS OF EXTERIOR SURFACES IN THE PROJECT

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 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
 (U-VALUE INCLUDES OUTSIDE AIR FILM; WINDOW INCLUDES FRAME, IF DEFINED)

SURFACE	- - - W I N D O W S - - -		- - - - W A L L - - - -		- W A L L + W I N D O W S -		AZIMUTH
	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	U-VALUE (BTU/HR-SQFT-F)	AREA (SQFT)	
WALL-1PB	0.000	0.00	0.067	200.00	0.067	200.00	NORTH
in space: PLENUM-1							
BACK-1	0.531	229.00	0.067	571.00	0.200	800.00	NORTH
in space: SPACE3-1							
RIGHT-1	0.428	100.00	0.067	300.00	0.157	400.00	EAST
in space: SPACE2-1							
WALL-1PR	0.000	0.00	0.067	100.00	0.067	100.00	EAST
in space: PLENUM-1							
WALL-1PF	0.000	0.00	0.067	200.00	0.067	200.00	SOUTH
in space: PLENUM-1							
FRONT-1	0.554	244.00	0.067	556.00	0.216	800.00	SOUTH
in space: SPACE1-1							
WALL-1PL	0.000	0.00	0.067	100.00	0.067	100.00	WEST
in space: PLENUM-1							
LEFT-1	0.428	100.00	0.067	300.00	0.157	400.00	WEST
in space: SPACE4-1							
TOP-1	0.000	0.00	0.168	5000.00	0.168	5000.00	ROOF
in space: PLENUM-1							
F1-1	0.000	0.00	0.453	1056.00	0.453	1056.00	UNDERGRND
in space: SPACE1-1							
F2-1	0.000	0.00	0.453	456.00	0.453	456.00	UNDERGRND
in space: SPACE2-1							
F3-1	0.000	0.00	0.453	1056.00	0.453	1056.00	UNDERGRND
in space: SPACE3-1							
F4-1	0.000	0.00	0.453	456.00	0.453	456.00	UNDERGRND
in space: SPACE4-1							
F5-1	0.000	0.00	0.453	1976.00	0.453	1976.00	UNDERGRND
in space: SPACE5-1							

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- LV-D Details of Exterior Surfaces in the Project WEATHER FILE- TRY CHICAGO
 -----(CO NTINUED)-----

	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	0.531	0.067	0.173	229.00	771.00	1000.00
EAST	0.428	0.067	0.139	100.00	400.00	500.00
SOUTH	0.554	0.067	0.186	244.00	756.00	1000.00
WEST	0.428	0.067	0.139	100.00	400.00	500.00
ROOF	0.000	0.168	0.168	0.00	5000.00	5000.00
ALL WALLS	0.509	0.067	0.166	673.00	2327.00	3000.00
WALLS+ROOFS	0.509	0.136	0.167	673.00	7327.00	8000.00
UNDERGRND	0.000	0.453	0.453	0.00	5000.00	5000.00
BUILDING	0.509	0.264	0.277	673.00	12327.00	13000.00

REPORT LS-B: SPACE PEAK LOAD COMPONENTS <space name>

This report gives a breakdown of a space’s cooling and heating peak loads according to the source of the load. 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. (This value is reported here as SPACE TEMPERATURE USED FOR THE LOADS CALCULATION.) These loads are modified in the SYSTEMS program to account for time-varying air temperatures.

Note that “DESIGN DAY” after the space name indicates that this report is for a design day run. If “DESIGN DAY” does not appear here, the report is for a weather file run. The name of the weather file, in this case “TRY CHICAGO” is indicated.

The following outside conditions are reported at the time the cooling or heating peak occurs: dry-bulb temperature, wet-bulb temperature, total horizontal solar radiation (direct plus diffuse), wind speed at space (which is the weather station wind speed modified for terrain conditions and space height), and cloud amount, which ranges from 0 for clear sky to 10 for overcast sky.

As indicated by Note (1) at the bottom of the report, the load associated with conditioning of outside ventilation air is not included in this report. This load is calculated in the SYSTEMS program.

As indicated by Note (2) at the bottom of the report, the times reported for the cooling and heating peaks are in standard time, i.e., they do not take daylighting savings, if applicable, into account.

The load components that are reported are the following:

- 1. WALL CONDUCTION is the load due to conduction through exterior walls (TILT ³ 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 UADT 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 a slab on grade or through basement or crawl space floors and walls.
- 8. The next five entries are the loads due to

<i>occupants</i>	resulting from user-supplied entries for the SPACE keywords PEOPLE-SCHEDULE, NUMBER-OF-PEOPLE, AREA/PERSON and PEOPLE-HEAT-GAIN
<i>electric lighting</i>	from the SPACE keywords LIGHTING-SCHEDULE, LIGHTING-TYPE, LIGHTING-W/AREA, TASK-LT-W/AREA, etc., or from the LIGHTING-SYSTEM, LUMINIARE-TYPE and LAMP-TYPE commands,

equipment from the SPACE keywords EQUIP-SCHEDULE, EQUIPMENT-W/AREA, etc),

process from the SPACE keywords SOURCE-SCHEDULE, SOURCE-TYPE, SOURCE-BTU/HR, etc., and

outside air infiltration from keywords INF-SCHEDULE, INF-METHOD, AIR-CHANGES/HR, etc..

9. The BDL RUN number in the upper right hand corner refers to the number of the pass through the program. For example, if you were doing parametric runs as part of the same job, successive passes would be recorded as RUN 1, RUN 2, RUN 3, etc.

```

Simple Structure Run 3, Chicago          Divide into zones; add plenum          DOE-2.2b-027  Fri Jan  9 15:25:08 1998BDL RUN  1
Design-day sizing of VAV system        Show All Reports
REPORT- LS-B Space Peak Load Components  SPACE1-1          DESIGN DAY  WEATHER FILE- TRY  CHICAGO
-----
SPACE  SPACE1-1
SPACE TEMPERATURE USED FOR THE LOADS CALCULATION IS  70 F /  21 C

          MULTIPLIER          1.0          FLOOR MULTIPLIER          1.0

          FLOOR AREA          1056  SQFT          98  M2
          VOLUME              8448  CUFT          239  M3

                                COOLING  LOAD
                                =====
                                AUG  5  5PM

          DRY-BULB TEMP          94 F          34 C
          WET-BULB TEMP          74 F          23 C
          TOT HORIZONTAL SOLAR RAD  186 BTU/H.SQFT  584 W/M2
          WINDSPEED AT SPACE      4.2 KTS          2.1 M/S
          CLOUD AMOUNT 0 (CLEAR) -10  0

                                HEATING  LOAD
                                =====
                                JAN  7  8AM

          DRY-BULB TEMP          -5 F          -21 C
          WET-BULB TEMP          -6 F          -21 C
          TOT HORIZONTAL SOLAR RAD   2 BTU/H.SQFT   5 W/M2
          WINDSPEED AT SPACE      8.3 KTS          4.3 M/S
          CLOUD AMOUNT 0 (CLEAR) -10  5

SENSIBLE    LATENT
(KBTU/H)    ( KW )    (KBTU/H)    ( KW )

-----    -----    -----    -----

WALL CONDUCTION          1.860    0.545    0.000    0.000
ROOF CONDUCTION          0.000    0.000    0.000    0.000
WINDOW GLASS+FRM COND    4.752    1.392    0.000    0.000
WINDOW GLASS SOLAR      12.107    3.547    0.000    0.000
DOOR CONDUCTION          0.000    0.000    0.000    0.000
INTERNAL SURFACE COND    0.000    0.000    0.000    0.000
UNDERGROUND SURF COND   -0.544   -0.159    0.000    0.000
OCCUPANTS TO SPACE       2.449    0.718    1.433    0.420
LIGHT TO SPACE           3.901    1.143    0.000    0.000
EQUIPMENT TO SPACE       3.182    0.932    0.000    0.000
PROCESS TO SPACE         0.000    0.000    0.000    0.000
INFILTRATION             0.000    0.000    0.000    0.000
-----    -----    -----    -----
TOTAL              27.707    8.118    1.433    0.420
TOTAL / AREA        0.026    0.083    0.001    0.004

TOTAL LOAD          29.140 KBTU/H          8.538 KW          -14.109 KBTU/H          -4.134 KW
TOTAL LOAD / AREA   27.59 BTU/H.SQFT      87.029 W/M2          13.361 BTU/H.SQFT      42.137 W/M2

*****
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----  LOADS                                             *
*  2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION        *
*  IN CONSIDERATION                                         *
*  3)THE ABOVE LOADS ARE CALCULATED ASSUMING A            *
*  CONSTANT INDOOR SPACE TEMPERATURE                      *
*****

```

REPORT LS-C: BUILDING PEAK LOAD COMPONENTS

This report is similar in format to LS-B, "Space Peak Load Components." 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 includes conditioned spaces only (ZONE-TYPE=CONDITIONED). It 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, you should realize how the program 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 an air flow at the calculated outside 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.

BASICS

APPENDIXES

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- LS-C Building Peak Load Components DESIGN DAY WEATHER FILE- TRY CHICAGO

*** BUILDING ***

FLOOR AREA 5000 SQFT 465 M2
 VOLUME 50000 CUFT 1416 M3

	COOLING LOAD		HEATING LOAD	
	=====		=====	
TIME	AUG 5	5PM	JAN 7	7AM
DRY-BULB TEMP	94 F	34 C	-5 F	-21 C
WET-BULB TEMP	74 F	23 C	-6 F	-21 C
TOT HORIZONTAL SOLAR RAD	186 BTU/H.SQFT	584 W/M2	0 BTU/H.SQFT	0 W/M2
WINDSPEED AT SPACE	4.4 KTS	2.2 M/S	8.7 KTS	4.5 M/S
CLOUD AMOUNT 0 (CLEAR)-10	0		5	

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(KW)	(KBTU/H)	(KW)	(KBTU/H)	(KW)
	-----	-----	-----	-----	-----	-----
WALL CONDUCTION	4.245	1.244	0.000	0.000	-7.911	-2.318
ROOF CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
WINDOW GLASS+FRM COND	10.182	2.983	0.000	0.000	-24.317	-7.125
WINDOW GLASS SOLAR	24.617	7.213	0.000	0.000	2.608	0.764
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	-1.639	-0.480	0.000	0.000	-4.370	-1.280
OCCUPANTS TO SPACE	12.195	3.573	6.776	1.985	0.000	0.000
LIGHT TO SPACE	19.296	5.654	0.000	0.000	0.000	0.000
EQUIPMENT TO SPACE	15.889	4.655	0.000	0.000	0.000	0.000
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-12.387	-3.629
TOTAL	84.785	24.842	6.776	1.985	-46.377	-13.589
TOTAL / AREA	0.017	0.053	0.001	0.004	-0.009	-0.029
TOTAL LOAD	91.561 KBTU/H	26.827 KW			-46.377 KBTU/H	-13.589 KW
TOTAL LOAD / AREA	18.31 BTU/H.SQFT	57.753 W/M2			9.275 BTU/H.SQFT	29.253 W/M2

 *
 * NOTE 1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR *
 * ---- LOADS *
 * 2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION *
 * IN CONSIDERATION *
 * 3)THE ABOVE LOADS ARE CALCULATED ASSUMING A *
 * CONSTANT INDOOR SPACE TEMPERATURE *
 *

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**
is the monthly sensible cooling load for all conditioned SPACES in the building.
3. **MAXIMUM COOLING LOAD**
is the peak coincident sensible cooling load for all conditioned SPACES in the building. To the left of this column are the day and hour (local standard time) of the peak cooling load along with the outside drybulb and wetbulb temperatures at that time.
4. **HEATING ENERGY**
is the monthly heating load for all conditioned SPACES in the building.
5. **MAXIMUM HEATING LOAD**
is the peak coincident heating load for all conditioned SPACES in the building. To the left of this column are the day and hour (local standard time) of the peak heating load along with the outside drybulb and wetbulb temperatures at that time.
6. **ELECTRICAL ENERGY**
is the monthly electrical consumption for lights, convenience outlets and non-HVAC equipment.
7. **MAXIMUM ELEC LOAD**
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.

APPENDIXES

WEATHER FILE- TRY CHICAGO

MONTH	C O O L I N G						H E A T I N G						E L E C	
	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	5.38947	31	15	30.F	25.F	45.418	-10.065	12	3	1.F	0.F	-37.352	3027.	12.000
FEB	4.90776	28	15	52.F	42.F	44.295	-9.185	4	6	7.F	6.F	-36.168	2654.	12.000
MAR	6.74509	3	16	79.F	62.F	52.219	-6.658	24	6	8.F	7.F	-38.381	2936.	12.000
APR	12.32965	2	15	69.F	53.F	57.821	-2.017	8	6	32.F	29.F	-16.160	2994.	12.000
MAY	14.45126	20	14	76.F	67.F	63.784	-0.757	9	5	40.F	38.F	-10.506	2936.	12.000
JUN	18.19720	20	15	90.F	77.F	69.729	-0.075	23	5	52.F	48.F	-4.085	2903.	12.000
JUL	22.84128	9	15	94.F	74.F	73.656	0.000	0	0	0.F	0.F	0.000	3027.	12.000
AUG	20.40500	19	16	90.F	71.F	72.721	-0.001	5	5	55.F	54.F	-0.557	2936.	12.000
SEP	16.13781	17	15	82.F	66.F	70.483	-0.371	22	6	35.F	31.F	-10.162	2903.	12.000
OCT	12.67929	10	15	68.F	54.F	65.100	-1.562	21	6	30.F	29.F	-13.971	3027.	12.000
NOV	6.27171	7	15	55.F	46.F	58.931	-5.518	28	7	26.F	24.F	-23.169	2629.	12.000
DEC	5.11098	10	15	41.F	35.F	47.798	-9.108	22	8	15.F	15.F	-30.361	3027.	12.000
TOTAL	145.467						-45.318						34996.	
MAX						73.656						-38.381		12.000

REPORT SV-A: SYSTEM DESIGN PARAMETERS FOR <system name>

This report echoes your input to the program for each system as interpreted by the SYSTEMS design routines. The report is divided into three sections: System-Level Design Values, Fan Design Values and Zone-Level Design Values.

For systems having mixing sections (dual-duct and multizone systems) an additional section appears detailing the cold duct, hot duct, and total zonal air flows, as well as the minimum air flow ratios for these quantities.

Note: the quantities in this report have been adjusted for altitude even though the program requires that any flows you enter in SYSTEMS be at sea level.

System-Level Design Values

1. **SYSTEM TYPE**
is the code-word identifying the type of system.
2. **ALTITUDE FACTOR**
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.
3. **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, that have non-zero occupancy.
4. **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 command; any variation in occupancy resulting from PEOPLE-SCHEDULE is ignored in calculating MAX PEOPLE.
5. **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 flow (as listed in the Fan Design Values section, below). 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 the Zone-Level Design Values section, below) divided by the supply fan flow. 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.

6. **COOLING CAPACITY**
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 flow rate chosen for the system is different from the user-specified value of RATED-FLOW, COOLING CAPACITY may reflect a correction for off-rated performance.

7. **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-FLOW. 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-FLOW.
8. **HEATING CAPACITY**
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.
9. **COOLING EIR and HEATING EIR**
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 flow differs from the RATED-FLOW.
10. **HEAT PUMP SUPP-HEAT**
is the heating capacity of the supplemental heating unit for a heat pump.

Fan Design Values

This section gives the characteristics of the system supply and return fans.

1. **FAN TYPE**
Indicates that the fan is either a SUPPLY, RETURN, or RELIEF fan.
2. **CAPACITY**
Is the design flowrate of the fan.
3. **DIVERSITY FACTOR**
is the supply flow divided by the sum of the zonal flows. For a building having one HVAC system only, the fan can be sized on the basis of either the coincident or non-coincident load. The diversity factor is usually less than 1.0 when sized on the coincident load. For fans sized on the non-coincident load, or buildings having more than one HVAC system, this value will be 1.0
4. **POWER DEMAND**
Is the power consumption of the fan at design flowrate and pressure..
5. **FAN DELTA-T**
Is the heat gain across the fan at design flowrate and pressure.
6. **STATIC PRESSURE**
Is the design total static pressure drop across the fan.
7. **TOTAL EFF**
Is the total overall efficiency of the fan (mechanical plus motor), at design flowrate and pressure..
8. **MECH EFF**
Is the mechanical efficiency of the fan at design flowrate and pressure.
9. **FAN PLACEMENT**
Indicates if the fan is up stream (BLOW-THRU) or down stream (DRAW-THRU) of the cooling coil.
10. **FAN CONTROL**
Indicates the type of fan flow control.

11. MAX FAN RATIO

Is the maximum flow fraction, as compared to the design flow, of the fan/motor/control system.

12. MIN FAN RATIO

Is the minimum flow fraction, as compared to the design flow, of the fan/motor/control system.

Zone-Level Design Values

The following quantities 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).

1. SUPPLY FLOW

is the calculated or user-specified supply flow for each zone. Only if you have specified a value for the ASSIGNED-FLOW keyword in the ZONE command will the value here correspond to your input. The ZONE keywords AIR-CHANGES/HR and FLOW/AREA will be accepted by SYSTEMS only if they are consistent with the user-supplied HEATING-CAPACITY and COOLING-CAPACITY and are equivalent to a flow larger than that of the exhaust from or the ventilation to the zone. The ALTITUDE FACTOR will be applied.

2. EXHAUST FLOW

is the flowrate of exhaust air from this zone by direct exhaust fans.

3. FAN

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.

4. MINIMUM FLOW

reflects the your input for MIN-FLOW-RATIO, unless that input is in conflict with exhaust or ventilation requirements. In the absence of user input, SYSTEMS will calculate the minimum flow ratio for VAV systems from the minimum flow needed to meet the minimum ventilation requirements and the required heating capacity.

5. OUTSIDE AIR FLOW

reflects the user-specified outside air quantity entered at the zone level. If OUTSIDE-AIR-FLOW is specified, its value is multiplied by the ALTITUDE FACTOR and reported here. Otherwise the reported value is the maximum of the flow-equivalent values of OA-CHANGES and OA-FLOW/PER, multiplied by ALTITUDE FACTOR. For the actual amount of outside air delivered to the zone for central systems, see OUTSIDE AIR RATIO above.

6. COOLING CAPACITY

will be zero at the zone level 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, and FC systems or at any conditions for IU systems. This is done similarly for HEATING CAPACITY for the above-mentioned systems and for UVT and UHT systems.

7. SENSIBLE

is the cooling sensible heat ratio for zonal systems.

8. EXTRACTION RATE

is the cooling extraction rate at design conditions. This is not the value used in the simulation; that value is recalculated hourly and depends on the loads, the conditions, the thermostat type and the thermostat throttling range. ADDITION RATE (heating) is treated similarly.

9. HEATING CAPACITY

is the capacity of any zone heating coils such as reheat coils, fan-coil unit heating coils, or zonal unit heating coils.

10. ZONE MULT

is the user-specified number of identical zones (product of MULTIPLIER and FLOOR-MULTIPLIER for the zone).

Design-day sizing of VAV system				Show All Reports							
REPORT- SV-A System Design Parameters for				SYST-1							
WEATHER FILE- TRY CHICAGO											
SYSTEM TYPE	ALTITUDE FACTOR	FLOOR AREA (SQFT)	MAX PEOPLE	OUTSIDE AIR RATIO	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)	HEAT PUMP SUPP-HEAT (KBTU/HR)	
VAVS	1.020	5000.0	52.	0.179	241.081	0.662	-50.000	0.000	0.000	0.000	
FAN TYPE	CAPACITY (CFM)	DIVERSITY FACTOR (FRAC)	POWER DEMAND (KW)	FAN DELTA-T (F)	STATIC PRESSURE (IN-WATER)	TOTAL EFF (FRAC)	MECH EFF (FRAC)	FAN PLACEMENT	FAN CONTROL	MAX FAN RATIO (FRAC)	MIN FAN RATIO (FRAC)
SUPPLY	5924.	1.00	6.817	3.63	5.5	0.55	0.72	DRAW-THRU	SPEED	1.10	0.30
ZONE NAME	SUPPLY FLOW (CFM)	EXHAUST FLOW (CFM)	FAN (KW)	MINIMUM FLOW (FRAC)	OUTSIDE AIR FLOW (CFM)	COOLING CAPACITY (KBTU/HR)	SENSIBLE (FRAC)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	ZONE MULT
ZONE1-1	1623.	0.	0.000	0.300	224.	0.00	0.00	32.64	-87.91	-54.50	1.
ZONE2-1	784.	0.	0.000	0.300	102.	0.00	0.00	15.78	-42.49	-26.34	1.
ZONE3-1	1207.	0.	0.000	0.300	224.	0.00	0.00	24.28	-65.40	-40.55	1.
ZONE4-1	765.	0.	0.000	0.300	102.	0.00	0.00	15.40	-41.46	-25.71	1.
ZONE5-1	1545.	0.	0.000	0.300	408.	0.00	0.00	31.08	-83.72	-51.91	1.

REPORT SS-A: SYSTEM LOADS SUMMARY FOR <system name>

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, RESYS and RESYS2 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**
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**
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 or BEPU 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 overheated or undercooled hours.

To the left of the MAXIMUM COOLING LOAD column are the day and hour (in standard time) of the peak cooling load along with the outside drybulb and wetbulb temperatures at the time of the peak.

5. **HEATING ENERGY**
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**
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 drybulb and wetbulb temperatures at the time of the peak.
7. **ELECTRICAL ENERGY**
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 shown in PLANT report PS-C, “Equipment Loads and Energy Use.”
8. **MAXIMUM ELEC LOAD**
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.

BASICS

APPENDIXES

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- SS-A System 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	31 24	22.F	19.F	0.000	-34.185	2 8	4.F	3.F	-302.628	3345.	12.808		
FEB	0.00000	28 24	31.F	28.F	0.000	-26.459	4 8	7.F	6.F	-282.776	2938.	12.813		
MAR	0.29252	3 17	78.F	61.F	38.440	-14.241	24 8	6.F	5.F	-288.753	3137.	12.817		
APR	2.21315	28 15	78.F	68.F	88.418	-3.037	8 8	31.F	28.F	-165.791	3165.	12.898		
MAY	5.73766	21 14	85.F	75.F	134.605	-0.417	9 8	43.F	39.F	-83.966	3126.	13.459		
JUN	13.74432	20 16	90.F	77.F	168.344	0.000	30 1	67.F	56.F	0.000	3206.	14.930		
JUL	26.51843	14 14	96.F	77.F	198.804	0.000	31 1	70.F	62.F	0.000	3540.	15.757		
AUG	20.47318	11 16	88.F	74.F	158.441	0.000	31 1	63.F	52.F	0.000	3322.	14.419		
SEP	9.37699	11 15	87.F	72.F	131.353	-0.239	23 8	36.F	34.F	-86.821	3140.	13.710		
OCT	2.91350	30 17	74.F	67.F	52.422	-2.618	20 8	42.F	36.F	-176.753	3193.	12.680		
NOV	0.00000	30 24	34.F	32.F	0.000	-11.372	28 8	24.F	22.F	-243.944	2802.	12.756		
DEC	0.00000	31 24	33.F	33.F	0.000	-25.084	26 8	15.F	15.F	-278.370	3313.	12.799		
TOTAL MAX	81.270				198.804	-117.652				-302.628	38225.	15.757		

REPORT SS-D: BUILDING HVAC LOAD SUMMARY

The cooling, heating and electrical energy required by the systems and zones served by the building's central 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.

1. **COOLING ENERGY**
is the total (sensible plus latent) monthly cooling required by all the SYSTEM's defined..
2. **TIME OF MAX**
gives the day and hour, in local standard time, that the maximum cooling load occurs.
3. **DRYBULB TEMP, WETBULB TEMP**
is the outside drybulb and wetbulb temperature, respectively, when the peak cooling load occurs.
4. **MAXIMUM COOLING LOAD**
is the peak cooling load for each month and for the year.
5. **HEATING ENERGY**
is the total monthly heating required by all the SYSTEMs defined.
6. **TIME OF MAX**
gives the day and hour, in local standard time, of maximum heating load.
7. **DRYBULB TEMP and WETBULB TEMP**
are the outside drybulb and wetbulb temperature, respectively, when the peak heating load occurs.
8. **MAXIMUM HEATING LOAD**
is the peak heating load for each month and for the year.
9. **ELECTRICAL ENERGY**
is the monthly electrical requirement for lights and convenience outlets for the building zones served by the plant. It also includes the fan electrical energy used by the systems and the 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 listed in PLANT reports such as PS-A, BEPS and BEPU.
10. **MAXIMUM ELEC LOAD**
is the monthly peak electrical consumption in a one-hour period for the items in ELECTRICAL ENERGY, above.
11. **BOTTOM OF REPORT**
The bottom of the report lists the integrated daily cooling load (sum of hourly cooling loads for the day) for the cooling design day (if specified) and the maximum integrated daily cooling load for the annual run. These numbers are used by HVAC to size cold storage systems.

BASICS

APPENDIXES

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- SS-D Building HVAC Load 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 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	31 24	22.F	19.F	0.000	-34.185	2 8	4.F	3.F	-302.628	3345.	12.808	
FEB	0.00000	28 24	31.F	28.F	0.000	-26.459	4 8	7.F	6.F	-282.776	2938.	12.813	
MAR	0.29252	3 17	78.F	61.F	38.440	-14.241	24 8	6.F	5.F	-288.753	3137.	12.817	
APR	2.21315	28 15	78.F	68.F	88.418	-3.037	8 8	31.F	28.F	-165.791	3165.	12.898	
MAY	5.73766	21 14	85.F	75.F	134.605	-0.417	9 8	43.F	39.F	-83.966	3126.	13.459	
JUN	13.74432	20 16	90.F	77.F	168.344	0.000	30 1	67.F	56.F	0.000	3206.	14.930	
JUL	26.51843	14 14	96.F	77.F	198.804	0.000	31 1	70.F	62.F	0.000	3540.	15.757	
AUG	20.47318	11 16	88.F	74.F	158.441	0.000	31 1	63.F	52.F	0.000	3322.	14.419	
SEP	9.37699	11 15	87.F	72.F	131.353	-0.239	23 8	36.F	34.F	-86.821	3140.	13.710	
OCT	2.91350	30 17	74.F	67.F	52.422	-2.618	20 8	42.F	36.F	-176.753	3193.	12.680	
NOV	0.00000	30 24	34.F	32.F	0.000	-11.372	28 8	24.F	22.F	-243.944	2802.	12.756	
DEC	0.00000	31 24	33.F	33.F	0.000	-25.084	26 8	15.F	15.F	-278.370	3313.	12.799	
TOTAL	81.270					-117.652					38225.		
MAX					198.804					-302.628		15.757	
MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY)						0.000 (KBTU)							
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE)						1997.705 (KBTU)							

REPORT SS-H: SYSTEM UTILITY ENERGY USE FOR <system name>

This report gives monthly values of electrical energy for fans, fuel energy for heating and cooling and electrical energy for heating and cooling for an HVAC system. The name of the system (SYST-1 in this case) 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 fuel consumption by packaged systems for heating. This will be zero unless at least one of the heat sources is FURNACE.
3. FUEL COOL
shows the total fuel consumption by packaged systems for cooling.
4. ELEC HEAT
shows the electrical consumption for heating. This includes 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.

Simple Structure Run 3, Chicago				Divide into zones; add plenum			DOE-2.2b-027				Fri Jan 9 15:25:08 1998BDL RUN 1	
Design-day sizing of VAV system				Show All Reports								
REPORT- SS-H System Utility Energy Use for SYST-1							WEATHER FILE- TRY CHICAGO					

	- F A N	E L E C - -	- F U E L	H E A T - -	- F U E L	C O O L - -	- E L E C	H E A T - -	- E L E C	C O O L - -		
		MAXIMUM		MAXIMUM		MAXIMUM		MAXIMUM		MAXIMUM		
	FAN	FAN	GAS OIL	GAS OIL	GAS OIL	GAS OIL	ELECTRIC	ELECTRIC	ELECTRIC	ELECTRIC		
	ENERGY	LOAD	ENERGY	LOAD	ENERGY	LOAD	ENERGY	LOAD	ENERGY	LOAD		
MONTH	(KWH)	(KW)	(MBTU)	(KBTU/HR)	(MBTU)	(KBTU/HR)	(KWH)	(KW)	(KWH)	(KW)		
JAN	318.	3.087	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
FEB	284.	3.002	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
MAR	202.	2.972	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
APR	171.	1.398	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
MAY	190.	1.959	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
JUN	304.	3.591	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
JUL	513.	4.971	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
AUG	386.	3.080	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
SEP	237.	2.391	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
OCT	166.	1.415	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
NOV	172.	2.649	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
DEC	286.	3.041	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		
TOTAL	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----		
MAX	3230.	4.971	0.000	0.000	0.000	0.000	0.	0.000	0.	0.000		

REPORT SS-L: FAN ELECTRIC ENERGY USE FOR <system name>

This report gives a breakdown of monthly electric energy for fans (central and zone level) and fan part load operation for an HVAC system. It also gives a breakdown of the annual energy use of the supply/return/relief fans.

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 ELEC DURING HEATING
gives the total electric energy used by the fans in all hours when only heating is required.
2. FAN ELEC DURING COOLING
gives the total electric energy used by the fans in all hours when only cooling is required.
3. FAN ELEC DURING HEAT & COOL
gives the total electric energy used by the fans in all hours when both heating and cooling are required.
4. FAN ELEC DURING FLOATING
gives the total electric energy used by the fans when neither heating nor cooling is provided.

Fan Part-Load Operation

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%, 10-20%, etc.) is given as well as the total hours of operation in each month. If the fan operates during an hour, its part load in percent is determined as $100 * (\text{total flow}) / (\text{design SUPPLY-FLOW})$.

BASICS

APPENDIXES

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- SS-L Fan Electric Energy Use for 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 -----											TOTAL RUN HOURS
					00	10	20	30	40	50	60	70	80	90	100	
					10	20	30	40	50	60	70	80	90	100	+	
JAN	318.090	0.000	0.000	0.000	0	0	0	395	10	4	7	0	0	0	0	416
FEB	283.986	0.000	0.000	0.000	0	0	0	356	5	3	8	0	0	0	0	372
MAR	190.102	6.798	0.000	4.759	0	0	0	254	10	3	2	0	0	0	0	269
APR	74.480	53.102	0.680	44.094	0	0	0	224	10	0	0	0	0	0	0	234
MAY	21.075	119.405	0.000	49.758	0	0	0	170	40	3	0	0	0	0	0	213
JUN	0.000	295.147	0.000	8.699	0	0	0	86	93	29	8	1	0	0	0	217
JUL	0.000	513.332	0.000	0.000	0	0	0	29	62	96	48	9	1	0	0	245
AUG	0.000	382.394	0.000	3.914	0	0	0	41	84	90	11	0	0	0	0	226
SEP	10.877	189.057	0.000	37.108	0	0	0	138	57	20	0	0	0	0	0	215
OCT	65.035	68.979	0.680	32.738	0	0	0	233	1	0	0	0	0	0	0	234
NOV	166.180	0.000	0.000	6.131	0	0	0	222	7	2	1	0	0	0	0	232
DEC	285.966	0.000	0.000	0.000	0	0	0	350	11	3	7	0	0	0	0	371
ANNUAL	1415.759	1628.213	1.360	187.201	0	0	0	2498	390	253	92	10	1	0	0	3244

BREAKDOWN OF ANNUAL FAN POWER USAGE

FAN TYPE	ANNUAL FAN ELEC (KWH)
SUPPLY	3230.
TOTAL	3230.

REPORT SS-M: BUILDING HVAC FAN ELEC ENERGY

This report gives a breakdown of the electric energy for each month for all the secondary-system fans in the building. 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.

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
Design-day sizing of VAV system Show All Reports
REPORT- SS-M Building HVAC Fan Elec Energy WEATHER FILE- TRY CHICAGO

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	318.090	0.000	0.000	0.000
FEB	283.986	0.000	0.000	0.000
MAR	190.102	6.798	0.000	4.759
APR	74.480	53.102	0.680	44.094
MAY	21.075	119.405	0.000	49.758
JUN	0.000	295.147	0.000	8.699
JUL	0.000	513.332	0.000	0.000
AUG	0.000	382.394	0.000	3.914
SEP	10.877	189.057	0.000	37.108
OCT	65.035	68.979	0.680	32.738
NOV	166.180	0.000	0.000	6.131
DEC	285.966	0.000	0.000	0.000
ANNUAL	1415.759	1628.213	1.360	187.201

REPORT SS-N: RELATIVE HUMIDITY SUMMARY FOR <system name>

In this scatter plot, the vertical axis, at the left, shows percent relative humidity bins. The horizontal axis, at the top, gives hours of the day in local standard time, where “1AM” is midnight to 1:00am, “2” is 1:00am to 2:00am, etc. 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 the particular hour of the day. Only hours for which the fans are on are counted in this plot, except that hours the fans are on due to NIGHT-CYCLE-CTRL are not counted.

The column at the far right, labeled “TOTAL”, 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 necessarily sum to the number of hours in the run.

```
Simple Structure Run 3, Chicago          Divide into zones; add plenum          DOE-2.2b-027  Fri Jan  9 15:25:08 1998BDL RUN  1
Design-day sizing of VAV system        Show All Reports
REPORT- SS-N Relative Humidity Summary for SYST-1                      WEATHER FILE- TRY  CHICAGO
```

TOTAL HOURS AT RELATIVE HUMIDITY LEVEL AND TIME OF DAY																										
HOURL	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	
90-100	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
80-89	0	0	0	0	0	0	0	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0	0	6	
70-79	0	0	0	0	0	0	0	0	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	4	
60-69	0	0	0	0	0	0	0	2	2	3	4	3	1	3	1	5	5	4	0	0	0	0	0	0	33	
50-59	0	0	0	0	0	0	0	45	45	31	19	10	12	7	9	9	13	5	0	0	0	0	0	0	205	
40-49	0	0	0	0	0	0	0	46	60	70	74	77	78	81	73	77	77	6	0	0	0	0	0	0	719	
30-39	0	0	0	0	0	0	0	31	60	63	64	58	44	58	67	61	57	26	0	0	0	0	0	0	599	
20-29	0	0	0	0	0	0	0	17	65	64	65	64	75	72	72	72	70	49	0	0	0	0	0	0	685	
10-19	0	0	0	0	0	0	0	0	17	19	25	38	39	29	28	28	30	21	0	0	0	0	0	0	274	
0-09	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0	14	

```
*****
*
*   NOTE  1) THE RELATIVE HUMIDITY COUNTS ARE MADE ONLY FOR
*           THE HOURS WHEN THE FANS ARE ON
*
*****
```

REPORT SS-O: SPACE TEMPERATURE SUMMARY FOR <zone name>

In this scatter plot the vertical axis, at the least, shows temperature bins. The horizontal axis, at the top, gives hours of the day in local standard time, where “1AM” is midnight to 1:00am, “2” is 1:00am to 2:00am, etc. 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 the particular hour of the day. Only hours for which the fans are on are counted in this plot, except that hours the fans are on due to NIGHT-CYCLE-CTRL are not counted.

The column at the far right, labeled “TOTAL”, 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.

```
Simple Structure Run 3, Chicago      Divide into zones; add plenum      DOE-2.2b-027  Fri Jan  9 15:25:08 1998BDL RUN  1
Design-day sizing of VAV system      Show All Reports
REPORT- SS-O Space Temperature Summary for  ZONE1-1                      WEATHER FILE- TRY  CHICAGO
```

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	54	72	83	94	103	121	137	141	142	126	1	0	0	0	0	0	0	1074		
70-75	0	0	0	0	0	0	0	85	176	168	157	148	130	114	110	108	125	108	0	0	0	0	0	0	1429		
65-70	0	0	0	0	0	0	0	0	2	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	4		
60-65	0	0	0	0	0	0	0	2	2	1	1	1	1	1	0	1	1	2	0	0	0	0	0	0	13		
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		

```
*****
*
*   NOTE  1) THE TEMPERATURE COUNTS ARE MADE ONLY FOR
*           THE HOURS WHEN THE FANS ARE ON
*
*****
```

REPORT PS-A: PLANT ENERGY UTILIZATION

This report shows monthly electrical and fuel energy demanded from and supplied to the central plant disaggregated into various categories, such as heating, cooling and recovered energy.

1. **TOTAL HEAT LOAD**

Total heating load = 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.

2. **TOTAL COOLING LOAD**

The total of the COOLING ENERGY values shown in the SS-D report plus tank and circulation loop losses; it represents the cooling energy needed each month.

3. **TOTAL ELECTR LOAD**

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.

4. **RECVRED ENERGY**

The recovered heat used to reduce heating loads. This includes waste heat from turbines, diesels, and double-bundle chillers.

5. **WASTED RECVRABL ENERGY**

The heat that could have been recovered had there been a need for it.

6. **FUEL INPUT COOLING**

The fuel used to drive engine chillers and gas fired absorption chiller/heaters, and regeneration fuel for desiccant cooling systems.

7. **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.

8. **FUEL INPUT HEATING**

The fuel used for heating by boilers, furnaces and hot water heaters.

9. **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.

10. **FUEL INPUT ELECT**

The fuel used by diesel and gas turbine generators.

11. **TOTAL FUEL INPUT**

The total fuel input, equal to the sum of FUEL INPUT COOLING, FUEL INPUT HEATING and FUEL INPUT ELECT.

12. **TOTAL SITE ENERGY**

The sum of the energy value at the building boundary of purchased fuel, electricity, chilled water and steam.

13. TOTAL SOURCE ENERGY

The energy used at the source to produce the energy used by the building. For each resource (electricity, oil, natural gas, etc.) used by the building, the site energy consumption of that resource is divided by the corresponding SOURCE-SITE-EFF to determine the energy consumed by the generating station (including transmission losses); the results are summed to get the total source energy.

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- PS-A Plant Energy Utilization WEATHER FILE- TRY CHICAGO

MONTH	S I T E E N E R G Y												* SOURCE
	2	3	4	5	6	7	8	9	10	11	12	13	14
	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	-33.9	0.0	3.5	0.0	0.0	0.0	0.0	58.8	0.0	0.0	58.8	70.7	94.5
FEB	-26.2	0.0	3.1	0.0	0.0	0.0	0.0	47.1	0.0	0.0	47.1	57.6	78.4
MAR	-14.0	0.3	3.3	0.0	0.0	0.0	0.0	27.0	0.0	0.0	27.0	38.2	60.5
APR	-2.9	2.4	3.6	0.0	0.0	0.0	0.3	7.4	0.0	0.0	7.4	19.6	44.0
MAY	-0.3	6.1	3.9	0.0	0.0	0.0	0.6	1.4	0.0	0.0	1.4	14.8	41.5
JUN	0.0	14.3	4.9	0.0	0.0	0.0	1.4	0.0	0.0	0.0	0.0	16.6	49.8
JUL	0.0	27.2	6.4	0.0	0.0	0.0	2.6	0.0	0.0	0.0	0.0	21.7	65.2
AUG	0.0	21.1	5.6	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	19.1	57.3
SEP	-0.2	9.8	4.3	0.0	0.0	0.0	1.0	0.7	0.0	0.0	0.7	15.4	45.0
OCT	-2.5	3.2	3.7	0.0	0.0	0.0	0.4	6.6	0.0	0.0	6.6	19.3	44.7
NOV	-11.2	0.0	2.9	0.0	0.0	0.0	0.0	22.5	0.0	0.0	22.5	32.3	52.0
DEC	-24.8	0.0	3.4	0.0	0.0	0.0	0.0	45.3	0.0	0.0	45.3	57.0	80.5
TOTAL	-116.0	84.3	48.5	0.0	0.0	0.0	8.4	216.8	0.0	0.0	216.8	382.3	713.3

REPORT PS-B: UTILITY AND FUEL USE SUMMARY

This report shows the monthly and annual consumption, the peak hourly demand and time of peak for all energy meters. Usage is displayed in the actual units of consumption (kWh, therms, etc.).

```

Simple Structure Run 3, Chicago          Divide into zones; add plenum          DOE-2.2b-027  Fri Jan  9 15:25:08 1998BDL RUN  1
Design-day sizing of VAV system        Show All Reports
REPORT- PS-B Utility and Fuel Use Summary                                     WEATHER FILE- TRY  CHICAGO
-----

```

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
EM1 ELECTRICITY													
KWH	3482.	3061.	3272.	3574.	3919.	4864.	6367.	5592.	4333.	3721.	2878.	3435.	48498.
MAX KW	13.1	13.1	17.5	22.7	26.9	30.4	35.0	29.7	27.6	18.9	13.1	13.1	35.0
DAY/HR	13/11	24/11	3/15	28/15	21/14	20/16	14/14	19/16	11/15	31/15	17/11	22/11	7/14
FUEL NATURAL-GAS													
THERM	588.	471.	270.	74.	14.	0.	0.	0.	7.	66.	225.	453.	2168.
MAX THERM/HR	4.0	3.7	3.8	2.8	1.9	0.0	0.0	0.0	1.9	2.9	3.5	3.8	4.0
DAY/HR	2/ 8	4/ 8	24/ 8	8/ 8	9/ 8	0/ 0	0/ 0	0/ 0	23/ 8	20/ 8	12/ 8	10/ 8	1/ 2

REPORT BEPS: BUILDING ENERGY PERFORMANCE

This report makes it possible to quickly review annual building energy use according to energy type (electricity, natural gas, etc.) and category of use (lights, space heating, space cooling, etc.). For direct comparison of end uses, all energy quantities are expressed in the same units. A related report, BEPU, gives the same information as the BEPS report, but in utility units.

The use categories are as follows:

1. **LIGHTS**
All lighting energy other than defined using the task light keywords.
2. **TASK LIGHTS**
All lighting energy defined using the task light keywords.
3. **MISC EQUIP**
Energy defined using the SPACE EQUIP keywords. Also energy defined in the *-METER INTERIOR-POWER keywords.
4. **SPACE HEATING**
All energy used to heat a zone, other than the supplemental heat of a heat pump, and other than the auxiliary power consumed by a furnace
5. **SPACE COOLING**
All energy used to cool a zone, other than energy used for heat-rejection, and crankcase heating
6. **HEAT REJECT**
All energy used to reject heat from a cooling process, such as cooling tower fans and DX condenser fans, but excluding pumping energy for spray pumps.
7. **PUMPS & AUX**
All pumping energy, all energy defined using any auxiliary energy keywords (such as for a boiler, chiller, or furnace), crankcase heat of DX equipment, and humidification energy.
8. **VENT FANS**
All fan energy used to move air into or out of a space.
9. **REFRIG DISPLAY**
All energy consumed by refrigeration systems, except for heat rejected to a condenser water loop (which falls into HEAT REJECT category).
10. **HT PUMP SUPPLEM**
Supplemental heat for a heat pump (used when ambient too cold, or load too large for heat pump compressor to handle)
11. **DOMEST HOT WTR**
Energy consumed to heat domestic water
12. **EXT USAGE**
Energy consumed using the meter level EXTERIOR-POWER keywords.

Bottom section of report

1. TOTAL SITE ENERGY

is the overall annual energy use at the building site for all energy types and categories of use.

2. TOTAL SOURCE ENERGY

is the annual energy at point of production used to produce the energy at the building site. Site and source energy are also given per unit of gross area (the value of GROSS-AREA in the BUILD-PARAMETERS command in LOADS) and per unit of net area, which is the sum of the floor areas of conditioned zones. Note that if GROSS-AREA is not specified it defaults to net area.

3. PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE

is the percentage of hours when any zone is being conditioned that the zone air temperature is too high (zone is undercooled) or too low (zone is overheated). This is a measure of the HVAC systems ability to hold zone thermostat setpoints.

4. PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED

is the percentage of hours that the central plant cannot meet the demand on the plant from the secondary systems. A large percentage here usually means that one or more pieces of primary equipment (boiler, chiller, etc.) is undersized.

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.

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Design-day sizing of VAV system				Show All Reports									
REPORT- BEPS Building Energy Performance				WEATHER FILE- TRY CHICAGO									

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
EM1 ELECTRICITY													
MBTU	74.7	0.0	44.7	0.0	28.8	0.0	6.3	11.0	0.0	0.0	0.0	0.0	165.5
FUEL NATURAL-GAS													
MBTU	0.0	0.0	0.0	216.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	216.8
	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
MBTU	74.7	0.0	44.7	216.8	28.8	0.0	6.3	11.0	0.0	0.0	0.0	0.0	382.3
TOTAL SITE ENERGY				382.28 MBTU		76.5 KBTU/SQFT-YR GROSS-AREA				76.5 KBTU/SQFT-YR NET-AREA			
TOTAL SOURCE ENERGY				713.33 MBTU		142.7 KBTU/SQFT-YR GROSS-AREA				142.7 KBTU/SQFT-YR NET-AREA			
PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 2.2													
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 for all of the utility rates that have been defined.

1. UTILITY-RATE
is the U-name of each UTILITY-RATE.
2. RESOURCE
lists the energy resource.
3. METERS
lists the meter to which each UTILITY-RATE applies.
4. METERED ENERGY
is the actual metered energy from PLANT, not adjusted for any minimum energy requirements. If ENERGY-QUALS are specified, and USE-MIN-QUALS=YES, then the minimum allowable quantity will be used in the cost calculations whenever the actual consumption drops below the minimum.
5. TOTAL CHARGE
is total annual utility charge for each resource.
6. VIRTUAL RATE
is the total annual charge divided by the metered energy for each resource.
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 UTILITY-RATE 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
gives the annual energy cost for all resources per unit building area. Here, gross building area is the value of the keyword GROSS-AREA in the BUILD-PARAMETERS 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.

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Simple Structure Run 3, Chicago      Divide into zones; add plenum      DOE-2.2b-027  Fri Jan  9 15:25:08 1998BDL RUN  1
Design-day sizing of VAV system    Show All Reports
REPORT- ES-D Energy Cost Summary
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UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE (\$)	VIRTUAL RATE (\$/UNIT)	RATE USED ALL YEAR?
ELEC-TARIFF	ELECTRICITY	EM1	48498. KWH	3059.	0.0631	YES
GAS-RATE	NATURAL-GAS	FUEL	2168. THERM	1301.	0.6000	YES
				=====		
				4360.		
ENERGY COST/GROSS BLDG AREA:				0.87		
ENERGY COST/NET BLDG AREA:				0.87		

REPORT ES-E: SUMMARY OF UTILITY-RATE: <utility rate 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 on 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 zero 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 take into account the DEMAND-INTERVAL.
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 zero if the UTILITY-RATE did not qualify for this month.
6. ENERGY CHARGE
is the energy charge, including BLOCK-CHARGEs.
7. DEMAND CHARGE
is the demand charge, including BLOCK-CHARGEs.
8. ENERGY CST ADJ
is the energy cost due to adjustments.
9. TAXES
is the sum of per unit and percentage taxes
10. SURCHRG
is the sum of per unit and percentage surcharges
11. FIXED CHARGE
are the UTILITY-RATE's MONTH-CHGS that you defined.
12. MINIMUM CHARGE
is the minimum monthly charge as determined by the UTILITY-RATE's MIN-MON-CHGS or MIN-MON-DEM-CHGS.
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.

BASICS

APPENDIXES

Simple Structure Run 3, Chicago Divide into zones; add plenum DOE-2.2b-027 Fri Jan 9 15:25:08 1998BDL RUN 1
 Design-day sizing of VAV system Show All Reports
 REPORT- ES-E Summary of Utility-Rate: ELEC-TARIFF WEATHER FILE- TRY CHICAGO

UTILITY-RATE: ELEC-TARIFF RESOURCE: ELECTRICITY DEMAND-WINDOW: 15 3413. BTU/KWH
 BILLING-DAY: 31 RATE-LIMITATION: 0.0000
 METERS: EM1
 POWER-FACTOR: 0.80 EXCESS-KVAR-FRAC: 0.75 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	3482	3482	14.0	14.0	216	0	0	0	0	0	0	0.0621	216
FEB	3061	3061	14.0	14.0	189	0	0	0	0	0	0	0.0619	189
MAR	3272	3272	18.1	18.1	205	0	0	0	0	0	0	0.0625	205
APR	3574	3574	24.2	24.2	226	0	0	0	0	0	0	0.0633	226
MAY	3919	3919	28.9	28.9	248	0	0	0	0	0	0	0.0634	248
JUN	4864	4864	33.0	33.0	310	0	0	0	0	0	0	0.0637	310
JUL	6367	6367	38.9	38.9	404	0	0	0	0	0	0	0.0635	404
AUG	5592	5592	32.6	32.6	356	0	0	0	0	0	0	0.0637	356
SEP	4333	4333	29.9	29.9	276	0	0	0	0	0	0	0.0637	276
OCT	3721	3721	19.6	19.6	236	0	0	0	0	0	0	0.0633	236
NOV	2878	2878	13.9	13.9	179	0	0	0	0	0	0	0.0620	179
DEC	3435	3435	14.0	14.0	214	0	0	0	0	0	0	0.0622	214
=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====	=====
TOTAL	48498	48498	38.9		3059	0	0	0	0	0		0.0631	3059