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DOE-2 BASICS

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INTRODUCTION

What Is DOE-2?

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

The DOE-2 program was developed by the Simulation Research Group at Lawrence Berkeley Laboratory, with major funding provided by the U.S. Department of Energy.

About This Manual

During the 12 years that DOE-2 has been in existence, it has grown to three times its original size due to the addition of new capabilities. As a result, using the program can be difficult not only for the novice but also for the experienced user.

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

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

There is a real danger in preparing a manual with a limited set of variables because so many useful features of the program are left out. To compensate for this, we have tried to direct the user to other program documentation that discusses the more complex features.

Other Documentation

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

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

Any user may receive the USER NEWS free of charge. To be put on the distribution list, please write the Simulation Research Group, Bldg. 90 - Room 3147, Lawrence Berkeley Laboratory, One Cyclotron Road, Berkeley, CA 94720.

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

Title of Document (version of DOE-2)	NTIS Order Number
Reference Manual (2.1A)	LBL-8706, Rev.2
Supplement (2.1E)	DE-890-17728
BDL Summary (2.1E)	DE-890-17726
Sample Run Book (2.1E)	DE-890-17727
Engineers Manual (2.1A)	DE-830-04575

What does a DOE-2 run look like?

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

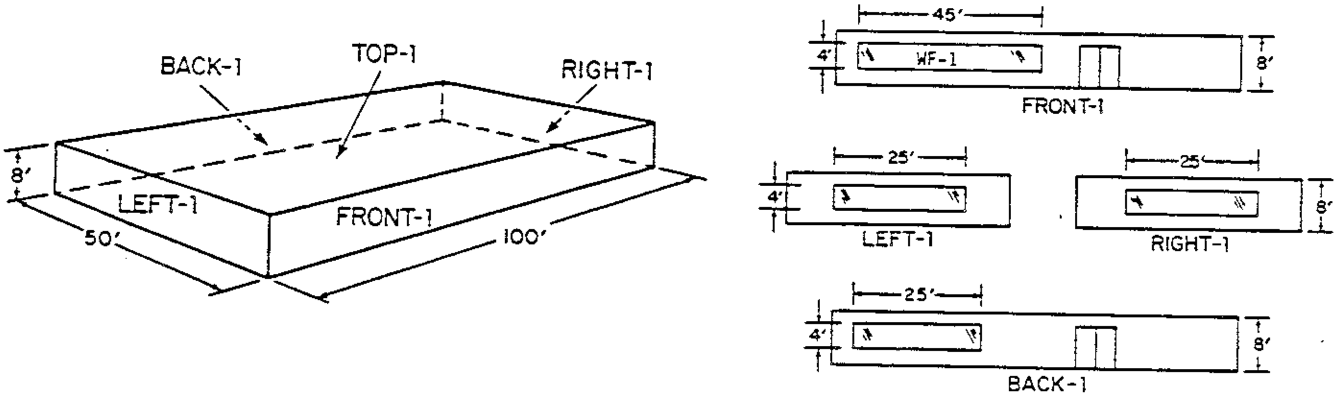


Figure 1.1: Simple Structure – Single Zone Building. LEFT–1, FRONT–1, etc. are user-defined names.

Sample Input

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

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

                ABORT               ERRORS   ..
                DIAGNOSTIC          WARNINGS  ..
                BUILDING-LOCATION   LATITUDE = 42.0   LONGITUDE = 88.0
                                    ALTITUDE = 610    TIME-ZONE = 6
                                    AZIMUTH  = 0      HOLIDAY   = YES  ..


                      $ CONSTRUCTION AND GLASS TYPES

WA-1-2    = LAYERS         MATERIAL = (WD01,PW03,IN02,GP01)  ..
RB-1-1    = LAYERS         MATERIAL = (RG01,BR01,IN22,WD01)
                                      INSIDE-FILM-RES = .76  ..
ROOF-1    = CONSTRUCTION   LAYERS = RB-1-1   ..
WALL-1    = CONSTRUCTION   LAYERS = WA-1-2   ..
FLOOR-1   = CONSTRUCTION   U-VALUE = .05   ..
D1        = CONSTRUCTION   U-VALUE = .5   ..
WINDOW-1  = GLASS-TYPE     SHADING-COEF = .9   PANES = 2    ..
G-DOOR    = GLASS-TYPE     SHADING-COEF = .8   PANES = 1    ..
```

```
                        $ OCCUPANCY SCHEDULE

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

                        $ LIGHTING SCHEDULE

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

                  $ OFFICE EQUIPMENT SCHEDULE

EQUIP-1   = SCHEDULE  THRU DEC 31
                             (WD) (1,8)(.2) (9,14)(.8)
                                  (15,20)(.8,.7,.5,.5,.3,.3)
                                  (21,24)(.02)
                            (WEH) (1,24)(.02)  ..

                  $ INFILTRATION SCHEDULE

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


                      $ GENERAL SPACE DEFINITION

OFFICE-ENV    = SPACE-CONDITIONS  PEOPLE-SCHEDULE    = OCCUPY-1
                                  LIGHTING-SCHEDULE  = LIGHTS-1
                                  EQUIP-SCHEDULE     = EQUIP-1
                                  LIGHTING-TYPE      = REC-FLUOR-NV
                                  LIGHTING-W/SQFT    = 1.5
                                  EQUIPMENT-W/SQFT   = 1
                                  AREA/PERSON        = 110
                                  FLOOR-WEIGHT       = 70
                                  INF-METHOD         = AIR-CHANGE
                                  INF-SCHEDULE       = INFIL-1
                                  AIR-CHANGES/HR     = 0.6
                                  PEOPLE-HEAT-GAIN   = 450  ..

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

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

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

                 WINDOW               WIDTH = 3    HEIGHT = 7
                                      GLASS-TYPE = G-DOOR .. $ A GLASS DOOR

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

                 WINDOW               LIKE WF-1    WIDTH = 25    ..

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

                 WINDOW               LIKE WF-1    WIDTH = 45    ..

                 DOOR                 HEIGHT = 7   WIDTH = 3
                                      CONSTRUCTION = D1   .. $ A WOOD DOOR

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

                 WINDOW               LIKE WF-1    WIDTH = 25    ..

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

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

BUILDING-RESOURCE   HW-SCHEDULE = OCCUPY-1   HOT-WATER = 10000      ..

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

END ..
COMPUTE LOADS   ..


INPUT SYSTEMS   ..

                 $ SYSTEMS SCHEDULES

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

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

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

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

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

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

END ..
COMPUTE SYSTEMS  ..



INPUT PLANT  ..

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

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

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

PLANT-PARAMETERS  BOILER-FUEL = NATURAL-GAS
                  HERM-REC-COND-TYPE = AIR  ..

PLANT-REPORT  SUMMARY = (BEPS)  ..

END  ..
COMPUTE PLANT  ..
```

```
INPUT ECONOMICS  ..

ENERGY-COST  RESOURCE = ELECTRICITY  ASSIGN-CHARGE = (ELCOST)     ..

ELCOST = CHARGE-ASSIGNMENT  RESOURCE = ELECTRICITY  TYPE = ENERGY
         BLOCK-RANGE = (800,1200,10000)
         BLOCK-CHARGE = (.075,.090,.10)  ..

ENERGY-COST  RESOURCE = NATURAL-GAS  UNIT = 100000  UNIFORM-COST =.62  ..
ECONOMICS-REPORT  SUMMARY = (ES-D)  ..

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

Sample Output

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

Sample Output

```
REPORT- LS-C BUILDING PEAK LOAD COMPONENTS                                                  WEATHER FILE- CHICAGO     TMY
------------------------------------------------------------------------------------------------------------------------------
*** BUILDING ***
                FLOOR  AREA      5000  SQFT        465  SQMT
                VOLUME          40000  CUFT       1133  CUMT

                                    COOLING  LOAD                              HEATING  LOAD
                                  ----------------                          ----------------
          TIME                      JUL  1  4PM                                JAN 26 12MDNT

          DRY-BULB TEMP              99F      37C                                -3F    -19C
          WET-BULB TEMP              75F      24C                                -4F    -20C

                              SENSIBLE            LATENT                         SENSIBLE
                          (KBTU/H)   ( KW )   (KBTU/H)  ( KW )              (KBTU/H)  ( KW )
                          --------   ------   --------  ------              --------  --------

   WALLS                     4.108    1.203      0.000   0.000                -8.461    -2.478
   ROOFS                    46.883   13.731      0.000   0.000               -61.990   -18.155
   GLASS CONDUCTION          7.233    2.118      0.000   0.000               -22.914    -6.711
   GLASS SOLAR              24.323    7.124      0.000   0.000                 2.424     0.710
   DOOR                      0.225    0.066      0.000   0.000                -0.706    -0.207
   INTERNAL SURFACES         0.000    0.000      0.000   0.000                 0.000     0.000
   UNDERGROUND SURFACES     -2.595   -0.760      0.000   0.000                -7.100    -2.079
   OCCUPANTS TO SPACE       10.313    3.021      8.056   2.359                 0.057     0.017
   LIGHT     TO SPACE       20.755    6.079      0.000   0.000                 1.461     0.428
   EQUIPMENT TO SPACE       11.118    3.256      0.000   0.000                 0.403     0.118
   PROCESS   TO SPACE        0.000    0.000      0.000   0.000                 0.000     0.000
   INFILTRATION              0.000    0.000      0.000   0.000               -74.095   -21.701
                          --------  -------    -------  ------              --------  --------
   TOTAL                   122.364   35.837      8.056   2.359              -170.922   -50.059

   TOTAL LOAD              130.420 KBTU/H       38.197  KW         -170.922 KBTU/H     -50.059  KW

   TOTAL LOAD / AREA        26.08BTU/H.SQFT     82.229  W /SQMT     34.184BTU/H.SQFT   107.766   W /SQMT

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

```
1SIMPLE EXAMPLE FOR DOE-2 BASICS
                                                                                       DOE-2.1E  Thu Jul 25 14:53:06 1991SDL RUN 1
 REPORT- SS-A  SYSTEM MONTHLY LOADS SUMMARY FOR                    AC-SYST                            WEATHER FILE- CHICAGO     TMY
 ---------------------------------------------------------------------------------------------------------------------------------


          - - - - - - - - C O O L I N G - - - - - - - -      - - - - - - - - H E A T I N G - - - - - - - -     - - - E L E C - - -

                                                MAXIMUM                                            MAXIMUM
         COOLING     TIME     DRY-   WET-       COOLING      HEATING      TIME     DRY-   WET-     HEATING       ELEC-     MAXIMUM
          ENERGY    OF MAX    BULB   BULB          LOAD       ENERGY     OF MAX    BULB   BULB       LOAD       TRICAL       ELEC
 MONTH    (MBTU)    DY  HR    TEMP   TEMP      (KBTU/HR)     (MBTU)     DY  HR    TEMP   TEMP   (KBTU/HR)      ENERGY       LOAD
                                                                                                                 (KWH)       (KW)


  JAN    0.00000                                   0.000     -40.966    28  10     7.F    5.F    -261.905       4669.     16.164

 FEB     0.00000                                   0.000     -32.624    19  10     5.F    4.F    -257.971       4038.     16.164

 MAR     0.00000                                   0.000     -22.734     4   8    13.F   10.F    -253.220       4194.     16.164

 APR     1.25083    16  16    76.F   55.F         75.535      -5.342     1   8    43.F   41.F    -195.084       4120.     16.164

 MAY     6.17676    13  16    89.F   73.F        121.053      -0.741     6   8    58.F   53.F    -101.213       4108.     16.164

  JUN   16.26140    10  15    90.F   74.F        180.526      -0.012    28   8    60.F   55.F      -9.234       3756.     16.164

  JUL   25.20025     1  15    99.F   75.F        182.437       0.000                                0.000       4108.     16.164

 AUG    24.64888     5  15    90.F   74.F        176.174       0.000                                0.000       4108.     16.164

 SEP    11.50235    24  15    85.F   78.F        139.495      -0.046    12   8    51.F   49.F     -21.535       3756.     16.164

 OCT     1.29870     7  16    76.F   65.F         87.260      -1.737    15   8    45.F   40.F     -97.968       4108.     16.164

 NOV     0.00000                                   0.000     -14.119    29   8    19.F   17.F    -229.204       3800.     16.164

 DEC     0.00000                                   0.000     -35.933     2  10    10.F    8.F    -258.266       4405.     16.164
        ---------                             ----------    --------                           ----------     --------   -------

 TOTAL    86.339                                            -154.253                                            49171.

 MAX                                             182.437                                         -261.905                 16.164
```

```
1SIMPLE EXAMPLE FOR DOE-2 BASICS                                               DOE-2.1E  Thu Jul 25 14:53:06 1991PDL RUN 1
 REPORT- BEPS  ESTIMATED BUILDING ENERGY PERFORMANCE                              WEATHER FILE- CHICAGO     TMY
 ---------------------------------------------------------------------------------------------------------------------------


                             ENERGY TYPE
                             IN SITE MBTU -  ELECTRICITY    NATURAL-GAS

                            CATEGORY OF USE

                              SPACE HEAT          8.32         227.23

                              SPACE COOL         31.64           0.00

                              HVAC AUX           54.52           0.00

                              DOM HOT WTR         0.00          35.89

                              AUX SOLAR           0.00           0.00

                              LIGHTS             74.75           0.00

                              VERT TRANS          0.00           0.00

                              MISC EQUIP         42.12           0.00
                                              ----------    ----------

                              TOTAL             211.35         263.13


                 TOTAL SITE ENERGY        474.47 MBTU     94.9 KBTU/SQFT-YR GROSS-AREA      94.9 KBTU/SQFT-YR NET-AREA
                 TOTAL SOURCE ENERGY      897.80 MBTU    179.6 KBTU/SQFT-YR GROSS-AREA     179.6 KBTU/SQFT-YR NET-AREA

                 PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  1.2
                 PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.1

                 NOTE  ELECTRICITY AND/OR FUEL USED TO GENERATE ELECTRICITY IS APPORTIONED BASED
                       ON THE YEARLY DEMAND.  ALL OTHER ENERGY TYPES ARE APPORTIONED HOURLY.
```

```
1SIMPLE EXAMPLE FOR DOE-2 BASICS                                                       DOE-2.1E  Thu Jul 25 14:53:06 1991EDL  RUN 1

 REPORT- ES-D  SUMMARY OF FUEL AND UTILITY USE AND COSTS
 -----------------------------------------------------------------------------------------------------------------------------------
                                          ELECTRIC      NTRL-GAS
  MONTH                                      UNIT=         UNIT=
                                           3412.97     100000.00
 -------                                  --------      --------
  JAN
    ENERGY CONSUMPTION (UNIT/MO)             5359.          621.
    PEAK DEMAND   (UNIT/HR)                    18.            3.
    TOTAL COST ($)                          503.86        384.95
  FEB
    ENERGY CONSUMPTION (UNIT/MO)             4621.          502.
    PEAK DEMAND   (UNIT/HR)                    18.            3.
    TOTAL COST ($)                          430.13        311.43
  MAR
    ENERGY CONSUMPTION (UNIT/MO)             4656.          370.
    PEAK DEMAND   (UNIT/HR)                    18.            3.
    TOTAL COST ($)                          433.64        229.20
  APR
    ENERGY CONSUMPTION (UNIT/MO)             4455.          117.
    PEAK DEMAND   (UNIT/HR)                    25.            3.
    TOTAL COST ($)                          413.47         72.74
  MAY
    ENERGY CONSUMPTION (UNIT/MO)             4901.           44.
    PEAK DEMAND   (UNIT/HR)                    30.            2.
    TOTAL COST ($)                          458.15         27.17
  JUN
    ENERGY CONSUMPTION (UNIT/MO)             5631.           29.
    PEAK DEMAND   (UNIT/HR)                    34.            0.
    TOTAL COST ($)                          531.07         17.86
  JUL
    ENERGY CONSUMPTION (UNIT/MO)             6874.           31.
    PEAK DEMAND   (UNIT/HR)                    35.            0.
    TOTAL COST ($)                          655.43         19.39
  AUG
    ENERGY CONSUMPTION (UNIT/MO)             6817.           31.
    PEAK DEMAND   (UNIT/HR)                    33.            0.
    TOTAL COST ($)                          649.73         19.39
  SEP
    ENERGY CONSUMPTION (UNIT/MO)             5109.           29.
    PEAK DEMAND   (UNIT/HR)                    31.            0.
    TOTAL COST ($)                          478.88         18.22
```

```
OCT
  ENERGY CONSUMPTION (UNIT/MO)          4340.          61.
  PEAK DEMAND  (UNIT/HR)                  26.           1.
  TOTAL COST ($)                        401.96       37.56
NOV
  ENERGY CONSUMPTION (UNIT/MO)          4129.         244.
  PEAK DEMAND  (UNIT/HR)                  18.           3.
  TOTAL COST ($)                        380.90      151.52
DEC
  ENERGY CONSUMPTION (UNIT/MO)          5033.         552.
  PEAK DEMAND  (UNIT/HR)                  18.           3.
  TOTAL COST ($)                        471.26      341.94
------                                --------    --------
TOTAL
  ENERGY CONSUMPTION (UNIT/YR)         61925.        2631.
  PEAK DEMAND  (UNIT/HR)                  35.           3.
  TOTAL COST ($)                       5808.49     1631.38
```

Structure of DOE-2

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

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

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

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

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

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

---

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

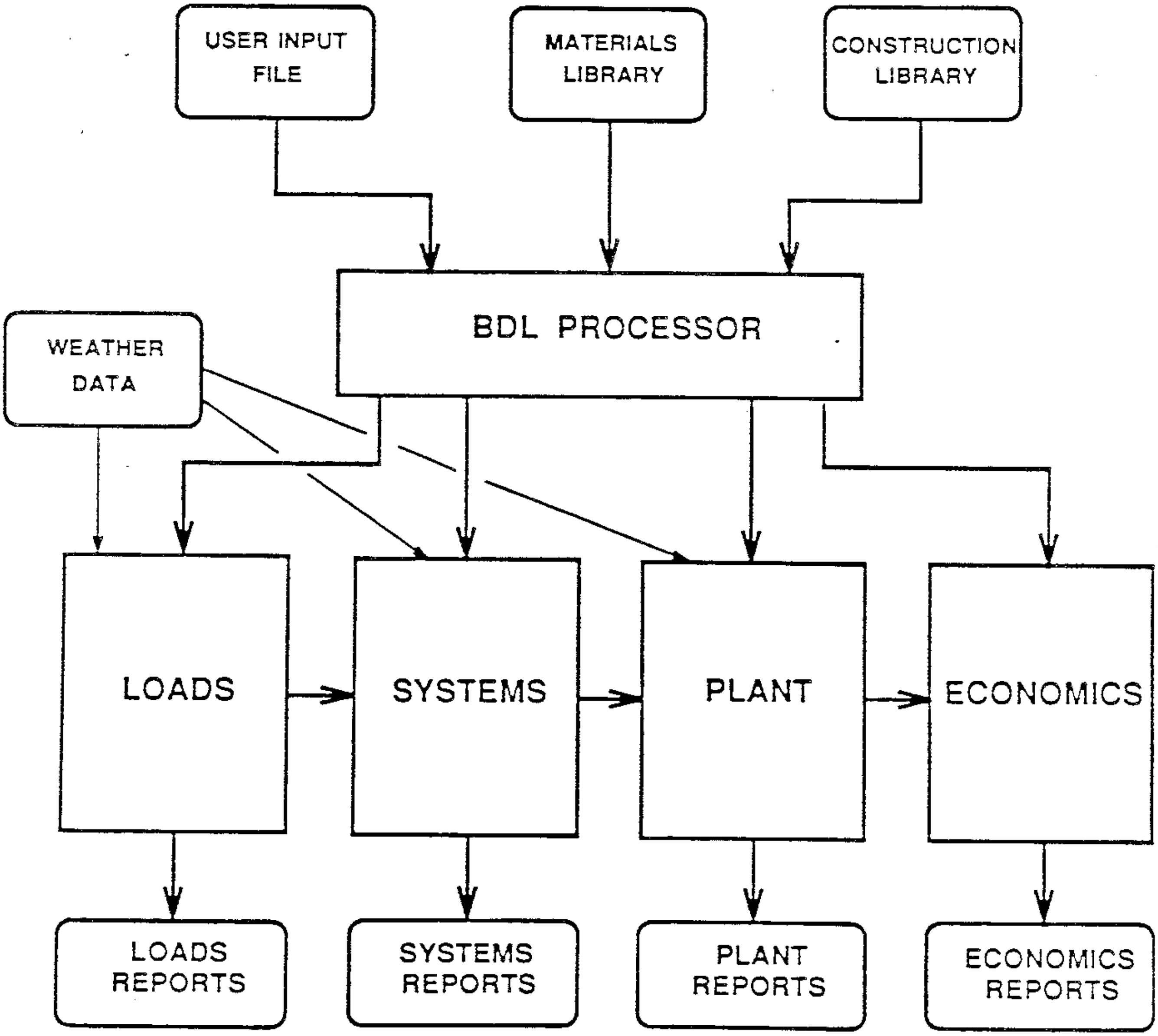


Figure 1.2: DOE-2 Program Flow

Uses for DOE-2

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

Energy Conservation Studies

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

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

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

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

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

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

Building Design Studies

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

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

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

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

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

How valid is DOE-2?

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

- *DOE-2 Verification Project, Phase 1, Interim Report,* Los Alamos National Laboratory, Report No. LA-8295-MS, 1981
- *DOE-2 Verification Project, Phase 1, Final Report,* Los Alamos National Laboratory, Report No. LA-10649-MS, 1986.

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

Weather Files

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

TMY or TRY weather tapes

National Climatic Data Center
Federal Building
Asheville, North Carolina 28801
(704) 259-0871 Climate Data
(704) 259-0682 Main Number

CTZ weather tapes

California Energy Commission
Attn: Bruce Maeda, MS-25
1516-9th Street
Sacramento, CA 95814-5512
1-800-772-3300 Energy Hotline

WYEC weather tapes

ASHRAE
1791 Tullie Circle N.E.
Atlanta, GA 30329
(404) 636-8400

Program-Related Software and Services

Each issue of the USER NEWS contains a directory of software and services pertaining to DOE-2. This listing includes names and addresses of consultants, information on training, where to purchase the PC versions of DOE-2, how to obtain pre- and post-processor software, etc.

To get current information, please contact the

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

BUILDING DESCRIPTION LANGUAGE (BDL)

BDL Instructions

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

To aid in understanding the following sections, we recommend that the reader refer to the "Sample Input", starting on p.1.9. The basic element of BDL is the *instruction*. An instruction corresponds roughly to an English sentence and always includes a *command*, which specifies the subject matter, and a *terminator*, which ends the command. An example is the BDL instruction that defines the run period for the simulation (see "Sample Input"):

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

Each instruction is assumed by BDL to stay in effect until it sees a terminator. If there is more data, it assumes a new instruction is coming and seeks out the controlling command word of that instruction. This process continues until BDL reads the command STOP. Note that no reference is made here to coming to the end of a line. An instruction may stretch over many lines without the user 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 the user to arrange the input in any fashion that is easily readable.

Terminator

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

Comments

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

INPUT Command

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

```
INPUT LOADS   ..
```

END Command

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

COMPUTE Command

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

Keywords*

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

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

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

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

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

```
LATITUDE 42
LATITUDE,42
LATITUDE=42
```

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

u-names and Referenced Commands

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

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

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

---

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

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

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

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

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

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

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

Choosing u-names

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

LIKE Keyword

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

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

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

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

---

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

Subcommands

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

Building Description

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

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

Internal Zoning

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

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

It is not even necessary to have zones separated by real partitions or interior walls. However, it is common in building energy analysis to create one internal zone and four external zones (one for each exposure — see p.B.3).

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

Use of Comments

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

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

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

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

Alternative Runs

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

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

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

---

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

Schedules

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

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

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

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

DAY–SCHEDULE

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

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

For example:

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

Optionally, this can be shortened by writing

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

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

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

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

WEEK–SCHEDULE

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

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

† days of week covered

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

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

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

Optionally, this can be shortened to:

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

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

SCHEDULE

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

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

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

In its simplest form, SCHEDULE takes the form of:

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

To finalize the example:

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

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

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

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

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

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

Flexibility of Input Format

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

The following 16 lines of input are identical in content to the plant and economics input on p.1.12. The purpose of this example is to display the free formatting available to the user, and at the same time display the use of abbreviations and lower case lettering. This also shows how confusing a jumble of input styles can be and the importance of annotating your inputs as you go along.

Organizing the input so that the most important items appear in the left column, plus indenting the information that is less pertinent, will make the original intent more readily apparent if you have to review it six months or more from now. To prove the point, compare the input in the sample run to the input below prepared with no recognizable format.

```
          INPUT PLANT ..

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

            ENERGY-COST  R = ELECTRICITY  A-C = (ELCOST)   ..
ELCOST = C-A  R = ELECTRICITY  TYPE = ENERGY
       B-R = (800,1200,10000)  B-C = (.075,.090,.10) ..
ENERGY-COST  RESOURCE  NATURAL-GAS  UNIT 100000  UNIFORM-COST .62 ..
ECONOMICS-REPORT  S = (ES-D) ..
end ..
compute economics ..
stop ..
```

LOADS

Introduction

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

External	components are the loads due to heat conduction through walls, heat conduction through windows, infiltration through windows and walls, and solar gain through windows.
Internal	components are the loads due to people, lights, and equipment inside the building.

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

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

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

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

---

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

LDL Input Instructions

Limitation on Number of Commands

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

Command	Maximum Number
BUILDING-LOCATION	1
BUILDING-RESOURCE	1
CONSTRUCTION	32
DAY-SCHEDULE	80
DOOR	64
EXTERIOR-WALL/ROOF	128
GLASS-TYPE	32
INTERIOR-WALL	no limit
LAYERS	16
LOADS-REPORT	1
RUN-PERIOD	1 *
SCHEDULE	60
SPACE	64
SPACE-CONDITIONS	32
TITLE	5 **
u-names	352 ***
UNDERGROUND-FLOOR	64
UNDERGROUND-WALL	64
WEEK-SCHEDULE	80
WINDOW	200

Description of LDL Input Instructions

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

INPUT

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

INPUT LOADS ..

---

* 1 command specifying up to 15 periods

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

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

RUN–PERIOD

The RUN–PERIOD instruction is used to specify the initial and final dates of the desired simulation period.

u-name	is not allowed
RUN–PERIOD	tells LOADS that the data to follow specify initial and final dates of a desired simulation period. The initial date is the first date of the simulation, given in the form: month day year. The LDL code-words to specify the names of the months are given below. The day and year are specified as numbers with a separator (blank or comma) on each side. The final date is the last simulation date, specified in the same manner as the initial date. The code-words for the months are:

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

Rules:

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

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

Example:

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

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

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

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

BUILDING-LOCATION

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

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

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

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

HOLIDAY

The LOADS program can calculate holiday loads using different schedules than for normal weekdays. The code-word YES (the default) gives the holidays; NO gives no holidays. The following table identifies the holiday list. *It is not possible for the user to change the holiday list without modifying the FORTRAN code.*

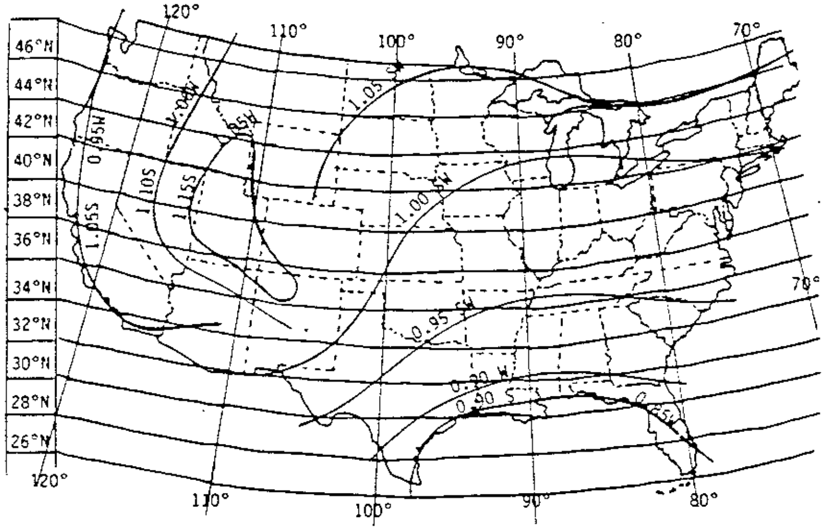
National Holidays of the United States

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

AZIMUTH

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

GROUND-T	is a list of the local mean ground temperatures for each month. The values should be in degrees Fahrenheit, and in a twelve-element list format. If not entered here, these data will be taken from the weather tape. The range is from -100.0 to 150.0°F.
CLEARNESS-NUMBER	is a list of the local monthly clearness numbers for each month of the year. This is applicable when the clearness numbers on the weather file being used are not appropriate. The allowable range is from 0.5 to 1.2. Table below is reprinted from ASHRAE Trans., Vol. 64, p. 67.



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

Rules:

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

Example:

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

LAYERS

The LAYERS instruction is used to specify the sequence of material layers of the cross section of a wall, roof, etc.

u-name	is required for this instruction. It is referenced in a CONSTRUCTION instruction.
LAYERS	tells LOADS that the data to follow identify the layers of material that are in a construction, the order of the layers, and the layer thicknesses. It tells the LDL Processor to calculate the response factors for the wall.
INSIDE–FILM–RES	specifies the combined convective and radiative air film resistance for the inside wall surface. The default of .68 hr-ft^2-°F/Btu is an appropriate value for vertical walls. For horizontal surfaces, such as ceilings and floors, the suggested inside-film-resistance can be found in the following table. Because only one value is allowed for each surface, the user should decide which is more important, cooling or heating. The allowable range is from 0.0 to 40.0 hr-ft^2-°F/Btu.

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

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

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

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

Rules:

1. The outside air film coefficient of an exterior wall or roof should not be specified as a layer because it is calculated by the LOADS program as a function of surface roughness and windspeed.
2. The list identified by MATERIAL and THICKNESS must have a one-to-one correspondence. For example, the first material listed in MATERIAL has a thickness equal to the first value listed in THICKNESS.
3. Both lists (MATERIAL and THICKNESS) must have the same number of elements.
4. A list element must be included in THICKNESS for layers specified by a RESISTANCE, but it is a dummy variable, used only to make the list length match with the MATERIAL list length.
5. For an exterior wall or roof, both lists start with the outside layer.
6. Maximum list length for MATERIAL and THICKNESS is 9 elements each.
7. Not all LAYERS can be specified by RESISTANCE (for MATERIAL) only. At least one must be specified as a transient type layer.

Example:

```
WA-1-2=LAYERS   MATERIAL=(WD01,PW03,IN02,GP01) ..
RB-1-1=LAYERS   MATERIAL=(RG01,BR01,IN22,WD01) I-F-R .76 ..
```

CONSTRUCTION

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

u-name	*must* be specified for this instruction in order to reference this CONSTRUCTION in a subsequent EXTERIOR-WALL, ROOF, INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR, or DOOR instruction.
CONSTRUCTION	tells LOADS that the data to follow specify the construction characteristics and properties of an exterior wall, roof, etc.
LIKE	may be used to copy data from a previously u-named CONSTRUCTION instruction.
LAYERS	entry for this keyword is the *u-name* of a previously defined (and entered) LAYERS instruction. This identifies the characteristics of the CONSTRUCTION and specifies heat transfer calculation by the *dynamic*, or delayed technique.
U-VALUE	may be used as a less accurate alternative to LAYERS when the construction has little heat capacitance, and the heat flow is not delayed. A steady-state, or "quick" calculation technique is used. For interior surfaces the U-VALUE should include both film coefficients. For exterior surfaces only the inside film coefficient should be included since the outside film coefficient is calculated hourly as a function of surface roughness and windspeed. The range is from 0.0 to 20.0 Btu/hr-ft^2-°F. Table 3.1 shows typical U-values for some low-heat capacity walls.

TABLE 3.1

Example U-values for Constructions
With Low Heat Capacity

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

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

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

TABLE 3.2

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

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

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

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

ABSORPTANCE

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

TABLE 3.3

Solar ABSORPTANCE for Various Exterior Surfaces (Clean)

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

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

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

TABLE 3.4

ROUGHNESS Code for Exterior Surface Finish

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

* 3 is the default value

Rules:

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

Example:

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

GLASS–TYPE

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

u-name	is a mandatory entry for this command in order to reference the GLASS–TYPE in a WINDOW instruction.
GLASS–TYPE	tells LOADS that the data to follow specify the characteristics of the glass used in a window.
LIKE	may be used to copy data from a previously u-named GLASS–TYPE instruction.
PANES	Number of panes of glass; the code numbers are 1, 2, or 3 for single-, double-, or triple-pane, respectively. The default is single-pane.
SHADING–COEF	is the ASHRAE shading coefficient of the glass. This keyword value is a number between 0.0 and 1.0, and there is no default. When SHADING–COEF is entered, the program will first calculate the solar heat gain using transmission and absorption coefficients for clear, 1/8" thick, single-pane, double-strength sheet glass. This solar heat gain is then multiplied by the value of SHADING–COEF to determine the resultant solar heat gain. Thus, resultant solar heat gain = SHADING–COEF x (solar heat gain for standard glass). The shading coefficient depends in general not only on the type of glass, but also on whether blinds, shades, draperies, etc., are used with the window. To simulate operable shading devices, the user may assign a SHADING–SCHEDULE to a window (see WINDOW command). The resultant solar heat gain each hour will then be multiplied by the schedule value. For shading coefficient values of different glazing types, see manufacturers' data sheets.
GLASS–CONDUCTANCE	is the conductance of the total window except for the outside film coefficient. The conductance given in glass manufacturers' data sheets usually includes the outside air film resistance for a windspeed of 7.5 mph (summer) or 15 mph (winter). The following table can be used to obtain the corresponding value of GLASS–CONDUCTANCE. For example, if U (7.5 mph) = 0.64 Btu/ft^2-hr-°F, then GLASS–CONDUCTANCE = 0.79 (by interpolation).

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

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

Example:

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

TABLE 3.5

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

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

SPACE–CONDITIONS

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

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

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

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

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

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

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

   The user should pay close attention when specifying SCHEDULEs. It cannot be over emphasized how important this is. All the SCHEDULEs associated with

SPACE-CONDITIONS, except INF-SCHEDULE, default to the off mode of operation. This means that even though the maximum output of the equipment, lights, etc. has been specified, the equipment and lights will not be turned on, unless the user specifies this mode of operation in the SCHEDULEs. Naturally, if the user fails to turn the equipment and lights on, the simulation will be faulty.

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

inputting PEOPLE–HG–LAT and PEOPLE–HG–SENS, should be used. For typical values for different degrees of activity, see the ASHRAE *1989 Handbook of Fundamentals*, Table 3, p.26.7.

PEOPLE–HG–LAT

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

PEOPLE–HG–SENS

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

LIGHTING–SCHEDULE

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

LIGHTING–TYPE

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

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

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

LIGHTING–KW

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

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

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

LIGHTING-W/SQFT

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

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

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

LIGHT-TO-SPACE

is the fraction, if any, of the lighting energy that is added to the space energy balance as a sensible heat gain. The remaining energy is added (in SYSTEMS) to the ductwork if RETURN-AIR-PATH = DUCT. The default is 1.0 for SUS-FLUOR, REC-FLUOR-NV, and INCAND; 0.8 for REC-FLUOR-RV and REC-FLUOR-RSV.

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

TASK-LIGHT-SCH

is the u-name of the schedule for task lighting in the space. A task light is any small lamp, such as a desk lamp, that would have a different schedule of use than the main space overhead lighting. Schedule inputs are fractions of maximum task lighting energy input (see TASK-LIGHTING-KW or TASK-LT-W/SQFT). If the TASK-LIGHT-SCH is not

	input, the schedule value will default to zero and no task lights will be simulated.
TASK-LIGHTING-KW	specifies the maximum electrical energy required for task lighting. All of this energy is added to the space. The default is 0.0, and the range is from 0.0 to 200.0 kW. The actual task lighting energy required in the SPACE during any given hour is the value assigned to this keyword multiplied by the fractional value assigned for that hour (see TASK-LIGHT-SCH). If both TASK-LIGHTING-KW and TASK-LT-W/SQFT are specified, the program adds the values. LIGHT-TO-SPACE is not appropriate to this keyword because 100% of task lighting energy goes to the space.
TASK-LT-W/SQFT	is an alternative keyword for TASK-LIGHTING-KW and is based on watts of task lighting per square foot of floor area of the space. The default is 0.0, and ranges from 0.0 to 10.0 W/ft^2. LIGHT-TO-SPACE is not appropriate to this keyword because 100% of task lighting energy goes to the space.
EQUIP-SCHEDULE	is the u-name of the schedule for space equipment operating schedule. Schedule inputs are fractions of maximum equipment energy input (see EQUIPMENT-KW or EQUIPMENT-W/SQFT). If the EQUIP-SCHEDULE is not input, the schedule value will default to zero and no space equipment loads will be simulated.
EQUIPMENT-KW	is the maximum amount of energy required to operate electrical equipment within the space and is *not necessarily* the sensible and/or latent heat added by the equipment to the space (see EQUIP-SENSIBLE and EQUIP-LATENT). The default is 0.0 and the range is from 0.0 to 200.0 kW. The actual equipment energy required by the space during any given hour is the value assigned to this keyword multiplied by the fractional value assigned to that hour (see EQUIP-SCHEDULE). The amount of equipment energy added to the space, if any, may be specified by its components (see EQUIP-LATENT and EQUIP-SENSIBLE). If both EQUIPMENT-KW and EQUIPMENT-W/SQFT are specified, the program adds the values.
EQUIPMENT-W/SQFT	is an alternative keyword for EQUIPMENT-KW and is based on watts of equipment energy per square foot of floor area of the space. The default is 0.0 and the range is from 0.0 to 100.0 W/ft^2.
EQUIP-SENSIBLE	is the fraction of EQUIPMENT-KW, if any, that is added to the space energy balance in the form of sensible heat. The sum of EQUIP-SENSIBLE and EQUIP-LATENT must not exceed 1.0; range is 0.0 to 1.0.

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

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

SOURCE-TYPE	is used when there are internal heating or cooling loads caused by a source other than people, lights, or equipment. The possible code-words for this keyword are:
GAS	The load will contribute to the natural gas use budget in PLANT. Examples include natural gas for ovens, kilns, dryers, etc. GAS is the default.
ELECTRIC	The load will contribute to electricity use budget in PLANT. Examples include electricity for cooking, electroplating, battery charging, etc.
HOT-WATER	The load will contribute to the hot-water budget (natural gas or fuel oil) in PLANT. This load will be reported as a domestic or service hot water load as will any hot water defined in the BUILDING-RESOURCE command. (The difference between these two types of hot water is that a portion of this HOT-WATER load can be added to the space heating and cooling by using the SOURCE-SENSIBLE and SOURCE-LATENT keywords. The HOT-WATER load specified in the BUILDING-RESOURCE command will be passed totally and directly to PLANT without contributing to any space load.) Both HOT-WATER loads will be passed to any *domestic* hot water heater defined in the PLANT-EQUIPMENT command.
PROCESS	Load will *not* contribute a utility load on PLANT (e.g., cooling load caused by a self-contained, portable energy source or other industrial processes). Examples of this type of load are gasoline powered fork trucks, oxyacetylene welders, wood stoves, bottled gas equipment, etc. The user should sum up all the PROCESS loads in the zone, be they electrical, gas, hot water, solar, nuclear, etc. and express the total in Btu/hr. This total

---

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

	value should be expressed with the keyword SOURCE-BTU/HR. The portion of the total PROCESS load that enters the zone as a heating or cooling load is then specified by using the SOURCE-LATENT and SOURCE-SENSIBLE keywords. This keyword is not operative unless SOURCE-SCHEDULE is defined. Note: Do not use the code-word ELECTRIC for specifying electrically heated hot water. Also, do not use the code-word GAS to specify gas heated hot water. In both cases, specify SOURCE-TYPE = HOT-WATER. This will pass a demand for hot water to PLANT, where the hot water heater is specified along with its fuel type. The first approach will pass the wrong type of demand to PLANT.
SOURCE-BTU/HR	is the maximum amount of energy supplied by the source defined by SOURCE-TYPE. This is the maximum amount of energy required to operate devices, other than lighting and equipment, within the space and is *not necessarily* the sensible and/or latent heat added by the source(s) to the load on the space (see SOURCE-SENSIBLE and SOURCE-LATENT). The default is 0.0, and the allowable range is from −10000000.0 to 1000000.0 Btu/hr. A negative value represents heat *removed* from the space. The actual source energy required by the space, during any given hour, is the value assigned to this keyword multiplied by the fractional value assigned to that hour (see SOURCE-SCHEDULE). This amount of SOURCE-BTU/HR energy added to the load of the space, if any, may be specified by SOURCE-LATENT and SOURCE-SENSIBLE.
SOURCE-SCHEDULE	is the u-name of the schedule for any source of internal energy (such as process equipment *within* a space) other than people, lights, or electrical equipment. Schedule inputs are fractions of SOURCE-BTU/HR. If the SOURCE-SCHEDULE is not entered, the schedule value will default to zero and no SOURCE loads will be simulated.
SOURCE-SENSIBLE	is the fraction of SOURCE-BTU/HR (after being multiplied by the hourly fractional value in SOURCE-SCHEDULE) that is added to the space energy balance in the form of sensible heat. The sum of SOURCE-SENSIBLE and SOURCE-LATENT must not exceed 1.0 and is likely to be less than 1.0 since all such energy is not necessarily added to the space load. The default is 1.0, and it can range from -1.0 to 1.0.

SOURCE-LATENT	is the fraction of SOURCE-BTU/HR (after being multiplied by the hourly fractional values in SOURCE-SCHEDULE), if any, that is added to the space energy balance in the form of latent heat. The sum of SOURCE-LATENT and SOURCE-SENSIBLE must not exceed 1.0 and is likely to be less than 1.0 since all such energy is not necessarily added to the space load. The default is 0.0.
INF-METHOD	equals a code-word that identifies the method used to calculate infiltration for the space. The possible code-words (italicized) are as follows (the default is NONE).
NONE	No infiltration is calculated.
AIR-CHANGE	The infiltration rate is calculated using the air-change method as described below for keywords AIR-CHANGES/HR and INF-CFM/SQFT. One of these keywords should be specified if INF-METHOD=AIR-CHANGE. AIR-CHANGES/HR will give a windspeed-*dependent* infiltration rate. INF-CFM/SQFT will give a windspeed-*independent* infiltration rate.
RESIDENTIAL	The infiltration rate will depend on both windspeed and inside-outside temperature differences as described below for keyword RES-INF-COEF.
RES-INF-COEF	is a list of 3 values which are coefficients in the following formula: Infiltration = value1 + (value2 x windspeed) + (value3 x ΔT) where infiltration is measured in air changes/hr, windspeed is in knots (taken from the weather tape) and ΔT (absolute value of outdoor-indoor temperature differential) is in °F. The keyword RES-INF-COEF is appropriate only if INF-METHOD = RESIDENTIAL. The default coefficients are 0.252, 0.0251, and 0.0084. The range is from 0.0 to 20.0 for each coefficient.
AIR-CHANGES/HR*	is the number of infiltration-caused air changes per hour at a windspeed of 10 mph for a space with INF-METHOD=AIR-CHANGE. The default is 0.0 and range is from 0.0 to 30.0. If this keyword is specified, the program will make a windspeed correction each hour to the infiltration rate, so that: Actual air changes per hour = (AIR-CHANGES/HR) x (windspeed)/(10 mph) (This keyword should not to be confused with a keyword of the same name in SYSTEMS.)

---

* One or both of these keywords should be entered. If both are entered their effects are summed. Choice should be based on whether or not a windspeed correction is desired.

INF-CFM/SQFT*	is the amount of infiltration into a space with INF-METHOD=AIR-CHANGE. It is expressed as the ratio (infiltration cfm)/(floor area). There is no correction for windspeed. The default is 0.0 and the range is from 0.0 to 20.0 cfm/ft^2.
INF-SCHEDULE	is the u-name of a schedule that specifies a multiplier on the amount of air infiltration into a space as a function of time. The schedule should contain values that modify the calculated infiltration values. A value of 1.0 would leave the infiltration values unmodified night and day, year round. Any value below 1.0 would represent reduction of infiltration such as that caused by pressurization from a supply fan. Any value above 1.0 would represent an increase in infiltration such as that caused by an exhaust fan, open window, or open door. If INF-SCHEDULE is not input the schedule will default to one for all hours. Ordinarily, INF-SCHEDULE should not be used with INF-METHOD=RESIDENTIAL method of infiltration because the schedule will distort wind information from the weather tape.
FLOOR-WEIGHT	is used to specify the composite weight of the floor, furnishings, and interior walls of a space divided by the floor area of the space. The value input by the user will determine the weighting factors associated with the space. Higher values give a longer time lag between heat gains and resultant cooling loads, and greater damping of peak loads. The default is 70.0, and the range is from 0.0 to 200.0 lb/ft^2.

Example:

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

---

* One or both of these keywords should be entered. If both are entered their effects are summed. Choice should be based on whether or not a windspeed correction is desired.

SPACE

The SPACE instruction is used to specify all the information that is associated with a space.

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

Rules:

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

Example:

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

EXTERIOR–WALL (or ROOF)

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

u-name	may be used to identify a wall surface.
EXTERIOR–WALL	(or **ROOF**) This command tells LOADS that the data to follow specify an exterior wall, roof, or exterior floor.
LIKE	may be used to copy data from a previously u-named EXTERIOR–WALL instruction.
GND–REFLECTANCE	is the solar reflectance of the ground; i.e., the fraction of sunlight incident on the ground that is reflected. The following table provides typical values for various surfaces. The default is 0.2.

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

MULTIPLIER	is used to specify the total number of identical (except for position) exterior wall panels located in the same plane. This reduces the amount of data input. It multiplies the net area of the exterior wall (exterior wall area minus window area minus door area). It also multiplies any WINDOW area and DOOR area associated with this exterior wall panel. The range is from 0.0 to 99.0, and default is 1.0.
AZIMUTH	is the azimuth of the exterior wall. The default is 0° (north-facing wall), and the range is from 0° to 360°; east-facing is 90°; south-facing is 180°; west-facing is 270°. Intermediate angles are acceptable.
HEIGHT	is the dimension of the exterior wall parallel to the Y axis. This is a required keyword, and the range is from 0.0 to 2000.0 feet.

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

Rules:

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

Example:

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

WINDOW

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

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

CONDUCT-SCHEDULE	identifies the u-name of the schedule that describes any change in the heat conductance of the window relative to the GLASS-CONDUCTANCE. The factor in the schedule may be less than, equal to, or greater than 1.0. The factor is used as a multiplier against GLASS-CONDUCTANCE. This represents the change of conductance associated with storm windows, insulated shutters, etc. Any accessories that are added to the window (such as a storm window) that change the conductance may also significantly change the light transmission properties of the window. If so, a matching SHADING-SCHEDULE should be used. *Note: If the CONDUCT-SCHEDULE is not input, the schedule value will default to 1 for all 24 hours.*
CONDUCT-TMIN-SCH	is a schedule of values of outside dry-bulb temperature below which movable insulation will be deployed on a window. If this keyword is specified, a corresponding SHADING-SCHEDULE and CONDUCT-SCHEDULE should be assigned to the window.

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

OVERHANG-A	Units are feet, 0.0 is the default, and there are no limits. See Fig. 3.1.
OVERHANG-B	Units are feet, 0.0 is the default, and there are no limits. See Fig. 3.1.
OVERHANG-W	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 3.1.
OVERHANG-D	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 3.1.
OVERHANG-ANGLE	is the angle between the overhang and the window. When set at 90°, the overhang is perpendicular to the window (the default); if $< 90°$, it is tilted down; if $> 90°$, it is tilted up. The range is 0.0 to 180.0°. Note: For overhang shading calculations to be performed, both OVERHANG-W and OVERHANG-D **must** be specified. If either of them is specified, but not both, a WARNING message is printed and overhang shading is not performed.

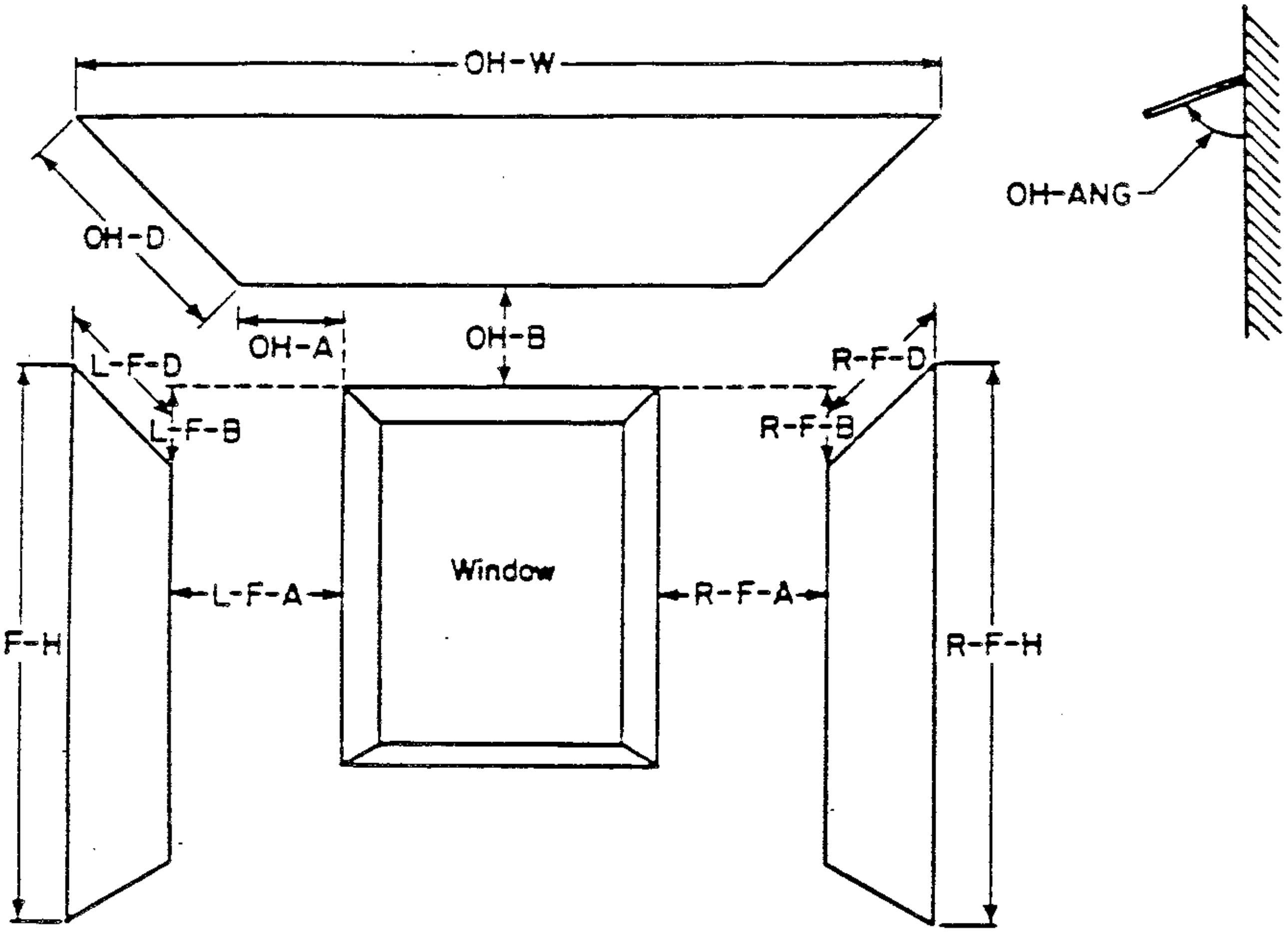


Figure 3.1: Positioning of overhang and fins with respect to a window. The values in this figure are all positive. If the value for L–F–B is input as negative, then the left fin will originate at a point above the top edge of the window, and similarly for R–F–B.

LEFT–FIN–A	Units are feet, 0.0 is the default, and there are no limits. See Fig. 3.1.
LEFT–FIN–B	Units are feet, 0.0 is the default, and there are no limits. See Fig. 3.1.
LEFT–FIN–H	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 3.1.
LEFT–FIN–D	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 3.1.
RIGHT–FIN–A	Units are feet, 0.0 is the default, and there are no limits. See Fig. 3.1.

RIGHT-FIN-B	Units are feet, 0.0 is the default, and there are no limits. See Fig. 3.1.
RIGHT-FIN-H	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 3.1.
RIGHT-FIN-D	Units are feet, 0.0 is the default, and the range is 0.0 to no limits. See Fig. 3.1.

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

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

Rules:

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

Example:

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

DOOR

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

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

Note: The overhang can be applied the same as for WINDOW command.

Example for a solid wood door:

```
D1      = CONSTRUCTION  U–VALUE = .5 ..
DOOR1   = DOOR      HEIGHT = 7
                    WEIGHT = 3
                    CONSTRUCTION = D1 ..
```

INTERIOR–WALL

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

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

Example for a case where there is an adjacent space:

```
P1          = CONSTRUCTION     U–VALUE = .2 ..
PARTITION   = INTERIOR–WALL    AREA  = 320
                               CONSTRUCTION = P1
                               NEXT–TO = SPACE–2 ..
```

UNDERGROUND-WALL or UNDERGROUND-FLOOR

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

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

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

Rules:

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

Example:

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

BUILDING–RESOURCE

The BUILDING–RESOURCE instruction is used to specify and schedule the building-level use of gas, electricity, and hot water. In this context, "building level" means not in any specified space. As such, these loads do not contribute heating or cooling demands on any space but rather they create demands on the plant for utilities. These loads are passed directly to PLANT, bypassing SYSTEMS. The user may use this command to specify electricity, gas, hot water, or elevators not in any particular space, and outside lighting, exterior electrical outlets, sidewalk defrosters, etc. Note that no BUILDING–RESOURCE keyword will work unless the referenced schedule is explicitly defined.

u-name	is not permitted
BUILDING–RESOURCE	This command tells LOADS that the data to follow specify *building level* (as opposed to space level) use of gas, electricity, and hot water.
GAS–SCHEDULE	identifies the previously entered schedule that is used to specify the building-level gas use as a function of time. Schedule inputs are fractions of the quantity given by the GAS–THERMS keyword. If GAS–SCHEDULE is not input, no gas usage will occur, regardless of the value specified for GAS–THERMS.
GAS–THERMS	is the maximum gas use at the building level in therms/hr. It is multiplied by the hourly schedule values defined through the GAS–SCHEDULE keyword. This gas use is in addition to any gas use specified in the SPACE or SPACE–CONDITIONS commands with the SOURCE–TYPE, SOURCE–BTU/HR, and SOURCE–SCHEDULE keywords. The allowable range is from 0.0 to 10.0 therms/hr and it defaults to 0.0.
HW–SCHEDULE	identifies a previously entered schedule that is used to specify the building level hot water use as a function of time. Schedule inputs are fractions of the quantity given by the HOT–WATER keyword. If HW–SCHEDULE is not input, no hot water (or steam) usage will occur, regardless of the value specified for HOT–WATER.
HOT–WATER	is the maximum building level hot water (or steam) use. The allowable range is from 0.0 to 10^7 Btu/hr and it defaults to 0.0. (in Btu/hr). It is adjusted by the schedule named in HW–SCHEDULE. This hot water use is in addition to any hot water use specified in the SPACE or SPACE–CONDITIONS instructions. The HOT–WATER load entered here is passed directly to the PLANT. A portion of the HOT–WATER load that is entered under the SPACE–CONDITIONS command, however, can be added to the space by the use of SOURCE–LATENT or SOURCE–SENSIBLE keywords. This may be desired when simulating a shower room, laundry, etc. Both types of HOT–WATER loads are passed to the same domestic hot

	water heater in the PLANT program.
ELEC-SCHEDULE	identifies a previously entered schedule that is used to specify the building level electricity use as a function of time. Schedule inputs are fractions of the quantity specified by the ELEC-KW keyword. If ELEC-SCHEDULE is not input, no electrical usage will occur, regardless of the value specified for ELEC-KW.
ELEC-KW	is the maximum building level electricity use. The allowable range is from 0.0 to 1000.0 kW and it defaults to 0.0. It is adjusted by the schedule named in ELEC-SCHEDULE. This electricity use is in addition to any electric use specified in the SPACE and SPACE-CONDITIONS instructions.
VERT-TRANS-SCH	identifies a schedule that is used to specify usage of vertical transportation devices, i.e., elevators and escalators. Schedule inputs are fractions of the quantity specified by the VERT-TRANS-KW keyword. If VERT-TRANS-SCH is not input, no power usage for elevators and escalators will occur, regardless of the value specified for VERT-TRANS-KW.
VERT-TRANS-KW	is the maximum building level demand kW for operating elevators and escalators. The allowable range is from 0.0 to 1000.0 kW and it defaults to 0.0. This electricity use is in addition to any electric use specified in the SPACE and SPACE-CONDITIONS instructions.

Example:

```
   BUILDING-RESOURCE    HW-SCHEDULE = OCCUPY-1
                        HOT-WATER = 10000 ..
```

LOADS-REPORT

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

Format:

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

Example:

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

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

SYSTEMS

Introduction

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

General Discussion of Systems

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

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

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

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

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

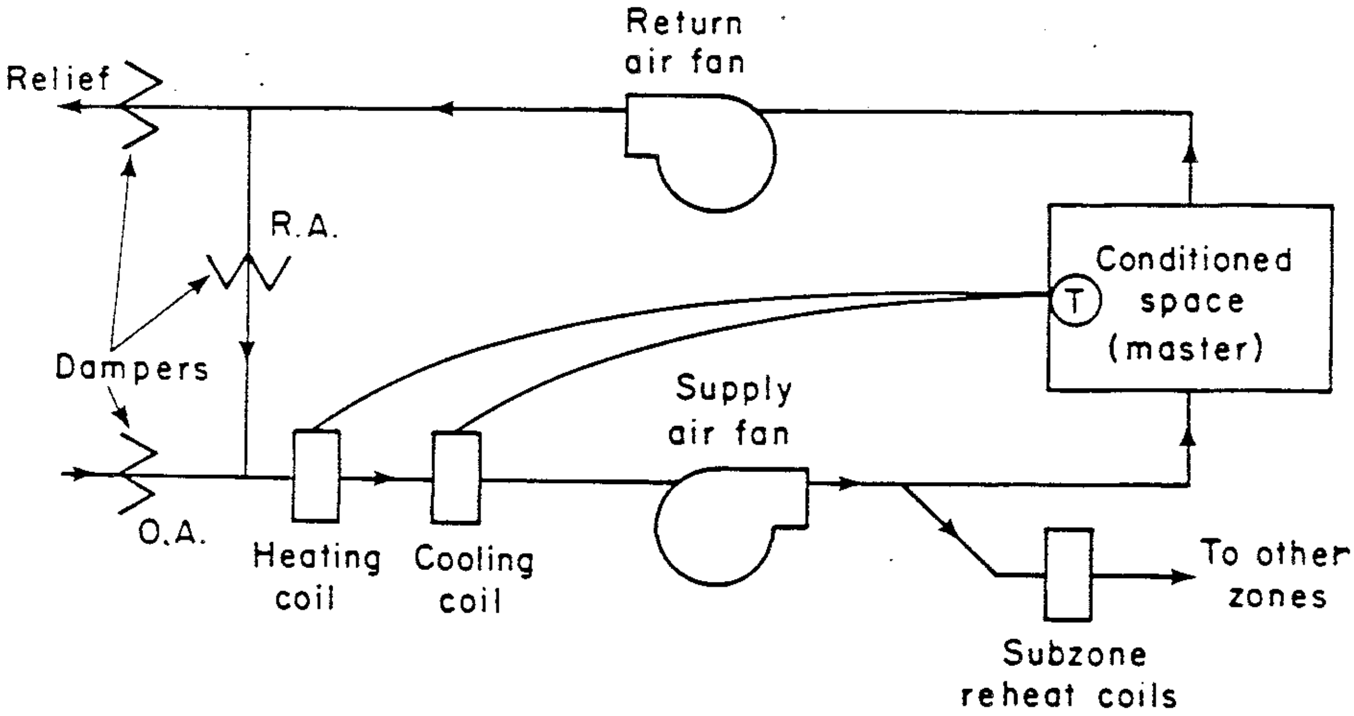


Figure 4.1: Variable Air Temperature System

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* The corresponding DOE-2 SYSTEM-TYPE code-words are given in parentheses; for example, PSZ is the DOE-2 "packaged single zone" system. See p.4.9 for a list of system types and code-words.

Reheat Systems (Constant Volume) (RHFS)

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

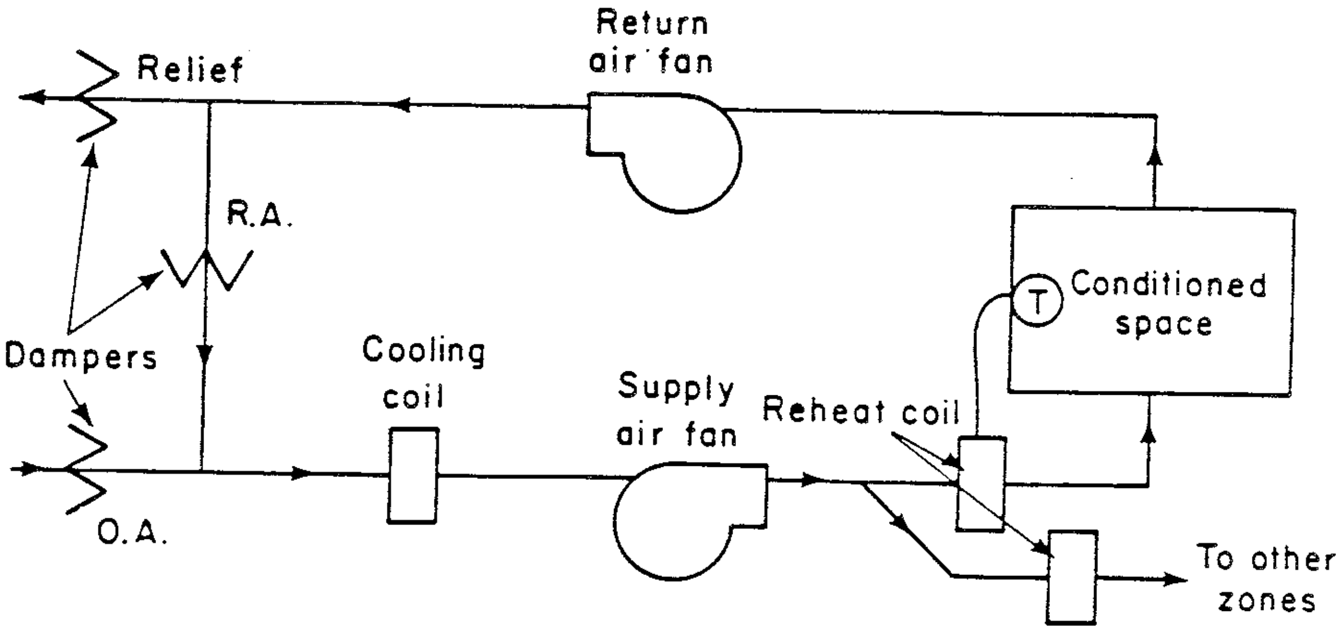


Figure 4.2: Reheat System

Air Mixing Systems (Constant Volume) (DDS, MZS, PMZS)

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

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

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

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

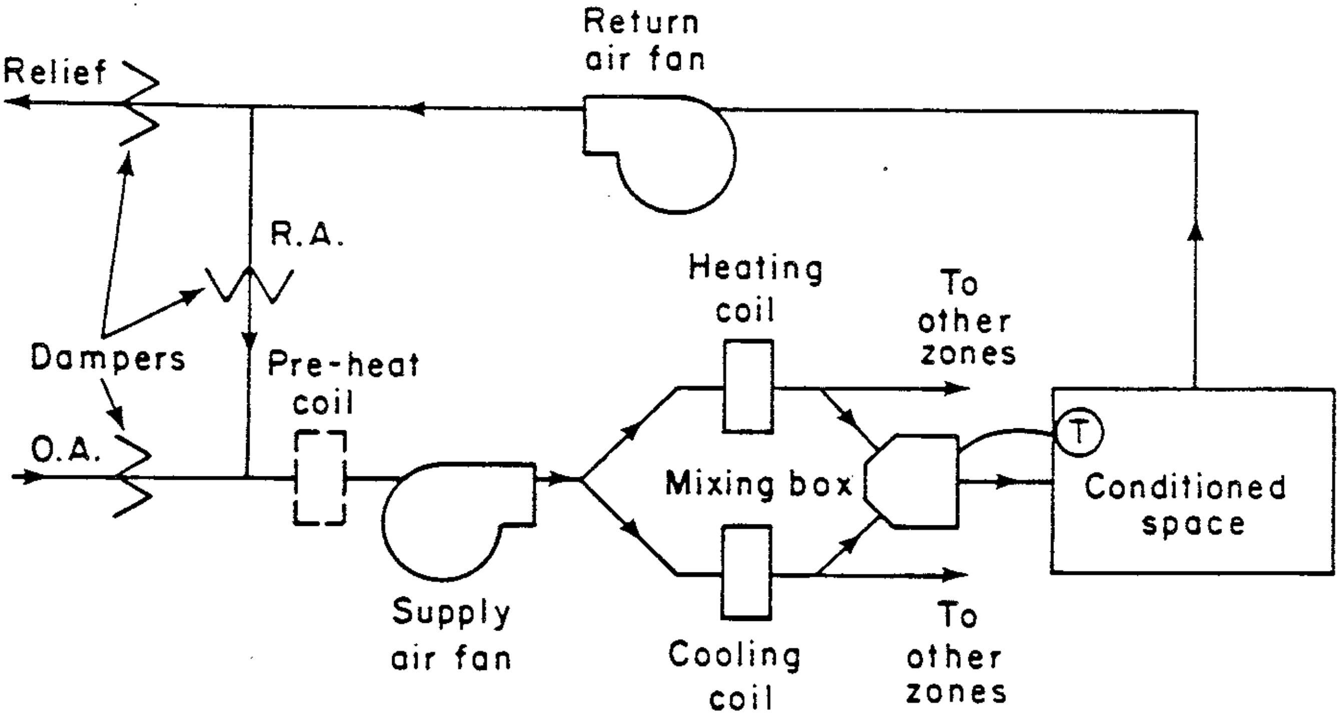


Figure 4.3: Air Mixing (Constant Volume) Systems

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

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

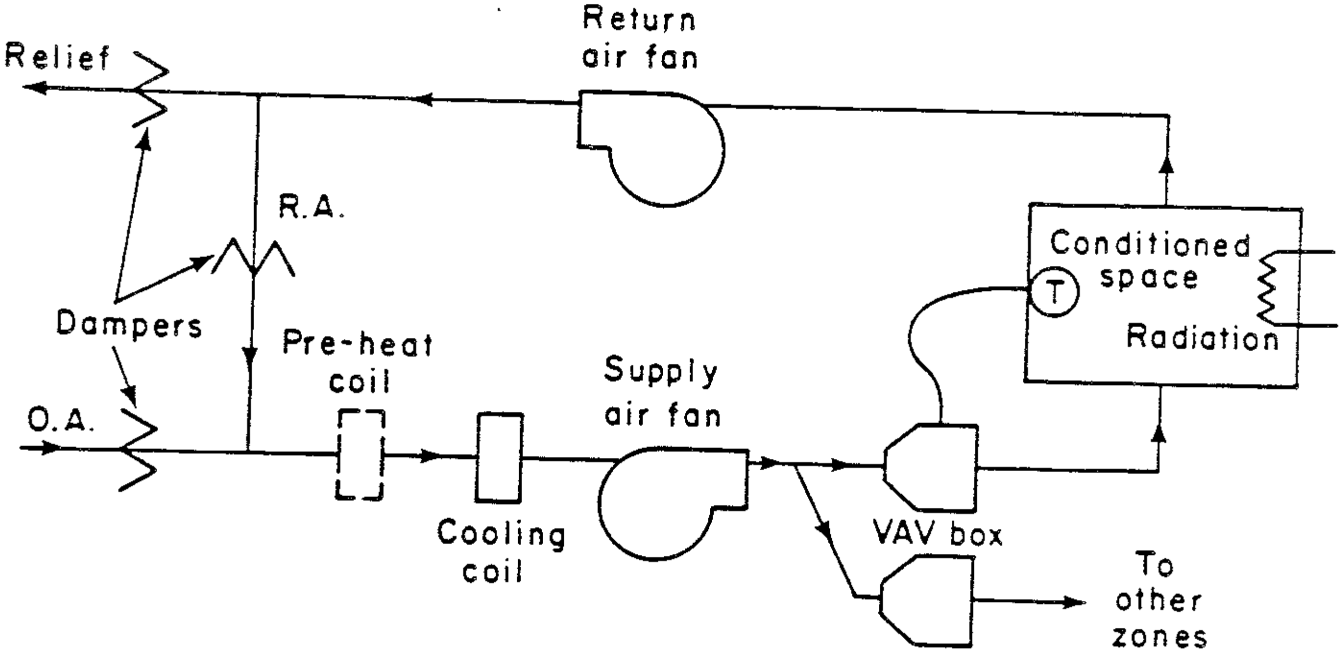


Figure 4.4: Variable Air Volume (Constant Temperature) System

Hybrid Systems

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

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

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

Other System Types in DOE-2

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

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

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

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

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

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

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

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

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

Specific HVAC Distribution Systems

The SYSTEMS program simulates the heat and moisture exchange processes that occur in secondary HVAC distribution systems. Likewise, it simulates the performance of air circulating fans used in these systems. The user selects appropriate systems (plus options) from a list of 17 different "standard" or familiar types of systems. There are an additional 6 system types that are used less commonly; see the *Reference Manual (2.1A)*. However, the SYSTEMS subprogram cannot simulate two different types of air systems in one zone at the same time. For example, it is not possible to simulate the cooling of a zone by both a Single Zone Fan System (SZRH) and a Two Pipe Fan Coil System (TPFC).

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

Built-Up Systems	Depending upon the system types chosen, *built-up systems* contain preheat coils, main heating coils, cooling coils, zone (reheat) coils, baseboard heaters, fans (supply, return, and exhaust), thermostats, humidifiers, dehumidifiers, economizers, outside air dampers, mixing dampers, throttling dampers, and air ducting. However, built-up systems are **not** usually self-contained; the central equipment (i.e., boilers, chillers, cooling towers, pumps, etc.) that produces hot or chilled water and electrical energy is separated from the distribution system. That equipment is simulated in DOE-2's PLANT subprogram. Built-up system simulations result in demands that are passed to PLANT, for hot water, chilled water, electricity, gas, and/or oil. These demands may be met in PLANT by purchased utilities or energy conversion equipment.
Packaged Systems	*Packaged systems* are usually self-contained units. These units are usually produced as one or more modular pieces of prematched equipment that only require installation. They possess all the necessary equipment for energy conversion and distribution and they, too, produce a utility demand for electricity, gas, and/or oil.
Zonal vs. Central Systems	Reference is sometimes made to a *zonal system*, defined herein to mean any system with an air-handling unit in each zone and controlled by a thermostat in that zone. It may be a packaged self-contained system (fueled only by a utility) or it may be supported by a *central system* (supplying hot water, chilled water, warm air, or cool air). Zonal systems are UHT, UVT, TPFC, FPFC, HP, and PTAC.

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

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

In the material that follows, the user will find

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

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

3) For each system type, a list of other capabilities that can be simulated, with pointers showing where the user can find an example or a more complete description.

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

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

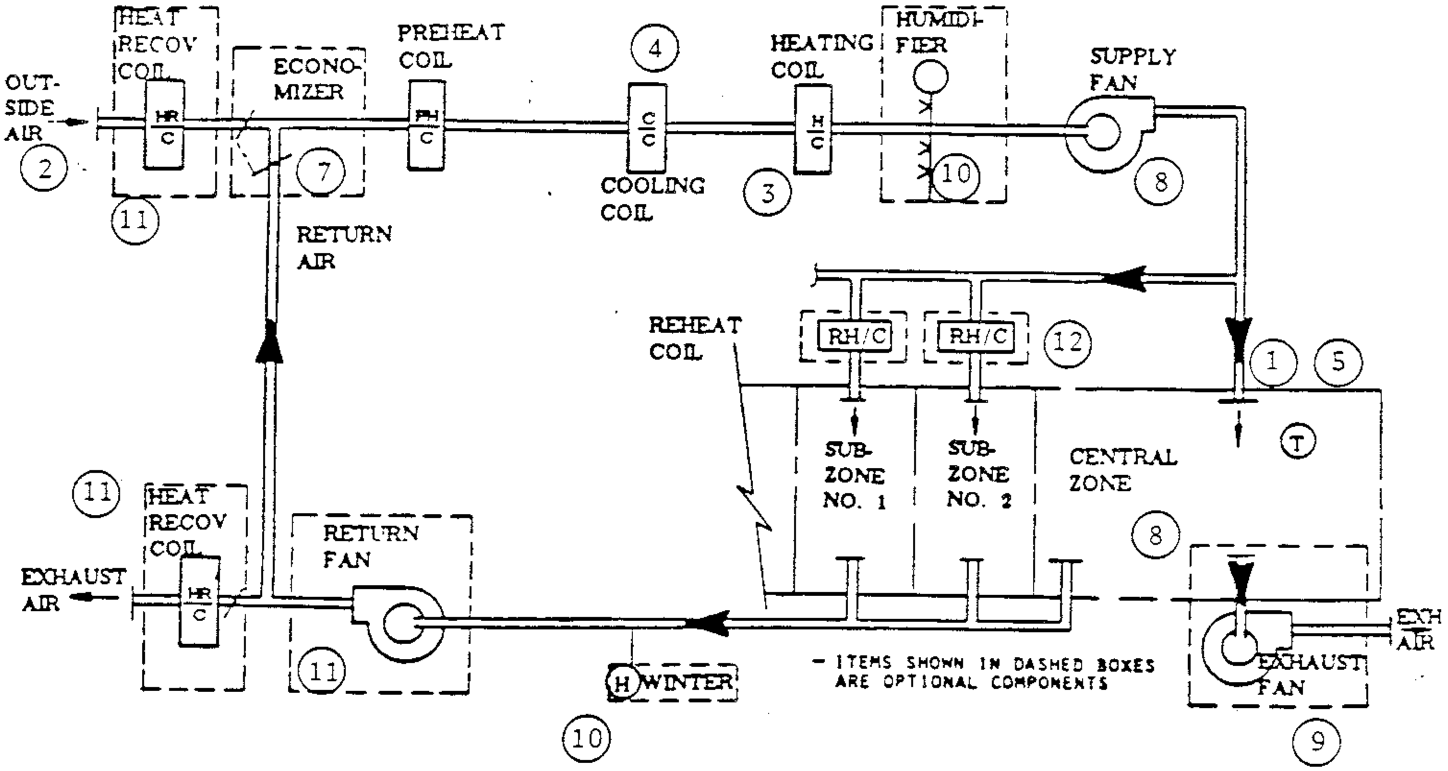


Figure 4.5: Single-Zone Fan System with Optional Subzone Reheat

Suggested minimal input for SZRH system with an economizer:

```
INPUT SYSTEMS ..

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

                        $ SYSTEMS SCHEDULES

FANS-ON = SCHEDULE THRU DEC 31         (WD)     (1,7)(0)
                                                (8,18)(1) (19,24)(0)
                                       (WEH)    (1,24)(0) ..
COOLSETPT = SCHEDULE THRU DEC 31       (WD)     (1,7)(99)
                                                (8,18)(76) (19,24)(99)
                                       (WEH)    (1,24)(99) ..
HEATSETPT = SCHEDULE THRU DEC 31       (WD)     (1,7)(55)
                                                (8,18)(72) (19,24)(55)
                                       (WEH)    (1,24)(55) ..


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

AC-SYST = SYSTEM       SYSTEM-TYPE         =    SZRH
                       MAX-SUPPLY-T        =    110 ③
                       MIN-SUPPLY-T        =    55 ④
                       NIGHT-CYCLE-CTRL    =    CYCLE-ON-FIRST ⑤
                       FAN-SCHEDULE        =    FANS-ON ⑥
                       ECONO-LIMIT-T       =    68 ⑦
                       OA-CONTROL          =    TEMP ⑦
                       ZONE-NAMES          =    (OFFICE) .. ⑧
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..

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

PLANT-PARAMETERS     BOILER-FUEL = NATURAL-GAS
                     HERM-REC-COND-TYPE = AIR ..

END ..

COMPUTE  PLANT ..
```

Additional capabilities for this system:

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

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

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

4) To disable the economizer change OA–CONTROL = TEMP to OA–CONTROL = FIXED. ⑦

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

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

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

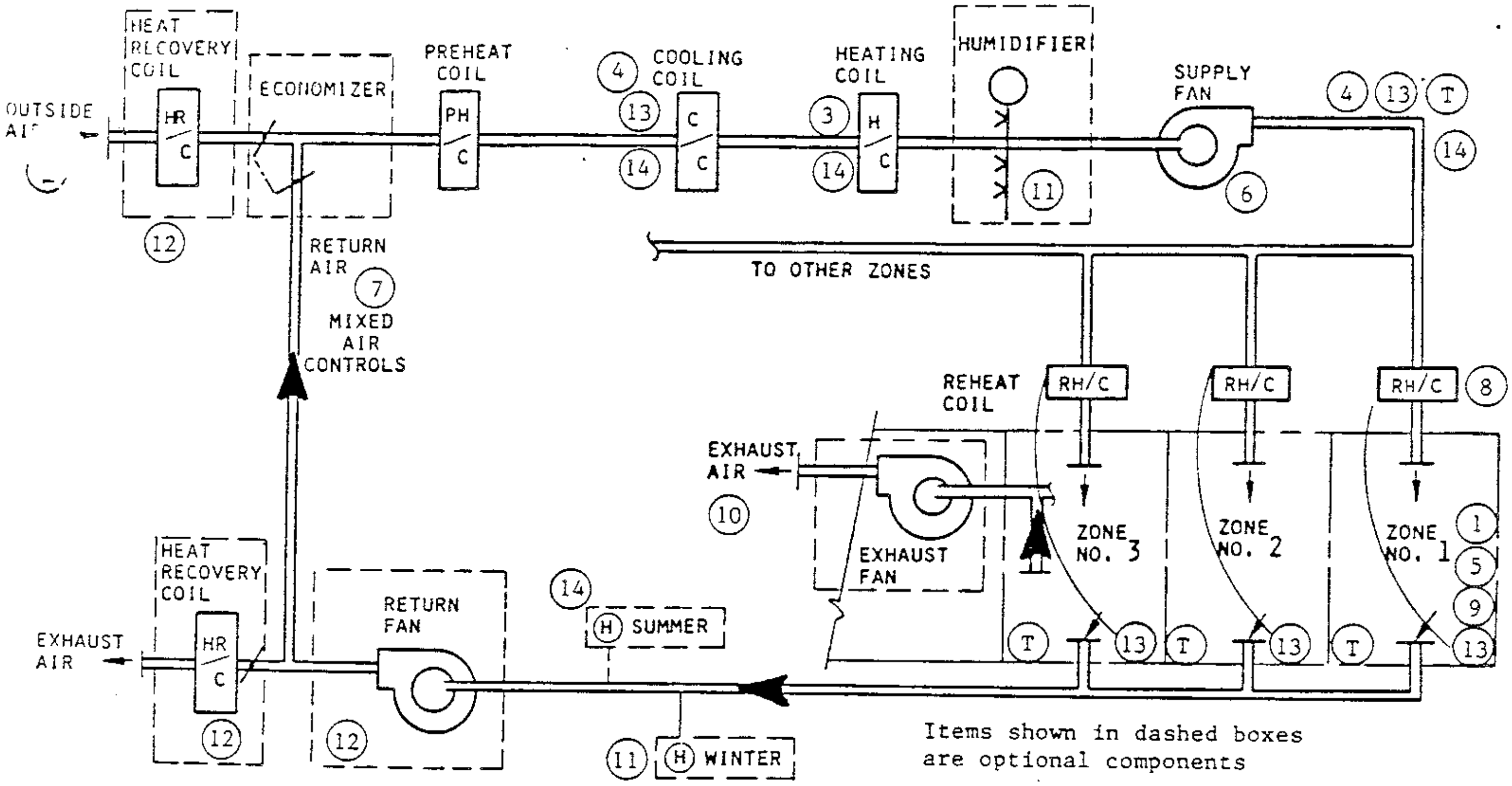
and add

```
COOLING–SCHEDULE = COOL–OFF
```

to the SYSTEM keyword list.

Constant-Volume Reheat Fan System (RHFS)

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



Items shown in dashed boxes are optional components

Figure 4.6: Constant-Volume Reheat Fan System (RHFS)

Suggested minimal input for RHFS system with an economizer:

```
INPUT SYSTEMS ..

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

                      $ SYSTEMS SCHEDULES

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

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

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


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

AC-SYST = SYSTEM      SYSTEM-TYPE           =    RHFS
                      MAX-SUPPLY-T          =    110③
                      MIN-SUPPLY-T          =    55 ④
                      NIGHT-CYCLE-CTRL      =    CYCLE-ON-FIRST⑤
                      FAN-SCHEDULE          =    FANS-ON ⑥
                      OA-CONTROL            =    TEMP ⑦
                      ECONO-LIMIT-T         =    68   7
                      REHEAT-DELTA-T        =    55 ⑧
                      ZONE-NAMES            =    (OFFICE) .. ⑨
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..

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

PLANT-PARAMETERS     BOILER-FUEL = NATURAL-GAS
                     HERM-REC-COND-TYPE = AIR  ..

END  ..
COMPUTE  PLANT  ..
```

Additional capabilities for this system:

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

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

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

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

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

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

7) To enable control of maximum humidity whenever the supply air temperature is reset, insert MAXIMUM-HUMIDITY = Value (60% is allowed in the new ASHRAE 90.1P 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.

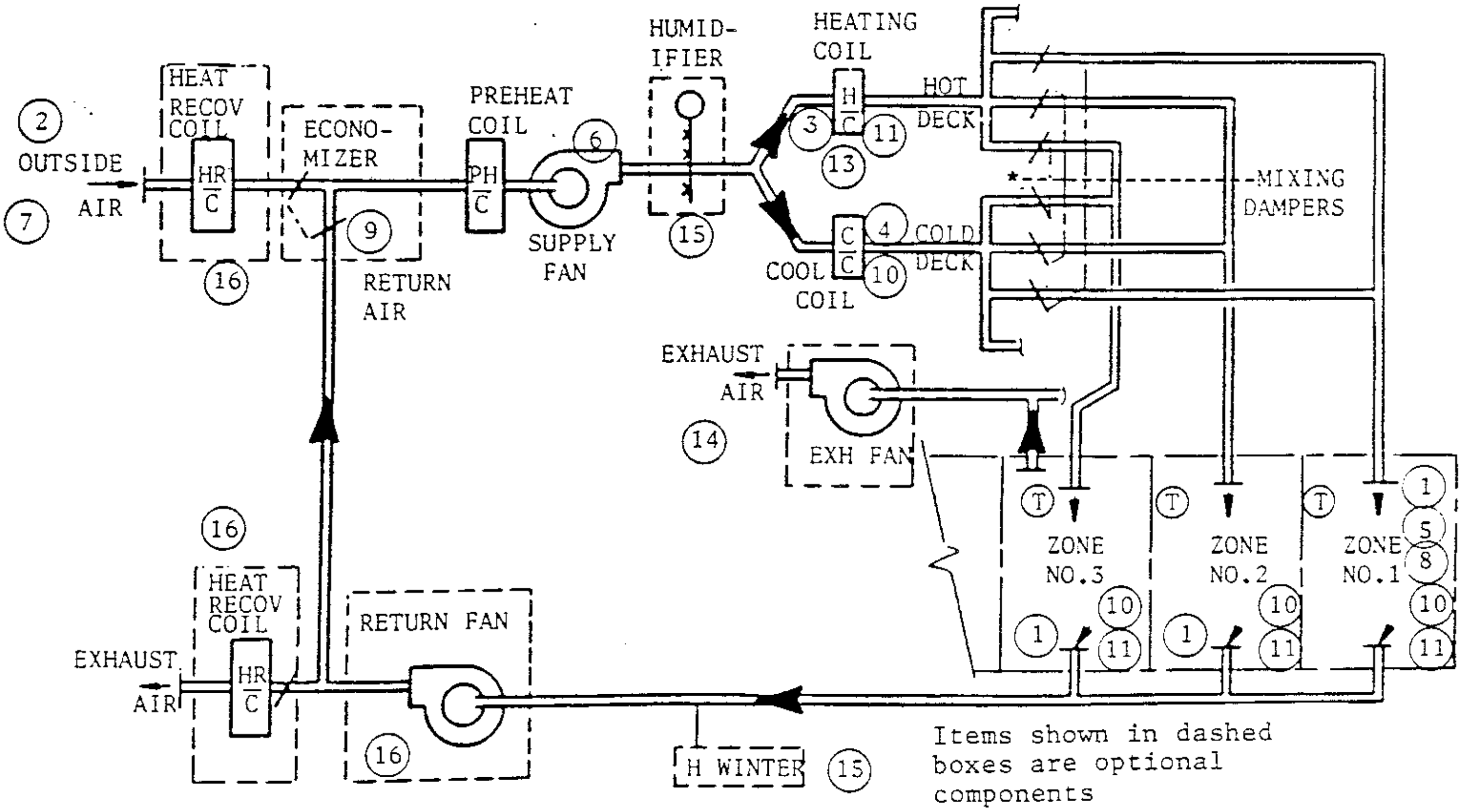


Figure 4.7: Multizone Fan System (MZS)

Suggested minimal input for MZS system:

```
INPUT SYSTEMS ..

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

                        $ SYSTEMS SCHEDULES

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

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


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

AC-SYST = SYSTEM     SYSTEM-TYPE            =     MZS
                     MAX-SUPPLY-T           =     110 ③
                     MIN-SUPPLY-T           =     55 ④
                     NIGHT-CYCLE-CTRL       =     CYCLE-ON-FIRST ⑤
                     FAN-SCHEDULE           =     FANS-ON ⑥
                     OA-CONTROL             =     FIXED⑦
                     ZONE-NAMES             =     (OFFICE) ..  ⑧
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..

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

PLANT-PARAMETERS    BOILER-FUEL = NATURAL-GAS
                    HERM-REC-COND-TYPE = AIR ..

END ..

COMPUTE  PLANT ..
```

Additional capabilities for this system:

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

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

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

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

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

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

   and add

   HEATING–SCHEDULE = HEAT–OFF

   to the SYSTEM keyword list.

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

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

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

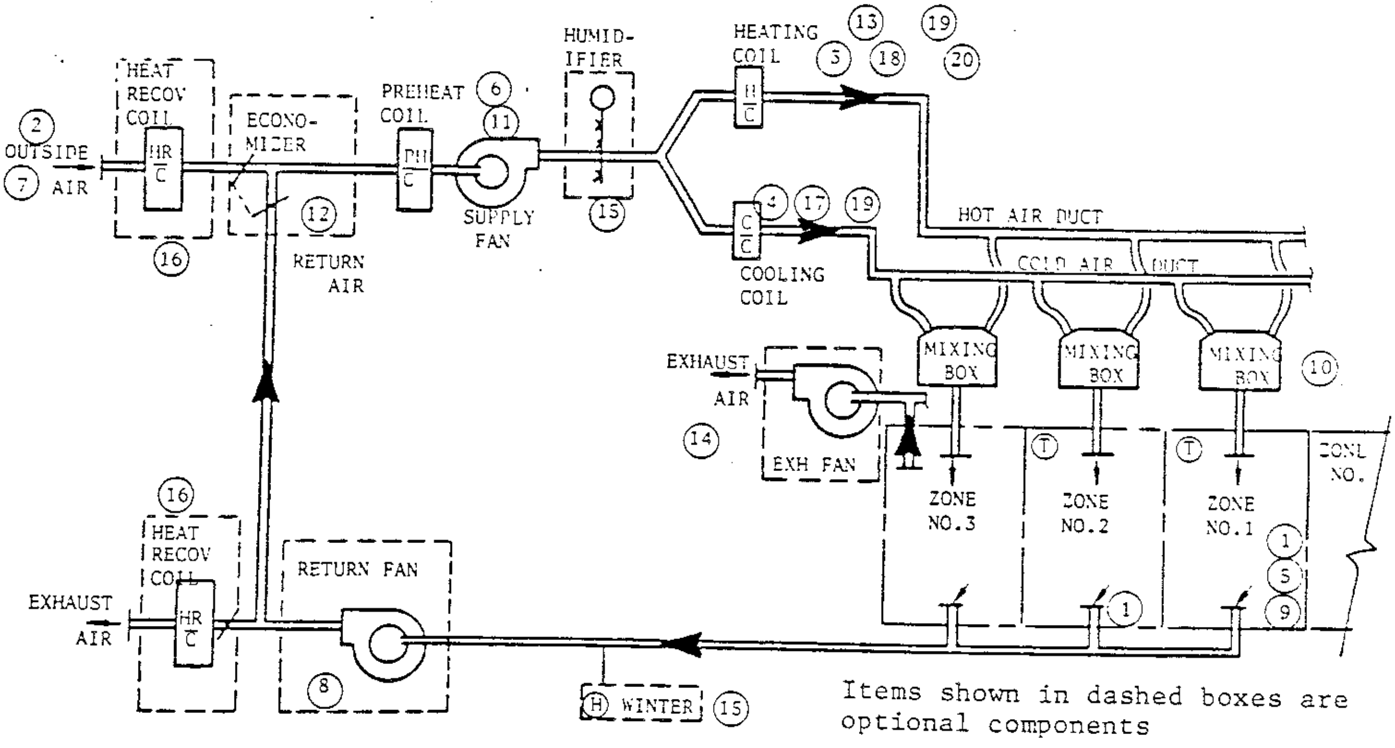
Dual-Duct Fan System (DDS)

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

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

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

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



Items shown in dashed boxes are optional components

Figure 4.8: Dual-Duct Fan System (DDS)

Suggested minimal input for DDS system:

```
INPUT SYSTEMS ..

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

                       $ SYSTEMS SCHEDULES

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

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

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

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

AC-SYST = SYSTEM     SYSTEM-TYPE           =    DDS
                     MAX-SUPPLY-T          =    110 ③
                     MIN-SUPPLY-T          =    55 ④
                     NIGHT-CYCLE-CTRL      =    CYCLE-ON-FIRST⑤
                     FAN-SCHEDULE          =    FANS-ON ⑥
                     OA-CONTROL            =    FIXED ⑦
                     RETURN-STATIC         =    1.0⑧
                     RETURN-EFF            =    .55⑧
                     ZONE-NAMES            =    (OFFICE) .. ⑨
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..

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

PLANT-PARAMETERS    BOILER-FUEL = NATURAL-GAS
                    HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

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

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

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

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

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

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

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

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

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

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

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

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

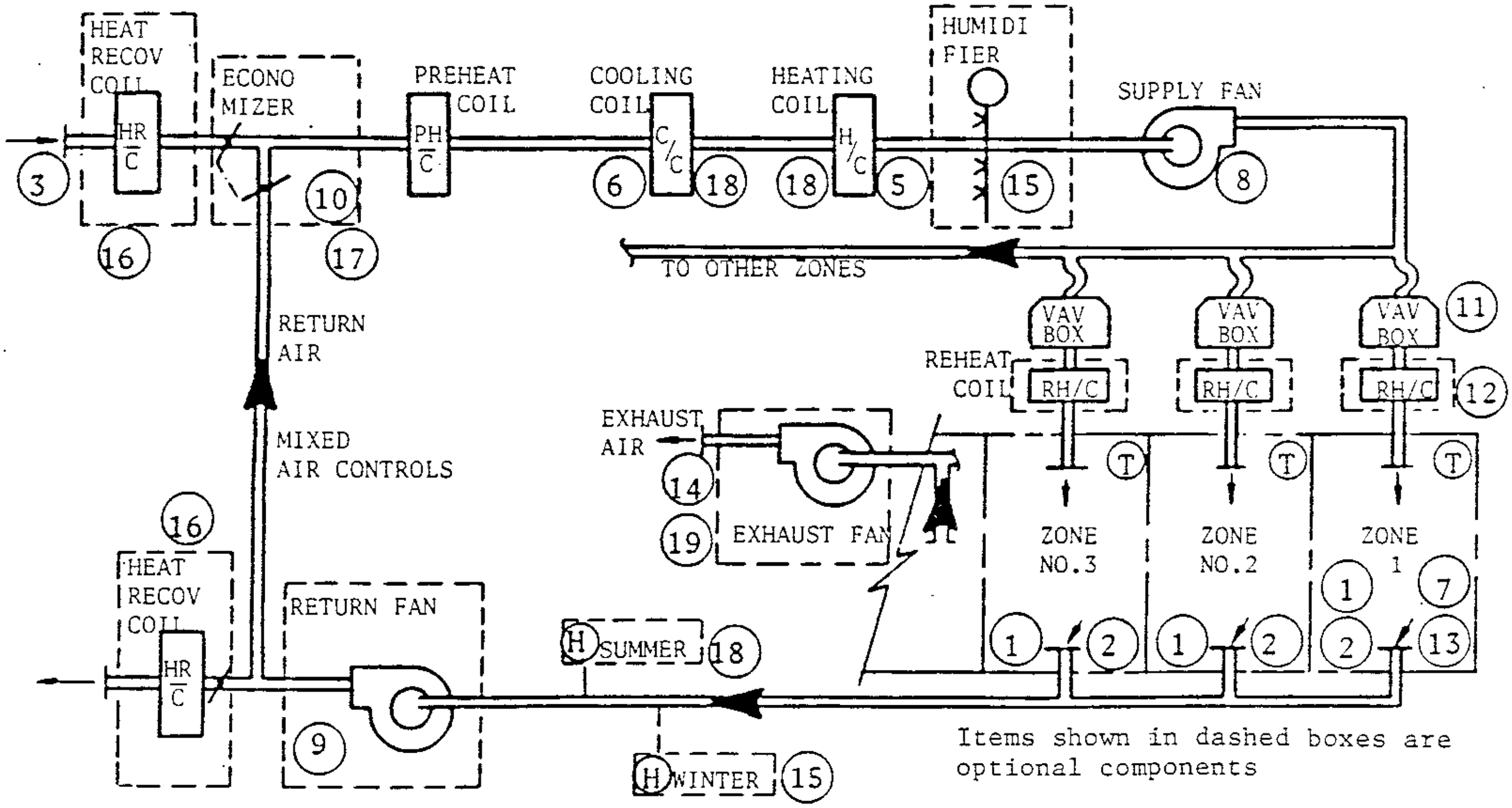
11) To simulate turning "off" the hot deck whenever the outside temperature is above 65°F, insert a new schedule like this: ⑳

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

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

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

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



Items shown in dashed boxes are optional components

Figure 4.9: Variable-Volume Fan System with Optional Reheat (VAVS)

Suggested minimal input for VAVS system:

```
INPUT SYSTEMS ..

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

                        $ SYSTEMS SCHEDULES

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

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

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


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

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

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

PLANT-PARAMETERS   BOILER-FUEL = NATURAL-GAS
                   HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

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

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

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

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

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

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

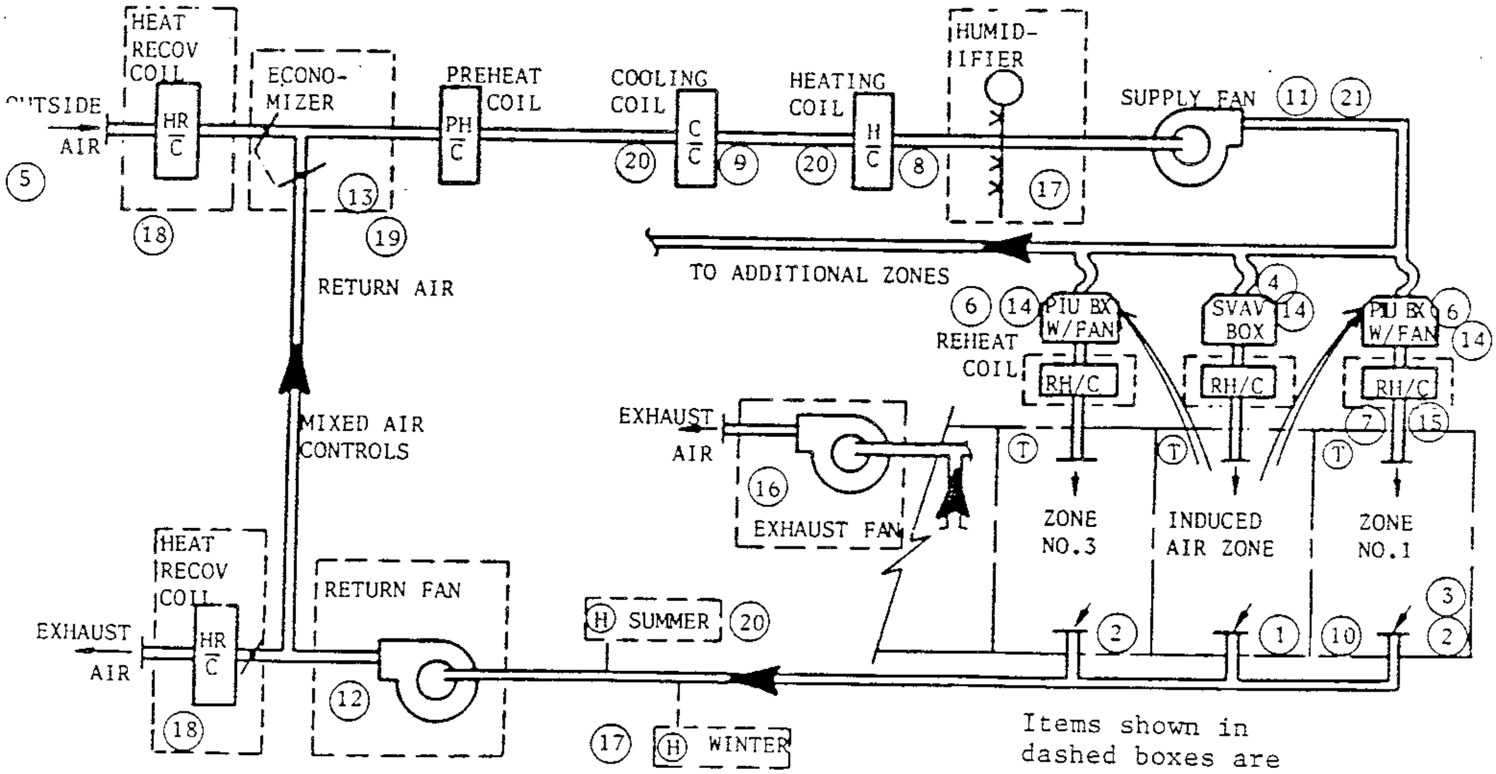
7) Simulating baseboard heat in lieu or in addition to reheat coils is demonstrated in the *Sample Run Book (2.1E)*, 31-Story Office Building, Run 1.

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

Powered Induction Unit (PIU)

The basic PIU consists of a central air-handling unit with filter (not shown), cooling and optional heating coils, and a draw-through type supply air fan. A return air fan is also usually used. Exhaust fans are optional for any or all zones.

The powered induction boxes are available in two configurations: *series* and *parallel.*



Items shown in dashed boxes are optional components

Figure 4.10: Powered Induction Unit System with Optional Reheat

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

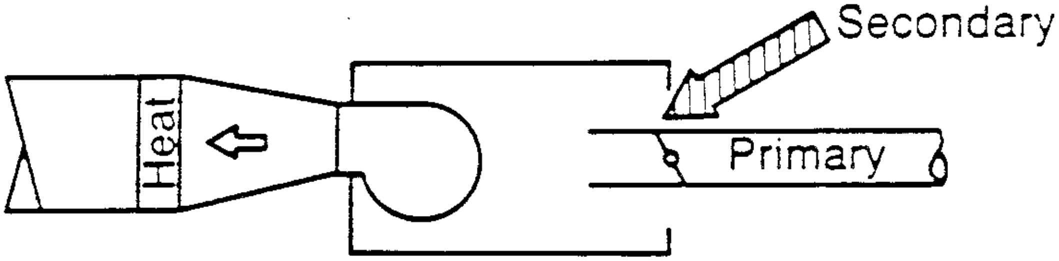


Figure 4.11: Series PIU

```
INPUT SYSTEMS ..

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

                     $ SYSTEMS SCHEDULES

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

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

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

CORE = ZONE        DESIGN-HEAT-T        =    72
   ①               DESIGN-COOL-T        =    74
                   HEAT-TEMP-SCH        =    HEATSETPT ③
                   COOL-TEMP-SCH        =    COOLSETPT ③
                   TERMINAL-TYPE        =    SVAV ④
                   CFM/SQFT             =    .7
                   OA-CFM/PER           =    15 .. ⑤
OFFICE = ZONE      LIKE CORE
   ②               TERMINAL-TYPE        =    SERIES-PIU
                   ZONE-FAN-RATIO       =    1 ⑥
                   ZONE-FAN-KW          =    .00033 ⑥
                   INDUCED-AIR-ZONE     =    CORE ①
                   REHEAT-DELTA-T       =    55 .. ⑮
```

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

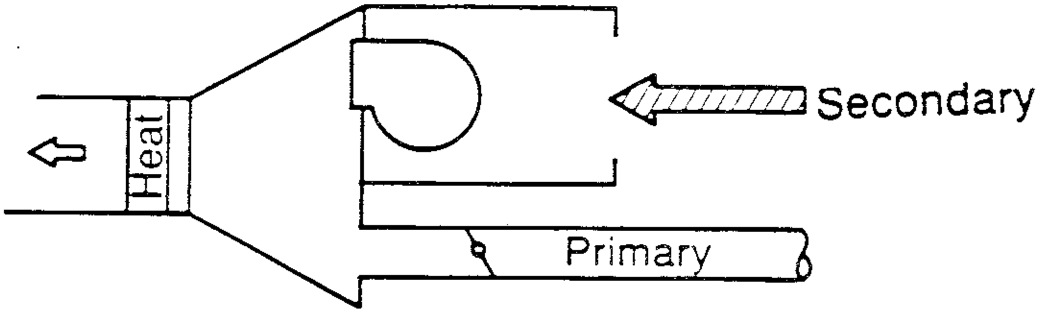


Figure 4.12: Parallel PIU

```
INPUT SYSTEMS ..

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

                    $ SYSTEMS SCHEDULES

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

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

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


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


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

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

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

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

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

PLANT-PARAMETERS    BOILER-FUEL = NATURAL-GAS
                    HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capabilities for this system:

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

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

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

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

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

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

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

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

Two-Pipe Fan Coil System (TPFC)

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

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

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

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

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

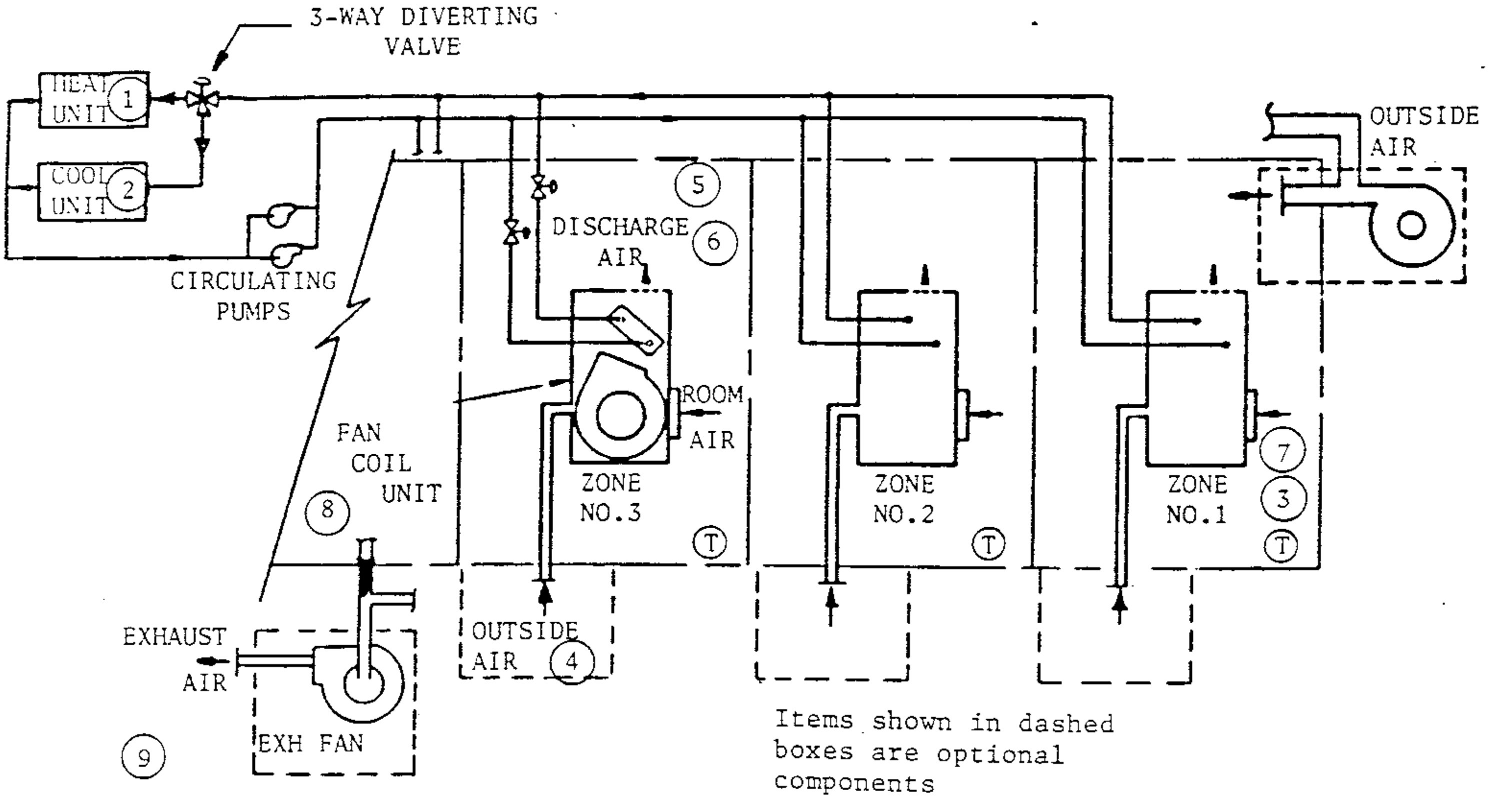


Figure 4.13: Two-Pipe Fan Coil System (TPFC)

Suggested minimal input for TPFC system:

```
INPUT SYSTEMS ..

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

                    $ SYSTEMS SCHEDULES

FANS-ON =   SCHEDULE THRU DEC 31        (WD)     (1,7)(0) (8,18)(1)
                                                 (19,24)(0)
                                        (WEH)    (1,24)(0) ..
COOLSETPT = SCHEDULE THRU DEC 31        (WD)     (1,7)(99) (8,18)(76)
                                                 (19,24)(99)
                                        (WEH)    (1,24)(99) ..
HEATSETPT = SCHEDULE THRU DEC 31        (WD)     (1,7)(55) (8,18)(72)
                                                 (19,24)(55)
                                        (WEH)    (1,24)(55) ..


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

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

OFFICE = ZONE        DESIGN-HEAT-T         =    72
                     DESIGN-COOL-T         =    74
                     HEAT-TEMP-SCH         =    HEATSETPT ③
                     COOL-TEMP-SCH         =    COOLSETPT ③
                     OA-CFM/PER            =    15 .. ④
AC-SYST = SYSTEM     SYSTEM-TYPE           =    TPFC
                     HEATING-SCHEDULE      =    HEAT-ON ①
                     COOLING-SCHEDULE      =    COOL-ON ②
                     MAX-SUPPLY-T          =    110 ⑤
                     MIN-SUPPLY-T          =    55  ⑥
                     NIGHT-CYCLE-CTRL      =    CYCLE-ON-ANY ⑦
                     FAN-SCHEDULE          =    FANS-ON ⑧
                     ZONE-NAMES            =    (OFFICE) ..
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
PLANT-REPORT SUMMARY = (BEPS) ..
```

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

PLANT-PARAMETERS    BOILER-FUEL = NATURAL-GAS
                    HERM-REC-COND-TYPE = AIR ..

END ..
COMPUTE PLANT ..
```

Additional capability for this system:

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

Four-Pipe Fan Coil System (FPFC)

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

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

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

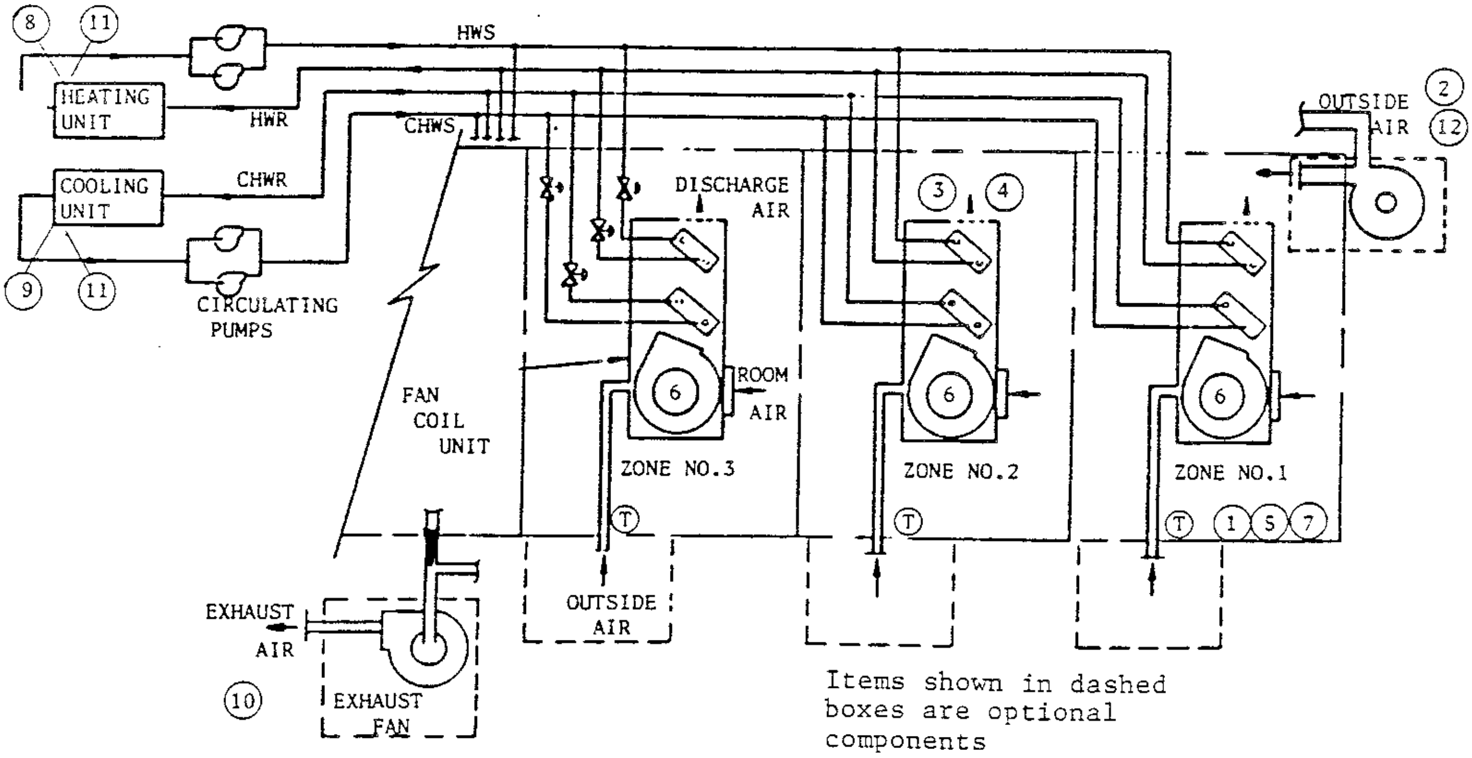


Figure 4.14: Four-Pipe Fan Coil System (FPFC)

Suggested minimal input for FPFC system:

```
INPUT SYSTEMS ..

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

                        $ SYSTEMS SCHEDULES

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

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

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


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

AC-SYST = SYSTEM      SYSTEM-TYPE         =     FPFC
                      MAX-SUPPLY-T        =     110 ③
                      MIN-SUPPLY-T        =     55  ④
                      NIGHT-CYCLE-CTRL    =     CYCLE-ON-ANY  ⑤
                      FAN-SCHEDULE        =     FANS-ON ⑥
                      ZONE-NAMES          =     (OFFICE) ..  ⑦
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..

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

PLANT-PARAMETERS    BOILER-FUEL = NATURAL-GAS
                    HERM-REC-COND-TYPE = AIR ..
END ..
COMPUTE  PLANT ..
```

Additional capabilities for this system:

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

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

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

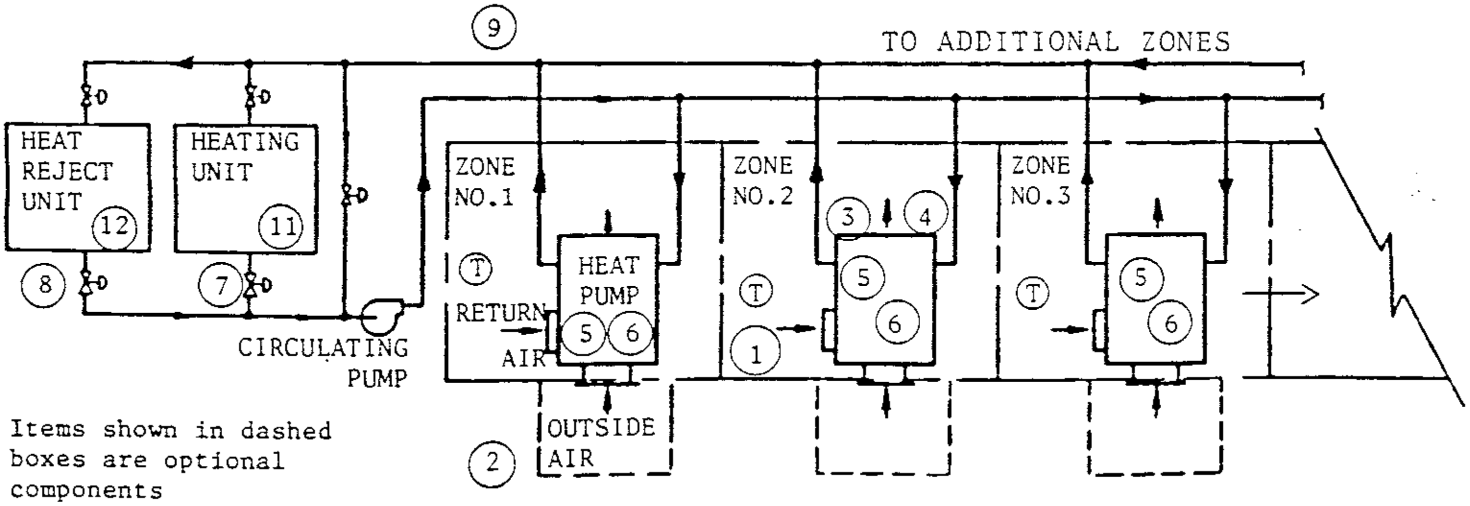
COOL–ON = SCHEDULE   THRU DEC 31 (ALL) (1,24)(60)
                     THRU SEP 15 (ALL) (1,24)(1)
                     THRU DEC 31 (ALL) (1,24)(60) ..
```

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

Unitary Hydronic Heat Pump System (HP)

The HP system provides heating and cooling for individually controlled zones through heat pump units located in each space to be conditioned. Each heat pump unit may provide a fixed quantity of outside air ventilation, or merely recirculate conditioned air. Each heat pump consists of a refrigerant compressor, room air-to-refrigerant heat exchanger, working fluid-to-refrigerant heat exchanger (connected to the pipe loop), controls to switch the evaporating and condensing functions from one heat exchanger to the other, supply air fan, and two-setpoint ZONE thermostat. When the heat pump is in the room heating mode of operation, the room air-to-refrigerant heat exchanger is used for refrigerant condensing. In the room cooling mode, this same heat exchanger is used for refrigerant evaporating. Each heat pump provides dehumidification in the cooling mode but has no dehumidification control.

Temperature is controlled in each zone by on-off operation of the heat pump unit (fan and compressor). The type of thermostat used for this system has two individual setpoints. The heat pump unit provides cooling when space temperature increases to the upper setpoint, and heating when the space temperature falls to the lower setpoint; it does not operate when space temperature is between setpoints. If outside air is specified the fan operates continuously; otherwise, the fan cycles on and off with the refrigeration compressor. A piping system with circulating fluid is connected to the water-to-refrigerant heat exchanger in the heat pump. The circulating fluid absorbs heat from units operating in the cooling mode, and gives up heat to units operating in the heating mode. Because some zone units may be cooling while others are heating, the temperature of the circulating fluid will depend on the relative quantities of each. When cooling demand exceeds heating demand, and the fluid temperature increases to the highest allowable value (see keyword MAX-FLUID-T in the SYSTEM-FLUID command), heat is dissipated to the atmosphere through an evaporative cooler or cooling tower. When heating demand exceeds cooling demand, and the fluid temperature decreases to the minimum allowable value (see keyword MIN-FLUID-T in the SYSTEM-FLUID instruction), heat is added from a boiler or other heat source. No heat is added or rejected when heating and cooling requirements balance. The most common hydronic heat pump systems maintain the water in the circulating loop between 60°F and 90°F. The heat rejection unit (evaporative condenser or cooling tower), heating unit, and circulating pump are simulated by PLANT.



Items shown in dashed boxes are optional components

Figure 4.15: Unitary Hydronic Heat Pump System (HP)

Suggested minimal input for HP system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..
                   $ SYSTEMS SCHEDULES
FANS-ON =   SCHEDULE THRU DEC 31      (WD)    (1,7)(0) (8,18)(1)
                                              (19,24)(0)
                                      (WEH)   (1,24)(0) ..
COOLSETPT = SCHEDULE THRU DEC 31      (WD)    (1,7)(99) (8,18)(76)
                                              (19,24)(99)
                                      (WEH)   (1,24)(99) ..
HEATSETPT = SCHEDULE THRU DEC 31      (WD)    (1,7)(55) (8,18)(72)
                                              (19,24)(55)
                                      (WEH)   (1,24)(55) ..

OFFICE = ZONE          DESIGN-HEAT-T        =   72
                       DESIGN-COOL-T        =   74
                       HEAT-TEMP-SCH        =   HEATSETPT ①
                       COOL-TEMP-SCH        =   COOLSETPT ①
                       OA-CFM/PER           =   15 .. ②
AC-SYST = SYSTEM       SYSTEM-TYPE          =   HP
                       MAX-SUPPLY-T         =   110  ③
                       MIN-SUPPLY-T         =   55   ④
                       NIGHT-CYCLE-CTRL     =   CYCLE-ON-ANY ⑤
                       FAN-SCHEDULE         =   FANS-ON ⑥
                       MIN-FLUID-T          =   60 ⑦
                       MAX-FLUID-T          =   90 ⑧
                       FLUID-HEAT-CAP*      =   (estimated lbs of water in system
                                                plus that in any storage tank)   ⑨
                       FLUID-VOLUME**       =   25.0 (gallons of water/ton)
                       ZONE-NAMES           =   (OFFICE) ..   ⑩
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..

SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER     SIZE = -999 ..
HWG = PLANT-EQUIPMENT    TYPE = HW-BOILER      SIZE = -999 ..  ⑪
WCL = PLANT-EQUIPMENT    TYPE = COOLING-TWR    SIZE = -999 ..  ⑫

PLANT-PARAMETERS    BOILER-FUEL = NATURAL-GAS ..
END ..
COMPUTE  PLANT ..
```

---

* use for program versions to and including 2.1D

** use for program version 2.1E

Additional capabilities for this system: (2.1E)

1) Outside air economizer and water side economizers.
2) Scheduled control of water loop temperatures.

Residential System (RESYS)

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

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

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

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

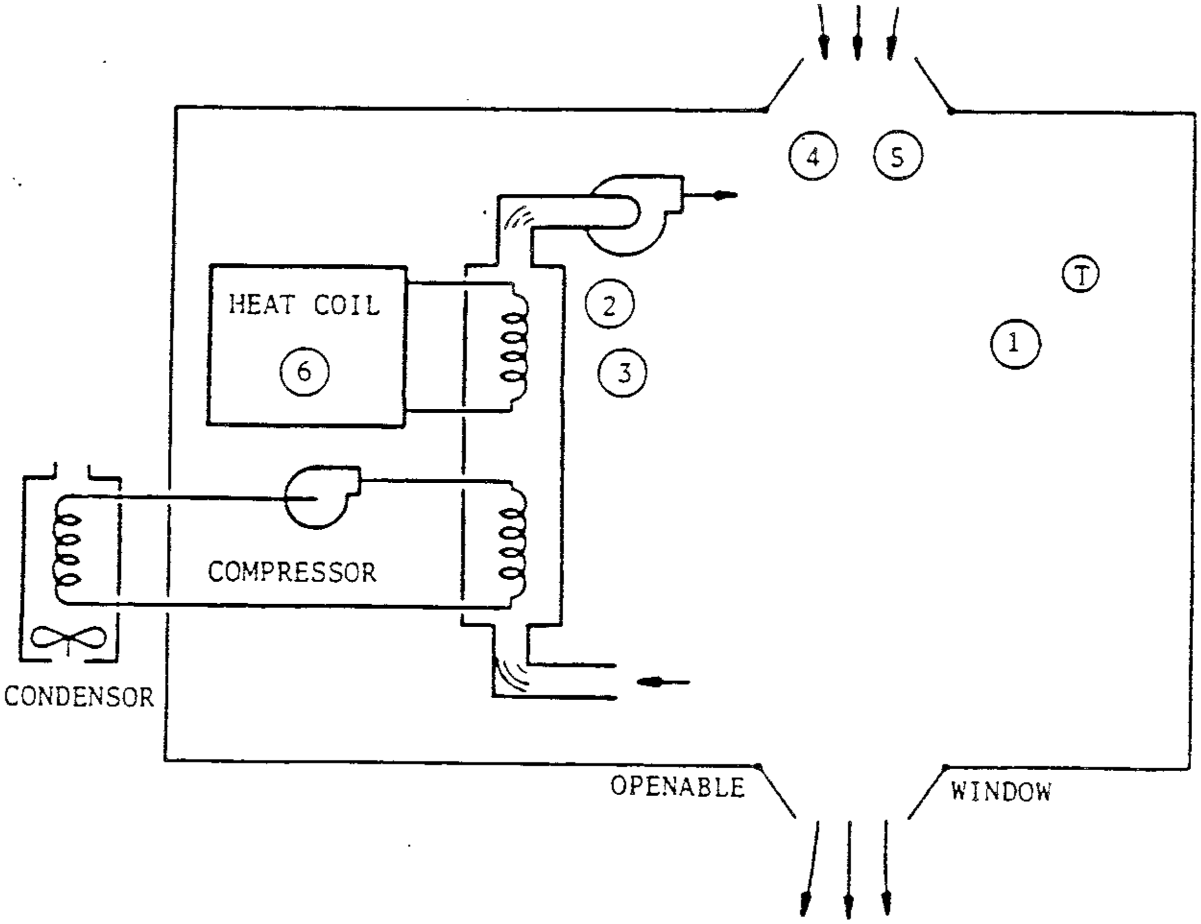


Figure 4.16: Residential System - DX with Heating Coil

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

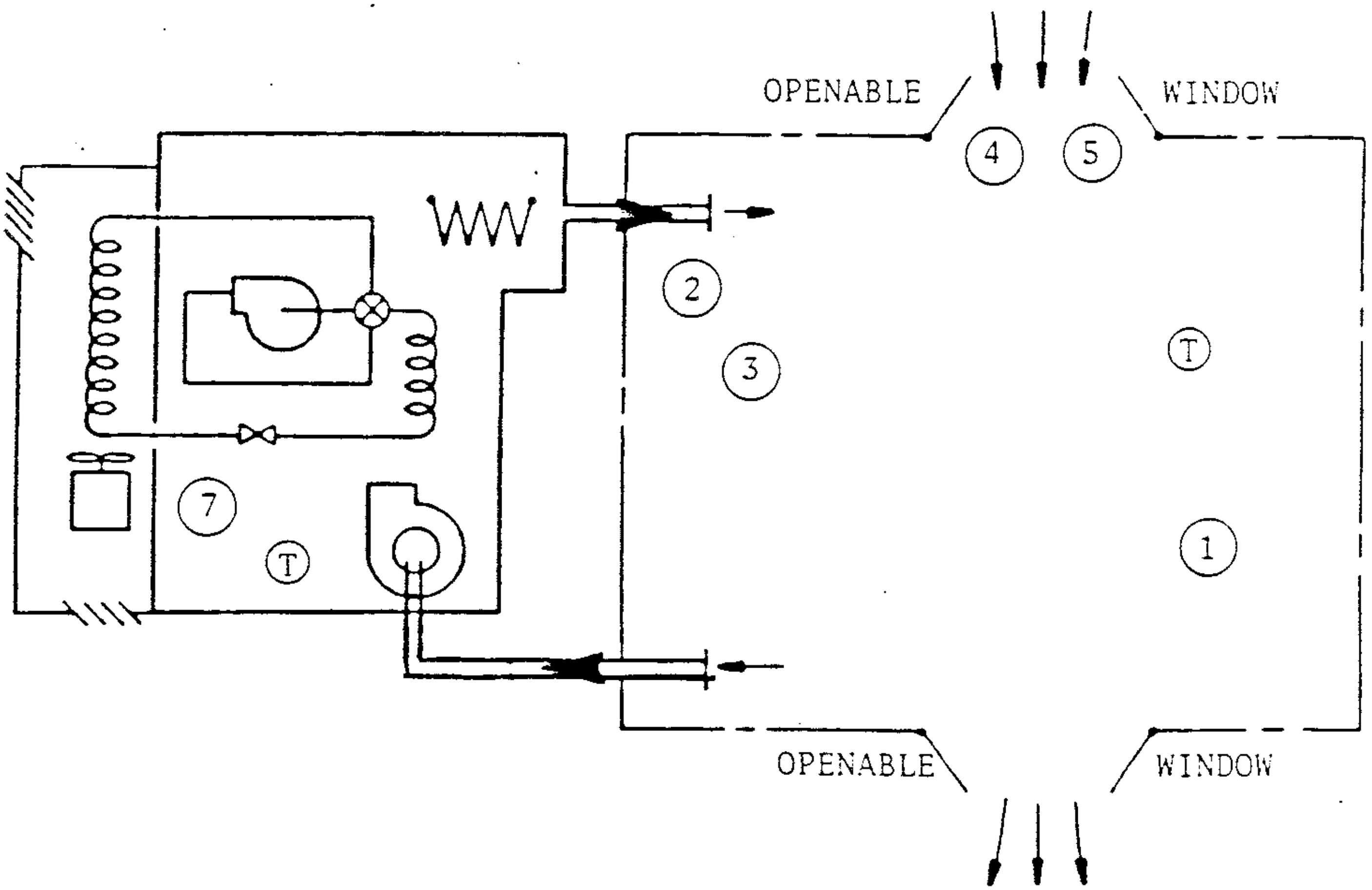


Figure 4.17: Residential Air-to-Air Heat Pump

Suggested minimal input for RESYS system:

```
INPUT SYSTEMS ..

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

                         $ SYSTEMS SCHEDULES

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

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

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


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

AC-SYST = SYSTEM       SYSTEM-TYPE            =    RESYS
                       MAX-SUPPLY-T           =    110②
                       MIN-SUPPLY-T           =    55 ③
                       NATURAL-VENT-AC        =    10 ④
                       NATURAL-VENT-SCH       =    WINDOWS-OPENABLE ⑤
                       HEAT-SOURCE            =    GAS-FURNACE ⑥
                                                      $ or HEAT-PUMP ⑦
                       ZONE-NAMES             =    (OFFICE) ..
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT  TYPE = DHW-HEATER  SIZE = -999 ..
END ..
COMPUTE PLANT ..
```

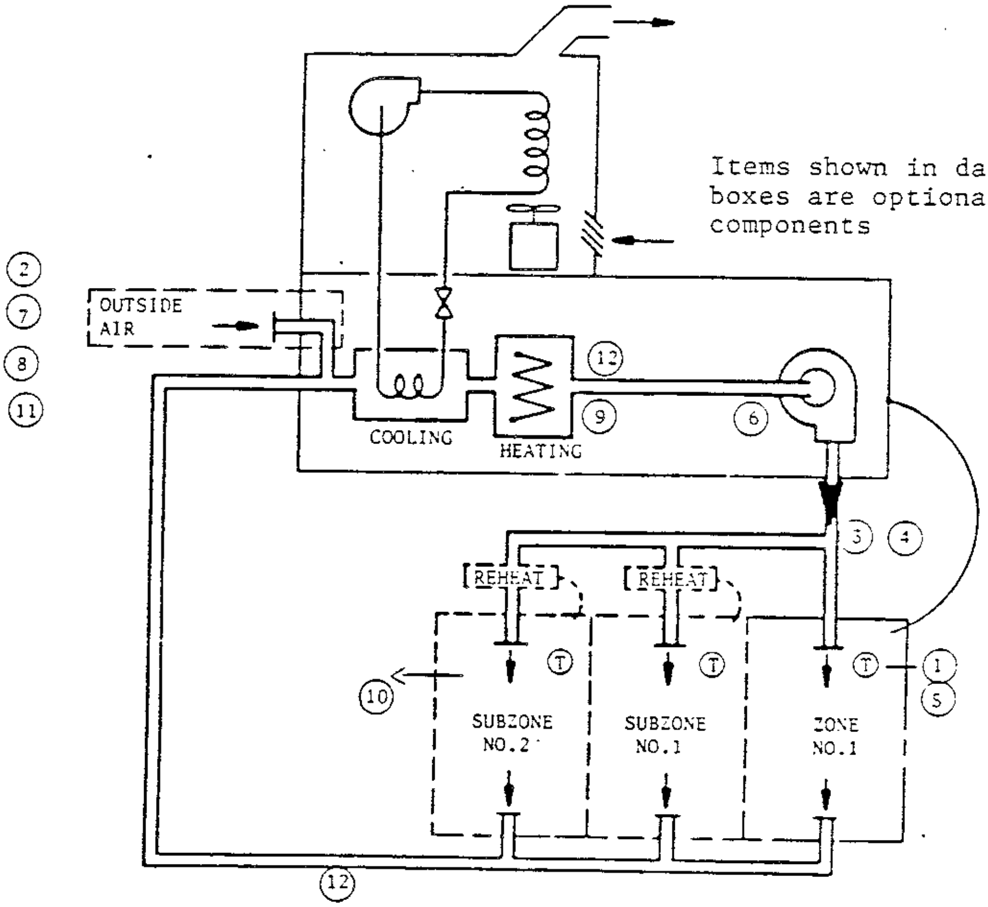
Additional capability for this system:

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

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

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

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



Items shown in dashed boxes are optional components

Figure 4.18: Packaged Single Zone Air Conditioner with Heating and Subzone Reheating Options (PSZ)

Suggested minimal input for PSZ system:

```
INPUT SYSTEMS ..

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

                        $ SYSTEMS SCHEDULES

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

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

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


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

AC-SYST = SYSTEM       SYSTEM-TYPE          =      PSZ
                       MAX-SUPPLY-T         =      110 ③
                       MIN-SUPPLY-T         =      55 ④
                       NIGHT-CYCLE-CTRL     =      CYCLE-ON-FIRST ⑤
                       FAN-SCHEDULE         =      FANS-ON ⑥
                       OA-CONTROL           =      TEMP ⑦
                       ECONO-LIMIT-T        =      60 ⑧
                       HEAT-SOURCE          =      GAS-FURNACE ⑨
                                                   $ or HEAT-PUMP,
                                                   $ ELECTRIC, or
                                                   $ HOT-WATER
                       ZONE-NAMES           =      (OFFICE) ..
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER   SIZE = -999 ..
END ..
COMPUTE  PLANT ..
```

Additional capabilities for this system:

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

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

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

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

5) For water cooled condenser and water side economizers, use DOE-2.1E.

Packaged Multizone Fan System (PMZS)

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

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

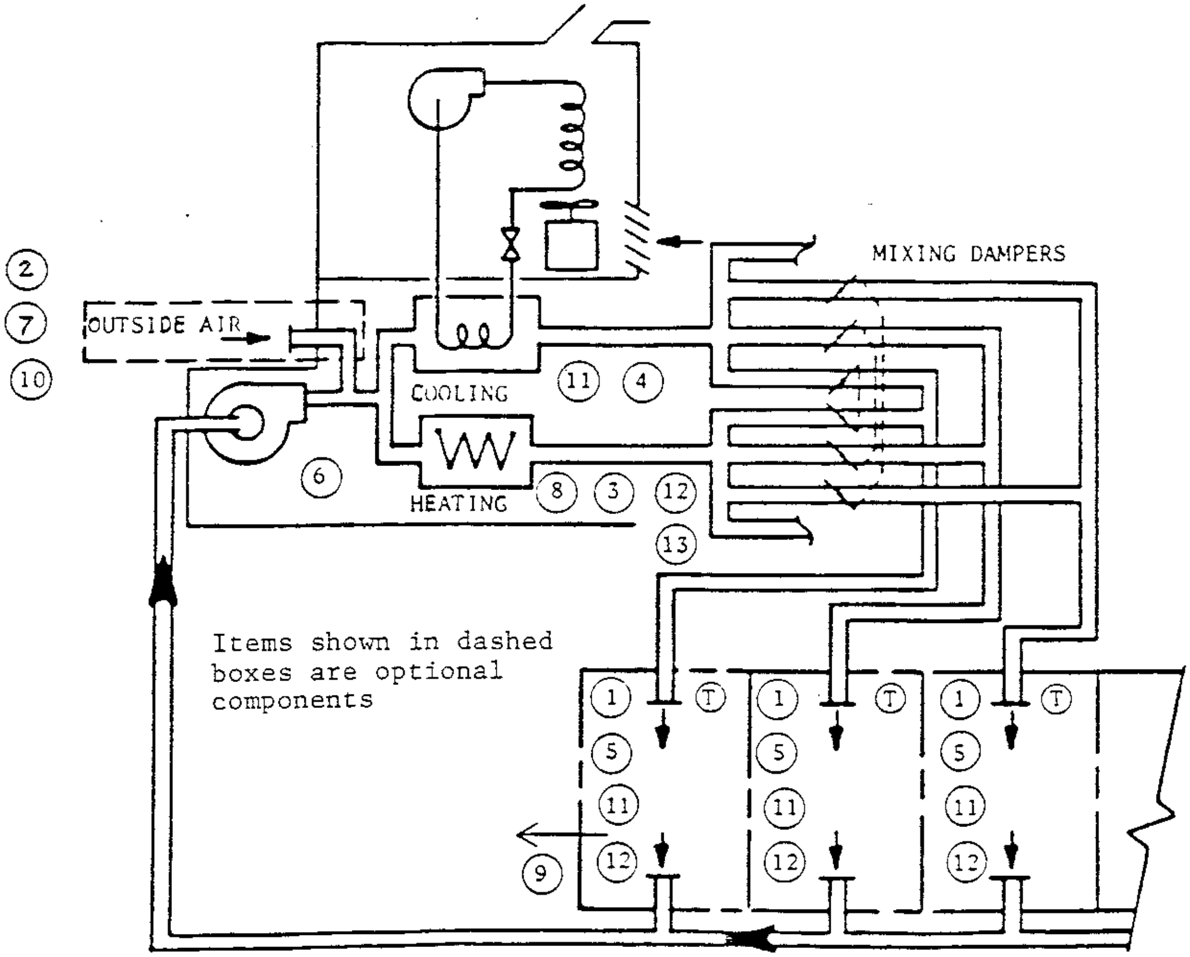


Figure 4.19: Packaged Multione Fan System (PMZS)

Suggested minimal input for PMZS system:

```
INPUT SYSTEMS ..

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

                          $ SYSTEMS SCHEDULES

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

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

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


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

AC-SYST = SYSTEM       SYSTEM-TYPE            =     PMZS
                       MAX-SUPPLY-T           =     110 ③
                       MIN-SUPPLY-T           =     55  ④
                       NIGHT-CYCLE-CTRL       =     CYCLE-ON-ANY ⑤
                       FAN-SCHEDULE           =     FANS-ON ⑥
                       OA-CONTROL             =     TEMP ⑦
                       ECONO-LIMIT-T          =     60 ⑦
                       HEAT-SOURCE            =     ELECTRIC ⑧
                       ZONE-NAMES             =     (OFFICE) ..
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER    SIZE = -999 ..
END ..
COMPUTE  PLANT ..
```

Additional capabilities for this system:

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

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

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

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

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

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

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

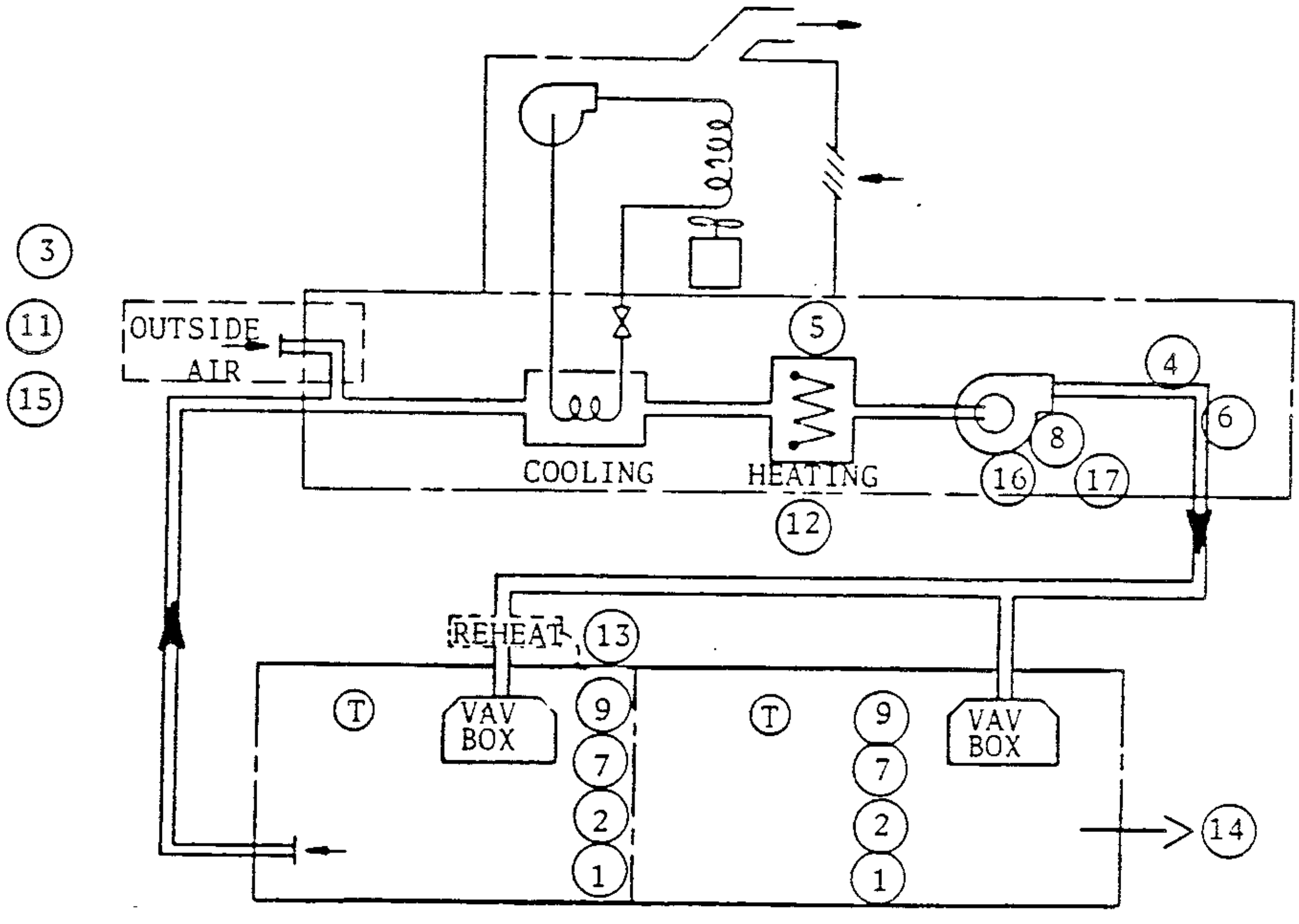
and add

HEATING-SCHEDULE = HEAT-OFF

to the SYSTEM keyword list.

Packaged Variable-Air-Volume System (PVAVS)

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



Items shown in dashed boxes are optional components

Figure 4.20: Packaged Variable-Air-Volume System (PVAVS)

Suggested minimal input for PVAVS system:

```
INPUT SYSTEMS ..

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

                    $ SYSTEMS SCHEDULES

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

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

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

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

AC-SYST = SYSTEM     SYSTEM-TYPE           =   PVAVS
                     MAX-SUPPLY-T          =   110 ④
                     HEAT-SET-T            =   70  ⑤
                     MIN-SUPPLY-T          =   55  ⑥
                     NIGHT-CYCLE-CTRL      =   CYCLE-ON-ANY⑦
                     FAN-SCHEDULE          =   FANS-ON ⑧
                     MIN-CFM-RATIO         =   .3 ⑨
                     REHEAT-DELTA-T        =   55 ⑩
                     OA-CONTROL            =   TEMP ⑪
                     ECONO-LIMIT-T         =   60  ⑪
                     HEAT-SOURCE           =   ELECTRIC  ⑫
                     ZONE-HEAT-SOURCE      =   ELECTRIC  ⑬
                     ZONE-NAMES            =   (OFFICE) ..
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT    TYPE = DHW-HEATER    SIZE = -999 ..
END ..
COMPUTE  PLANT ..
```

Additional capabilities for this system:

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

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

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

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

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

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

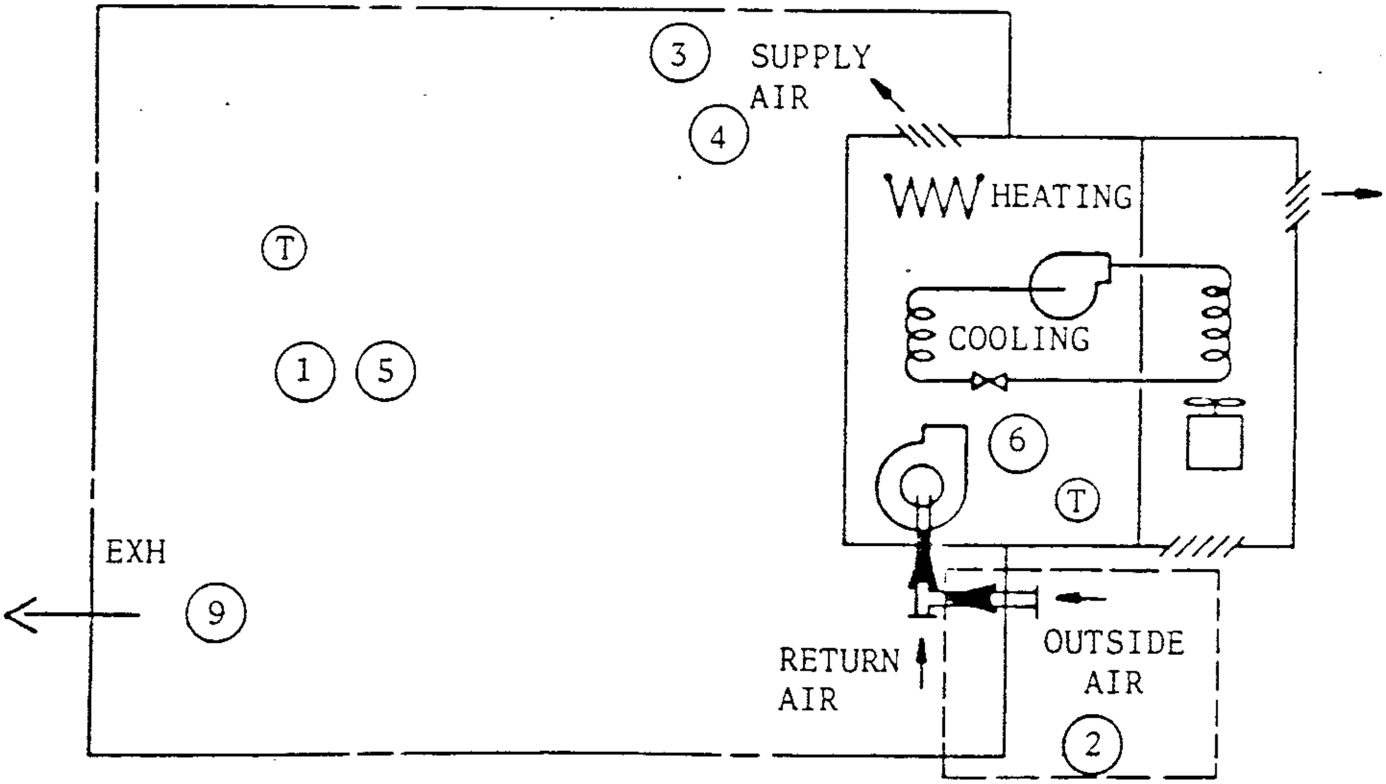
7) For water cooled condenser and water side economizers, use DOE-2.1E.

Packaged Terminal Air Conditioner (PTAC)

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

PTAC with DX Cooling and Electric Resistance Heating

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

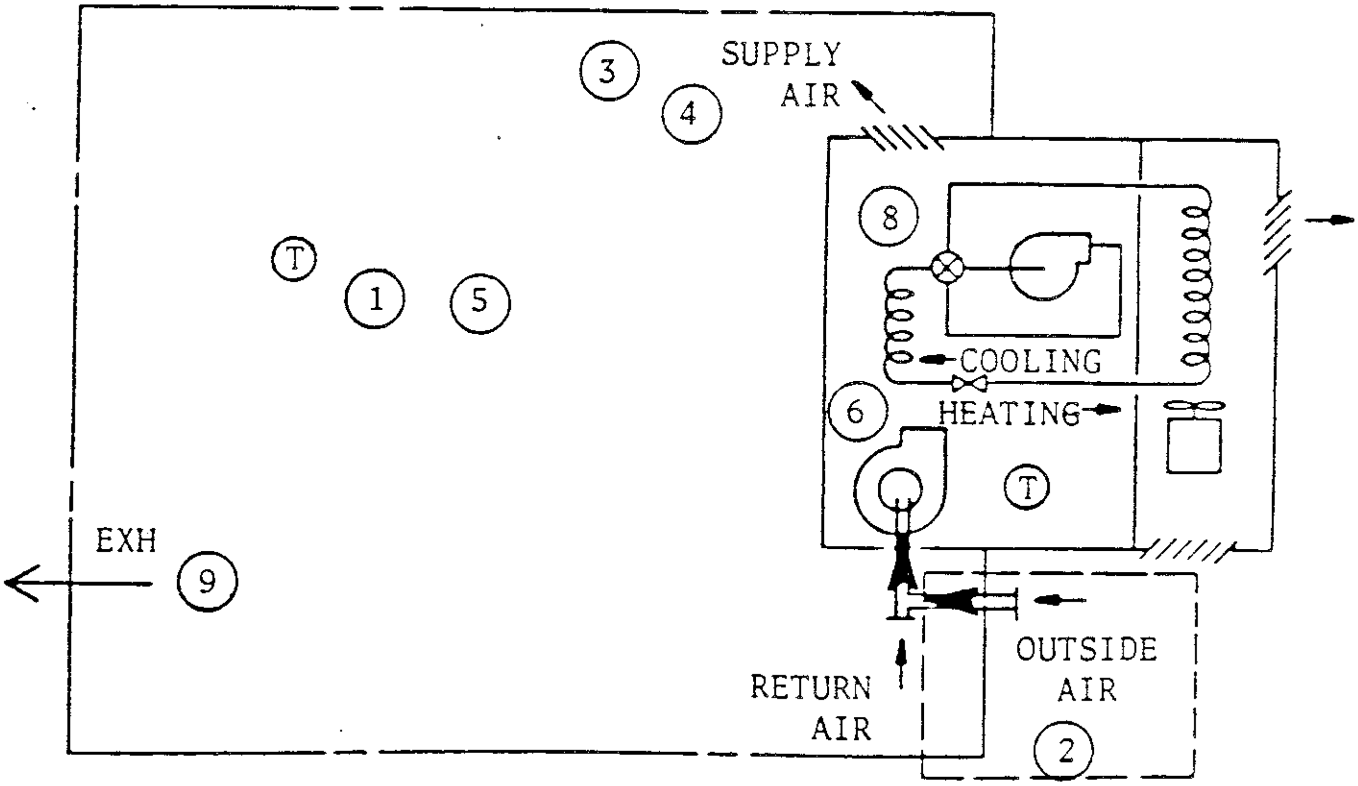


Items shown in dashed boxes are optional components

Figure 4.21: PTAC with DX Cooling

PTAC with Air-to-Air Heat Pump

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



Items shown in dashed boxes are optional components

Figure 4.22: PTAC with Air-to-Air Heat Pump

Suggested minimal input for PTAC system:

```
INPUT SYSTEMS ..

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

                    $ SYSTEMS SCHEDULES

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

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

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

OFFICE = ZONE       DESIGN-HEAT-T        =   72
                    DESIGN-COOL-T        =   74
                    HEAT-TEMP-SCH        =   HEATSETPT ①
                    COOL-TEMP-SCH        =   COOLSETPT ①
                    OA-CFM/PER           =   15 .. ②
AC-SYST = SYSTEM    SYSTEM-TYPE          =   PTAC
                    MAX-SUPPLY-T         =   110 ③
                    MIN-SUPPLY-T         =   55  ④
                    NIGHT-CYCLE-CTRL     =   CYCLE-ON-ANY ⑤
                    FAN-SCHEDULE         =   FANS-ON ⑥
                    HEAT-SOURCE          =   ELECTRIC ⑦
                                             $ alternatively
                                             $ HEAT-PUMP ⑧
                    ZONE-NAMES           =   (OFFICE) ..
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER   SIZE = -999 ..
END ..
COMPUTE  PLANT ..
```

Additional capability for this system:

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

Packaged Total Gas Solid Desiccant System (PTGSD)*

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

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

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

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

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

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

---

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

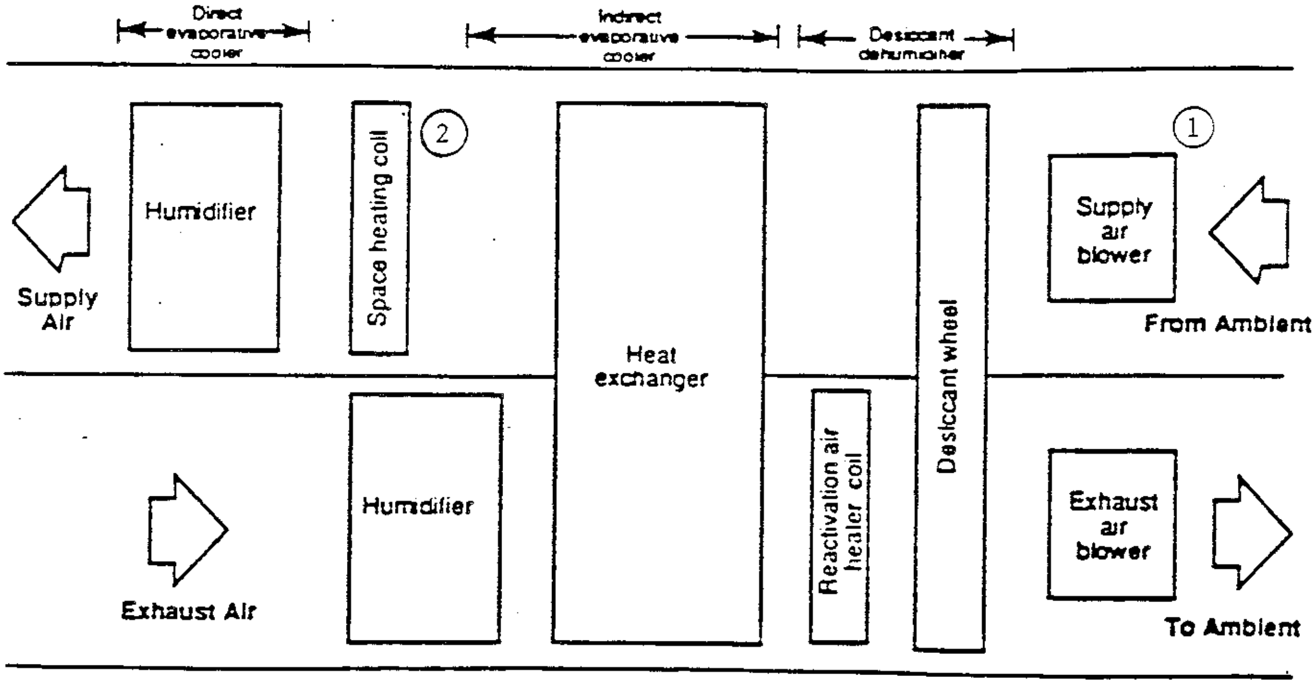


Figure 4.23: Packaged Total Gas Solid Desiccant System

Suggested minimal input for PTGSD system with an economizer:

```
INPUT SYSTEMS ..

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

                        $ SYSTEMS SCHEDULES

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

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

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

OFFICE = ZONE          DESIGN-HEAT-T          = 72
                       DESIGN-COOL-T          = 74
                       HEAT-TEMP-SCH          = HEATSETPT
                       COOL-TEMP-SCH          = COOLSETPT
                       OA-CFM/PER             = 15
```

```
                        BASEBOARD-CTRL        = THERMOSTATIC
                        BASEBOARD-RATING      = -30000 ..

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

END ..

COMPUTE SYSTEMS ..

INPUT PLANT ..

PLANT-REPORT  SUMMARY (BEPS)

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

END ..

COMPUTE PLANT ..
```

Additional capabilities for this system:

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

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

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

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

   NIGHT-CYCLE-CTRL = STAY-OFF

   to

   NIGHT-CYCLE-CTRL = CYCLE-ON-ANY.

Unit Heater (UHT)

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

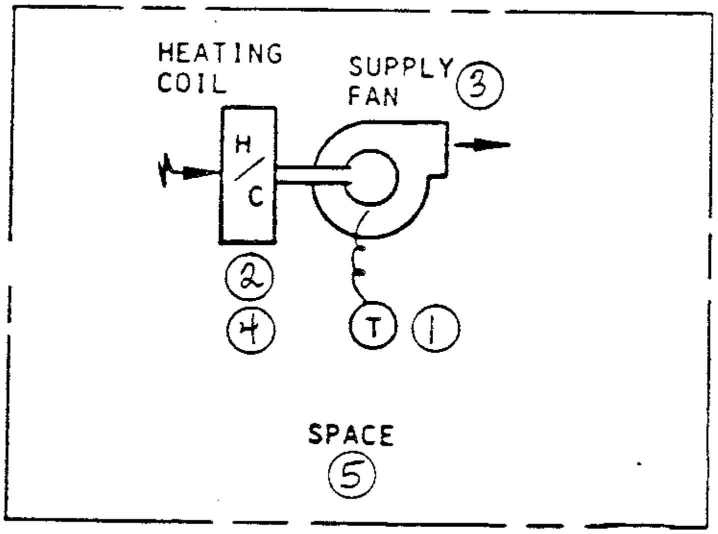


Figure 4.24: Unit Heater (UHT)

Suggested minimal input for UHT system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..
                         $ SYSTEMS SCHEDULES
FANS-ON =   SCHEDULE THRU DEC 31     (WD)    (1,7)(0) (8,18)(1)
                                             (19,24)(0)
                                     (WEH)   (1,24)(0) ..
HEATSETPT = SCHEDULE THRU DEC 31     (WD)    (1,7)(55) (8,18)(72)
                                             (19,24)(55)
                                     (WEH)   (1,24)(55) ..

OFFICE = ZONE           DESIGN-HEAT-T    =    72
                        HEAT-TEMP-SCH    =    HEATSETPT .. ①
AC-SYST = SYSTEM        SYSTEM-TYPE      =    UHT
                        MAX-SUPPLY-T     =    110 ②
                        FAN-SCHEDULE     =    FANS-ON ③
                        HEAT-SOURCE      =    ELECTRIC
                                              $ or GAS-FURNACE ④
                        ZONE-NAMES       =    (OFFICE) ..
END ..
COMPUTE  SYSTEMS ..
INPUT  PLANT ..
PLANT-REPORT  SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT   TYPE = DHW-HEATER   SIZE = -999 ..
```

Unit Ventilator (UVT)

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

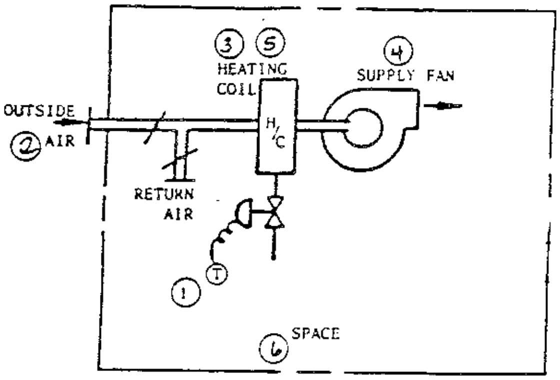


Figure 4.25: Unit Ventilator (UVT)

Suggested minimal input for UVT system:

```
INPUT SYSTEMS ..

SYSTEMS-REPORT   SUMMARY=(SS-A,SS-O) ..
                        $ SYSTEMS SCHEDULES
FANS-ON =   SCHEDULE THRU DEC 31       (WD)      (1,7)(0) (8,18)(1)
                                                 (19,24)(0)
                                       (WEH)     (1,24)(0) ..
HEATSETPT = SCHEDULE THRU DEC 31       (WD)      (1,7)(55) (8,18)(72)
                                                 (19,24)(55)
                                       (WEH)     (1,24)(55) ...

OFFICE = ZONE          DESIGN-HEAT-T      =     72
                       HEAT-TEMP-SCH      =     HEATSETPT ..①
                       OA-CFM/PER         =     15 .. ②
AC-SYST = SYSTEM       SYSTEM-TYPE        =     UVT
                       MAX-SUPPLY-T       =     110③
                       FAN-SCHEDULE       =     FANS-ON ④
                       HEAT-SOURCE        =     ELECTRIC ⑤
                                                $ or GAS-FURNACE
                                                $ or HOT-WATER with
                                                $ a HWG in PLANT
                       ZONE-NAMES         =     (OFFICE) .. ⑥
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
PLANT-REPORT SUMMARY = (BEPS) ..
SHW = PLANT-EQUIPMENT  TYPE = DHW-HEATER  SIZE = -999 ..
```

SDL Input Instructions

Limitation on the Number of Commands

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

Command	Maximum Number
DAY-RESET-SCH and/or DAY-SCHEDULE	60 combined
RESET-SCHEDULE and/or SCHEDULE	40 combined
SYSTEM	40
SYSTEM-AIR	20
SYSTEM-CONTROL	20
SYSTEM-EQUIPMENT	20
SYSTEM-FANS	20
SYSTEM-FLUID	20
SYSTEM-TERMINAL	20
SYSTEMS-REPORT	1 command (200 reports)
TITLE	5
u-names	180
WEEK-SCHEDULE	40
ZONE	64
ZONE-AIR	20
ZONE-CONTROL	20

Description of SDL Input Instructions

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

In the previous description of DOE-2 system types, only two commands were used: ZONE and SYSTEM. In the following material, SUBCOMMANDS are re-introduced; remember in the discussion of loads input (LDL) that SPACE-CONDITIONS was introduced as a sub-command of the SPACE command. Sub-commands are used to "group" keywords of similar meaning and use into a separate list that makes discussion of them a manageable task. The user has the option of either separating the input into separate lists using sub-commands or combining them all into one list under the command itself, as we did in the "suggested minimal inputs" for different system types, p.4.10ff.

The first instruction in the list of SDL input is

```
INPUT SYSTEMS ..
```

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

Reset Schedule Instructions

DAY-RESET-SCH and RESET-SCHEDULE

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

RESET-SCHEDULE	is almost identical to SCHEDULE. The LIKE keyword is not applicable to RESET-SCHEDULE, but it is applicable to DAY-RESET-SCH. In the DAY-RESET-SCH instruction, rather than entering 24 hourly values, as normally entered for a DAY-SCHEDULE instruction, four keywords and their associated values are entered. All four keywords are *required* if this command is specified.
DAY-RESET-SCH	defines how a system control parameter is to vary in response to changes in outside air temperature. A u-name for each DAY-RESET-SCH instruction is required in order to reference it.
SUPPLY-HI	is the upper supply air setpoint temperature corresponding to the user input value for OUTSIDE-LO. When this instruction is specified for the reset of cooling air or heating air temperature, the user input is a temperature. The range, in this case, is from 0.0 to 120.0°F. (See keywords HEAT-RESET-SCH and COOL-RESET-SCH in the SYSTEM-CONTROL subcommand.) Fig. 4.26 illustrates this application. When this instruction is specified for baseboard heating, the user input is a heating output ratio. (See keyword BASEBOARD-SCH in the SYSTEM-CONTROL subcommand.) The heating output is expressed as a decimal fraction of the maximum zone baseboard heating capacity (see keyword BASEBOARD-RATING in the ZONE-CONTROL subcommand). Fig. 4.27 illustrates this application.
SUPPLY-LO	is the lower supply air setpoint temperature (or output ratio) corresponding to the input value for OUTSIDE-HI; see also the discussion for SUPPLY-HI. The range, for temperature input, is from 0.0 to 120.0°F.
OUTSIDE-HI	is the outside dry-bulb air temperature which corresponds to the input value for SUPPLY-LO (lower supply air setpoint temperature).

OUTSIDE-LO	is the outside dry-bulb air temperature which corresponds to the input value for SUPPLY-HI (upper supply air setpoint temperature). The value for OUTSIDE-LO must *not* be equal to or greater than the value for OUTSIDE-HI (the program will abort and give an error message if this occurs).

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

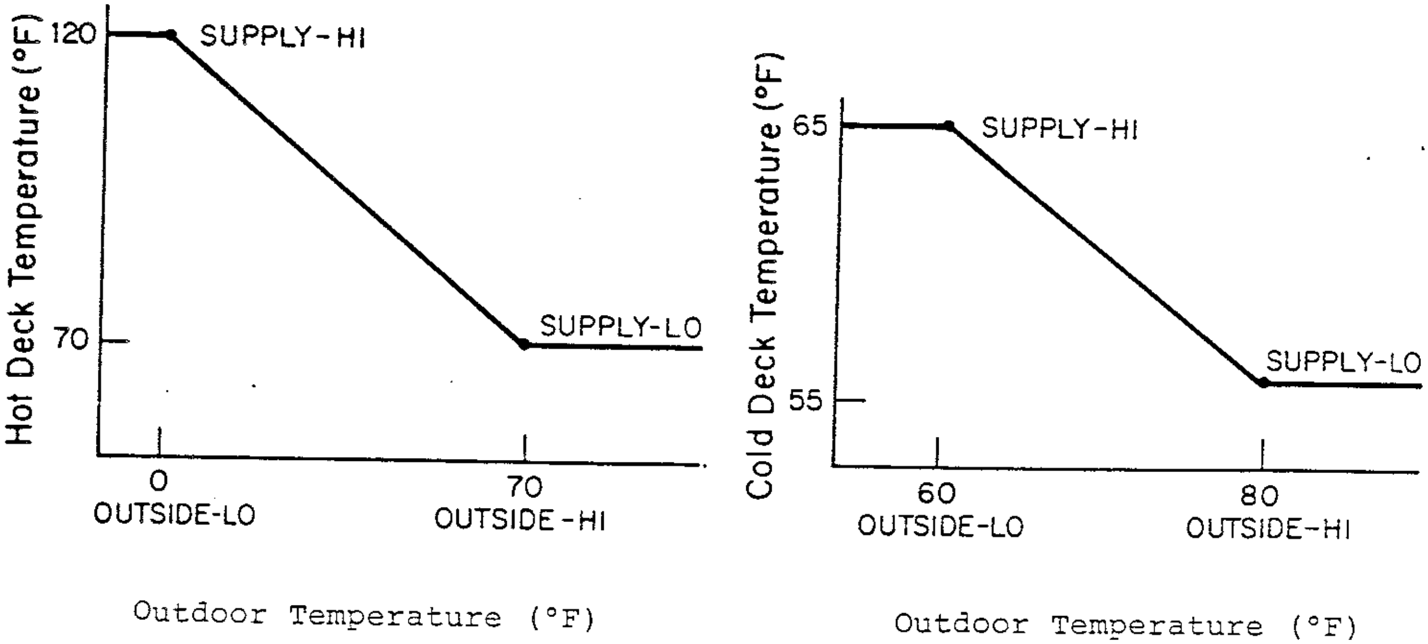


Figure 4.26: Typical DAY-RESET-SCH when used for simulation of hot deck or cold deck temperature control.

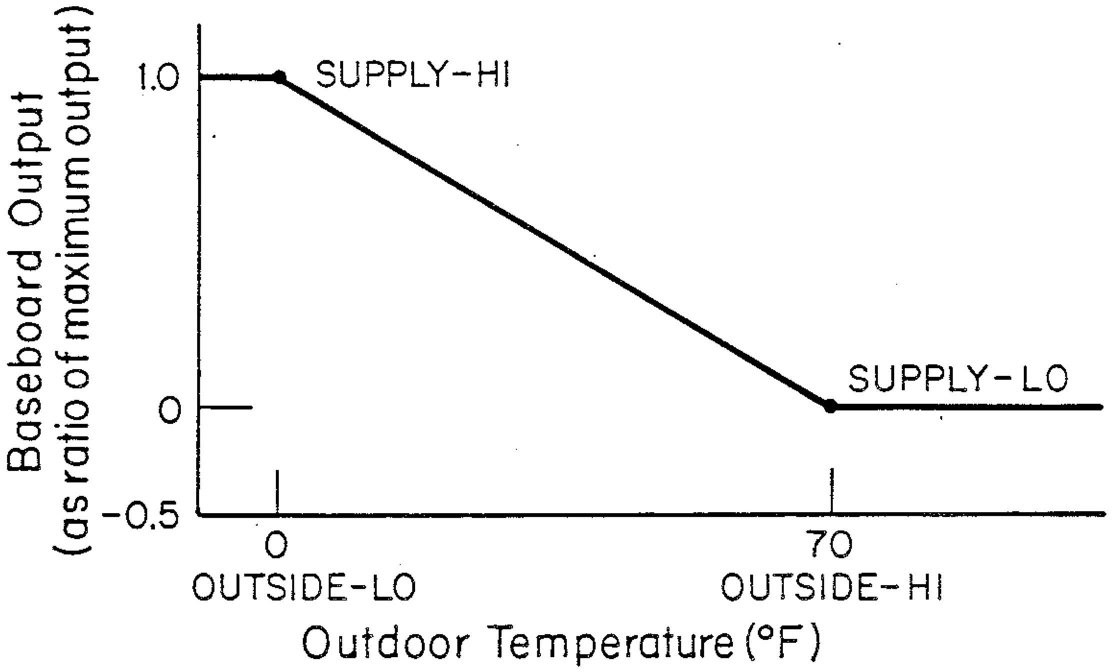


Figure 4.27: Typical DAY-RESET-SCH when used for simulation of baseboard heating output.

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

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

The correct input is as follows:

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

ZONE-CONTROL

The function of the ZONE-CONTROL instruction is to provide information on zone temperature control characteristics such as setpoint, type of thermostat, and throttling range. A number of ZONE-CONTROL instructions may be entered to account for zone-to-zone variations in these characteristics and/or to permit comparison studies.

ZONE-CONTROL	is a "subcommand" of ZONE and, as such, can be used to input a subset of data to ZONE.
U-name	is required.
DESIGN-HEAT-T	specifies the space temperature that the program uses to calculate the supply air flow rate required to meet peak (or design day) heating loads for the zone.
HEAT-TEMP-SCH	is the u-name of the SCHEDULE instruction that specifies the setpoint of the zone heating thermostat. If no data entry is made, the program will assume that the zone has no zone-activated heating control.
DESIGN-COOL-T	specifies the space temperature used to calculate the supply air flow rate required to meet peak (or design day) cooling loads for the zône.
COOL-TEMP-SCH	is the u-name of the SCHEDULE instruction that specifies the setpoint of the zone cooling thermostat. If no data entry is made, the program will assume that the zone has no zone-activated cooling control.
BASEBOARD-CTRL	Input for this keyword is a code-word that specifies the method used for controlling the output of the baseboard heating element in the zone. The applicable code-words are:
THERMOSTATIC	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 prior to zone reheat coils (if any) in response to a drop in space temperature.

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

THERMOSTAT-TYPE	identifies the type of thermostat action to be simulated. Note that the program will assume the same type of thermostat action for both cooling and heating. The applicable code-words are:
PROPORTIONAL	(default) Thermostat throttles heat addition rate (or heat extraction rate) in linear proportion to the difference between zone setpoint temperature and actual zone temperature. The proportional band is input by the user (see keyword THROTTLING-RANGE).
TWO-POSITION	Specifies an on-off type thermostat (which is simulated as a very narrow fixed throttling range around each setpoint). This code-word is only used for the Residential System (RESYS).
REVERSE-ACTION	In variable air volume systems, this thermostat type allows the air flow rate to go above the design minimum cfm for heating, as defined by MIN-CFM-RATIO. Otherwise, the effect is the same as for THERMOSTAT-TYPE=PROPORTIONAL.
THROTTLING-RANGE	specifies the number of degrees that room temperature must change to go from full heating to zero heating and/or from full cooling to zero cooling. Zone temperature setpoint is assumed to be at the midpoint of the throttling range. This keyword is appropriate to PROPORTIONAL and REVERSE-ACTION thermostats only.

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

ZONE–AIR

All air quantities should be input at sea level (standard) values because the program makes a correction for altitude. Input of air quantities corrected for altitude above sea level will result in a double correction.

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

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

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

OA-CFM/PER	is the minimum flow rate of outside air (in standard, or sea level, cfm) per zone occupant at peak occupancy. OUTSIDE-AIR-CFM takes precedence over this input.
EXHAUST-CFM	is the flow rate (in standard, or sea level, cfm) of direct exhaust from the zone. This data entry can be omitted if there is no exhaust from the zone, or if there is only central exhaust by way of the system return. DOE-2 will not allow MIN-OUTSIDE-AIR to be less than the sum of EXHAUST-CFMs for all zones divided by the sum of supply cfm's for all zones. That is, MIN-OUTSIDE-AIR will not restrict the operation of exhaust fans.
EXHAUST-STATIC	is the total pressure (in inches of water) produced by the exhaust fan serving the zone. This data entry is applicable only if a data entry is made for the keyword EXHAUST-CFM.
EXHAUST-EFF	is the combined efficiency of the zone exhaust fan and motor at design conditions. This data entry is applicable only if a data entry is made for the keyword EXHAUST-CFM. The program calculates exhaust fan horsepower on the basis of the value of this data entry and the entries for the keywords EXHAUST-CFM and EXHAUST-STATIC. The exhaust fan is assumed to be constant flow (not greater than the supply air flow rate) and to operate only when the system supply and return fans operate (see the keyword FAN-SCHEDULE in the SYSTEM-FANS instruction).
EXHAUST-KW	is an alternative to using EXHAUST-STATIC and EXHAUST-EFF. It provides information about the electrical energy consumption of the exhaust fan in this zone. It is expressed in kW consumed by the fan per cfm of exhaust.

ZONE

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

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

The following keywords apply only to PIU systems.

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

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

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

REHEAT-DELTA-T	should be specified (if reheat or booster heat is desired) for the PIU system only. This is a keyword in both the SYSTEM and ZONE commands, and the ZONE level use takes precedence over the SYSTEM level. (At the zone level, this keyword does not apply to any other system types.)
ZONE-FAN-CFM	allows the user to size the fan. If ZONE-FAN-CFM is not specified, the program will size the fan assuming series PIU fans. The blower is sized to the zone cfm; i.e., the maximum of the cfm input via ASSIGNED-CFM, AIR-CHANGES/HR, or CFM/SQFT; or the cfm derived from the heating and cooling peaks from LOADS. For parallel PIU's, ZONE-FAN-CFM must be input. The ZONE level cfm keywords are assumed to refer to the primary air from the central system. The range is from 0.0 to 99999999.0 cfm.
ZONE-FAN-RATIO	allows the user to enter a value which sets the ZONE-FAN-CFM as a fraction of the primary air. If both ZONE-FAN-CFM and ZONE-FAN-RATIO are specified, ZONE-FAN-CFM takes precedence.
ZONE-FAN-KW	specifies the power consumption of the fan. The default is .00033 kW/cfm. The range is from 0.0 to 0.01.
ZONE-FAN-T-SCH	is the u-name of a schedule which gives, for zones with parallel PIU's, the space temperature at which the terminal blower turns on. This temperature must be above the heating range. This keyword is required for zones with TERMINAL-TYPE = PARALLEL-PIU.
MIN-CFM-RATIO	should be specified for PIU at the ZONE level. The usual input for PIU terminals should be to specify a ratio that just satisfies the minimum ventilation air requirements of the zone. This keyword applies to other types of VAV systems and will override any value assigned at the SYSTEM level.

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

SYSTEM–CONTROL

The SYSTEM–CONTROL instruction provides information on supply air temperature (setpoint, control strategy, and limits) and humidity limits, and identifies the appropriate equipment operating schedules.

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

HEAT-SET-SCH

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

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

Then, in SYSTEM, the schedule is referenced by setting

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

HEAT-RESET-SCH

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

The following is an example. First define:

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

Then, in SYSTEM, the schedule is referenced by setting

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

MIN-SUPPLY-T

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

This entry is mandatory for all systems with cooling capability; i.e., all systems except the Unit Heater (UHT) and Unit Ventilator (UVT).

COOLING-SCHEDULE

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

COOL-CONTROL	Input for this keyword is a code-word that identifies the strategy to be used for control of the air temperature leaving the system (central) cooling coil. The code-words and a brief description of the control strategy each represents for either heating or cooling are as follows:
CONSTANT	Sets heating supply and/or cooling supply air temperature to a fixed value. Values should then be entered for keywords HEAT-SET-T and/or COOL-SET-T, respectively.
COLDEST	Sets the heating coil (hot deck) temperature each hour to adequately heat the ZONE with the lowest temperature. The limits on the supply air temperature are governed by coil capacities, heating schedules, and MAX-SUPPLY-T.
WARMEST	Sets the cooling coil (cold deck) temperature each hour to adequately cool the ZONE with the highest temperature. The limits on the supply air temperature are governed by coil capacities, cooling schedules, and MIN-SUPPLY-T.
RESET	Specifies use of HEAT-RESET-SCH or COOL-RESET-SCH for control of heating and/or cooling air supply temperature, based upon outdoor air temperature.
SCHEDULED	Specifies use of HEAT-SET-SCH or COOL-SET-SCH for control of heating and/or cooling air supply temperature.
COOL-RESET-SCH	is the u-name of the RESET-SCHEDULE instruction that defines the relationship between cooling air temperature and outside air temperature, and specifies the days of the year during which this relationship applies. This data entry is used only when the RESET control strategy is selected and entry for keyword COOL-CONTROL = RESET.
COOL-SET-SCH	is the u-name used to identify the schedule for controlling cooling air supply temperature when COOL-CONTROL = SCHEDULED.
MAX-HUMIDITY	is the highest allowable relative humidity in the return air from zones served by the system. Because the program calculates the relative humidity in the return air, dehumidification is based on the average humidity condition for all the zones served by the system, as weighted by the relative return air flow rate from each zone. This data entry should be used only for those systems that have the components required for

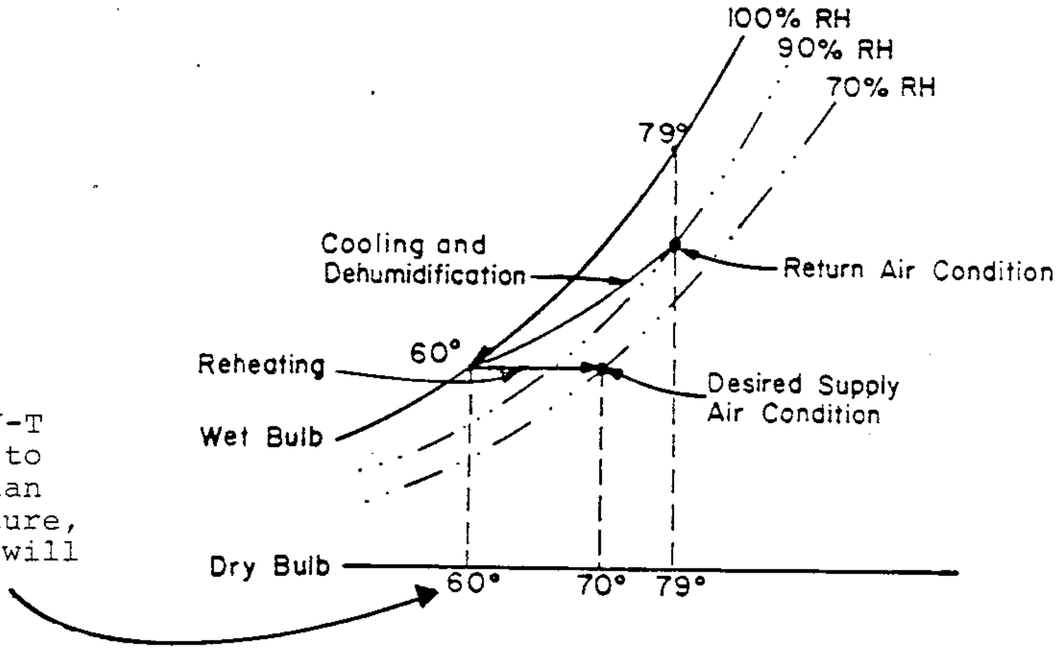
---

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

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% is intended to specify no upper limit on humidity, that is, no humidity control.

DOE-2 will not force the cooling coil to perform beyond its dehumidification capability. The program will not be able to hold a specified MAX-HUMIDITY if MIN-SUPPLY-T is not low enough. Fig. 4.28 shows one type of dehumidification cycle.

MAX-HUMIDITY causes the simulation to function differently for system types SZRH, PSZ, and PVAVS. For SZRH, if the MAX-HUMIDITY level is exceeded, the system reverts to a full reheat. The cooling coil leaving air temperature is driven lower and reheat is added at the fan unit to satisfy the first-named zone. Further, for PSZ and PVAVS systems, specification of MAX-COND-RCVRY will activate the use of condenser recovery to accomplish a similar result. If a lower MAX-HUMIDITY is required to meet desired space conditions, a lower MIN-SUPPLY-T should be entered.



If MIN-SUPPLY-T is not equal to or is less than this temperature, MAX-HUMIDITY will reset upwards

Figure 4.28: Relationship of MAX-HUMIDITY to MIN-SUPPLY-T

MIN-HUMIDITY	is the lowest allowable relative humidity in the return air from zones served by the system. This data entry should be used only for those systems that have the components required for minimum humidity control (i.e., humidistat and humidifier). If no data entry is made, the program will assume that minimum humidity control capability does not exist. The program simulates the use of a humidifier and the required heat for humidification is passed to PLANT as a steam or hot water load.
BASEBOARD-SCH	is the u-name of the RESET-SCHEDULE instruction that defines the relationship between baseboard heat output and outside air temperature, and specifies the days of the year during which this relationship applies. This keyword applies only if the ZONE-CONTROL keyword BASEBOARD-CTRL = OUTDOOR-RESET and the capacity is defined using BASEBOARD-RATING = value (negative) at the zone level.
ECONO-LIMIT-T	is the outside air temperature above which the economizer returns to minimum outside air operation as shown in Fig. 4.29. ECONO-LIMIT-T will default to the return air temperature.
PREHEAT-T	is the minimum temperature of air leaving the preheat coil. The SYSTEMS program calculates the necessary preheat coil energy input to maintain this temperature.

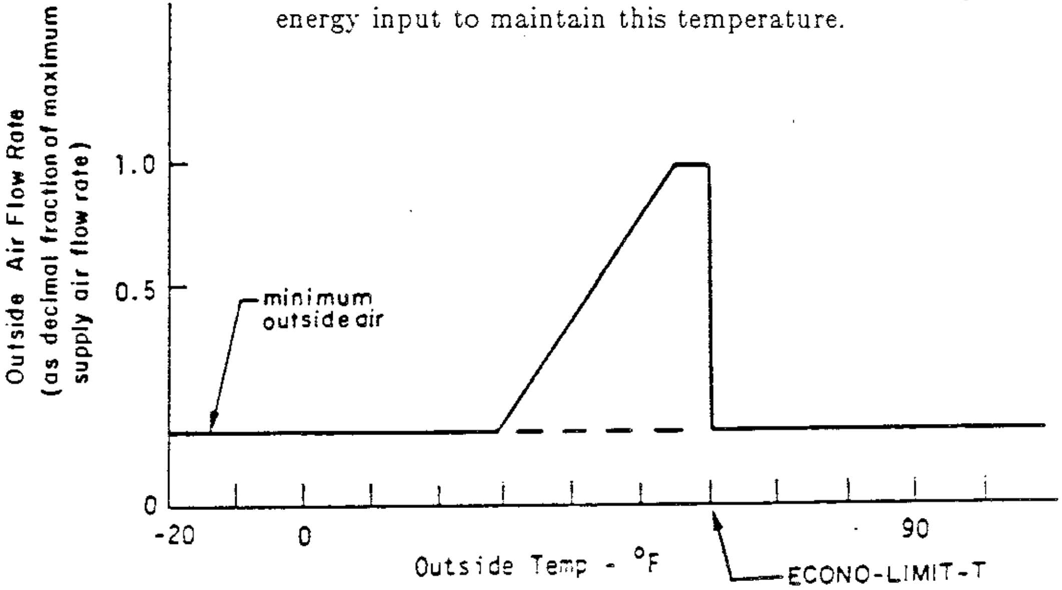


Figure 4.29: Typical curve of air flow vs outside air temperature for systems with temperature type economizer (illustrating use of keyword ECONO-LIMIT-T)

SYSTEM–AIR

The SYSTEM–AIR instruction provides information on system supply air and outside air flow rate.

SYSTEM–AIR	is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM. All air quantities should be input as sea level (standard) values because the program makes a correction for altitude. Input of air quantities corrected for altitude above sea level will result in a double correction.
U–name	is required for SYSTEM–AIR.
SUPPLY–CFM	is the design capacity (in standard, or sea level, cfm) of the system air supply fan. *This entry is normally omitted, unless fan capacity is a known value and different from the air flow rates calculated by the program.* The user will improve his/her simulation accuracy for existing buildings by inputting known system SUPPLY–CFM. The program proportions the specified total supply air into zone air quantities as follows: $Adj.\ CFM = \left(\frac{<SUPPLY\text{-}CFM>}{\sum Calculated\ Zone\ Air\ CFMs} \right) * (Calculated\ Zone\ .Air)$ where Adj. CFM = Adjusted Zone Air CFM. Note that user inputs of zone-level ASSIGNED–CFM and EXHAUST–CFM (but only when the latter exceeds calculated zone CFM) replace the "Calculated Zone Air CFM" in the summation.
MIN–OUTSIDE–AIR	is the minimum acceptable *constant* flow rate of fresh air, expressed as a decimal fraction of the maximum air supply flow rate. The user may alternatively, or additionally, specify outside air quantities at the zone level (keywords OA–CHANGES, OA–CFM/PER, or OUTSIDE–AIR–CFM in the ZONE–AIR instruction). If a value is specified for this keyword and values are also specified for the zone level keywords OUTSIDE–AIR–CFM, OA–CHANGES, OA–CFM/PER, or EXHAUST–CFM, the zone level values take precedence over the system level value. If no zone level value(s) are specified, the value specified here will be used. If MIN–AIR–SCH is used, the value of the outside air flow rate, to be used in the design calculations, should be specified either in this keyword or in the zone level keywords. The program will not allow MIN–OUTSIDE–AIR to be less than the sum of EXHAUST–CFMs for all zones divided by the sum of all supply cfm's for all zones. That is, the exhaust fan operation will override MIN–OUTSIDE–AIR, if MIN–OUTSIDE–AIR is set too low.

MIN-AIR-SCH	allows an hourly variation of the minimum outside air. Any fractional input defines the hourly value of the minimum outside air damper position as a ratio of design flowrate; it also enables the economizer. The two exceptions to this definition are when the schedule has a value of either zero or -999.0, in which case special meanings are assumed. When the value is zero, a no outside air situation with no movable dampers (economizer inactive if specified) is simulated. This usage is common for nighttime heating or a warmup cycle. If this schedule has a value of -999.0, the calculated or specified value for MIN-OUTSIDE-AIR (found on report SV-A for the SYSTEM or for each zone for zonal systems) is used as the minimum damper position for the current hour. If this value is zero, the discussion above for that special value applies. During a warmup period, this schedule is normally set to zero and can then be set to -999.0 during other hours to allow the specified or calculated ventilation minimum damper position to be used.
OA-CONTROL	Input for this keyword is the code-word for the type of outside air control strategy selected. See code-words below. This keyword must equal FIXED if the user does *not* want an economizer; otherwise, it will default to TEMP, which will simulate a temperature-controlled economizer. If no outside air has been specified, no movable dampers are simulated, even if OA-CONTROL equals TEMP or ENTHALPY.
FIXED	No movable dampers. Outside air quantity is a fixed amount specified, calculated, or scheduled.
TEMP	Temperature-controlled economizer. In response to the mixed air temperature going above the controller setpoint (equal to the supply air setpoint for the hour), the outside air damper is opened. (This assumes a cooling mode and that the outside air is cooler than the return air.) The outside air quantity returns to its minimum (outside air dampers close but minimum outside air dampers remain open) when the outside air temperature is at or above the ECONO-LIMIT-T.
ENTHALPY	Enthalpy-controlled economizer. Same as TEMP above except that if the return air enthalpy is less than the outside air enthalpy, the dampers are forced to minimum outside air position.
RECOVERY-EFF	is applicable only to those systems provided with heat recovery coils (or other devices) for the exchange of heat between the air exhausted from the building (by the return air fan) and the fresh air supplied to the building. The input is the ratio

---

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

(decimal fraction) of the energy actually exchanged to the total sensible energy that would be exchanged if the exhaust air were cooled to outside air temperature. The program uses this ratio (plus outside air and return air temperatures and return air flow rate) to calculate the energy that can be added to the outside air make-up. If the recoverable energy is greater than that needed by the supply air, the program will use the smaller quantity. If the outside air temperature is above the temperature setpoint of the mixed air, no energy is exchanged. If the difference between return and outside air temperatures is less than 10 degrees, no recovery is simulated.

Note: heat recovery can be simulated only when the return air is *warmer* than the outside air.

(If the heat recovery occurs through a single heat exchanger, i.e., heat pipe or thermal wheel, then RECOVERY-EFF is identical to the heat exchanger effectiveness. See Kays and London, "Compact Heat Exchangers", 2nd edition, McGraw-Hill, 1964).

VENT-TEMP-SCH	accepts as input the u-name of a schedule giving the hourly minimum temperature setpoint for the natural venting algorithm. This keyword is appropriate to system type RESYS only. The hourly values that should be specified in the SCHEDULE referenced by VENT-TEMP-SCH are the indoor dry-bulb temperature to which the user would like to cool through natural ventilation, in lieu of mechanical cooling. This hourly temperature is generally below the hourly temperature in the SCHEDULE referred to by COOL-TEMP-SCH. This latter schedule specifies the zone cooling thermostat setpoint. The windows are assumed to be closed if the temperature in the room falls below this point. If VENT-TEMP-SCH is not specified, all its hourly SCHEDULE values will default to the temperature at the top of the heating THROTTLING-RANGE as defined by HEAT-TEMP-SCH.
NATURAL-VENT-AC	is the peak number of air changes per hour due to natural ventilation through open windows. This value is constant and is not a function of wind speed. This keyword is appropriate only to system type RESYS.
NATURAL-VENT-SCH	is the u-name of a schedule which determines when the windows can be open vs. when they are always closed. The hourly values given in the SCHEDULE (and referenced by this keyword) are 0, 1, or -1. This keyword is appropriate only to system type RESYS. A schedule value of zero (0) indicates that the windows are always closed for this hour. A schedule value of one (1) indicates that the windows will be

opened, for part or all of this hour, only if this provides enough cooling to keep the zone temperature within or below the throttling range associated with COOL-TEMP-SCH. The zone may be cooled down to the hourly minimum value specified by VENT-TEMP-SCH. Note that this assumes the occupant will open the windows if the condition is met.

A schedule value of minus one (-1) indicates that the windows will be opened, for part or all of this hour, only if the condition for the value of one (1) is met (above) and also that the outside air enthalpy is lower than the inside air enthalpy. The zone may be cooled down to the hourly minimum value specified by VENT-TEMP-SCH. This assumes the occupant will open the windows if both the conditions are met.

To further illustrate, assume that the occupant arises at 6:00 a.m., goes to work at 8:00 a.m., returns from work at 5:00 p.m., and retires at 10:00 p.m. every day of the year. The DAY-SCHEDULE describing the window management would be:

```
VENT-DAY = DAY-SCHEDULE  (1,6) (0) (7,8) (1) (9,17) (0) (18,22) (-1) (23,24) (0)  ..
```

The schedule for the year becomes:

```
VENTING = SCHEDULE  THRU DEC 31 (ALL) VENT-DAY  ..
```

Having defined the schedule, the entry under the SYSTEM-AIR subcommand would be:

```
HOME-AIR = SYSTEM-AIR
                    .
                    .
                    .
     NATURAL-VENT-SCH = VENTING
                    .
                    .
                    .  ..
```

If the values in VENT-DAY during the sleeping hours were 1's, it would imply that the occupant got out of bed, as often as necessary, to open and close the windows, whenever the conditions called for it. Should the user wish to specify "temperature limits" for cooling by natural ventilation, he should specify VENT-TEMP-SCH in the SYSTEM-AIR subcommand. For example, suppose this schedule describes the cooling setpoint of the mechanical system:

```
MECH-COOL-TEMP = SCHEDULE  THRU DEC 31 (ALL) (1,8) (78) (9,17) (90) (18,24) (78)  ..
```

The following schedule describes the minimum below which the windows will be closed.

```
MIN-VENT-TEMP = SCHEDULE  THRU DEC 31 (ALL) (1,6) (60) (7,22) (68) (23,24) (60)  ..
```

Then, under ZONE-CONTROL, the user should specify COOL-TEMP-SCH = MECH-COOL-TEMP, while under SYSTEM-AIR, VENT-TEMP-SCH should be set to MIN-VENT-TEMP. The preceding example can be restated as the following:

SCHEDULE hours (clock time)	Temperature Range*
1,6 (midnight to 6 a.m.)	78°F max (provided by mechanical cooling)
7,8 (6 a.m. to 8 a.m.	78°F max (provided by mech cooling) 68°F min (provided by occupant operating windows)
9,17 (8 a.m. to 5 p.m.).	90°F max (provided by mechanical cooling)
18,22 (5 p.m. to 10 p.m.)	78°F max (provided by mechanical cooling) 68°F min (provided by occupant operating windows)
23,24 (10 p.m. to midnight)	78°F max (provided by mechanical cooling)

* Note that during the hours when the windows are constantly closed (10 p.m. to 6 a.m. and 8 a.m. to 5 p.m.), the temperatures referenced by VENT-TEMP-SCH are disabled. Note also that VENT-TEMP-SCH does not necessarily say that cooling by natural ventilation will be done satisfactorily. VENT-TEMP-SCH only sets the minimum indoor temperature limits for natural ventilation. The conditions specified in NATURAL-VENT-SCH, determine when, and if, cooling by natural ventilation is done.

SYSTEM–FANS

The function of the SYSTEM–FANS instruction is to provide information on supply and return fan operating schedules, control modes, static pressures, and efficiencies. In short, this instruction provides everything the program needs to know (with the exception of fan capacity and flow rate) for calculation of the energy consumed by and the heat input from these fans. The same type of information is provided for exhaust fans, if any, at the zone level (keywords EXHAUST–CFM, EXHAUST–STATIC, etc. in ZONE–AIR instruction).

SYSTEM–FANS	is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.
U–name	is required.
FAN–SCHEDULE	is the u-name of the SCHEDULE instruction giving the time periods (hours and days) during which this system's fans (supply, return, and exhaust) are operating and not operating. If the hourly values in the SCHEDULE that is referenced by FAN–SCHEDULE are positive, such as 1, the fans are on. If the hourly SCHEDULE values are 0, the fans are off but may be turned on by NIGHT–CYCLE–CTRL if ZONE temperatures warrant it. If the hourly SCHEDULE values are negative, such as -1, the fans are not permitted to be on for any reason. If the user does not specify a SCHEDULE, the program will assume the fans run continuously. When the fans are scheduled to be off, baseboard units (if specified) can be operational.
FAN–CONTROL	equals a code-word that specifies the kind of flow reduction or control methods to be simulated. Listed below are the code-words and a brief description of the method each represents. The program calculates the part-load horsepower consumption for the supply fan and return fan (if any), on the basis of the part-load versus fan horsepower characteristics that are typical for the control mode selected (see Fig. 4.30). The program assumes that both supply and return fans have the same kind of flow control.
SPEED	Variable speed motor (Curve #1 in Fig. 4.30). [For systems that have variable flow central air-handlers only.] Note, the PTGSD system defaults to SPEED control.
INLET	Fan inlet vanes (Curve #2 in Fig. 4.30). [For systems that have variable flow central air-handlers only.]
DISCHARGE	Damper in fan discharge (Curve #3 in Fig. 4.30). [For systems that have variable flow central air-handlers only.]
CYCLING	Cycles on and off (Curve #4 in Fig. 4.30)

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

TWO-SPEED	High or low speed (for PTAC only - represented as 100% and another point lower on Curve #1)
CONSTANT-VOLUME	Volume kept constant

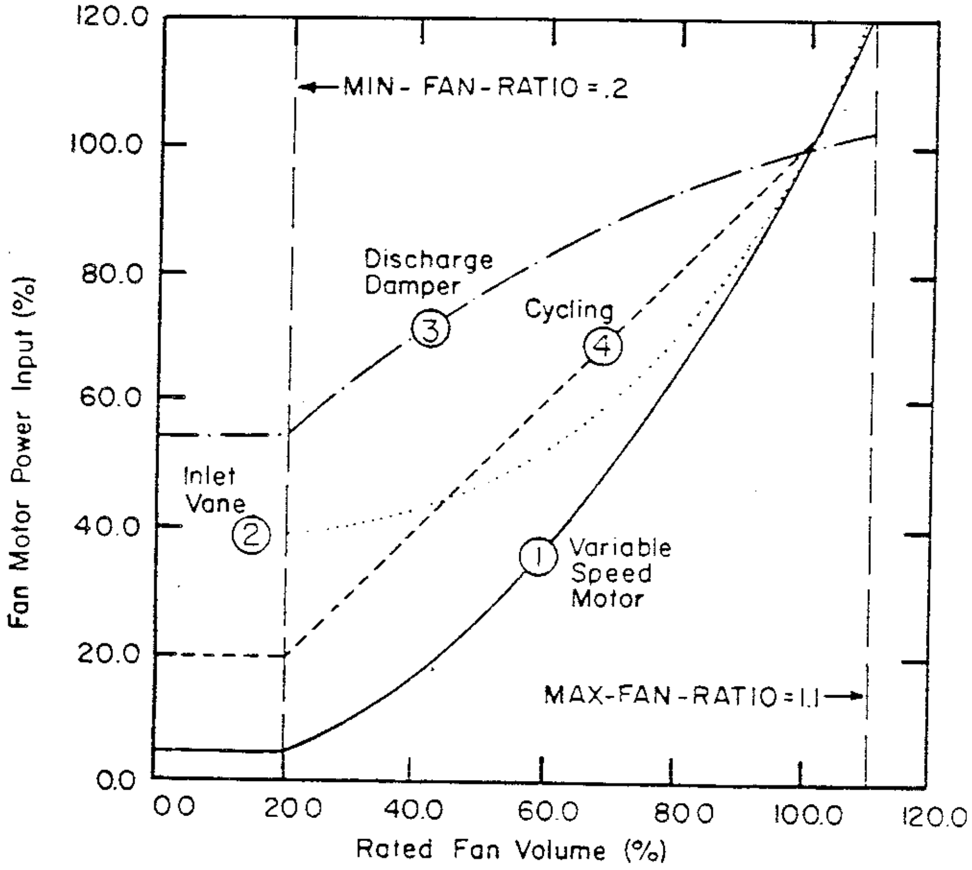


Figure 4.30: Typical power requirements at part-load operation for four different methods of capacity control (Note that with the CYCLING code-word, the MIN-FAN-RATIO is meaningless for those hours when the fan is off.

SUPPLY-DELTA-T	is used in conjunction with SUPPLY-KW. It is the temperature rise in the air stream across the supply fan. It is expressed in °F and its default value can be found in Table 4.1, based on SYSTEM-TYPE.
SUPPLY-KW	is used in conjunction with SUPPLY-DELTA-T. It is the design full load power consumption of the supply fan per unit of supply air moved for one hour. It is expressed in kW/cfm at sea level (or kW/standard cfm) and its default value can be found in Table 4.1, based on SYSTEM-TYPE.

TABLE 4.1

Default Value for SYSTEM-TYPE	Effective Default Value for SUPPLY-DELTA-T (°F)	Default Value for Total SUPPLY-KW (kW/std. cfm)	Effective Default Value for FAN-STATIC* (inches, W.G.)	FAN-EFFICIENCY* (fraction)
SZRH	2.42	.000783	4	.6
RHFS	3.11	.00101	6	.7
MZS	2.723	.00088	4.5	.6
DDS	3.37	.00109	6.5	.7
VAVS	3.37	.00109	6.5	.7
PIU	3.37	.00109	6.5	.7
TPFC	.218	.00007	.3	.5
FPFC	.218	.00007	.3	.5
HP	.218	.00007	.3	.5
RESYS	.396	.000128	.6	.55
PSZ	1.815	.000587	3	.6
PMZS	2.117	.000685	3.5	.6
PVAVS	2.117	.000685	3.5	.6
PTAC	.218	.00007	.3	.5
PTGSD	1.2	*	*	*
UHT	.218	.00007	.3	.5
UVT	.182	.000059	.3	.6

* Not applicable as supply fan and pump energy are included in a fixed Electric-Input of .098 w/CFM for this system at full load.

RETURN-DELTA-T is used in conjunction with RETURN-KW. It is the temperature rise in the air stream across the return air fan. It is expressed in °F and its default value is zero.

RETURN-KW is used in conjunction with RETURN-DELTA-T. It is the design full load power consumption of the return fan per unit of return air moved for one hour. It is expressed in kW/cfm at sea level (or kW/standard cfm) and its default value is zero. The user 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 the user must input a -1 in the FAN-SCHEDULE for the summer (cooling) period.

NIGHT-CYCLE-CTRL only affects the fan operation. Once the fans have cycled on, the availability of heating or cooling is controlled by the HEATING SCHEDULE and COOLING-SCHEDULE.

The code-words for NIGHT-CYCLE-CTRL are:

STAY-OFF	indicates that regardless of conditions, the fans are to stay off (default value).
CYCLE-ON-ANY	means that if the temperature in *any* ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, the fans are cycled on for that hour.
CYCLE-ON-FIRST	indicates that if the temperature in the *first*, or control, ZONE in the SYSTEM falls below the THROTTLING-RANGE for heating, the fans are cycled on for that hour.
ZONE-FANS-ONLY	applies only to PIU. If input, the main or central system PIU fan will remain off; however, the individual zone terminal fans will cycle on separately to satisfy the heating setback temperature for each zone.

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

SYSTEM-FLUID

The function of the SYSTEM-FLUID instruction is to provide information that is applicable specifically to the hydronic part of two pipe induction (TPIU) and water/air heat pump (HP) systems.

SYSTEM-FLUID	is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.
U-name	is required.
MIN-FLUID-T	is the minimum allowable temperature (entering the heat pumps) for the circulating heat addition/heat extraction fluid. The program then simulates the addition of heat in PLANT to prevent fluid temperature from falling below this value.
MAX-FLUID-T	is the maximum allowable temperature (entering the heat pumps) for the circulating heat addition/heat extraction fluid. The program then simulates the heat extraction in PLANT to prevent fluid temperature from exceeding this value.
FLUID-HEAT-CAP	is the thermal capacitance of the fluid in the system. The value specified is the number of Btus required to raise (or lower) the temperature of the total fluid volume in the system (pipe loop and coils) by 1°F. Thus, it is equal to the total mass of the fluid, in pounds, multiplied by the specific heat of the fluid, in Btu/lb-°F. The piping system of a water/air HP system will normally hold approximately 4 pounds of water per ton of total capacity. If there is a storage tank, convert the gallons of water stored to pounds of water.

SYSTEM

The SYSTEM instruction gives specifications for the secondary HVAC distribution system. The information provided includes system type, size, zones served, optional components, operating schedules, temperature and humidity limits, control strategies, outside air requirements, and fan static pressures and efficiencies. In addition, the user may reference "subcommands" (SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, and SYSTEM-FLUID) that contain the needed information.

TABLE 4.2

Code-Word	SYSTEM-TYPE	Generic Type
SZRH	Single Zone Fan System w/Optional Subzone Reheat	Built-up/central
RHFS	Constant Volume Reheat Fan System	Built-up/central
MZS	Multizone Fan System	Built-up/central
DDS	Dual Duct Fan System	Built-up/central
VAVS	Variable Volume Fan System w/optional reheat	Built-up/central
PIU	Powered Induction Unit	Built-up/central
TPFC	Two Pipe Fan Coil System	Built-up/zonal
FPFC	Four Pipe Fan Coil System	Built-up/zonal
HP	Unitary Hydronic Heat Pump System	Built-up/zonal
RESYS	Residential System	Packaged/central
PSZ	Packaged Single Zone Air Conditioner (w/optional heating and subzone reheating)	Packaged/central
PMZS	Packaged Multizone Fan System	Packaged/central
PVAVS	Packaged Variable Air Volume System	Packaged/central
PTAC	Package Terminal Air Conditioner	Packaged/zonal
PTGSD	Package Total Gas Solid Desiccant	Packaged/central
UHT	Unit Heater	Built-up/zonal
UVT	Unit Ventilator	Built-up/zonal

U-name	required input for SYSTEM
SYSTEM-TYPE	identifies the type of system to be simulated. The user must select one of 17 types of commonly used energy distribution systems. A discussion of the features of each system and a "suggested minimal input" for each system type can be found on p.4.9ff.
SYSTEM-CONTROL	references the u-name of a previously assigned SYSTEM-CONTROL instruction.
SYSTEM-AIR	references the u-name of a previously assigned SYSTEM-AIR instruction.
SYSTEM-FANS	references the u-name of a previously assigned SYSTEM-FANS instruction.
SYSTEM-FLUID	references the u-name of a previously assigned SYSTEM-FLUID instruction.
HEAT-SOURCE	is the code-word that identifies the heat source for the distribution system for heating coils. See the following table for the applicable code-words. This is the appropriate keyword for UHT, UVT, TPFC, FPFC and PTAC zone heating coils since they are all served by a central distribution system. It defaults to GAS-HYDRONIC for the Packaged Total Gas Solid Desiccant (PTGSD) system; this should not be changed nor applied to any other system type.
ZONE-HEAT-SOURCE	identifies the heat source for the zone heating coils (reheat coils) in central air handler systems. See the following table for the applicable code-words, and Appendix F for default values.
PREHEAT-SOURCE	identifies the heat source for the preheat coils. See the following table for the applicable code-words, and Appendix F for default values.
BASEBOARD-SOURCE	identifies the heat source for the baseboard heaters. See the following table for the applicable code-words, and Appendix F for default values. It defaults to GAS-HYDRONIC for the Packaged Total Gas Solid Desiccant (PTGSD) system. This should not be changed nor applied to any other system type.

Code-words for
BASEBOARD–SOURCE, HEAT–SOURCE, PREHEAT–SOURCE and ZONE–HEAT–SOURCE

Code-Word	Meaning
HOT-WATER	The source of heat is hot-water, provided by conventional equipment specified in the PLANT program. This code-word is appropriate for central heating coils, preheat coils, baseboard heaters, and zone heating coils.
ELECTRIC	The source of heat is an electric resistance element. This code-word is appropriate for central heating coils, preheat coils, baseboard heaters, and zone heating coils.
GAS-FURNACE	The source of heat is a gas-fired furnace, which will be simulated in SYSTEMS.
OIL-FURNACE	The source of heat is an oil-fired furnace, which will be simulated in SYSTEMS.
HEAT-PUMP	The source of heat is an air-to-air heat pump. Note: This code-word is appropriate only as a HEAT–SOURCE for the RESYS, PSZ, and PTAC systems. It should not be used for any other system types.
GAS-HYDRONIC	Applies to BASEBOARD–SOURCE and HEAT–SOURCE for PTGSD system only. The source in this case is a gas-fired hot water generator.

HUMIDIFIER–TYPE	defines the source of heat used to provide humidification in those SYSTEM–TYPEs that allow MIN–HUMIDITY to be specified. It takes one of the standard heat source code-words: HOT–WATER (default), ELECTRIC, GAS–FURNACE, or OIL–FURNACE. The gas and oil furnace sources should be used with caution since the same HIR and part-load functions are used as for other furnaces specified in the same system.
SIZING–RATIO	is used to deliberately oversize or undersize all equipment in the system.
ZONE–NAMES	is a list of zone names (enclosed in parentheses) of the ZONEs that are assigned to this SYSTEM. This data entry, with the u-name of at least *one ZONE*, is required. If the SYSTEM being simulated is the type that serves both a central zone and one or more subzones (i.e., SZRH, PSZ and RESYS), the u-

---

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

	name of the control ZONE must be listed *first.* Example: ZONE-NAMES=(ZONE-1,ZONE-2)
MAX-COND-RCVRY	enables recovery of condenser heat from packaged single zone units (PSZ). The input is the fraction of recoverable heat from the condenser for reheating.
REHEAT-DELTA-T	is the maximum increase in temperature for supply air passing through the zone (or subzone) reheat coils. The value specified here applies to all zones in the system.
MIN-CFM-RATIO	is the minimum allowable supply air flow rate, expressed as a decimal fraction of design flow rate. This keyword applies only to variable-volume type systems. (This keyword appears also under the ZONE command. The value specified here in the SYSTEM command applies to all zones in the system that do not have an overriding specification at the zone level in the ZONE command.) A low value for MIN-CFM-RATIO can result in reducing the flow of air below that set by MIN-OUTSIDE-AIR, thus simulating the system operation below minimum ventilation criteria.
HEATING-CAPACITY	is **required** for the PTGSD system and is input as a minus value; **must be sized by the user**

SYSTEMS–REPORT

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

Format:

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

Example:

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

will print verification report SV–A, "System Design Parameters", and summary reports SS–A, "System Monthly Loads Summary", and SS–O, "Temperature Scatter Plot".

A definition of all reports, with corresponding code-words, is given in Appendix D.

PLANT

Introduction

The PLANT program translates the energy supplied to space heating and cooling equipment into the energy actually consumed by boilers, chillers, pumps, engines, etc. It sums the hourly demands of the electricity used by lights, fans and equipment and of the fuel used by boilers and engines. It also accounts for any heat recovered. From these totals it generates reports on monthly and yearly usage.

For each hour simulated the following information is passed from SYSTEMS to PLANT:

For Boilers, Chiller, Electric Utility or Total Energy Plant

Heating Load in Btu/hr Cooling Load in Btu/hr Electric Load in kW Hot water in Btu/hr Gas in Btu/hr Oil in Btu/hr	} As modified by SYSTEMS

For Cooling Tower Simulation

Ambient air temperature in °F
Humidity ratio in lb water/lb dry air

Utility usage is based on a conversion factor called SOURCE-SITE-EFF, to reflect the energy consumed at the source to create the utility-supplied energy. All energy conversions are based on actual curve fits of representative equipment. Users should examine the default parameters to be sure that they represent the equipment to be simulated.

Suggested Sequence of PLANT Program Input

First enter an

```
INPUT PLANT ..
```

instruction. The BDL processor will expect a

```
PLANT-EQUIPMENT
```

instruction next. At least one PLANT-EQUIPMENT instruction must be entered for PLANT to run. The following instructions may then be entered as desired or required:

```
PART-LOAD-RATIO
PLANT-PARAMETERS
HEAT-RECOVERY
ENERGY-RESOURCE
```

After the keywords and values required by the above instructions are specified, an END instruction is entered to indicate that the input data is finished; finally, an instruction is entered that tells the PLANT program to perform the desired computations:

```
END ..
COMPUTE PLANT ..
```

In the following, the user will find:

- A description of each type of plant equipment.
- A sample input for each type of equipment. For trial purposes, these inputs can be used to replace the PDL input on p.B.11 (Appendix B).
- A list of other capabilities for each type of equipment.

Description of ELEC–STM–BOILER

The electric boiler in DOE-2 is a multi-staged electric resistance unit. The default condition is no electricity use for feed water or condensate pumps. Suggested minimal input for ELEC–STM–BOILER is:

```
STM-B = PLANT-EQUIPMENT    TYPE = ELEC-STM-BOILER    SIZE = -999 ..
```

Note that SIZE = -999 will cause the program to automatically size the boiler based on the peak demand calculated by SYSTEMS.

Additional Capabilities for ELEC–STM–BOILER:

1. To simulate additional electricity use for feed water or condensate pumps, insert the command

```
PART-LOAD-RATIO   TYPE = ELEC-STM-BOILER   E-I-R = 1.05 ..
```

This provides a 5% additional electric requirement for pumping, which is assumed to vary proportionately to the load on the boiler.

Description of STM–BOILER

The steam boiler in DOE-2 is an oil-fired boiler with an induced draft fan. The default for the combined electricity use of the power burner and draft fan is 2.2% of the boiler size. Suggested minimal input for STM–BOILER is as follows:

```
STM-B = PLANT-EQUIPMENT    TYPE = STM-BOILER    SIZE = -999 ..
```

Additional Capabilities for STM–BOILER:

1. To simulate a gas-fired rather than an oil-fired steam boiler, insert the command:

```
PLANT-PARAMETERS  BOILER-FUEL = NATURAL-GAS ..
```

2. To simulate additional electricity use for feed water or condensate pumps, refer to the suggested input for ELEC–STM–BOILER.

Description of HW–BOILER

The hot water boiler is also referred to as a hot water generator. It is an oil-fired unit with a default of 2.2% added electric for power burner and an induced draft fan. A hot water recirculating pump is automatically included by the program and is sized to the system peak. Suggested minimal input for HW–BOILER is as follows:

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

Additional Capabilities for HW-BOILER:

1. To simulate a unit without a power gas burner and induced draft fan, insert:

```
PART-LOAD-RATIO   TYPE = HW-BOILER   E-I-R = 0 ..
```

2. To change the pumping requirements, to change the unit to gas-fired, or to change the efficiency of the burner, there are a number of keywords to use:

```
PLANT-PARAMETERS   HCIRC-SIZE-OPT          = INST-PLANT-EQUIP
                   HCIRC-PUMP-TYPE         = VARIABLE-SPEED
                   HCIRC-DESIGN-T-DROP     = value desired
                   HCIRC-HEAD              = value desired
                   BOILER-FUEL             = NATURAL-GAS
                   BOILER-HIR              = 1.25  ..  $ 1/efficiency
```

Description of ELEC-HW-BOILER

The electric hot water boiler is a multi-stage electric resistance hot water generator with a hot water pump. See the description of HW-BOILER above.

Description of ABSOR1-CHLR

The one-stage absorption chiller in DOE-2 is a unit that can be supplied by either 12-lb steam or 240°F water. The solution pumps for the unit require only 0.4% additional electric energy based on the size of the unit. A chilled water pump is called automatically, and sized on the peak system requirement. The user must input either a steam boiler, a hot water boiler, or district steam to supply heat to drive the absorption chiller. A cooling tower is also called automatically; the user can input it if desired, but is cautioned not to input the size nor the number of units. Suggested minimal input for ABSOR1-CHLR is as follows:

```
AB-CHLR = PLANT-EQUIPMENT   TYPE = ABSOR1-CHLR   SIZE = -999 ..
```

Additional Capabilities for ABSOR1-CHLR:

1. To increase the electric requirements for solution pumps insert:

```
PART-LOAD-RATIO   TYPE = ABSOR1-CHLR   E-I-R = value desired
```

2. To input a cooling tower explicitly, insert:

```
CTOW = PLANT-EQUIPMENT   TYPE = COOLING-TWR   SIZE = -999 ..
```

It is suggested that you do not enter the size of the tower because in DOE-2, size refers to the tower cell size and INSTALLED-NUMBER refers to the number of cells.

3. To change the pumping requirements to suit specific project needs, use PLANT-PARAMETERS:

```
PLANT-PARAMETERS   CHILL-WTR-T          = value desired
                   ABSOR1-HIR           = .66 is default, but
                                          old units may
                                          have degraded
                                          to as low as .4
                   TWR-TEMP-CONTROL     = FLOAT or FIXED
```

TWR-WTR-SET-POINT = value desired
(use if FIXED temp selected)
TWR-DESIGN-WETBULB = value desired
TWR-PUMP-HEAD = value desired
(condenser water pump)
CCIRC-DESIGN-T-DROP = value desired
CCIRC-HEAD = value desired
CCIRC-SIZE-OPT = INST-PLANT-EQUIP
CCIRC-PUMP-TYPE = VARIABLE-SPEED ..

4. To supply steam to the building for space heating or for the absorption chiller from a district steam (or hot water) system, use:

ENERGY-RESOURCE RESOURCE = STEAM ..

Description of ABSOR2-CHLR
The two-stage absorption chiller in DOE-2 is the same as the one-stage chiller (ABSOR1-CHLR), except that it operates with 125-lb steam or 400°F hot water. The electric requirement for solution pumps in 0.7% of the unit size. All of the additional capabilities described for the ABSOR1-CHLR also apply here. Suggested minimal input for ABSOR2-CHLR is:

AB2-CHLR = PLANT-EQUIPMENT TYPE = ABSOR2-CHLR SIZE = -999 ..

Description of ABSORG-CHLR
The direct gas-fired absorption chiller can also operate as a hot water generator. Therefore, all accessories are called such as the cooling tower, chilled water pump, condenser water pump, and hot water pump. The solution pumps default to 0.7% of the unit size since this, too, is a two-stage unit. All of the additional capabilities described for ABSOR1-CHLR apply, with the following additions:

PLANT-PARAMETERS ABSORG-HIR = value desired (1.0 is default)
ABSORG-FUEL = NATURAL-GAS (default), FUEL-OIL, or LPG
ABSORG-HEAT-XEFF = value desired for the HWG efficiency (decimal fraction) ..

Description of HERM-CENT-CHLR
The hermetic centrifugal chiller in DOE-2 has a default COP of 4.55 and a KW/Ton of .77, which makes it a very conservatively rated unit for present day practice. The cooling tower, condenser water pump, and chilled water pump are all called by default; however, the user can modify the selection of these auxiliaries using the keywords described for ABSOR1-CHLR. Suggested minimal input for HERM-CENT-CHLR is as follows:

CHL = PLANT-EQUIPMENT TYPE = HERM-CENT-CHLR SIZE = -999 ..

Additional Capabilities for HERM-CENT-CHLR:

1. To change to an air-cooled condenser, specify:

```
PLANT-PARAMETERS   HERM-CENT-COND-TYPE = AIR  ..
```

2. To change the COP of the unit to 5.0 (0.7 KW/Ton), set ELEC-INPUT-RATIO, which is the inverse of COP, as follows:

```
PART-LOAD-RATIO   TYPE = HERM-CENT-CHLR   E-I-R = .2  ..
```

Description of HERM-REC-CHLR
The hermetic reciprocating chiller in DOE-2 is a unit characteristic of multi-compressor or unloading compressor types. It has a default COP of 3.65 or a KW/Ton of .96, which is still reasonable for today. The user can change the unit to an air-cooled condenser (the default is a cooling tower with condenser water pump) and chilled water pump. The unit can be modified as described for ABSOR1-CHLR. Suggested minimal input for HERM-REC-CHLR is:

```
CHL =   PLANT-EQUIPMENT    TYPE = HERM-REC-CHLR  SIZE = -999  ..
        PLANT-PARAMETERS   HERM-REC-COND-TYPE = AIR  ..
```

Description of DBUN-CHLR
The double bundle chiller in DOE-2 is a centrifugal type chiller with two condenser tube bundles, one of which is piped to the cooling tower and the other piped to the building hot water heating circuit. The unit operates as a straight chiller whenever there is no call for heat and operates as a heat pump to reject heat to the heating circuit up to its maximum capacity; it is then supplemented by a hot water boiler. Suggested minimal input for DBUN-CHLR is:

```
HP-CHLR   = PLANT-EQUIPMENT   TYPE = DBUN-CHLR   SIZE = -999  ..
HWG       = PLANT-EQUIPMENT   TYPE = HW-BOILER   SIZE = -999  ..
```

Additional Capabilities for DBUN-CHLR:

1. In the building heating mode, to change the leaving water temperature from the condenser (default = 105°F), insert:

```
PLANT-PARAMETERS   DBUN-COND-T-REC = value desired  ..
```

2. If there is a chiller other than the double bundle, the program will stage the units to favor the double bundle when heating is required. When entering another chiller, the user should size both units, since the program doesn't know what split is required.

```
CHLR = PLANT-EQUIPMENT   TYPE = HERM-CENT-CHLR
                         SIZE = value (millions of Btu/hr)  ..
```

Description of ENG-CHLR

The gas engine chiller in DOE-2 is a nominal 100-ton reciprocating chiller driven by a modified diesel engine. The unit capacity is controlled by varying the speed of the engine to meet the building load; it has a default evaporator/engine COP of 1.4. It is possible to recover heat from the engine to satisfy space heating loads and/or provide service hot water. The unit defaults to cooling tower but can also be air-cooled. Suggested minimal input for ENG-CHLR is as follows:

```
ECHL = PLANT-EQUIPMENT   TYPE = ENG-CHLR   SIZE = -999 ..
```

Additional Capabilities for ENG-CHLR:

1. To recover heat from the engine for both space heat and service hot water, insert:

```
HEAT-RECOVERY   SUPPLY-1 = (ENG-CHLR)
                DEMAND-1 = (SPACE-HEAT,PROCESS-HEAT) ..
```

2. To change the unit to air-cooled, insert:

```
PLANT-PARAMETERS   ENG-CH-COND-TYPE = AIR ..
```

Description of COOLING-TWR

The cooling tower in DOE-2 is an induced draft tower with a propeller type fan at the top. There are numerous plant parameters that allow the user to modify the design wet bulb temperature and to satisfy other specific requirements. Most users do not input the tower because DOE-2 automatically calls for one and sizes it whenever one is needed. However, the default design wet bulb is 75°F, which is acceptable for some locations but not all. Suggested minimal input for COOLING-TWR is as follows:

```
CTW = PLANT-EQUIPMENT   TYPE = COOLING-TWR   SIZE = -999 ..
```

Additional Capabilities for COOLING-TWR:

1. To change the design wet bulb, insert:

```
PLANT-PARAMETERS   TWR-DESIGN-WETBULB = value desired ..
```

Description of DHW-HEATER and ELEC-HEATER

The service hot water heaters in DOE-2 are standard units. The DHW-HEATER is gas fired (default). There is no pumping assigned to either unit type, but the user can use the PART-LOAD-RATIO command to assign pumping if desired. If the user wants to recover waste heat (previously demonstrated for ENG-CHLR), a hot water heater must not be entered because it locks out recovery. Also, to simulate an indirect exchanger inside the hot water generator for service hot water heating, a hot water heater should not also be entered.

PDL INPUT INSTRUCTIONS

Limitation on the Number of Commands

The maximum allowable number of PDL instructions for specifying required PLANT data is as follows:

Instruction	Maximum Number
TITLE	5
PLANT-EQUIPMENT	6 for each equipment type
PLANT-PARAMETERS	1
HEAT-RECOVERY	1
ENERGY-RESOURCE	5
PLANT-REPORT	1 command
U-names	118

Description of PDL Input Instructions

PLANT-EQUIPMENT

U-name	is not required but is advisable in order to identify equipment in reports.
TYPE	is the type of equipment to be used. See following Table 5.1 for allowed code-words.
SIZE	is the nominal rated output capacity, expressed in units of one million Btu's per hour (MBtu/hr), for the item of equipment being specified. For example, a 100-ton chiller should be specified as SIZE = 1.20 since the conversion factor is 12,000 Btu/hr per ton. A ten million Btu/hr boiler is specified as SIZE = 10.0. If SIZE = −999 is entered, PLANT automatically sizes, in accordance with peak load, the following types of equipment: all boilers, chillers, towers, and diesel and gas electric generators. Steam turbine generators will not be automatically sized. Hot water and chilled water circulation pumps are **always** automatically sized by the PLANT program. The flow rate, electrical power, and heat gain are calculated from the values of PLANT-PARAMETERS keywords as follows:

Flow Rate: $GPM_p = \frac{\text{Design-Load}}{\text{X-DESIGN-T-DROP} \times 60 \text{ min/h} \times 8.34 \text{ Btu/gallon-}^\circ\text{F}}$

Power: $Elect_p = \frac{\text{X-HEAD} \times GPM_p \times 0.643 \text{ Btu-min/ft-gallon-hr}}{\text{X-MOTOR-EFF} \times \text{X-IMPELLER-EFF}}$

Heat Gain: $Gain_p = (\text{Design-Load} \times \text{X-LOSS}) + (Elect_p \times \text{X-MOTOR-EFF})$

INSTALLED-NUMBER is the total number of units of the type and size previously specified. As an example, if three 100-ton chillers have been specified, enter INSTALLED-NUMBER = 3.

Note: input the actual sizes and number of equipment when known (such as in retrofit studies) in order to improve the accuracy of the simulation.

TABLE 5.1

TYPE Code-Words for PLANT Equipment

Equipment	Code-Word
Heating	
Electric boiler	ELEC-STM-BOILER
Steam boiler	STM-BOILER
Hot-water boiler	HW-BOILER
Electric hot-water boiler	ELEC-HW-BOILER
Cooling	
One-stage absorption chiller	ABSOR1-CHLR
Two-stage absorption chiller with economizer	ABSOR2-CHLR
Absorption chiller/HWG (gas fired)	ABSORG-CHLR
Hermetic centrifugal compression chiller	HERM-CENT-CHLR
Hermetic reciprocating compression chiller	HERM-REC-CHLR
Double bundle chiller	DBUN-CHLR
Cooling tower	COOLING-TWR
Gas Engine driven reciprocating chiller	ENG-CHLR
Domestic Hot Water*	
Domestic hot-water heater	DHW-HEATER
Electric domestic hot-water heater	ELEC-DHW-HEATER

* If a domestic hot water heater is not input, hot water loads input in LOADS through the BUILDING-RESOURCE instruction or the SOURCE-BTU/HR keyword in the SPACE-CONDITIONS subcommand will be passed to other heating equipment. If no heating equipment is defined, the domestic hot water demand will appear as a load not met.

PART–LOAD–RATIO

The equipment PART–LOAD–RATIO instruction specifies the nominal electric power input ratio to operate the equipment and/or supporting electric auxiliaries. The **PART–LOAD–RATIO** command tells the PDL Processor that the data to follow are related to the part-load operation of a specific type of equipment.

TYPE	is the code-word selected from Table 5.1 that identifies the type of equipment to which the part-load ratios specified in this instruction are applicable. Only one TYPE may be specified per instruction.
ELEC–INPUT–RATIO	The electric input to nominal capacity ratio is expressed as

$$\text{ratio} = \frac{\text{electric power input to electric auxiliaries (Btu/hr)}}{\text{nominal capacity of equipment being defined (Btu/hr)}}$$

or

ratio = 1/COP for refrigeration machines
See Table 5.2 for default values.

This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself. For an absorption refrigeration chiller, the electric power input to the solution pump must be considered. Similarly, for a fossil-fueled boiler, the electric power input to the boiler draft fan and power burners must be considered. However, when defining the ELEC–INPUT–RATIO for this equipment, the user should realize that the electric power delivered to the hot, chilled, and condenser water pumps is calculated separately and size and capacities are controlled through PLANT–PARAMETER keywords. This is also true for cooling tower fans.

TABLE 5.2

Equipment PART-LOAD-RATIO Default Values

TYPE Code-Word		Electric Input to Nominal Capacity (default)
Heating Equipment		
ELEC-STM-BOILER	Electric boiler	1.000
STM-BOILER	Steam boiler	0.022
HW-BOILER	Hot water boiler	0.022
ELEC-HW-BOILER	Electric hot water boiler	1.000
Cooling Equipment		
ABSOR1-CHLR	One-stage absorption chiller	0.004
ABSOR2-CHLR	Two-stage absorption chiller w/economizer	0.004
ABSORG-CHLR	Gas-driven absorption chiller	.00
HERM-CENT-CHLR	Hermetic centrifugal chiller	0.220
HERM-REC-CHLR	Hermetic reciprocating chiller	0.274
DBUN-CHLR	Double-bundle chiller	0.220
ENG-CHLR	Gas engine driven reciprocating chiller	0.0053
Domestic Hot Water		
DHW-HEATER	Water heater	0.000
ELEC-DHW-HEATER	Electric water heater	1.000

PLANT-PARAMETERS

The PLANT-PARAMETERS instruction is used to change the value of many of the variables used by the PLANT program in the simulation of plant components. Detailed descriptions of how the variables represented by each keyword are used in the PLANT program calculations are provided in the *DOE-2 Engineers Manual.* Following is additional discussion of specific keywords.

Chillers

CHILL-WTR-T	is the chilled water temperature at the middle of the throttling range for chillers. Default is 44°F.
MIN-COND-AIR-T	is the minimum entering air temperature allowed for an air-cooled condenser (°F). This is the minimum operating temperature below which control action is initiated to maintain at least this temperature.
ABSOR1-HIR	is the full-load heat input ratio for a 1-stage absorption chiller. The heat input ratio is the ratio of heat energy input to cooling energy output.
ABSOR2-HIR	is the full-load heat input ratio for a 2-stage absorption chiller with an economizer (see ABSOR1-HIR).
ABSORG-HIR	is the full-load heat input ratio for a direct gas fired absorption chiller.
ABSORG-FUEL	accepts a code-word for the type of fuel used in a direct fired absorption chiller. The default is NATURAL-GAS. Other fuels that could be used are FUEL-OIL and LPG.
ABSORG-HEAT-XEFF	is the efficiency of the hot water heat exchanger used in the heating mode. The default is 0.8.
ENG-CH-COP	is the overall COP of the engine driven reciprocating chiller. or the evaporator capacity of the chiller divided by the heat input of the engine. The default is 1.4, which is appropriate when the engine operates at nominal speed to meet its design load. A COP in the range of 1.1 to 1.2 should be entered for a machine that is anticipated to operate at full speed to meet the design load.
ENG-CH-FUEL	accepts a code-word that specifies the type of fuel supplied to the engine. The default is NATURAL-GAS; other fuels are not recommended by the manufacturer. FUEL-OIL and LPG are possible alternatives for future equipment.

ENG-CH-COND-TYPE	accepts a code-word that specifies how heat is rejected from the chiller. The default is TOWER and the alternative is AIR (for air cooled).
HERM-CENT-COND-TYPE	accepts a code-word that specifies the condenser heat rejection method for a hermetic centrifugal chiller. The default code-word is TOWER, used when heat is rejected through an evaporative cooling tower. The alternative is AIR, which implies an air-cooled condenser.
HERM-REC-COND-TYPE	is the code-word that specifies the condenser type for a hermetic reciprocating chiller (see HERM-CENT-COND-TYPE keyword description).
DBUN-COND-T-REC	is the leaving condenser temperature when the chiller is in the heat recovery mode. This parameter is used in calculating adjustment factors for the capacity and power consumption. The leaving condenser temperature in both the heat-recovery mode and the non-heat-recovery mode at the design point (calculated from DBUN-COND-T-ENT, ELEC-INPUT-RATIO, and DBUN-TO-TWR-WTR) is used to calculate the condenser temperature rise in the heat recovery mode. The temperature rise is then used in the functions DBUN-CAP-FTRISE and DBUN-EIR-FTRISE.

Cooling Tower

MIN-TWR-WTR-T	specifies the minimum temperature for leaving tower cooling water. If the temperature falls below this minimum operating temperature, control action is initiated to maintain at least this temperature.
TWR-DESIGN-WETBULB	is the wet-bulb temperature used in the cooling tower design calculations.
TWR-FAN-CONTROL	accepts a code-word that specifies whether the tower fan is ONE-SPEED (the default) or TWO-SPEED.
TWR-PUMP-HEAD	is the pressure head in the tower water circulation loop.
TWR-TEMP-CONTROL	accepts a code-word that defines how the exiting water temperature is to be determined. The default, FLOAT, means that the exiting temperature will float with the wet-bulb temperature. The alternative code-word, FIXED, means that the exiting water temperature is fixed. (See TWR-WTR-SET-POINT keyword description).

TWR-WTR-SET-POINT	specifies the exiting water temperature setpoint when TWR-TEMP-CONTROL is set to FIXED.

Boilers

BOILER-FUEL	accepts a code-word that specifies the type of fuel used in a boiler. The allowable code-words are DIESEL-OIL, NATURAL-GAS, FUEL-OIL, LPG, COAL, METHANOL, and BIOMASS.
HW-BOILER-HIR	is, for a hot-water boiler, the ratio of fuel input (Btu) to heat energy output at full load.
STM-BOILER-HIR	is, for a steam boiler, the ratio of fuel input (Btu) to heat energy output.

Domestic Hot-Water Heaters

DHW-HIR	is, for a domestic water heater at full load, the ratio of fuel input (Btu) to heat energy produced.
DHW-HEATER-FUEL	accepts a code-word that specifies the type of fuel used by a domestic hot water heater. The default is NATURAL-GAS. The allowable code-words are DIESEL-OIL, NATURAL-GAS, FUEL-OIL, LPG, COAL, METHANOL, and BIOMASS.

Pumps

CCIRC-DESIGN-T-DROP	is the temperature drop in the chilled water circulation loop at design; it is used to establish the appropriate water flow rate.
CCIRC-HEAD	is the head pressure in the chilled water circulation loop. Setting this keyword to zero will result in a circulation pump power of zero.
CCIRC-LOSS	is the fraction of the design load in the chilled water circulation loop that is lost to the environment and therefore does no useful cooling.
HCIRC-DESIGN-T-DROP	is the temperature drop in the hot water circulation loop at design conditions. It is used to establish the appropriate water flow rate. Note that if the user has input a STM-BOILER, ELEC-STM-BOILER, or FURNACE, this keyword is ignored. Note also that the heating load satisfied by a DHW-HEATER or ELEC-DHW-HEATER is not considered to be a part of this heating circulation loop.
HCIRC-HEAD	specifies the head pressure in the hot water circulation loop. If this is set equal to 0., circulation pump power will also be set

to zero.

HCIRC-LOSS	is the fraction of the design load that is lost to the environment from the hot water circulation loop and therefore does no useful heating. In the case of a hot water boiler, this value does not include any heat gain caused by pump energy. If the user has input a FURNACE, this keyword is ignored.
CCIRC-SIZE-OPT	accepts a code-word that indicates how much load the chilled water circulation pumps will be sized to meet. The allowable code-words are SYSTEM-PEAK (the default) and INST-PLANT-EQUIP. Specifying SYSTEM-PEAK will result in the pumps being sized to meet the peak load passed from SYSTEMS. Specifying INST-PLANT-EQUIP will result in the pumps being sized to meet the total installed capacity of PLANT-EQUIPMENT specified (regardless of whether this equipment was specified by default or input by the user).
HCIRC-SIZE-OPT	accepts a code-word that indicates how much load the hot water circulation pumps will be sized to meet. The allowable code-words and definitions are identical to those available for CCIRC-SIZE-OPT.
CCIRC-PUMP-TYPE	accepts a code-word that specifies whether the chilled water circulation pumps are fixed- or variable-speed pumps. The allowable code-words are FIXED-SPEED (the default) and VARIABLE-SPEED. If this keyword is set equal to VARIABLE-SPEED, then losses will be determined on the basis of the actual loads being served by the pumps.
HCIRC-PUMP-TYPE	accepts a code-word that specifies whether the hot water circulation pumps are fixed- or variable-speed pumps. The allowable code-words and definitions are identical to those available for CCIRC-PUMP-TYPE.
CCIRC-MIN-PLR	accepts a numeric value between 0.0^+ and 1.0 that places a low limit on the electricity consumption of the chilled water circulation pumps. It is expressed as as a fraction of the full load electricity consumption of the pumps. The default is 0.50.
HCIRC-MIN-PLR	accepts a numeric value between 0.0^+ and 1.0 that places a low limit on the electricity consumption of the hot water circulation pumps. It is expressed as fraction of the full load electricity consumption of the pumps. The default is 0.50.

HEAT-RECOVERY

The function of the HEAT-RECOVERY instruction is to specify the equipment or process from which energy can be recovered and to direct that energy to a process or other equipment. Only one HEAT-RECOVERY instruction is allowed per PLANT run. If a double-bundle chiller is specified without defining a HEAT-RECOVERY instruction, the heat rejected from the double bundle is delivered only to space heating. See the *DOE-2 Engineers Manual* for a description of heat recovery in appropriate equipment simulations. The **HEAT-RECOVERY** command tells the PDL Processor that the data to follow are related to recovered energy from plant equipment or processes.

SUPPLY-1

The user enters a list of code-words that describes the equipment or process that *supplies* recoverable heat. The specification

SUPPLY-1 = (DBUN-CHLR)

assigns the waste heat from the double bundle chiller to the highest temperature level to meet demands. Heat can also be recovered from the gas engine chiller, ENG-CHLR.

DEMAND-1

The user enters a list of code-words that describes the equipment or process that *demands* recoverable heat. For example,

DEMAND-1 = (SPACE-HEAT, PROCESS HEAT)

specifies that the heat from the sources indicated in SUPPLY-1 are to go to fulfill the unmet demand for space heating and for domestic hot water or process heat, which will be done in proportion to their corresponding loads.

ENERGY-RESOURCE

This instruction allows the user to enter information about the types of energy used in PLANT. The ENERGY-RESOURCE command can be used up to five times to specify up to five different types of energy. An ENERGY-RESOURCE command must be entered if a steam/hot-water (code-word STEAM) or a chilled water (code-word CHILLED-WATER) utility is to be used.

RESOURCE

accepts a code-word that tells the simulation which fuel or utility will be used.

The acceptable code-words are
STEAM
CHILLED-WATER
ELECTRICITY
NATURAL-GAS
FUEL-OIL
DIESEL-OIL
LPG
COAL
METHANOL
and
BIOMASS

SOURCE-SITE-EFF

is the generating efficiency of the fuel or utility prior to its use in the building being simulated. Failure to specify an ENERGY-RESOURCE command for a fuel or utility will result in the use of the default values for SOURCE-SITE-EFF listed below.

TABLE 5.3
Source-to-Site Generating Efficiency
Default Values for ENERGY-RESOURCE

RESOURCE	SOURCE-SITE-EFF
CHILLED-WATER	1.5*
STEAM	0.60**
ELECTRICITY	0.333
NATURAL-GAS	1.0
FUEL-OIL	1.0
COAL	1.0
DIESEL-OIL	1.0
METHANOL	1.0
LPG	1.0
BIOMASS	1.0

* Efficient electrically-driven chillers in a central chilled-water plant.

** Steam produced by heat-only boiler in a central steam generation plant.

PLANT-REPORT

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

Format:

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

Example:

```
PLANT-REPORT    VERIFICATION = (PV-A)
                SUMMARY = (PS-D, BEPS) ..
```

will print verification report PV–A, "Equipment Sizes", and summary reports PS–D, "Plant Loads Satisfied", and BEPS, "Estimated Building Energy Performance".

A definition of all reports, with corresponding code-words, is given in Appendix D.

ECONOMICS

Introduction

There are three commands for all utilities (ENERGY–COST, CHARGE–ASSIGNMENT, and DAY–CHARGE–SCH) and one special command for electricity (COST–PARAMETERS) which are used in the ECONOMICS sub-program for the calculation of energy costs. The interactions among them can be summarized as follows: The most basic features of a tariff — units, uniform cost rates, monthly charges, etc. — are all contained in an ENERGY–COST command, which is entered for each fuel or utility used in the previous PLANT run. The CHARGE–ASSIGNMENT is used primarily to specify block-rate structures but can also be used for simple uniform rate charges on demands as well as energy. CHARGE–ASSIGNMENTs can be referenced by the ENERGY–COST command in two ways, directly or through a SCHEDULE. Seasonal and time-of-day variations in tariffs require the use of a SCHEDULE (referenced in the ENERGY–COST command for that utility or fuel), which reference DAY–CHARGE–SCHs that, in turn, reference CHARGE–ASSIGNMENTs. The complex features of tariffs for electricity, which include provisions for demand ratchets and the sell-back of electricity to a utility, are specified through COST–PARAMETERS.

Example EDL Input

The best way to learn to input tariffs in EDL is to study the input examples in conjunction with the command and keyword descriptions. A simple example is given below. See also Appendix B and Examples 1 through 5 at the end of this section.

```
INPUT ECONOMICS ..

ENERGY-COST  RESOURCE = ELECTRICITY  ASSIGN-CHARGE = (ELCOST)  ..

ELCOST = CHARGE-ASSIGNMENT  RESOURCE = ELECTRICITY  TYPE = ENERGY
      BLOCK-RANGE = (800,1200,10000)
      BLOCK-CHARGE = (.075,.090,.10)  ..

ENERGY-COST  RESOURCE = NATURAL-GAS  UNIT = 100000  UNIFORM-COST =.62  ..
ECONOMICS-REPORT  SUMMARY = (ES-D) ..

END ..
COMPUTE ECONOMICS ..
```

ENERGY-COST

For each utility or fuel used in PLANT, a separate ENERGY-COST command must be entered. The ENERGY-COST command has associated with it several keywords pertaining to the specified utility or fuel. For a simple energy cost calculation in which all units consumed are valued at one rate, only the ENERGY-COST command and the associated keywords need be entered. Failure to specify an ENERGY-COST command for a utility or fuel used in PLANT will result in the use of the default values listed in Table 6.1. For more complex tariffs, involving either blocks or time-of-use/seasonal features, two additional commands, CHARGE-ASSIGNMENT and DAY-CHARGE-SCH, are required.

RESOURCE	is a required keyword that indicates which fuel or utility is being valued. The code-words associated with this keyword are identical to those available in PLANT (STEAM, CHILLED-WATER, ELECTRICITY, NATURAL-GAS, LPG, FUEL-OIL, DIESEL-OIL, COAL, METHANOL, BIOMASS).
UNIT	accepts a numeric input that specifies the number of Btu's in the unit to which the following tariff rates or schedules apply. This value can range from 0.0^+ to 100000000.0 Btu/unit. Table 6.1 lists default values for this keyword by resource.
UNIFORM-COST	accepts a uniform charge rate in dollars per unit. This value can range from 0.0 to 100000.0 $/unit. In the absence of references to a CHARGE-ASSIGNMENT, either directly or through a schedule, this keyword will default in accordance with Table 6.1.
ESCALATION	is the annual rate of "real" escalation (relative to the general inflation rate) in percent to be used in life-cycle cost calculations. This value can range from 0.0 to 100.0%. The default values are listed on Table 6.1.

TABLE 6.1

Default Values for ENERGY-COST

RESOURCE	UNIT	UNIFORM-COST ($/Unit)	ESCALATION (%/Year)
STEAM	1000000.00 Btu/unit	13.00	5.0
CHILLED-WATER	1000000.00 Btu/unit	13.4	5.0
ELECTRICITY	3412.97 Btu/kWh	0.0686	5.0
NATURAL-GAS	1031000.00 Btu/MCF	5.53	5.0
LPG	95500.00 Btu/gal.	1.50	5.0
FUEL-OIL	138700.00 Btu/gal.	1.186	5.0
DIESEL-OIL	138700.00 Btu/gal.	1.005	5.0
COAL	24580000.00 Btu/ton	30.00	5.0
METHANOL	63500.00 Btu/gal.	1.13	5.0
BIOMASS	1000000.00 Btu/unit	0.95	5.0

MIN-MONTHLY-CHG	accepts a value that places a floor on the cost of a fuel or utility for each month that costs are calculated. This value can range from 0.0 to 100000.0 $/month and defaults to 0.0.
FIXED-MONTH-CHG1	accepts a numeric value that adds a fixed charge to each month in the first SEASON, as designated in the CHARGE-ASSIGNMENTs for this utility or fuel. If no CHARGE-ASSIGNMENTs are used, SEASON is always assumed to be the first. If CHARGE-ASSIGNMENTs with different SEASONs overlap in one month, FIXED-MONTH-CHG1 is prorated by hours with FIXED-MONTH-CHG2. This value can range from 0.0 to 100000.0 $/month and defaults to 0.0.
FIXED-MONTH-CHG2	is identical to FIXED-MONTH-CHG1 except it applies to the second SEASON specified in a CHARGE-ASSIGNMENT. If allowed to default, it will be set equal to FIXED-MONTH-CHG1.
RATE-LIMITATION	accepts a value in dollars per unit that places a ceiling on the effective rate that will be assessed on a utility or fuel for any month. This value can range from 0.0 to 100000.0 $/unit and defaults to 10000.0.
ASSIGN-CHARGE	accepts, in parentheses, the U-names of up to two CHARGE-ASSIGNMENTs. There is no default for this keyword.

ASSIGN-SCHEDULE	accepts, not in parentheses, the U-name of a SCHEDULE that references CHARGE-ASSIGNMENTs (through WEEK-SCHEDULEs and DAY-CHARGE-SCHs). There is no default for this keyword.

CHARGE–ASSIGNMENT

The CHARGE–ASSIGNMENT command is used to specify block-style tariffs. Several keywords associated with this command may be entered more than once. Note that the repeatable keywords, beginning with TYPE (defined below) must be entered *after* the non-repeatable keywords (RESOURCE, C–A–LINK, and SEASON) or an error will result. CHARGE–ASSIGNMENTs for a utility or fuel are referenced through the ENERGY–COST command directly or through a schedule. In the latter case, the DAY–CHARGE–SCH command is used in conjunction with the existing SCHEDULE and WEEK–SCHEDULE commands to reflect seasonal and time-of-day tariff schedules. A total of six CHARGE–ASSIGNMENTs may be entered for each utility or fuel. Additional CHARGE–ASSIGNMENTs will generate a warning indicating that they will be ignored.

U-name	is required.
RESOURCE	is a required keyword that identifies the fuel or utility that this CHARGE–ASSIGNMENT is to be applied against. The code-words are: STEAM CHILLED–WATER ELECTRICITY LPG NATURAL–GAS DIESEL–OIL FUEL–OIL COAL METHANOL and BIOMASS
C–A–LINK	accepts the U-name of a different CHARGE–ASSIGNMENT, which becomes linked to the present one. This keyword is *only* used when the RESOURCE is ELECTRICITY and charges are being assessed for demand (kW); it will not affect the calculation of charges, if specified for other fuels or utilities. This link will be used to allocate charges between CHARGE–ASSIGNMENTs in the event that, as a result of scheduling, more than one appears in the same month. For example, if Summer on-peak demands switch to Winter on peak-demands in mid-September, only the fraction the demand charge corresponding to the ratio of hours of Winter on-peak to total on-peak hours (and vice-versa) will be assessed. This prevents the double counting of two "whole-month" demand charges in a single month.

	A second use of C-A-LINK is to link two CHARGE-ASSIGNMENTs dedicated to TYPE=DEMAND (see below) that describe seasonal charges that differ from Summer to Winter. The link allows a ratchet to be carried from one season to the next when DEM-PERIOD-Tn=WHOLE-YEAR.
SEASON	accepts an integer value of 1 or 2 (default = 1) that is used when there are seasonal changes in a set of scheduled CHARGE-ASSIGNMENTs. This keyword will be used to determine which FIXED-MONTH-CHG(1 or 2) or demand ratchet option (see COST-PARAMETERS) will be used. Like C-A-LINK, if there are overlaps in a month, FIXED-MONTH-CHG will be prorated on the basis of hours.
TYPE	accepts a code-word which determines the type of energy units for which the charge assignment is to be applied. The code-word ENERGY means that this type of charge is for units per month, and the code-word DEMAND means that the type is for units per hour. With the exception of electricity (see discussion of demand ratchets in COST-PARAMETERS), DEMAND is always taken to be the highest use of energy (or "peak") per hour in the hours of the month to which the CHARGE-ASSIGNMENT applies. ENERGY is the default value. TYPE is the first repeatable keyword allowed in a CHARGE-ASSIGNMENT; a maximum of two TYPEs may appear in one CHARGE-ASSIGNMENT. Note that the keywords listed before TYPE (RESOURCE, C-A-LINK, SEASON), if they are to be used, must be entered before TYPE.
UNIFORM-CHARGE	accepts a numeric value that specifies a uniform charge rate in dollars per unit, where unit is determined by the previous TYPE. The use of this keyword implies that there is no block rate structure to follow, all units of energy are priced equally. Only one UNIFORM-CHARGE is allowed per TYPE. The range is from 0.0 to 1000.0 $/unit, and there is no default.
OVER-BLOCK-RANGE	accepts a numeric value in units of TYPE that defines ranges of applicability for the keywords that follow. It corresponds exactly to the LOAD-RANGE keyword in a LOAD-ASSIGNMENT. Up to three OVER-BLOCK-RANGEs can be specified for each TYPE so that the user can specify up to three ranges for which a different set of tariffs is to apply. In operation the code will check to see that the value for TYPE (ENERGY or DEMAND) is less than or equal to the value of OVER-BLOCK-RANGE in order for the following keywords to apply. If it exceeds this value, the code will skip to the next OVER-BLOCK-RANGE and repeat this check until the appropriate set of tariffs is found. If no

	OVER-BLOCK-RANGE can be found large enough, a warning is issued and no charges are assessed for this TYPE. If no OVER-BLOCK-RANGE is specified, it is assumed that there is only one OVER-BLOCK-RANGE of a very large size. The range is from 0.0 to 10^9 units.
BLOCK-UNIT	accepts a code-word that can be used to change the units of TYPE being assessed within the OVER-BLOCK-RANGE. The code-words are ENERGY, DEMAND, and KWH/KW. If not specified, BLOCK-UNIT will default to either the previous BLOCK-UNIT or TYPE specified in the OVER-BLOCK-RANGE. BLOCK-UNITs must be consistent with one another; BLOCK-UNITs of DEMAND and ENERGY can not appear in the same OVER-BLOCK-RANGE. Note that KWH/KW is used to specify blocks of energy whose size is a function of demand and therefore is a unit consistent with ENERGY.
BLOCK-RANGE	accepts a list enclosed by parentheses of up to ten values indicating the size of the blocks to be used in assessing block-charges. Blocks are increments; hence each successive block covers the next size increment. Rates written as "up to X" must be translated (see Example 2, **Inverted Block**). The range is from 0.0 to 10^9, and there is no default.
BLOCK-CHARGE	accepts a list enclosed by parentheses of up to ten values corresponding to the charges to be assessed for each of the blocks previously specified in the BLOCK-RANGE. Up to two sets of BLOCK-RANGE/BLOCK-CHARGEs can be specified in each OVER-BLOCK-RANGE. The range is from -1000.0 to 1000.0 $/unit, and there is no default.

DAY–CHARGE–SCH

This command accepts, in parentheses, integer values referring to hours and, for each of these groups of hours also in parentheses, up to two U-names of CHARGE–ASSIGNMENTs. In a manner similar to the DAY–ASSIGN–SCH command used in PLANT to schedule LOAD–ASSIGNMENTs, DAY–CHARGE–SCH is referenced by U-name in a WEEK–SCHEDULE command, which, in turn, is referenced by a SCHEDULE command (see the discussion of scheduling concepts in the *Reference Manual (2.1A)*, p.II.12ff and in the *DOE-2 User News*, Fall 1988). The U-name for the SCHEDULE is referenced in the ENERGY–COST command by the keyword ASSIGN–SCHEDULE. DAY–CHARGE–SCH U-names can be nested in the SCHEDULE, thus bypassing WEEK–SCHEDULE.

U-name	A unique user-defined name must be entered to identify this instruction.

For an example, see the ECONOMICS input in the Sample Run, Appendix B.

COST-PARAMETERS

A final command, COST-PARAMETERS, is used to specify the special features of tariffs for electricity. These include the characteristics of demand ratchets, where the billing demand (kW) is taken to be the larger of the highest demand in the relevant period of the month and a "ratchet" based on previous recorded demands. In calculating demand ratchets, previous recorded demands can include months in the simulation that are "downstream" of the current one. That is, since DOE-2 run periods are for a single year, information from the entire year may be used in calculating the ratchet for a particular month. The COST-PARAMETERS command also accepts keywords that specify how electricity generated on-site (via diesel engines. gas and steam turbines; see the description of PLANT-EQUIPMENT in the PLANT EQUIPMENT OPERATION MODES section, starting on p.4.1, of the *DOE-2 Supplement (2.1D)*) is to be accounted for with respect to interconnection with a utility.

DEM-RATCHET-T1	accepts a code-word that identifies how the demand is billed for SEASON = 1. The code-words are MEASURED. HIGHEST, and AVERAGE. MEASURED (the default) implies no ratchet and the billing demand is the highest measured demand for any hour in every given month. HIGHEST implies a ratchet based on the highest demand in the period(s) defined in the ASSIGN-SCHEDULE. AVERAGE implies a ratchet based on an average of highest demand in the period(s) defined in the ASSIGN-SCHEDULE.
DEM-RATCHET-T2	is identical to DEM-RATCHET-T1, but applies to SEASON = 2 as defined by the ASSIGN-SCHEDULE. The default value is that specified (or defaulted) for DEM-RATCHET-T1.
DEM-PERIOD-T1	accepts a code-word that limits the duration of a ratchet. The code-words are SEASON and WHOLE-YEAR (the default). SEASON limits the ratchet to a comparison against the highest demand in the months of SEASON = 1. WHOLE-YEAR allows the ratchet to carry for twelve months and, hence, into SEASON = 2 as well.
DEM-PERIOD-T2	is identical to DEM-PERIOD-T1, but applies to SEASON = 2. Note that if Winter is season 1 and Summer is season 2, setting DEM-PERIOD-T1 = SEASON and DEM-PERIOD-T2 = WHOLE-YEAR causes the Winter months to be charged the higher of either Winter or Summer ratchet. For Summer months, only the Summer ratchet (i.e.. highest demand during Summer season) applies. The default is DEM-PERIOD-T1.
DEM-AVERAGE-MON1	accepts an integer value of 2 (the default) or 3. The program seeks the peak demand for SEASON = 1 as defined in the CHARGE-ASSIGNMENT commands, averages the highest

	demands for the month on each side of the peak, then compares and selects the higher peak average. The value of 2 limits this comparison to months on each side of the peak month. The value of 3 means that the selection is from the highest average from the combination of one month on either side of the peak, two consecutive months before, or two consecutive months after.
DEM–AVERAGE–MON2	is identical to DEM–AVERAGE–MON1, except that it applies to SEASON = 2. The default value is DEM–AVERAGE–MON1.
DEM–RATCHET–FRC1	accepts a numeric value between 0.0 and 1.0 that is multiplied against either the highest or averaged value for months in the first season. The default value is 1.0.
DEM–RATCHET–FRC2	is identical to DEM–RATCHET–FRC1 except that it applies to ratchets calculated in the second season. The default is DEM–RATCHET–FRC1.
POWER–FACT–CORR	accepts a numeric value between 0.0 and 1.0 that is divided into the kW demand or ratchet (whichever is greater) to arrive at the billing demand. Electricity demands are thus adjusted for power phase imbalances between the utility and the site. The default value is 1.0.
KWH/KW–DEM–TYPE	accepts a code-word that indicates which demand is being used to partition blocks of energy charges in a CHARGE–ASSIGNMENT. The code-words are RECORDED (the default) and BILLING. The code-word RECORDED means that the highest measured demand will be used, when BLOCK–UNIT is KWH/KW; BILLING means that the billing demand as determined by the COST–PARAMETERS keywords will be used.

Examples of Electricity Tariffs

To illustrate the use of the ECONOMICS commands and keywords, a series of examples is presented. The examples are for various electricity tariffs commonly found in the United States which, with the exception of COST-PARAMETERS keywords, can be extended to other fuels and utilities.

Example 1: Uniform Charge

The most basic tariff is a uniform-charge levied on all units consumed in a month. For this example, all kilowatt-hours cost $.05 and there is a monthly customer charge of $15.00. The minimum bill is $17.00 and there are no demand charges.

```
ENERGY-COST
  RESOURCE=ELECTRICITY          $ THIS IS A REQUIRED KEYWORD $
  UNIT = 3413                   $ THIS IS THE DEFAULT VALUE $
  UNIFORM-COST = .05
  MIN-MONTHLY-CHG = 17
  MONTH-CHG1 = 15    ..
```

Example 2: Inverted Block

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 as a "baseline" or "lifeline" 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.

```
ENERGY-COST
  RESOURCE = ELECTRICITY                  $ THIS KEYWORD IS REQUIRED $
  ASSIGN-CHARGE = (INVBLK)    ..

INVBLK = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY                  $ THIS KEYWORD IS REQUIRED $
  TYPE = ENERGY                           $ THIS IS THE DEFAULT VALUE $
  BLOCK-RANGE = (500,400,10000000)        $ THE SECOND ENTRY IS THE
                                          $ SIZE OF THE "NEXT" BLOCK
                                          $ AND THE THIRD IS JUST
                                          $ SOME LARGE NUMBER $

  BLOCK-CHARGE = (.0535,.0725,.1245)    ..
```

Example 3: Seasonal

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 lifeline allowances at this time of year.

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  ASSIGN-SCHEDULE = TWOSEASON    ..

WINTERBLK = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  BLOCK-RANGE = (1000,1000000)         $ SECOND ENTRY
                                       $ IS A BIG NUMBER $
  BLOCK-CHARGE = (.07,.10)    ..

SUMMERBLK = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  BLOCK-RANGE = (500,1000000)
  BLOCK-CHARGE = (.06,.09)    ..

WINTERDY = DAY-CHARGE-SCH
  (1,24) (WINTERBLK)    ..

SUMMERDY = DAY-CHARGE-SCH
  (1,24) (SUMMERBLK)    ..

TWOSEASON = SCHEDULE
  THRU MAY 31  (ALL)  WINTERDY         $ NOTE NESTING
  THRU SEP 30  (ALL)  SUMMERDY         $ OF WEEK-SCHEDULE $
  THRU DEC 31  (ALL)  WINTERDY    ..
```

Example 4: kWh/kW Energy Charge

Some block rate structures partition energy use by blocks, the size of which is determined by demands (kW). There may also be instances where it is unclear which schedule of charges applies because this decision is determined by, say, the kW demand, which is still unknown. In this example, the OVER-BLOCK-RANGE is used to decide which schedule to use and BLOCK-UNITs are used to set the actual charges. For this utility, a demand greater than 50 kW means using one schedule of charges, while a demand of less than or equal to 50 kW requires using another. The schedules are identical in the manner in which the blocks are sized, but the charges differ.

	≤ 50 kW	> 50kW	
first 1000 kWh	.050	.060	$/kWh
next 4000 kWh	.045	.055	
next 200 kWh per kW demand	.040	.050	
all remaining kWh	.035	.045	

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  ASSIGN-CHARGE = (KWHKWBLOCK) ..
KWHKWBLOCK = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY   TYPE = DEMAND
    OVER-BLOCK-RANGE = 50                    $ THIS SAYS TO USE THE
                                             $ FOLLOWING CHARGES WHEN
                                             $ DEMAND IS LESS THAN 50 KW
      BLOCK-UNIT = ENERGY
      BLOCK-RANGE = (1000,4000)
      BLOCK-CHARGE = (.05,.045)
      BLOCK-UNIT = KWH/KW
      BLOCK-RANGE = (200,1000000)            $ THE SECOND ENTRY IS
                                             $ JUST SOME LARGE NUMBER
    BLOCK-CHARGE = (.040,.035)
    OVER-BLOCK-RANGE = 1000000               $ ANOTHER LARGE NUMBER
                                             $ INDICATING THAT DEMANDS
                                             $ WILL BE GREATER THAN THE
                                             $ PREVIOUS ONE FOR THIS SET
                                             $ OF CHARGES
      BLOCK-UNIT = ENERGY
      BLOCK-RANGE = (1000,4000)
      BLOCK-CHARGE = (.06,.055)
      BLOCK-UNIT = KWH/KW
      BLOCK-RANGE = (200,1000000)
      BLOCK-CHARGE = (.050,.045)    ..
```

In this example, if the demand to be used in determining the size of the third block is the billing demand not the measured demand, the following command must be included:

```
COST-PARAMETERS
  KWH/KW-DEM-TYPE = BILLING    $ DEFAULT VALUE IS MEASURED $   ..
```

Example 5: Ratchet

The most significant difference between residential and commercial electricity tariffs is the inclusion of demand charges. Typically, the highest measured demand (integrated over some fraction of an hour) is compared against a "ratchet" chosen or calculated from some set of previous highest demands and the larger of the two is taken to be the billing demand. 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. We first present an example in which the ratchet is taken to be 90% of the highest demand recorded in the previous 12 months and the charge is $12.00 per kW. There is a flat charge on energy of $.05 per kWh but in no circumstance can the effective rate (i.e., including the demand charges) exceed $.07 per kWh.

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  RATE-LIMITATION = .07
  ASSIGN-CHARGE = (HIDEMAND)    ..

HIDEMAND = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  TYPE = ENERGY
    UNIFORM-CHARGE = .05
  TYPE = DEMAND
    UNIFORM-CHARGE = 12.00    ..

COST-PARAMETERS
  DEM-RATCHET-T1 = HIGHEST
  DEM-PERIOD-T1  = WHOLE-YEAR
  DEM-RATCHET-FRC1 = .90    ..
```

We can alter this example by specifying the ratchet to be the average of the two highest demands in the previous twelve simply by substituting code-words in the COST-PARAMETERS command as follows:

```
COST-PARAMETERS
  DEM-RATCHET-T1 = AVERAGE
  DEM-PERIOD-T1  = WHOLE-YEAR
  DEM-AVERAGE-MON1 = 2  ..
```

Example 6: Time-of-Use

An innovation in rate design was the introduction of time-of-use rates wherein the time of day, week, and year in which 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, for each season an on-peak, and off-peak period for each weekday, and only off-peak on Saturday, Sunday and holidays. There is no demand ratchet but there are two demand charge periods corresponding to the the month in each season.

```
ENERGY-COST
  RESOURCE = ELECTRICITY
  ASSIGN-SCHEDULE = TIMEOFUSE    ..

WINDEM = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 1                        $ FOR THIS EXAMPLE
  C-A-LINK = SUMDEM                 $ WINTER=1 SUMMER=2 $
  TYPE = DEMAND
  UNIFORM-CHARGE = 5.00    ..

WINOFF = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 1                        $ C-A-LINK ONLY FOR DEMANDS $
  TYPE = ENERGY                     $ NOT NEEDED FOR THIS C-A $
  UNIFORM-CHARGE = .04    ..

WINON = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 1
  TYPE = ENERGY                     $ ENERGY IS THE DEFAULT VALUE
  UNIFORM-CHARGE = .06    ..

SUMDEM = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 2
  C-A-LINK = WINDEM
  TYPE = DEMAND
  UNIFORM-CHARGE = 15.00    ..

SUMOFF = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 2
  TYPE = ENERGY
  UNIFORM-CHARGE = .05    ..

SUMON = CHARGE-ASSIGNMENT
  RESOURCE = ELECTRICITY
  SEASON = 2
  TYPE = ENERGY
  UNIFORM-CHARGE = .07    ..
```

```
WINWEEKDY = DAY-CHARGE-SCH
  (1,8)       (WINOFF,WINDEM)
  (9,22)      (WINON,WINDEM)
  (23,24)     (WINOFF,WINDEM)    ..

WINWKND = DAY-CHARGE-SCH
  (1,24)      (WINOFF,WINDEM)    ..

SUMWEEKDY = DAY-CHARGE-SCH
  (1,8)       (SUMOFF,SUMDEM)
  (9,20)      (SUMON,SUMDEM)
  (21,24)     (SUMOFF,SUMDEM)    ..

SUMWKND = DAY-CHARGE-SCH
  (1,24)      (SUMOFF,SUMDEM)    ..

TIMEOFUSE = SCHEDULE
  THRU MAY 15     (WD)     WINWEEKDY
                  (WEH)    WINWKND
  THRU SEP 15     (WD)     SUMWEEKDY
                  (WEH)    SUMWKND
  THRU DEC 31     (WD)     WINWEEKDY
                  (WEH)    WINWKND    ..
```

We now modify the time-of-day example by substituting a DAY-CHARGE-SCH that has shoulder- or partial-peak periods in addition to on- and off-peak periods. For this sub-example, we ignore the specification of the corresponding CHARGE-ASSIGNMENTs beyond mention of the U-name in the DAY-CHARGE-SCH command.

```
WWKDY = DAY-CHARGE-SCH
  (1,8)      WOFF
  (9,16)     WPAR
  (17,20)    WON
  (21,22)    WPAR        $ WPAR IS WINTER PARTIAL PEAK  $
  (23,24)    WOFF  ..

WWKND = DAY-CHARGE-SCH
  (1,24)     WOFF  ..
SWKDY = DAY-CHARGE-SCH
  (1,8)      SOFF
  (9,12)     SPAR
  (13,17)    SON
  (18,21)    SPAR        $ SPAR IS SUMMER PARTIAL PEAK $
  (22,24)    SOFF  ..
SWKND = DAY-CHARGE-SCH
  (1,24)

TIME-OF-DAY = SCHEDULE
  THRU MAY 15    (WD)    WWKDY    (WEH)    WWKND
  THRU SEP 15    (WD)    SWKDY    (WEH)    SWKND
  THRU DEC 31    (WD)    WWKDY    (WEH)    WWKND    ..
```

ECONOMICS-REPORT

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

Format:

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

Example:

```
ECONOMICS-REPORT    VERIFICATION = (none required)
                    SUMMARY = (ES-D, ES-E) ..
```

will print summary reports ES-D, "Summary of Fuel and Utility Use and Costs", and ES-E, "Summary of Electricity Charges". A definition of all reports, with corresponding code-words, is given in Appendix D.

Appendix A

Additional Capabilities of DOE-2

DOE-2 has many capabilities other than those covered in the main text of this manual; following is a list of these capabilities. Items in the list point to the source (i.e. other pieces of DOE-2 documentation) where the user will find the capability as it was presented originally or in some cases modified and enhanced. In some cases the *Sample Run Book (2.1E)* is referenced in order to demonstrate the simulation method. Because there are other phrases or terms that are often used to reference the capability that may be of interest, we have cross referenced a number of them in this list.

The items in the list appear alphabetically and are not separated into the LOADS, SYSTEMS, PLANT, and ECONOMICS subprograms.

ASHRAE Constructions for Walls and Roofs	In lieu of entering a LAYERS command, the user can reference ASHRAE pre-specified layers found in the *Reference Manual (2.1A)*, Table 26, pp.III.63-66.
ASHRAE Materials Library	In lieu of using the materials library provided in this manual the user can reference ASHRAE pre-specified materials found in the *Reference Manual (2.1A)*, Table 8, pp.III.63-66.
ASHRAE Weather Design Criteria	see **Design Day**
Atria	see **Sunspace**
Building Coordinate System	An X Y Z three-dimensional description of the building and shading surfaces can be entered. The method is described in detail in the *Reference Manual (2.1A)*, p.III.8; additional features are described on p.2.63. of the *Supplement (2.1E)*. Specifying surface coordinates is generally only necessary if (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 *Sample Run Book (2.1E)*, p.452ff.
Casework Heat Recovery	see **Refrigerated Casework**
CBS/ICE (Component-Based Ice Storage Simulation)	Allows users to assemble static (ice-on-coil) ice storage systems from components. See **Energy Storage**; also refer to p.4.22 of the *Supplement (2.1E)*.

Chilled Water Storage	see **Energy Storage**
Cogeneration	using either gas turbine, diesel, or natural gas engines can be modeled. See the writeup on p.4.8 of the *Supplement (2.1E)*, and an example on pp.287-301 of the *Sample Run Book (2.1E)*.
Curve Fit	allows the user to input new performance curves. Since most vendor-supplied equipment information is provided in the form of curves or tabulated data, the user can enter new data and overwrite the curves stored in the program. A detailed description of how to input the data is found on p.IV.180 of the *Reference Manual (2.1A)*. Examples appear on pp.202 and 305 of the *Sample Run Book (2.1E)*.
Custom Weighting Factors	allow the user to tailor the weighting factors used in the load calculations to the building being modeled. This improves the accuracy of the calculation. A detailed discussion is found on pp.III.141-153 of the *Reference Manual (2.1A)*. Numerous examples also appear in the *Sample Run Book (2.1E)* but the one on p.454 was prepared to highlight this capability.
Daily Reports	see **Hourly Reports**
Daylighting	simulates control of lighting fixtures in response to the level of natural lighting from the sun, sky, and reflection off the inside surfaces of the space. Both dimming and step control can be modeled. Window shade management to control solar gain and/or glare can be modeled. See pp.2.33-44 of the *Supplement (2.1E)*. The example starting on p.493 of the *Sample Run Book (2.1E)* covers the method of input and shows the reports available.
Desiccant Cooling	see System Type PTGSD in this manual and the PTGSD writeup on p.3.29 of the *Supplement (2.1E)*.

Desiccant Add-On Units	see writeup on p.3.81 of the *Supplement (2.1E)* for Integrated Desiccant Cooling, covering both solid and liquid systems.
Design Day	is a feature that allows the user to enter the design criteria for outside weather conditions. Peak loads are calculated based on these conditions rather than those on the weather tape. The automatic sizing for systems is based on the design criteria; the plant is sized on the maximum loads that occur during the systems design day run period. See the *Sample Run Book (2.1E)*, p.14.
Energy Storage	Hot and cold water storage is described on pp.V.73-81 of the *Reference Manual (2.1A)*. The *Sample Run Book (2.1E)* shows an example of cold water storage on p.218 and hot water storage on p.266. Ice storage systems are described on pp.4.25-45 of the *Supplement (2.1E)* and an example is given in the *Sample Run Book (2.1E)* under "Office Building and Open Atrium".
Evaporative Cooling	see writeup on three configurations of evaporative cooling in the *Supplement (2.1E)*: Stand-alone Evaporative Cooling, p.3.73, Add-on Evaporative Cooling, p.3.75, Residential Swamp Cooler, p.3.79.
Fabric Roof Pressurization	see **Night Ventilation**
Fan Power	can be input using alternative keywords for fan location, total static pressure, and fan efficiency. Most building codes use watts/cfm to determine limits for fan power and the program defaults to these approximate values. However, the alternative capability is often preferred by design engineers. The keywords are discussed on pp.IV.224-227 of the *Reference Manual (2.1A)*. Also, see the *Sample Run Book (2.1E)*, p.201.

Functions	In LOADS, this allows the user to replace DOE-2 code with his/her own algorithms to model options like non-linear dimming controls, complex window management, etc. In SYSTEMS, this allows the user to replace DOE-2 code with his/her own algorithms to model things like non-standard economizer controls, control of supply air with a return air controller, etc. A detailed discussion with numerous examples is found on pp.1.1-30 of the *Supplement (2.1E)*. Also, see the *Sample Run Book (2.1E)*, p.493.ff.
Gas Heat Pumps	See **Heat Pumps**
Glass Coefficients	for windows is an alternative and more accurate method of calculating solar gains through window glazings than the shading coefficient method. See **Window Library**; also refer to p.2.89 of the *Supplement (2.1E)*.
Grocery Store Heat Recovery Systems	see **Refrigerated Casework**
Heat Pumps	with user-defined type of defrost control and of supplemental heat in lieu of electric resistance heat is covered in detail on p.3.15 and p.3.53 of the *Supplement (2.1E)*.
Hot Water Storage	see **Energy Storage**
Hourly Reports	are a means of displaying user-selected hourly values calculated by the program. Hourly reports also give daily sums, maxima, minima, and averages. See p.1.25 and *Appendix A* of the *Supplement (2.1E)*, and pp.III.127-130 of the *Reference Manual (2.1A)*. The *Sample Run Book (2.1E)* has an example starting on p.518.
Ice Rink Modeling	see **Refrigerated Casework**
Ice Storage Model	see **Energy Storage**

Infiltration Modeling	using the CRACK Method is found on p.III.50 of the *Reference Manual (2.1A)*. Infiltration modeling using the Sherman-Grimsrud Method is found on p.2.74 of the *Supplement (2.1E)*.
Input Macros	allow keywords to be set equal to the result of adding, subtracting, multiplying and/or dividing other values. See p.1.32ff of the *Supplement (2.1E)*.
Interior Walls	The different types of interior walls that can be specified (STANDARD, AIR, ADIABATIC, and INTERNAL) are described on pp.2.82ff of the *Supplement (2.1E)*. For a discussion of convective heat transfer across interior walls between a sunspace (atrium) and adjacent space, see the *Supplement (2.1E)*, p.2.6ff.
Life Cycle Cost Analysis	see Economics Component-Costs on p.VI.6 of the *Reference Manual (2.1A)*. See also the *Sample Run Book (2.1E)*, p.172.
Lighting Control	see **Daylighting**
Load Assignment	is a feature in PLANT that makes it possible to control the operation of plant equipment based on operating range or selection, e.g. switching from a centrifugal chiller to an absorption chiller for peak shaving. See the *Reference Manual (2.1A)*, p.V.52 and the *Supplement (2.1E)*, p.4.2. An example is shown in the *Sample Run Book (2.1E)*, p.218.
Load Management	is used in combination with load assignment to control the operation of plant equipment based on scheduling requirements, etc. See the *Reference Manual (2.1A)*, p.V.59 and the *Sample Run Book (2.1E)*, p.219.
Loads Reports	see *Appendix C* of the *Supplement (2.1E)* for a description of all reports available.
Management of Plant Equipment Operation	see **Load Assignment** and **Load Management**

Mfr's Equipment Data	see **Curve Fit**
Metric Input/Output	allows the user to enter and report values in metric (SI) units rather than English (Imperial) units. See the *Supplement (2.1E)*, p.1.2ff.
Monthly Reports	see **Hourly Reports**
Motorized Drapes or Blinds	see **Window Management**
Natural Ventilation	Enhancements for residential models can be found on p.3.33 of the *Supplement (2.1E)*. The model simulates the amount of air movement through the space due to open windows as a function of wind speed and features of the surrounding terrain. See the *Sample Run Book (2.1E)*, p.457.
Night Insulation of Windows	see **Window Management**
Night Ventilation	uses outside air to purge and precool the building, primarily at night. The method can also be used to simulate pressurization of fabric roof arenas. See the *Supplement (2.1E)*, p.3.19ff and the *Sample Run Book (2.1E)*, pp.201-202.
Optimum Fan Start	simulates advancing the system start time to bring a building to comfort conditions at start of occupancy. See the *Supplement (2.1E)*, p.3.17ff and the *Sample Run Book (2.1E)*, p.264.
Outside Air Economizers (nonstandard)	see **Functions**
Parametric Input	is a feature that is convenient when many DOE-2 runs are necessary. The user can change one parameter (or additional related parameters) at the top of the input file and replacements are made automatically in the body of the input. This is especially helpful for the researcher. See the *Reference Manual (2.1A)*, p.II.8 and the *Sample Run Book (2.1E)*, p.459ff.

Peak Integrated Cooling Load	is information that is needed for Thermal Energy Storage Systems. Report SS-J shows both the day on which the peak hour occurs and the day on which the sum of the peaks occur. See the *Supplement (2.1E)*, p.C.82.
Peak Shaving	see **Load Management**
Plant Reports	see *Appendix C* the *Supplement (2.1E)* for a description of all reports available.
Plenums	for return air systems can be found on p.IV.198 of the *Reference Manual (2.1A)*. Note that it is unnecessary to define plenums in both LOADS and SYSTEMS if the user requests RETURN-AIR-PATH = DUCT. This input is sufficient to simulate light heat from return air vented lighting fixtures. There are other ways to apply the plenum model for areas that are used to vent adjacent spaces; for applicable keywords see p.iii, "Miscellaneous Changes", of the *Supplement (2.1E)*, and p.3.21 for heating of these spaces.
Predefined Input Segments	see **Input Macros**
Refrigerated Casework	applies primarily to food stores where there is considerable interest in recovering the heat from the refrigeration compressors serving the casework. The reason for this is that the cold air off the display cases drops the temperature in the store approximately 10°F, and heating is required even in mild weather. Control of the relative humidity in the space to limit the build-up of frost on the evaporator coils also requires heat. The algorithms can also be used to simulate ice rinks. See the *Supplement (2.1E)*. p.3.6ff and the *Sample Run Book (2.1E)*, p.393.
Replacing DOE-2 Code	see **Functions**

Reports	In the *Supplement (2.1E)*, see the following sections for information on **Reports:** *Appendix A: Hourly Report Variable List*, and *Appendix C: Verification and Summary Reports.*
Self Shading	When one surface of a building shades another, see p.2.67 of the *Supplement (2.1E).*
Shading	by adjacent buildings is discussed on p.III.35 of the *Reference Manual (2.1A)* and on p.2.63 of the *Supplement (2.1E).* Except for "fins and overhangs" the simulation of shading requires the user to input the building surfaces that are involved into a three-dimensional coordinate system; see **Building Coordinate System.** Also, see the *Sample Run Book (2.1E)*, p.455, for an example.
Sunspace	is a feature that is used to simulate atria for large buildings and for attached sunrooms for residences. It is possible to simulate the effect of solar radiation through both exterior and interior space glazing. Air movement between spaces can be simulated either by natural convection or forced using a fan. See pp.2.1-2.21 of the *Supplement (2.1E)*, and p.541ff of the *Sample Run Book (2.1E).*
Sun Control Shading	see **Window Management**
Switchable Glazing	that changes from clear to colored depending on ambient conditions can be modeled. An example is electrochromic glass. See p.2.100 of the *Supplement (2.1E)*, and the "Office/Deli-Restaurant" example in the *Sample Run Book (2.1E).*
System Equipment Default Curves	are listed on p.3.26 of the *Supplement (2.1E).* The user should plot and look at the default curves before replacing them with other data.

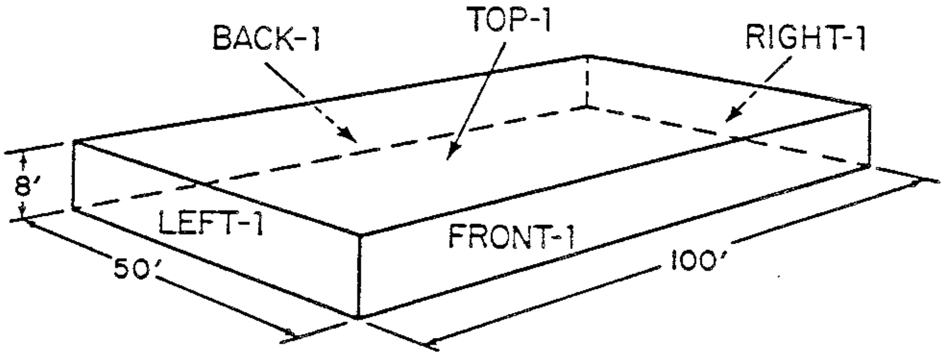
System Reports	see *Appendix C* of the *Supplement (2.1E)* for a description of all reports available.
System Types	- Single Zone Ceiling Induction (SZCI) - Ceiling Bypass (CBVAV) - Two Pipe Induction (TPIU) - Four Pipe Induction (FPIU) - Panel Heating (PH) - Central Ventilation (HVSYS) are the six system types that are available in addition to those covered in this manual; they are discussed on pp.IV.33-81 of the *Reference Manual (2.1A).*
Thermal Energy Storage	see **Energy Storage**
Three Dimensional Building Input	see **Building Coordinate System**
Trombe Walls	Vented and unvented Trombe walls can be simulated. See p.2.60ff of the *Supplement (2.1E).*
Unconditioned Spaces	such as attics and basements can be modeled. See p.IV.198 of the *Reference Manual (2.1A).*
VAV Systems	
with Warm-Up Cycle	see p.215 of the *Sample Run Book (2.1E).*
with Baseboard Heat with Outside Air Reset	see p.234 of the *Sample Run Book (2.1E)*
with Supply Air Reset	see p.20 of the *Sample Run Book (2.1E)*
Venting of Sunspace	see **Sunspace**
Window Library	a library of 176 entries covering commonly-available glazing is discussed in detail on p.2.89 of the *Supplement (2.1E).*
Window Management	to control solar gain or daylight glare; window management is discussed in detail on p.2.3 of the *Supplement (2.1E).* For examples, see p.193 and p.495 of the *Sample Run Book (2.1E).*

Appendix B

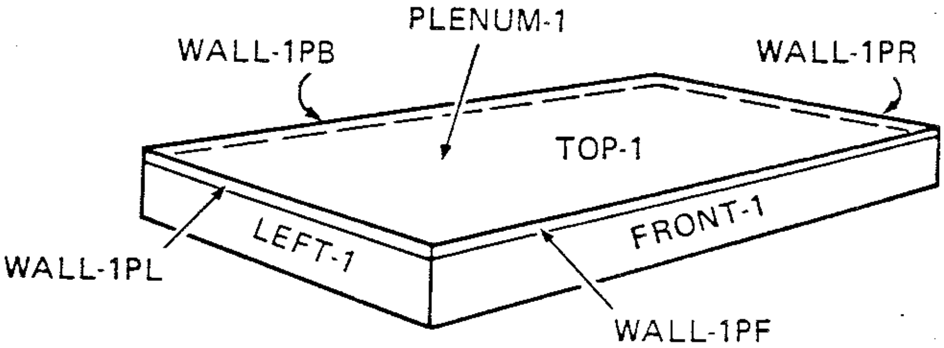
Examples of DOE-2 Input and Output

This Appendix gives a sample input and output of a DOE-2 run with annotations that direct the user to items of interest. This run is the same as that on pp.1.9-18 of this manual, but with the following modifications:

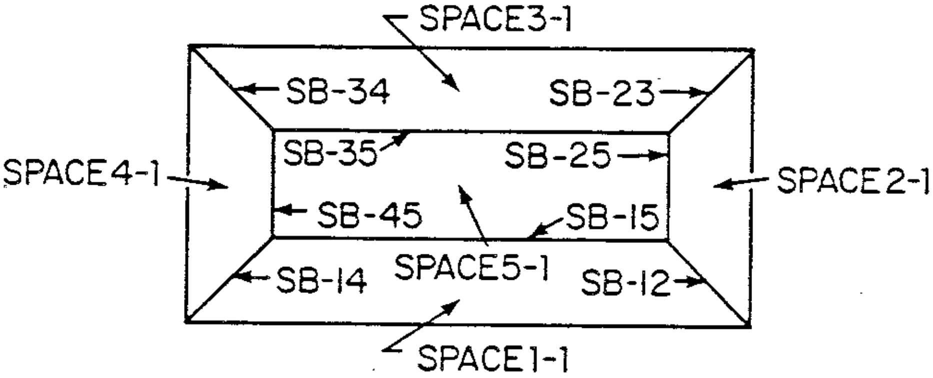
- — the input is three dimensional,
- — instead of one single zone the floor space has been separated into five zones,
- — there is a return air plenum,
- — a time-of-day electric rate structure has been included,
- — additional output reports are shown, and
- — the input and output have been annotated to highlight important features.



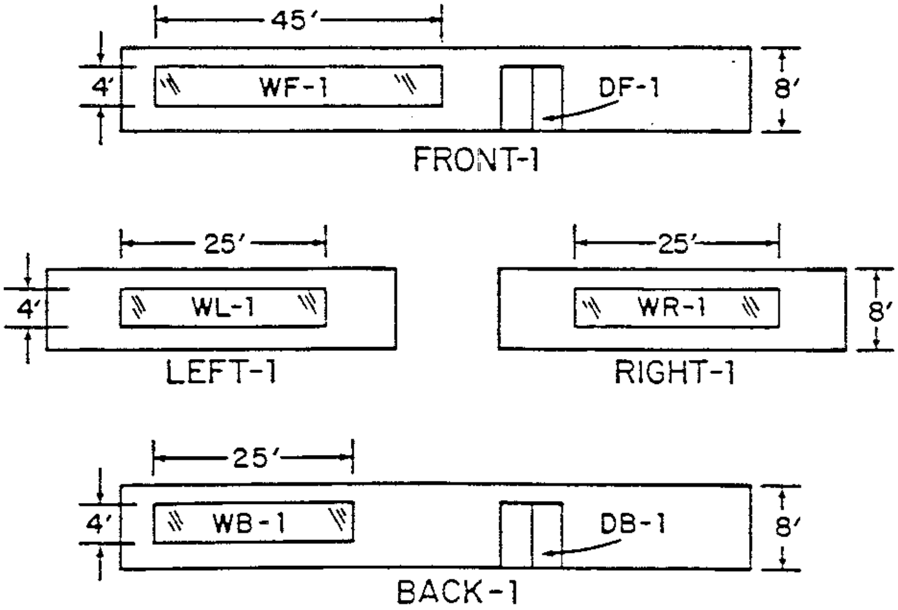
Isometric view of basic building showing orientation. FRONT–1, RIGHT–1, etc., are u-names (user-defined names) for the front wall, right-hand wall, etc. The building coordinate axes (X, Y, and Z) are shown. The building is oriented 30° from true north.



Basic building with plenum and its walls (u-named WALL–1PF, WALL–1PL, etc.).



Plan view showing zoning and u-names of spaces and interior walls.



Elevations showing placement of windows, doors, and their u-names.

Sample Input

```
INPUT LOADS  INPUT-UNITS  = ENGLISH
             OUTPUT-UNITS = ENGLISH  ..

TITLE            LINE-1 *SIMPLE STRUCTURE RUN, CHICAGO *
                 LINE-2 *EXAMPLE FOR DOE2.1E OVERVIEW*  ..

                 ABORT              ERRORS  ..
                 DIAGNOSTIC         WARNINGS  ..
                 RUN-PERIOD         JAN 1 1974 THRU DEC 31 1974  ..
                 LOADS-REPORT       VERIFICATION = (LV-D)
                                    SUMMARY      = (LS-C)  ..
                 BUILDING-LOCATION  LATITUDE = 42.0  LONGITUDE = 88.0
                                    ALTITUDE = 610   TIME-ZONE = 6
                                    AZIMUTH  = 10.0  ..

                    $ CONSTRUCTION AND GLASS-TYPES

WA-1-2  = LAYERS   MATERIAL = (WD01,PW03,IN02,GP01)  ..
RB-1-1  = LAYERS   MATERIAL = (RG01,BR01,IN46,WD01)
                         INSIDE-FILM-RES = .76  ..

WALL-1  = CONSTRUCTION      LAYERS  = WA-1-2  ..
ROOF-1  = CONSTRUCTION      LAYERS  = RB-1-1  ..

CLNG-1  = CONSTRUCTION      U-VALUE = 0.27  ..
SB-U    = CONSTRUCTION      U-VALUE = 1.5   ..
FLOOR-1 = CONSTRUCTION      U = 0.05  ..

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

The year of the weather tape used

Building is oriented 10 degrees from true north

These code-words for building materials were selected from the stored DOE-2 library

A user-assigned name (u-name) for later reference

```
                    $ OCCUPANCY SCHEDULE

OCCUPY-1      - SCHEDULE   THRU DEC 31
                           (MON,FRI)(1,8) (0) (9,11) (1)
                                    (12,14) (.8,.4,.8) (15,18) (1)
                                    (19,21) (.5,.1,.1) (22,24) (0)
                           (SAT,HOL)(1,24) (0.0)   ..
```

The daily profiles
Hours 1 to 8 at zero occupancy
Hours 15 to 18 at full occupancy

```
                    $ LIGHTING SCHEDULE

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

               $ OFFICE EQUIPMENT SCHEDULE
```

Comment lines start with $;
they are ignored by the program

```
EQUIP-1       - SCHEDULE   THRU DEC 31
                              (WD) (1,8) (.02) (9,14) (.8)
                                   (15,20) (.8,.7,.5,.5,.3,.3)
                                   (21,24) (0.2)
                             (WEH) (1,24) (.02)   ..

               $ INFILTRATION SCHEDULE

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

Infiltration is on during winter

```
               $ SET DEFAULT VALUES

              SET-DEFAULT FOR SPACE   FLOOR-WEIGHT = 70   ..
              SET-DEFAULT FOR WINDOW  HEIGHT = 4.0
                                      GLASS-TYPE = W-1   ..
```

Same as "SET MASTER DATA"
in other programs

```
$ GENERAL SPACE DEFINITION

OFFICE        = SPACE-CONDITIONS  PEOPLE-SCHEDULE      = OCCUPY-1
                                  NUMBER-OF-PEOPLE     = 50
                                  PEOPLE-HEAT-GAIN     = 400
                                  LIGHTING-SCHEDULE    = LIGHTS-1
                                  LIGHTING-TYPE        = REC-FLUOR-RV
                                  LIGHT-TO-SPACE       = .80
                                  LIGHTING-W/SQFT      = 3
                                  EQUIP-SCHEDULE       = EQUIP-1
                                  EQUIPMENT-W/SQFT     = 1
                                  INF-METHOD           = AIR-CHANGE
                                  AIR-CHANGES/HR       = 0.25
                                  INF-SCHEDULE         = INFIL-SCH ..

                $ SPECIFIC SPACE DETAILS

PLENUM-1      = SPACE        ZONE-TYPE = PLENUM  AREA = 5000
                             VOLUME = 10000  FLOOR-WEIGHT = 5  ..

   WALL-1PF   = EXTERIOR-WALL     HEIGHT = 2  WIDTH = 100
                                  AZIMUTH = 180
                                  CONSTRUCTION = WALL-1  ..

   WALL-1PR   = EXTERIOR-WALL     HEIGHT = 2  WIDTH = 50
                                  AZIMUTH = 90
                                  CONSTRUCTION = WALL-1  ..

   WALL-1PB   = EXTERIOR-WALL     HEIGHT = 2  WIDTH = 100
                                  AZIMUTH = 0
                                  CONSTRUCTION = WALL-1  ..

   WALL-1PL   = EXTERIOR-WALL     HEIGHT = 2  WIDTH = 50
                                  AZIMUTH = 270
                                  CONSTRUCTION = WALL-1  ..
```

maximum values that are multiplied by occupancy profiles

The infiltration schedule is referenced in the definition of space conditions

The first space definition, using the u-names of the plenum walls and roof; see p.B 2, lower figure (basic building with plenum and its walls)

```
TOP-1      = ROOF                 HEIGHT = 50  WIDTH = 100
                                  X = 0   Y = 0   Z = 10  AZIMUTH = 180
                                  TILT = 0  GND-REFLECTANCE = 0
                                  CONSTRUCTION = ROOF-1   ..
SPACE1-1   = SPACE                SPACE-CONDITIONS = OFFICE
                                  AREA = 1056  VOLUME = 8448
                                  NUMBER-OF-PEOPLE = 11   ..
FRONT-1    = EXTERIOR-WALL        HEIGHT = 8          WIDTH = 100
                                  X = 0   Y = 0   Z = 0  AZIMUTH = 180
                                  CONSTRUCTION = WALL-1   ..
WF-1       = WINDOW               WIDTH = 45
                                  OVERHANG-A = 1  OVERHANG-B = .5
                                  OVERHANG-W = 47 OVERHANG-D = 4   ..
C1-1       = INTERIOR-WALL        AREA = 1056  NEXT-TO  PLENUM-1
                                  CONSTRUCTION = CLNG-1   ..
F1-1       = UNDERGROUND-FLOOR    AREA = 1056  CONSTRUCTION = FLOOR-1 ..
SB12       = INTERIOR-WALL        AREA =135.7  NEXT-TO SPACE2-1
                                  CONSTRUCTION = SB-U   ..
SB14       = INTERIOR-WALL        LIKE SB12  NEXT-TO SPACE4-1   ..
SB15       = INTERIOR-WALL        AREA = 608   NEXT-TO SPACE5-1
                                  CONSTRUCTION = SB-U   ..
SPACE2-1   = SPACE                SPACE-CONDITIONS = OFFICE
                                  AREA = 456  VOLUME = 3648
                                  NUMBER-OF-PEOPLE = 5   ..
RIGHT-1    = EXTERIOR-WALL        HEIGHT = 8  WIDTH = 50
                                  X = 100  Y = 0   Z = 0  AZIMUTH = 90
                                  CONSTRUCTION = WALL-1   ..
```

Notice the hierarchy of input
First is the space, then the
exterior wall, then the
windows within each wall.

Input for an overhang over
the south window

This assigns the general
conditions (energy use and profiles)
to the space

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

     C2-1      = INTERIOR-WALL      AREA = 456  NEXT-TO PLENUM-1
                                    CONSTRUCTION = CLNG-1     ..

     F2-1      = UNDERGROUND-FLOOR  AREA = 456  CONSTRUCTION = CLNG-1 ..

     SB23      = INTERIOR-WALL      AREA = 135.7  NEXT-TO SPACE3-1
                                    CONSTRUCTION = SB-U   ..

     SB25      = INTERIOR-WALL      AREA = 208  NEXT-TO SPACE5-1
                                    CONSTRUCTION = SB-U   ..

SPACE3-1       = SPACE              LIKE SPACE1-1 ..

     BACK-1    = EXTERIOR-WALL      HEIGHT = 8  WIDTH = 100
                                    X = 100  Y = 50  Z = 0  AZIMUTH = 0
                                    CONSTRUCTION = WALL-1  ..

      WB-1     = WINDOW             WIDTH = 45   ..

     C3-1      = INTERIOR-WALL      AREA = 1056  NEXT-TO PLENUM-1
                                    CONSTRUCTION = CLNG-1     ..

     F3-1      = UNDERGROUND-FLOOR  AREA = 1056
                                    CONSTRUCTION = FLOOR-1     ..

     SB34      = INTERIOR-WALL      AREA = 135.8  NEXT-TO SPACE4-1
                                    CONSTRUCTION = SB-U   ..

     SB35      = INTERIOR-WALL      AREA = 608  NEXT-TO SPACE5-1
                                    CONSTRUCTION = SB-U   ..

SPACE4-1       = SPACE              SPACE-CONDITIONS = OFFICE
                                    AREA = 456  VOLUME = 3648
                                    NUMBER-OF-PEOPLE = 5    ..
```

This is the input for the ceiling of SPACE2-1 which is shared by the plenum (as are the ceilings of the other four spaces).

Making SPACE3-1 like SPACE1-1 copies the previous input

```
LEFT-1      - EXTERIOR-WALL        HEIGHT = 8  WIDTH = 50
                                   X = 0  Y = 50  Z = 0  AZIMUTH = 270
                                   CONSTRUCTION = WALL-1  ..

  WL-1      - WINDOW               WIDTH = 25  ..

C4-1        - INTERIOR-WALL        AREA = 456  NEXT-TO PLENUM-1
                                   CONSTRUCTION = CLNG-1  ..

F4-1        - UNDERGROUND-FLOOR    AREA = 456
                                   CONSTRUCTION = FLOOR-1  ..

SB45        - INTERIOR-WALL        AREA = 208  NEXT-TO SPACE5-1
                                   CONSTRUCTION = SB-U  ..

SPACE5-1    - SPACE                SPACE-CONDITIONS = OFFICE
                                   AREA = 1976  VOLUME = 15808
                                   NUMBER-OF-PEOPLE = 20  ..

C5-1        - INTERIOR-WALL        AREA = 1976  NEXT-TO PLENUM-1
                                   CONSTRUCTION = CLNG-1  ..

F5-1        - UNDERGROUND-FLOOR    AREA = 1976  CONSTRUCTION = FLOOR-1 ..

END ..
COMPUTE  LOADS  ..

INPUT SYSTEMS  ..

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

            $ SYSTEMS SCHEDULES

FAN-SCHED   - SCHEDULE    THRU DEC 31
                   (WD)   (1,6)(0)(7,8)(-999)(9,18)(1) (19,24)(0)
                  (WEH)   (1,24) (0)  ..
```

The fan profile has an optimum start period (-999) from 7am to 8am

```
HEAT-SCHED      - SCHEDULE        THRU DEC 31
                            (WD)  (1,8)(55) (9,18)(70)(19,24)(55)
                           (WEH)  (1,24)(55)  ..
COOL-SCHED      - SCHEDULE        THRU DEC 31
                            (WD)  (1,8)(99)  (9,18)(78)(19,24)(99)
                           (WEH)  (1,24)(99)  ..

COOLOFF         - SCHEDULE        THRU DEC 31 (ALL) (1,24) (60)  ..
HEATOFF         - SCHEDULE        THRU DEC 31 (ALL) (1,24) (60)  ..

R1              - DAY-RESET-SCH     SUPPLY-HI - 60    SUPPLY-LO - 52
                                    OUTSIDE-LO - 30   OUTSIDE-HI - 75  ..
SAT-RESET       - RESET-SCHEDULE    THRU DEC 31 (ALL) R1  ..


                $ SYSTEM DESCRIPTION

CONTROL       - ZONE-CONTROL     DESIGN-HEAT-T - 70
                                 DESIGN-COOL-T - 78
                                 HEAT-TEMP-SCH - HEAT-SCHED
                                 COOL-TEMP-SCH - COOL-SCHED
                                 THERMOSTAT-TYPE - REVERSE-ACTION  ..

SPACE1-1      - ZONE             ZONE-CONTROL  - CONTROL
                                 SIZING-OPTION - ADJUST-LOADS
                                 OA-CFM/PER    - 7  ..

SPACE2-1      - ZONE             LIKE SPACE1-1    ..
SPACE3-1      - ZONE             LIKE SPACE1-1    ..
SPACE4-1      - ZONE             LIKE SPACE1-1    ..
SPACE5-1      - ZONE             LIKE SPACE1-1    ..

PLENUM-1      - ZONE             ZONE-TYPE     - PLENUM
                                 SIZING-OPTION - ADJUST-LOADS
                                 DESIGN-HEAT-T - 50
                                 DESIGN-COOL-T - 95  ..
```

The heating setpoint of the thermostat is 70F during the day and 55F at night

Cooling setpoint is 78F

Cooling is available year around when outside temperature exceeds 60F

The minimum ventilation per person

The same u-names of spaces as input in the LOADS portion of the program

```
S-CONT     = SYSTEM-CONTROL  COOLING-SCHEDULE = COOLOFF
                             HEATING-SCHEDULE = HEATOFF
                             HEAT-SET-T       = 65
                             COOL-CONTROL     = RESET
                             COOL-RESET-SCH   = SAT-RESET
                             MIN-SUPPLY-T     = 60 ..

SYST-1     = SYSTEM          SYSTEM-TYPE      = VAVS ------------------ System type selected is
                             SYSTEM-CONTROL   = S-CONT                  variable air volume (VAVS)
                             FAN-SCHEDULE     = FAN-SCHED
                             FAN-CONTROL      = SPEED
                             SUPPLY-STATIC    = 5.5
                             SUPPLY-EFF       = .55
                             NIGHT-CYCLE-CTRL = CYCLE-ON-ANY
                             REHEAT-DELTA-T   = 58
                             MIN-CFM-RATIO    = .3
                             ECONO-LIMIT-T    = 65
                             RETURN-AIR-PATH  = PLENUM-ZONES
                             PLENUM-NAMES     = (PLENUM-1)
                             ZONE-NAMES       = (SPACE5-1,SPACE1-1, --- The assignment of spaces
                                                 SPACE2-1,SPACE3-1,     (zones) to the VAVS system
                                                 SPACE4-1,PLENUM-1) ..
END ..
COMPUTE SYSTEMS ..

INPUT PLANT ..

           PLANT-REPORT  SUMMARY = (BEPS) ..

            $ EQUIPMENT DESCRIPTION

            $ HOT-WATER BOILER

SBOIL1     = PLANT-EQUIPMENT  TYPE = HW-BOILER
                              SIZE = .4 .. ------------------ 400,000 Btu/hr peak output capacity
```

```
              $ AIR-COOLED RECIPROCATING CHILLER

CHIL1         = PLANT-EQUIPMENT  TYPE = HERM-REC-CHLR
                                 SIZE = -.18   ..   $ 15 TONS

PLANT-PARAMETERS  BOILER-FUEL = NATURAL-GAS
                  HERM-REC-COND-TYPE = AIR  ..
```

The code-word for a hermetic-reciprocating chiller with a condenser that usually defaults to water cooled. PLANT-PARAMETERS changes it to AIR.

```
END  ..
COMPUTE PLANT   ..
INPUT ECONOMICS   ..

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

          $ GAS ENERGY COSTS

ENERGY-COST  RESOURCE = NATURAL-GAS   UNIT = 100000
             UNIFORM-COST = .6        ESCALATION = 8  ..
```

A simple, uniform cost of 60¢ per therm for gas

```
          $ ELECTRIC ENERGY COSTS

ENERGY-COST  RESOURCE = ELECTRICITY  ASSIGN-SCHEDULE = TIMEOFDAY
             ESCALATION = 7   ..
NIGHT = CHARGE-ASSIGNMENT  RESOURCE = ELECTRICITY
                           TYPE = ENERGY
                           UNIFORM-CHARGE = .05 ..

SHD-P = CHARGE-ASSIGNMENT  RESOURCE = ELECTRICITY
                           TYPE = ENERGY
                           UNIFORM-CHARGE = .06  ..


PEAK  = CHARGE-ASSIGNMENT  RESOURCE = ELECTRICITY
                           TYPE = ENERGY
                           UNIFORM-CHARGE = .07  ..
```

electricity during the weekdays
   5¢/kwh at night (11pm to 8am)
   6¢/kwh shoulder (9am to 12 noon)
   7¢/kwh at peak (1pm to 5pm)
There are no demand charges

```
WD-RATE = DAY-CHARGE-SCH   (1,8) (NIGHT) (9,12) (SHD-P)
                           (13,17) (PEAK)  (18,22) (SHD-P)
                           (23,24) (NIGHT)  ..

SAT-RATE = DAY-CHARGE-SCH  (1,8) (NIGHT) (9,17) (SHD-P)
                           (18,24) (NIGHT)  ..

WEH-RATE = DAY-CHARGE-SCH  (1,24) (NIGHT)  ..


TIMEOFDAY = SCHEDULE  THRU DEC 31
                     (MON,FRI) WD-RATE
                         (SAT) SAT-RATE
                     (SUN,HOL) WEH-RATE  ..

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

```
                    ****     ***    *****           ***      *     *****
                    *   *   *   *   *              *   *    **     *
                    *   *   *   *   *****   ***       *      *     *****
                    *   *   *   *   *               **       *     *
                    ****     ***    *****          *****  * ***    *****

            B U I L D I N G   E N E R G Y   A N A L Y S I S   P R O G R A M

                                    DEVELOPED BY
                   LAWRENCE BERKELEY LABORATORY/UNIVERSITY OF CALIFORNIA
                                WITH MAJOR SUPPORT FROM
                             UNITED STATES DEPARTMENT OF ENERGY
                 ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY
                              OFFICE OF BUILDING TECHNOLOGIES
                           BUILDING SYSTEMS AND MATERIALS DIVISION
                                AND ADDITIONAL SUPPORT FROM
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```

```
REPORT- LV-D  DETAILS OF EXTERIOR SURFACES IN THE PROJECT                       WEATHER FILE- CHICAGO    WYEC
---------------------------------------------------------------------------------------------------------------------------
NUMBER OF EXTERIOR SURFACES    9          RECTANGULAR   9      OTHER   0
(U-VALUE INCLUDES INSIDE AIR FILM PLUS OUTSIDE AIR FILM AT 7.5 MPH WINDSPEED )
                                    - - - - G L A S S - - - -   - - - - W A L L - - - -   - W A L L + G L A S S -
SURFACE          SPACE                U-VALUE          AREA       U-VALUE          AREA      U-VALUE          AREA     AZIMUTH
                                  (BTU/HR-SQFT-F)     (SQFT)  (BTU/HR-SQFT-F)     (SQFT)  (BTU/HR-SQFT-F)     (SQFT)

WALL-1PB         PLENUM-1              0.000            0.00        0.068         200.00       0.068          200.00  NORTH

BACK-1           SPACE3-1              0.490          180.00        0.068         620.00       0.163          800.00  NORTH

RIGHT-1          SPACE2-1              0.490          100.00        0.068         300.00       0.173          400.00  EAST

WALL-1PR         PLENUM-1              0.000            0.00        0.068         100.00       0.068          100.00  EAST

WALL-1PF         PLENUM-1              0.000            0.00        0.068         200.00       0.068          200.00  SOUTH

FRONT-1          SPACE1-1              0.490          180.00        0.068         620.00       0.163          800.00  SOUTH

WALL-1PL         PLENUM-1              0.000            0.00        0.068         100.00       0.068          100.00  WEST

LEFT-1           SPACE4-1              0.490          100.00        0.068         300.00       0.173          400.00  WEST

TOP-1            PLENUM-1              0.000            0.00        0.047        5000.00       0.047         5000.00  ROOF

F1-1             SPACE1-1              0.000            0.00        0.050        1056.00       0.050         1056.00  UNDERGRND

F2-1             SPACE2-1              0.000            0.00        0.270         456.00       0.270          456.00  UNDERGRND

F3-1             SPACE3-1              0.000            0.00        0.050        1056.00       0.050         1056.00  UNDERGRND

F4-1             SPACE4-1              0.000            0.00        0.050         456.00       0.050          456.00  UNDERGRND

F5-1             SPACE5-1              0.000            0.00        0.050        1976.00       0.050         1976.00  UNDERGRND
```

* * * * * An echo of your input * * * * *

```
REPORT- LV-D  DETAILS OF EXTERIOR SURFACES IN THE PROJECT                          WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------(CONTINUED)-------

                    AVERAGE            AVERAGE         AVERAGE U-VALUE      GLASS        OPAQUE      GLASS+OPAQUE
                 U-VALUE/GLASS      U-VALUE/WALLS       WALLS+GLASS         AREA          AREA           AREA
                (BTU/HR-SQFT-F)    (BTU/HR-SQFT-F)    (BTU/HR-SQFT-F)      (SQFT)        (SQFT)         (SQFT)


NORTH                0.490              0.068              0.144           180.00        820.00        1000.00

EAST                 0.490              0.068              0.162           100.00        400.00         500.00

SOUTH                0.490              0.068              0.144           180.00        820.00        1000.00

WEST                 0.490              0.068              0.162           100.00        400.00         500.00

ROOF                 0.000              0.047              0.047             0.00       5000.00        5000.00

ALL WALLS            0.490              0.068              0.147           560.00       2440.00        3000.00

    WALLS+ROOFS      0.490              0.064              0.086           560.00       7440.00        8000.00

    UNDERGRND        0.000              0.070              0.070             0.00       5000.00        5000.00

BUILDING             0.490              0.061              0.079           560.00      12440.00       13000.00
```

This report checks wall and glass U-factors (and overall U-factors) plus the areas of wall, roof, and floor surfaces resulting from the inputs.

```
REPORT- LS-C BUILDING PEAK LOAD COMPONENTS                                        WEATHER FILE- CHICAGO     WYEC
------------------------------------------------------------------------------------------------------------------
*** BUILDING ***    FLOOR  AREA      5000  SQFT      465  SQMT
                    VOLUME          50000  CUFT     1416  CUMT

                                         COOLING  LOAD                          HEATING  LOAD
                                   ________________________               ________________________

                TIME                AUG 23  4PM                             JAN  7  8AM

                DRY-BULB TEMP         94F      34C                            16F      -9C
                WET-BULB TEMP         75F      24C                            14F     -10C

                                   SENSIBLE          LATENT                      SENSIBLE
                              (KBTU/H)   ( KW )  (KBTU/H)  ( KW )          (KBTU/H)   ( KW )
                              --------   ------  --------  ------          --------  --------
        WALLS                    3.293    0.964     0.000   0.000            -6.778    -1.985
        ROOFS                    0.000    0.000     0.000   0.000             0.000     0.000
        GLASS CONDUCTION         5.391    1.579     0.000   0.000           -16.049    -4.700
        GLASS SOLAR              9.347    2.737     0.000   0.000             0.928     0.272
        DOOR                     0.000    0.000     0.000   0.000             0.000     0.000
        INTERNAL SURFACES        0.000    0.000     0.000   0.000             0.000     0.000
        UNDERGROUND SURFACES    -2.347   -0.687     0.000   0.000            -9.949    -2.914
        OCCUPANTS TO SPACE      11.309    3.312     6.776   1.984             0.001     0.000
        LIGHT     TO SPACE      34.965   10.240     0.000   0.000             2.051     0.601
        EQUIPMENT TO SPACE      11.122    3.257     0.000   0.000             0.342     0.100
        PROCESS   TO SPACE       0.000    0.000     0.000   0.000             0.000     0.000
        INFILTRATION             0.000    0.000     0.000   0.000           -21.530    -6.306
                              --------  -------   -------  ------          --------  --------
        TOTAL                   73.079   21.403     6.776   1.984           -50.986   -14.932
        TOTAL LOAD              79.854 KBTU/H      23.387  KW         -50.986 KBTU/H    -14.932  KW
        TOTAL LOAD / AREA       16.97BTU/H.SQFT    50.348   W /SQMT    10.197BTU/H.SQFT   32.146   W /SQMT

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

Building peak sensible load

```
REPORT- SV-A  SYSTEM DESIGN PARAMETERS                    SYST-1                    WEATHER FILE- CHICAGO    WYEC
---------------------------------------------------------------------------------------------------------------------
     SYSTEM        ALTITUDE
       NAME      MULTIPLIER

SYST-1                1.020

   SUPPLY                        RETURN                         OUTSIDE   COOLING               HEATING   COOLING   HEATING
      FAN    ELEC    DELTA-T        FAN      ELEC    DELTA-T       AIR   CAPACITY  SENSIBLE  CAPACITY       EIR       EIR
    (CFM )   (KW)       (F)      (CFM )      (KW)       (F)      RATIO  (KBTU/HR)     (SHR) (KBTU/HR) (BTU/BTU) (BTU/BTU)

    5012.   5.768       3.6          0.     0.000       0.0      0.074    149.499     0.791     0.000      0.00      0.37

                                                     MINIMUM   OUTSIDE   COOLING             EXTRACTION   HEATING  ADDITION
        ZONE           SUPPLY   EXHAUST       FAN       FLOW       AIR  CAPACITY  SENSIBLE        RATE  CAPACITY      RATE
        NAME             FLOW      FLOW      (KW)      RATIO      FLOW (KBTU/HR)     (SHR)   (KBTU/HR) (KBTU/HR) (KBTU/HR) MULTIPLIER

 SPACE5-1               1627.        0.     0.000      0.300      143.      0.00      0.00       31.62   -101.89    -84.32        1.0

 SPACE1-1               1077.        0.     0.000      0.300       79.      0.00      0.00       20.93    -67.45    -55.82        1.0

 SPACE2-1                567.        0.     0.000      0.300       36.      0.00      0.00       11.02    -35.51    -29.39        1.0

 SPACE3-1               1071.        0.     0.000      0.300       79.      0.00      0.00       20.83    -67.11    -55.54        1.0

 SPACE4-1                671.        0.     0.000      0.300       36.      0.00      0.00       13.04    -42.03    -34.78        1.0

 PLENUM-1                  0.        0.     0.000      0.000        0.      0.00      0.00        0.00      0.00      0.00        1.0
```

System
design
air flow

Zone space
design air
flow

Air handling
unit cooling
coil capacity

Heating capacity
of zone reheat
coils

```
REPORT- SS-A  SYSTEM MONTHLY LOADS SUMMARY FOR          SYST-1                         WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------
        - - - - - - - - C O O L I N G - - - - - - - -      - - - - - - - - H E A T I N G - - - - - - - -    - - - E L E C - - -

                                             MAXIMUM                                            MAXIMUM     ELEC-    MAXIMUM
         COOLING    TIME     DRY-  WET-      COOLING    HEATING    TIME     DRY-  WET-          HEATING     TRICAL      ELEC
          ENERGY   OF MAX    BULB  BULB         LOAD     ENERGY   OF MAX    BULB  BULB             LOAD     ENERGY      LOAD
MONTH     (MBTU)   DY  HR    TEMP  TEMP    (KBTU/HR)     (MBTU)   DY  HR    TEMP  TEMP        (KBTU/HR)      (KWH)      (KW)

JAN      0.00000                               0.000    -14.837   28   8    24.F  23.F         -326.986      5014.    19.937

FEB      0.00000                               0.000    -12.802   25   8    11.F  11.F         -336.072      4367.    19.757

MAR      0.09026   19  16    65.F  51.F       17.771     -8.824   18   8    27.F  24.F         -333.405      4784.    19.601

APR      2.09777   26  17    87.F  62.F       80.260     -2.564   15   8    34.F  32.F         -202.321      4947.    21.409

MAY      6.49387   22  18    78.F  72.F       87.580     -0.170   20   8    48.F  46.F          -72.549      5060.    21.364

JUN     13.24104   13  17    85.F  74.F      112.120      0.000                                   0.000      4846.    22.658

JUL     20.60470   17  15    90.F  73.F      113.657      0.000                                   0.000      5513.    22.912

AUG     20.39339   20  17    90.F  77.F      122.824      0.000                                   0.000      5497.    23.085

SEP     10.49018    9  16    91.F  73.F      120.529      0.000                                   0.000      4850.    23.216

OCT      3.68348   17  16    82.F  69.F       88.442     -0.095   28   8    37.F  32.F          -68.152      5040.    21.866

NOV      0.05012    1  14    62.F  53.F        9.753     -4.140   12   8    37.F  32.F         -291.337      4347.    19.976

DEC      0.00000                               0.000    -12.164   16   8     8.F   7.F         -334.756      4797.    19.712
        ---------                          ---------  ---------                               ---------   --------   -------
TOTAL     77.146                                        -55.686                                            59058.
MAX                                          122.824                                           -336.072               23.216
```

Total cooling
coil load
passed to
the chiller

Maximum
cooling
load

```
REPORT- PV-A  EQUIPMENT SIZES                                                                   WEATHER FILE- CHICAGO    WYEC
---------------------------------------------------------------------------------------------------------------------------

                    -------------  -------------  -------------  -------------  -------------  -------------
                           NUMBER         NUMBER         NUMBER         NUMBER         NUMBER         NUMBER
E Q U I P M E N T   SIZE   INSTD   SIZE   INSTD   SIZE   INSTD   SIZE   INSTD   SIZE   INSTD   SIZE   INSTD
                    (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL
------------------  ------ -- --   ------ -- --   ------ -- --   ------ -- --   ------ -- --   ------ -- --

HW-BOILER            0.400  1  1

HERM-REC-CHLR        0.180  1  1
```

```
REPORT- PS-B  MONTHLY PEAK AND TOTAL ENERGY USE                                    WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------------------------

          MO      UTILITY-      ELECTRICITY     NATURAL-GAS
                TOTAL(MBTU)         18.600          24.023
          JAN    PEAK(KBTU)         78.120         424.617
                     DY/HR            2/11           28/ 8

                TOTAL(MBTU)         16.200          20.926
          FEB    PEAK(KBTU)         77.504         434.433
                     DY/HR            4/11           25/ 8

                TOTAL(MBTU)         17.388          14.626
          MAR    PEAK(KBTU)         76.888         431.557
                     DY/HR           19/15           18/ 8

                TOTAL(MBTU)         18.349           4.540
          APR    PEAK(KBTU)        106.917         285.794
                     DY/HR           26/16           15/ 8

                TOTAL(MBTU)         20.341           0.315
          MAY    PEAK(KBTU)        105.224         122.214
                     DY/HR           22/16           20/ 8

                TOTAL(MBTU)         22.157           0.000
          JUN    PEAK(KBTU)        121.111           0.000
                     DY/HR           12/15           30/ 1

                TOTAL(MBTU)         26.818           0.000
          JUL    PEAK(KBTU)        121.924           0.000
                     DY/HR           17/15           31/ 1

                TOTAL(MBTU)         26.686           0.000
          AUG    PEAK(KBTU)        125.569           0.000
                     DY/HR           23/15           31/ 1

                TOTAL(MBTU)         20.902           0.000
```

SEP	PEAK(KBTU)	124.635	0.000
	DY/HR	9/15	30/ 1
	TOTAL(MBTU)	18.937	0.181
OCT	PEAK(KBTU)	108.456	115.029
	DY/HR	18/15	28/ 8
	TOTAL(MBTU)	15.406	7.009
NOV	PEAK(KBTU)	75.219	385.706
	DY/HR	12/11	12/ 8
	TOTAL(MBTU)	17.606	19.710
DEC	PEAK(KBTU)	77.353	433.014
	DY/HR	16/11	16/ 8
	ONE YEAR	239.391	91.329
	USE/PEAK	125.569	434.433

```
REPORT- PS-D  PLANT LOADS SATISFIED                                         WEATHER FILE- CHICAGO    WYEC
---------------------------------------------------------------------------------------------------------

                     HEATING LOADS            MBTU SUPPLIED   PCT OF TOTAL LOAD
                     ------------------------ -------------   ----------------
                        HW-BOILER                     58.6          100.0
                                              =============   ================
                            LOAD SATISFIED            58.6          100.0
                        TOTAL LOAD ON PLANT           58.6


                     COOLING LOADS            MBTU SUPPLIED   PCT OF TOTAL LOAD
                     ------------------------ -------------   ----------------

                        HERM-REC-CHLR                 80.0          100.0
                                              =============   ================

                            LOAD SATISFIED            80.0          100.0
                        TOTAL LOAD ON PLANT           80.0


                     ELECTRICAL LOADS         MBTU SUPPLIED   PCT OF TOTAL LOAD
                     ------------------------ -------------   ----------------

                        ELECTRICITY                  239.4          100.0
                                              =============   ================

                            LOAD SATISFIED           239.4          100.0
                        TOTAL LOAD ON PLANT          239.4
```

```
REPORT- PS-D  PLANT LOADS SATISFIED                                                  WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------(CONTINUED)-------

                                   SUMMARY OF LOADS MET

                                 TOTAL       LOAD       TOTAL      PEAK       HOURS
         TYPE OF LOAD            LOAD      SATISFIED   OVERLOAD   OVERLOAD   OVERLOADED
                                (MBTU)      (MBTU)      (MBTU)     (MBTU)
     -------------------      ----------  ----------  ---------- ---------- ----------

     HEATING LOADS                58.6        58.6       0.000      0.000          0
     COOLING LOADS                80.0        80.0       0.000      0.000          0
     ELECTRICAL LOADS            239.4       239.4       0.000      0.000          0
```

```
REPORT- BEPS  ESTIMATED BUILDING ENERGY PERFORMANCE                                        WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------


                 ENERGY TYPE
                 IN SITE MBTU -  ELECTRICITY     NATURAL-GAS

                CATEGORY OF USE

                  SPACE HEAT          4.34           91.33

                  SPACE COOL         30.18            0.00

                  HVAC AUX           16.34            0.00

                  DOM HOT WTR         0.00            0.00

                  AUX SOLAR           0.00            0.00

                  LIGHTS            149.50            0.00

                  VERT TRANS          0.00            0.00

                  MISC EQUIP         39.03            0.00
                                 ----------      ----------
                   TOTAL            239.40           91.33

        TOTAL SITE ENERGY       330.72 MBTU     66.1 KBTU/SQFT-YR GROSS-AREA     66.1 KBTU/SQFT-YR NET-AREA
        TOTAL SOURCE ENERGY     810.22 MBTU    162.0 KBTU/SQFT-YR GROSS-AREA    162.0 KBTU/SQFT-YR NET-AREA

        PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  1.0
        PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.0

        NOTE  ELECTRICITY AND/OR FUEL USED TO GENERATE ELECTRICITY IS APPORTIONED BASED
              ON THE YEARLY DEMAND.  ALL OTHER ENERGY TYPES ARE APPORTIONED HOURLY.
```

```
  TOTAL COST ($)                       498.44          0.00
 SEP
  ENERGY CONSUMPTION (UNIT/MO)         6124.             0.
  PEAK DEMAND   (UNIT/HR)                37.             0.
  TOTAL COST ($)                       390.19          0.00
 OCT
  ENERGY CONSUMPTION (UNIT/MO)         5549.             2.
  PEAK DEMAND   (UNIT/HR)                32.             1.
  TOTAL COST ($)                       353.08          1.08
 NOV
  ENERGY CONSUMPTION (UNIT/MO)         4514.            70.
  PEAK DEMAND   (UNIT/HR)                22.             4.
  TOTAL COST ($)                       284.35         42.05
 DEC
  ENERGY CONSUMPTION (UNIT/MO)         5159.           197.
  PEAK DEMAND   (UNIT/HR)                23.             4.
  TOTAL COST ($)                       324.35        118.26
......                               ........      ........
 TOTAL
  ENERGY CONSUMPTION (UNIT/YR)        70142.           913.
  PEAK DEMAND   (UNIT/HR)                37.             4.
  TOTAL COST ($)                      4445.99        547.97
```

REPORT- ES-E SUMMARY OF ELECTRICITY CHARGES

MONTH	CHARGE-ASSIGNMENT (U-NAME)	LENGTH (HR/MO)	CONSUMPTION BY C-A (KWH)	ENERGY CHARGE ($)	MEASURED DEMAND (KW)	BILLING DEMAND (KW)	DEMAND CHARGE ($)	TOTAL CHARGES ($)
JAN								
	NIGHT	400	595.	29.75	9.	9.	0.00	
	SHD-P	234	2729.	163.77	23.	23.	0.00	
	PEAK	110	2126.	148.78	22.	22.	0.00	
								342.30
FEB								
	NIGHT	370	571.	28.54	9.	9.	0.00	
	SHD-P	207	2350.	141.02	23.	23.	0.00	
	PEAK	95	1826.	127.79	21.	21.	0.00	
								297.34
MAR								
	NIGHT	405	513.	25.67	9.	9.	0.00	
	SHD-P	234	2569.	154.14	22.	22.	0.00	
	PEAK	105	2012.	140.86	23.	23.	0.00	
								320.67
APR								
	NIGHT	376	401.	20.07	6.	6.	0.00	
	SHD-P	234	2738.	164.27	30.	30.	0.00	
	PEAK	110	2237.	156.60	31.	31.	0.00	
								340.93
MAY								
	NIGHT	400	386.	19.26	4.	4.	0.00	
	SHD-P	234	3011.	180.63	30.	30.	0.00	
	PEAK	110	2564.	179.49	31.	31.	0.00	
								379.38
JUN								
	NIGHT	395	407.	20.37	11.	11.	0.00	
	SHD-P	225	3187.	191.21	34.	34.	0.00	
	PEAK	100	2898.	202.86	35.	35.	0.00	

								414.43
JUL								
	NIGHT	400	544.	27.19	11.	11.	0.00	
	SHD-P	234	3863.	231.79	34.	34.	0.00	
	PEAK	110	3451.	241.55	36.	36.	0.00	
								500.53
AUG								
	NIGHT	391	526.	26.28	11.	11.	0.00	
	SHD-P	243	3839.	230.33	35.	35.	0.00	
	PEAK	110	3465.	241.83	37.	37.	0.00	
								498.44
SEP								
	NIGHT	404	415.	20.75	11.	11.	0.00	
	SHD-P	216	3021.	181.26	35.	35.	0.00	
	PEAK	100	2688.	188.18	37.	37.	0.00	
								390.19
OCT								
	NIGHT	400	382.	19.12	4.	4.	0.00	
	SHD-P	234	2767.	166.02	30.	30.	0.00	
	PEAK	110	2399.	167.94	32.	32.	0.00	
								353.08

```
REPORT- ES-E  SUMMARY OF ELECTRICITY CHARGES
--------------------------------------------------------------------------------------------CONTINUED-----------

         CHARGE-                       CONSUMPTION    ENERGY     MEASURED    BILLING     DEMAND       TOTAL
MONTH    ASSIGNMENT          LENGTH     BY C-A        CHARGE      DEMAND      DEMAND     CHARGE      CHARGES
          (U-NAME)           (HR/MO)    (KWH)          ($)         (KW)        (KW)       ($)          ($)
-------  ---------------     -------   ----------   ----------   --------   --------   ----------   ----------

NOV
         NIGHT                 409        439.        21.96         8.          8.        0.00
         SHD-P                 216       2284.       137.05        22.         22.        0.00
         PEAK                   95       1791.       125.34        22.         22.        0.00
                                                                                                     284.35
DEC
         NIGHT                 414        539.        26.96         9.          9.        0.00
         SHD-P                 225       2596.       155.78        23.         23.        0.00
         PEAK                  105       2023.       141.61        21.         21.        0.00
                                                                                                     324.35
----------                           ------------  ------------                         ------------  ------------
TOTAL                                    70142.      4445.99                                 0.00      4445.99
```

Appendix C

Basic Reports: Examples and Descriptions

This Appendix shows examples of the verification and summary reports printed by the DOE-2 LOADS, SYSTEMS, PLANT and ECONOMICS sub-programs. A description of the contents of each summary report and selected verification reports is given. The corresponding input for these reports can be found in the *Sample Run Book (2.1E)* for the building indicated in the first line of the report title.

Table of Contents

REPORT LV-A

```
REPORT- LV-A  GENERAL PROJECT AND BUILDING INPUT                                        WEATHER FILE- CHICAGO    WYEC
----------------------------------------------------------------------------------------------------------------------
PERIOD OF STUDY

    STARTING DATE    ENDING DATE    NUMBER OF DAYS

       1 JAN 1974    31 DEC 1974              365

SITE CHARACTERISTIC DATA

                                                                  BUILDING
    STATION              LATITUDE  LONGITUDE   ALTITUDE      TIME   AZIMUTH
    NAME                    (DEG)      (DEG)       (FT)      ZONE     (DEG)

CHICAGO   WYEC               42.0       88.0       610.   6  CST      10.0
```

REPORT LV-D

```
REPORT- LV-D  DETAILS OF EXTERIOR SURFACES  IN THE PROJECT                                  WEATHER FILE- CHICAGO    WYEC
----------------------------------------------------------------------------------------------------------------------------
NUMBER OF EXTERIOR SURFACES    9          RECTANGULAR   9      OTHER    0
(U-VALUE INCLUDES INSIDE AIR FILM PLUS OUTSIDE AIR FILM AT 7.5 MPH WINDSPEED )
                                      - - - - G L A S S - - - -    - - - - W A L L - - - -    - W A L L + G L A S S -
SURFACE          SPACE                 U-VALUE           AREA      U-VALUE -        AREA      U-VALUE          AREA    AZIMUTH
                                   (BTU/HR-SQFT-F)     (SQFT)  (BTU/HR-SQFT-F)    (SQFT)  (BTU/HR-SQFT-F)     (SQFT)

WALL-1PB         PLENUM-1               0.000             0.00       0.068        200.00      0.068         200.00  NORTH

BACK-1           SPACE3-1               0.490           180.00       0.068        620.00      0.163         800.00  NORTH

RIGHT-1          SPACE2-1               0.490           100.00       0.068        300.00      0.173         400.00  EAST

WALL-1PR         PLENUM-1               0.000             0.00       0.068        100.00      0.068         100.00  EAST

WALL-1PF         PLENUM-1               0.000             0.00       0.068        200.00      0.068         200.00  SOUTH

FRONT-1          SPACE1-1               0.490           180.00       0.068        620.00      0.163         800.00  SOUTH

WALL-1PL         PLENUM-1               0.000             0.00       0.068        100.00      0.068         100.00  WEST

LEFT-1           SPACE4-1               0.490           100.00       0.068        300.00      0.173         400.00  WEST

TOP-1            PLENUM-1               0.000             0.00       0.047       5000.00      0.047        5000.00  ROOF

F1-1             SPACE1-1               0.000             0.00       0.050       1056.00      0.050        1056.00  UNDERGRND

F2-1             SPACE2-1               0.000             0.00       0.270        456.00      0.270         456.00  UNDERGRND

F3-1             SPACE3-1               0.000             0.00       0.050       1056.00      0.050        1056.00  UNDERGRND

F4-1             SPACE4-1               0.000             0.00       0.050        456.00      0.050         456.00  UNDERGRND

F5-1             SPACE5-1               0.000             0.00       0.050       1976.00      0.050        1976.00  UNDERGRND
```

```
REPORT- LV-D  DETAILS OF EXTERIOR SURFACES IN THE PROJECT                          WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------(CONTINUED)-------

                     AVERAGE           AVERAGE          AVERAGE U-VALUE      GLASS       OPAQUE     GLASS+OPAQUE
                 U-VALUE/GLASS      U-VALUE/WALLS        WALLS+GLASS          AREA        AREA          AREA
                (BTU/HR-SQFT-F)    (BTU/HR-SQFT-F)     (BTU/HR-SQFT-F)       (SQFT)      (SQFT)        (SQFT)


NORTH                0.490              0.068               0.144          180.00       820.00       1000.00

EAST                 0.490              0.068               0.152          100.00       400.00        500.00

SOUTH                0.490              0.068               0.144          180.00       820.00       1000.00

WEST                 0.490              0.068               0.152          100.00       400.00        500.00

ROOF                 0.000              0.047               0.047            0.00      5000.00       5000.00

ALL WALLS            0.490              0.068               0.147          560.00      2440.00       3000.00

   WALLS+ROOFS       0.490              0.064               0.085          560.00      7440.00       8000.00

   UNDERGRND         0.000              0.070               0.070            0.00      5000.00       5000.00

BUILDING             0.490              0.061               0.079          560.00     12440.00      13000.00
```

REPORT LS–B -- SPACE PEAK LOAD COMPONENTS

This report gives a breakdown of cooling and heating peak loads, according to the source of the load, for each space. A "load" here is defined as the amount of heat that must be added or removed from the space air per hour to maintain a *constant* air temperature equal to the TEMPERATURE keyword value in SPACE–CONDITIONS. These loads are modified in the SYSTEMS program to account for time-varying air temperatures. There are several important points that the user should become acquainted with.

1. WALLS
   correspond to exterior walls with TILT $\geq 45°$, whereas ROOFS correspond to exterior walls with TILT $< 45°$. The WALLS and ROOF loads (sensible) are due to conduction.

2. GLASS CONDUCTION
   is the sum of the UAΔT heat gain through all the windows in the space plus solar energy absorbed by the glass and conducted into the space.

3. GLASS SOLAR
   is the heat gain caused by direct and diffuse solar radiation transmitted by the windows 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 GLASS SOLAR at night.

4. DOOR
   loads are those due to conduction through external doors in the space.

5. INTERNAL SURFACES
   loads are those due to conduction through INTERIOR–WALLs such as partitions and drop ceilings. These loads will be zero in this report if, as in the example, the user chooses the same LOADS calculation temperature for all spaces.

6. UNDERGROUND SURFACES
   can be basement floors and walls or slabs on grade. The user should take care to adjust either the area or u-value to approach the anticipated heat transfer. For example, a slab-on-grade should ordinarily include only perimeter areas, since the soil under the central part of the building will not significantly conduct heat away from the slab. On the other hand, if the walls and basement floor are below the water table, they should not be adjusted, since water is a good conductor of heat.

7. The EQUIPMENT–TO–SPACE
   load results from the user-supplied entries for EQUIP–SCHEDULE, EQUIPMENT–KW, EQUIPMENT–W/SQFT, EQUIP–SENSIBLE and EQUIP–LATENT.
   The PROCESS–TO–SPACE load results from the user-supplied entries for SOURCE–SCHEDULE, SOURCE–TYPE, SOURCE–BTU/HR, SOURCE–SENSIBLE, and SOURCE–LATENT.

8. Latent loads do not account for moisture absorption and desorption by room surfaces.

9. The RUN number in the upper right hand corner refers to the number of the pass through the LOADS program. For example, if the user were doing parametric runs as part of the same job, successive passes through LOADS would be recorded as RUN 1, RUN 2, RUN 3, etc.

```
REPORT- LS-B SPACE PEAK LOAD COMPONENTS                       PLENUM-1                          WEATHER FILE- CHICAGO    WYEC
-------------------------------------------------------------------------------------------------------------------------------
SPACE  PLENUM-1       MULTIPLIER         1.0          FLOOR MULTIPLIER         1.0
                      FLOOR  AREA       5000  SQFT        465    M2
                      VOLUME           10000  CUFT        283    M3

                                              COOLING  LOAD                                     HEATING  LOAD
                                             ===============                                  ===============
                 TIME                          JUL 10   5PM                                     FEB  2   9AM
                 DRY-BULB TEMP                  88F     31C                                       -7F     -22C
                 WET-BULB TEMP                  67F     19C                                       -7F     -22C

                                         SENSIBLE            LATENT                               SENSIBLE
                                    (KBTU/H)    ( KW )  (KBTU/H)   ( KW )                     (KBTU/H)   ( KW )
                                    --------    ------  --------   ------                     --------  --------
     WALLS                             1.264     0.370     0.000    0.000                       -3.254    -0.953
     ROOFS                            15.341     4.493     0.000    0.000                      -19.610    -5.743
     GLASS CONDUCTION                  0.000     0.000     0.000    0.000                        0.000     0.000
     GLASS SOLAR                       0.000     0.000     0.000    0.000                        0.000     0.000
     DOOR                              0.000     0.000     0.000    0.000                        0.000     0.000
     INTERNAL SURFACES                 0.000     0.000     0.000    0.000                        0.000     0.000
     UNDERGROUND SURFACES              0.000     0.000     0.000    0.000                        0.000     0.000
     OCCUPANTS TO SPACE                0.000     0.000     0.000    0.000                        0.000     0.000
     LIGHT       TO SPACE              0.000     0.000     0.000    0.000                        0.000     0.000
     EQUIPMENT TO SPACE                0.000     0.000     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                        0.000     0.000
                                    --------   -------   -------   ------                     --------  --------
     TOTAL                            16.604     4.863     0.000    0.000                      -22.864    -6.696
     TOTAL LOAD                       16.604 KBTU/H        4.863    KW                  -22.864 KBTU/H      -6.696   KW

     TOTAL LOAD / AREA                3.32BTU/H.SQFT      10.469    W / M2                4.573BTU/H.SQFT   14.416   W / M2

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

```
REPORT- LS-B SPACE PEAK LOAD COMPONENTS                 SPACE1-1                    WEATHER FILE- CHICAGO     WYEC
------------------------------------------------------------------------------------------------------------------
SPACE   SPACE1-1
               MULTIPLIER          1.0          FLOOR MULTIPLIER        1.0

               FLOOR  AREA        1056  SQFT        98   M2
               VOLUME             8448  CUFT       239   M3

                                      COOLING  LOAD                              HEATING  LOAD
                                   ________________                            ________________
           TIME                       FEB 28   4PM                              FEB  2   7AM

           DRY-BULB TEMP              68F      14C                                -9F     -23C
           WET-BULB TEMP              63F      12C                                -9F     -23C

                                 SENSIBLE          LATENT                          SENSIBLE
                             (KBTU/H)   ( KW )  (KBTU/H)  ( KW )               (KBTU/H)  ( KW )
                             --------   ------  --------  ------               --------  --------
      WALLS                     0.470    0.138     0.000   0.000                 -3.187    -0.934
      ROOFS                     0.000    0.000     0.000   0.000                  0.000     0.000
      GLASS CONDUCTION         -1.509   -0.442     0.000   0.000                 -7.052    -2.066
      GLASS SOLAR               8.187    2.398     0.000   0.000                  0.979     0.287
      DOOR                      0.000    0.000     0.000   0.000                  0.000     0.000
      INTERNAL SURFACES         0.000    0.000     0.000   0.000                  0.000     0.000
      UNDERGROUND SURFACES     -1.690   -0.495     0.000   0.000                 -1.689    -0.495
      OCCUPANTS TO SPACE        2.392    0.701     1.433   0.420                  0.138     0.040
      LIGHT     TO SPACE        7.385    2.163     0.000   0.000                  1.001     0.293
      EQUIPMENT TO SPACE        2.349    0.688     0.000   0.000                  0.245     0.072
      PROCESS   TO SPACE        0.000    0.000     0.000   0.000                  0.000     0.000
      INFILTRATION             -0.500   -0.146     0.000   0.000                 -3.004    -0.880
                             --------  -------   -------  ------               --------  --------
      TOTAL                    17.083    5.003     1.433   0.420                -12.569    -3.681
      TOTAL LOAD               18.517 KBTU/H       5.423  KW               -12.569 KBTU/H    -3.681  KW
      TOTAL LOAD / AREA         17.53BTU/H.SQFT   55.278   W / M2          11.903BTU/H.SQFT   37.523   W / M2

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

```
REPORT- LS-B SPACE PEAK LOAD COMPONENTS                    SPACE2-1                    WEATHER FILE- CHICAGO    WYEC
--------------------------------------------------------------------------------------------------------------------
SPACE   SPACE2-1
                  MULTIPLIER        1.0          FLOOR MULTIPLIER        1.0
                  FLOOR  AREA       456   SQFT          42    M2
                  VOLUME           3648   CUFT         103    M3

                                     COOLING  LOAD                              HEATING  LOAD
                                     -------------                              -------------
                TIME                 SEP 10 12NOON                              FEB  3   5AM

                DRY-BULB TEMP          90F      32C                              -3F     -19C
                WET-BULB TEMP          75F      24C                              -4F     -20C

                              SENSIBLE            LATENT                        SENSIBLE
                           (KBTU/H)   ( KW )  (KBTU/H)  ( KW )              (KBTU/H)  ( KW )
                           --------   ------  --------  ------              --------  --------
WALLS                        0.656    0.192    0.000    0.000                -1.464    -0.429
ROOFS                        0.000    0.000    0.000    0.000                 0.000     0.000
GLASS CONDUCTION             0.738    0.216    0.000    0.000                -3.788    -1.109
GLASS SOLAR                  4.028    1.180    0.000    0.000                 0.336     0.099
DOOR                         0.000    0.000    0.000    0.000                 0.000     0.000
INTERNAL SURFACES            0.000    0.000    0.000    0.000                 0.000     0.000
UNDERGROUND SURFACES        -0.788   -0.231    0.000    0.000                -3.940    -1.154
OCCUPANTS TO SPACE           0.854    0.250    0.521    0.153                 0.003     0.001
LIGHT       TO SPACE         2.761    0.809    0.000    0.000                 0.198     0.058
EQUIPMENT TO SPACE           1.026    0.300    0.000    0.000                 0.036     0.010
PROCESS     TO SPACE         0.000    0.000    0.000    0.000                 0.000     0.000
INFILTRATION                 0.000    0.000    0.000    0.000                -1.341    -0.393
                           --------   ------  -------   ------              --------  --------
TOTAL                        9.275    2.716    0.521    0.153                -9.961    -2.917
TOTAL LOAD                   9.796 KBTU/H      2.869   KW           -9.961 KBTU/H     -2.917   KW
TOTAL LOAD / AREA           21.48BTU/H.SQFT   67.726   W / M2       21.844BTU/H.SQFT  68.862   W / M2
 NOTE   1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION
```

```
REPORT- LS-B SPACE PEAK LOAD COMPONENTS                 SPACE3-1                        WEATHER FILE- CHICAGO     WYEC
-----------------------------------------------------------------------------------------------------------------------
SPACE  SPACE3-1
               MULTIPLIER          1.0          FLOOR MULTIPLIER         1.0
               FLOOR  AREA        1056  SQFT        98    M2
               VOLUME             8448  CUFT       239    M3

                                       COOLING  LOAD                              HEATING  LOAD
                                     -----------------                         -----------------
            TIME                       AUG 20   4PM                              FEB  2  8PM

            DRY-BULB TEMP                94F      34C                                 1F    -17C
            WET-BULB TEMP                73F      23C                                 0F    -18C

                                   SENSIBLE          LATENT                          SENSIBLE
                                (KBTU/H)   ( KW )  (KBTU/H)  ( KW )              (KBTU/H)  ( KW )
                                --------   ------  --------  ------              --------  --------
        WALLS                      1.017    0.298     0.000   0.000                -2.983    -0.874
        ROOFS                      0.000    0.000     0.000   0.000                 0.000     0.000
        GLASS CONDUCTION           1.732    0.507     0.000   0.000                -6.690    -1.959
        GLASS SOLAR                2.118    0.620     0.000   0.000                 0.814     0.239
        DOOR                       0.000    0.000     0.000   0.000                 0.000     0.000
        INTERNAL SURFACES          0.000    0.000     0.000   0.000                 0.000     0.000
        UNDERGROUND SURFACES      -0.354   -0.104     0.000   0.000                -1.689    -0.495
        OCCUPANTS TO SPACE         2.391    0.700     1.433   0.420                 0.023     0.007
        LIGHT      TO SPACE        7.379    2.161     0.000   0.000                 0.526     0.154
        EQUIPMENT TO SPACE         2.347    0.687     0.000   0.000                 0.100     0.029
        PROCESS    TO SPACE        0.000    0.000     0.000   0.000                 0.000     0.000
        INFILTRATION               0.000    0.000     0.000   0.000                -4.387    -1.285
                                --------  -------   -------  ------              --------  --------
        TOTAL                     16.631    4.871     1.433   0.420               -14.287    -4.184
        TOTAL LOAD                18.064 KBTU/H       6.290   KW           -14.287 KBTU/H    -4.184  KW
        TOTAL LOAD / AREA          17.11BTU/H.SQFT   53.926   W / M2       13.530BTU/H.SQFT   42.652   W / M2
          NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR LOADS
                2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION IN CONSIDERATION
```

```
REPORT- LS-B SPACE PEAK LOAD COMPONENTS                    SPACE4-1                    WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------------------------------
SPACE   SPACE4-1
                 MULTIPLIER          1.0         FLOOR MULTIPLIER        1.0
                 FLOOR  AREA         456  SQFT        42   M2
                 VOLUME             3648  CUFT       103   M3

                                      COOLING  LOAD                          HEATING  LOAD
                                    ==================                     ==================
             TIME                     JUL 10  6PM                            FEB  2  7AM
             DRY-BULB TEMP              89F    32C                            -9F    -23C
             WET-BULB TEMP              68F    20C                            -9F    -23C

                                  SENSIBLE          LATENT                     SENSIBLE
                              (KBTU/H)  ( KW )  (KBTU/H)  ( KW )           (KBTU/H)  ( KW )
                              --------  ------  --------  ------           --------  --------
  WALLS                          0.947   0.277     0.000   0.000             -1.556    -0.456
  ROOFS                          0.000   0.000     0.000   0.000              0.000     0.000
  GLASS CONDUCTION               0.582   0.171     0.000   0.000             -3.982    -1.166
  GLASS SOLAR                    4.710   1.380     0.000   0.000              0.321     0.094
  DOOR                           0.000   0.000     0.000   0.000              0.000     0.000
  INTERNAL SURFACES              0.000   0.000     0.000   0.000              0.000     0.000
  UNDERGROUND SURFACES          -0.239  -0.070     0.000   0.000             -0.729    -0.214
  OCCUPANTS TO SPACE             1.130   0.331     0.652   0.191              0.063     0.018
  LIGHT      TO SPACE            3.322   0.973     0.000   0.000              0.432     0.127
  EQUIPMENT TO SPACE             0.808   0.237     0.000   0.000              0.106     0.031
  PROCESS    TO SPACE            0.000   0.000     0.000   0.000              0.000     0.000
  INFILTRATION                   0.000   0.000     0.000   0.000             -1.297    -0.380
                              --------  ------  --------  ------           --------  --------
  TOTAL                         11.259   3.298     0.652   0.191             -6.643    -1.946
  TOTAL LOAD                    11.911 KBTU/H      3.488  KW          -6.643 KBTU/H      -1.946  KW
  TOTAL LOAD / AREA              26.12BTU/H.SQFT  82.343  W / M2      14.568BTU/H.SQFT   45.926  W / M2

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

```
REPORT- LS-B SPACE PEAK LOAD COMPONENTS                SPACE5-1                  WEATHER FILE- CHICAGO    WYEC
----------------------------------------------------------------------------------------------------------------
SPACE  SPACE5-1
                 MULTIPLIER        1.0        FLOOR MULTIPLIER       1.0
                 FLOOR  AREA      1976   SQFT        184    M2
                 VOLUME          15808   CUFT        448    M3

                                      COOLING  LOAD                           HEATING  LOAD
                                   ==================                     ==================
              TIME                   SEP 27   4PM                           MAR 16  10PM
              DRY-BULB TEMP            57F      14C                           24F      -4C
              WET-BULB TEMP            47F       8C                           23F      -6C

                                  SENSIBLE            LATENT                   SENSIBLE
                              (KBTU/H)   ( KW )  (KBTU/H)  ( KW )          (KBTU/H)   ( KW )
                              --------   ------  --------  ------          --------  --------
         WALLS                   0.000    0.000     0.000   0.000             0.000     0.000
         ROOFS                   0.000    0.000     0.000   0.000             0.000     0.000
         GLASS CONDUCTION        0.000    0.000     0.000   0.000             0.000     0.000
         GLASS SOLAR             0.000    0.000     0.000   0.000             0.000     0.000
         DOOR                    0.000    0.000     0.000   0.000             0.000     0.000
         INTERNAL SURFACES       0.000    0.000     0.000   0.000             0.000     0.000
         UNDERGROUND SURFACES   -0.632   -0.185     0.000   0.000            -3.191    -0.935
         OCCUPANTS TO SPACE      4.360    1.274     2.606   0.763             0.031     0.009
         LIGHT     TO SPACE     13.818    4.047     0.000   0.000             0.941     0.276
         EQUIPMENT TO SPACE      4.395    1.287     0.000   0.000             0.176     0.051
         PROCESS   TO SPACE      0.000    0.000     0.000   0.000             0.000     0.000
         INFILTRATION            0.000    0.000     0.000   0.000            -8.668    -2.539
                              --------  -------   -------  ------          --------  --------
         TOTAL                  21.931    6.423     2.606   0.763           -10.713    -3.137
         TOTAL LOAD             24.537 KBTU/H       7.186   KW         -10.713 KBTU/H    -3.137  KW
         TOTAL LOAD / AREA       12.42BTU/H.SQFT   39.146   W / M2       5.421BTU/H.SQFT  17.091  W / M2

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

REPORT LS–C -- BUILDING PEAK LOAD COMPONENTS

This report is similar in format to LS–B. The major difference is that LS–C is generated at the "building level"; i.e., the space loads are summed each hour to give the building coincident load and the peak values of this load are shown here.

The building coincident peak load does not include plenums or other unconditioned spaces. Although no infiltration is indicated for the peak cooling load for the Example Building, the user should realize how DOE-2 treats infiltration loads. The sensible portion is treated as an instantaneous heat gain or loss. The latent portion is reported in LOADS, but is passed to SYSTEMS as a CFM with the calculated humidity ratio for each hour. The contribution of the latent heat (negative or positive in relation to room humidity) is then calculated from a mass balance of moisture in the space, to determine the return air humidity ratio. In dry climates the infiltration may actually result in a decreased space latent load and thus a decreased total SYSTEMS load. The opposite is true in humid climates where infiltration acts to increase the SYSTEMS load.

The heat gain or loss that occurs in plenums, including heat due to lights, is accounted for in the SYSTEMS simulation and causes a temperature change in the return air flowing through the plenum. Therefore, the user 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.

```
REPORT- LS-C BUILDING PEAK LOAD COMPONENTS                                         WEATHER FILE- CHICAGO     WYEC
-----------------------------------------------------------------------------------------------------------------
*** BUILDING ***     FLOOR  AREA       5000  SQFT        465  SQMT
                     VOLUME           50000  CUFT       1416  CUMT

                                       COOLING  LOAD                            HEATING  LOAD
                                       =============                            =============
               TIME                    AUG 23   4PM                             JAN  7   8AM

               DRY-BULB TEMP             94F      34C                             16F     -9C
               WET-BULB TEMP             75F      24C                             14F    -10C

                                  SENSIBLE           LATENT                       SENSIBLE
                               (KBTU/H)   ( KW )  (KBTU/H)  ( KW )             (KBTU/H)   ( KW )
                               --------   ------  --------  ------             --------  --------
    WALLS                         3.293    0.964     0.000   0.000               -6.778    -1.985
    ROOFS                         0.000    0.000     0.000   0.000                0.000     0.000
    GLASS CONDUCTION              5.391    1.579     0.000   0.000              -16.049    -4.700
    GLASS SOLAR                   9.347    2.737     0.000   0.000                0.928     0.272
    DOOR                          0.000    0.000     0.000   0.000                0.000     0.000
    INTERNAL SURFACES             0.000    0.000     0.000   0.000                0.000     0.000
    UNDERGROUND SURFACES         -2.347   -0.687     0.000   0.000               -9.949    -2.914
    OCCUPANTS TO SPACE           11.309    3.312     6.776   1.984                0.001     0.000
    LIGHT     TO SPACE           34.965   10.240     0.000   0.000                2.051     0.601
    EQUIPMENT TO SPACE           11.122    3.257     0.000   0.000                0.342     0.100
    PROCESS   TO SPACE            0.000    0.000     0.000   0.000                0.000     0.000
    INFILTRATION                  0.000    0.000     0.000   0.000              -21.530    -6.306
                               --------  -------   -------  ------             --------  --------
    TOTAL                        73.079   21.403     6.776   1.984              -50.986   -14.932
    TOTAL LOAD                   79.854 KBTU/H      23.387   KW             -50.986 KBTU/H   -14.932  KW
    TOTAL LOAD / AREA             15.97BTU/H.SQFT   50.348   W /SQMT         10.197BTU/H.SQFT  32.146  W /SQMT

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

REPORT LS–D -- BUILDING MONTHLY LOADS SUMMARY

This report gives a summary of monthly cooling, heating, and electrical requirements plus annual total energy requirements and maximum monthly peak loads. Unconditioned spaces are not included in this report's monthly load.

Once again, the user should be aware that these loads are based on a constant temperature within each SPACE (that is, no setback, no floating, and no variations within the SPACE). Additionally, these loads do not account for conditioning of outside ventilation air. Later, in SYSTEMS, these items will be accounted for.

1. COOLING, HEATING, and ELEC
   are the three sections of this building level report.

2. COOLING ENERGY
   (millions of Btu) is the monthly sensible load for all SPACEs in the building.

3. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) is the peak sensible space cooling load. To the left of this column are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

4. HEATING ENERGY
   (millions of Btu) is the monthly heating load.

5. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) is the peak space heating load. To the left of this column are the day and hour of the peak heating load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

6. ELECTRICAL ENERGY (kWh)
   is the monthly electrical consumption for lights, convenience outlets, and non-HVAC equipment.

7. MAXIMUM ELEC LOAD (kW)
   is the monthly peak electrical consumption in a one-hour period for lights, convenience outlets, and miscellaneous equipment input as SOURCE.

8. TOTAL
   is the annual total for the cooling load, heating load, and electrical loads of the building.

9. MAX
   is the highest monthly peak cooling load, heating load, and electrical load.

```
REPORT- LS-D BUILDING MONTHLY LOADS SUMMARY                                                    WEATHER FILE- CHICAGO     WYEC
---------------------------------------------------------------------------------------------------------------------------------
       - - - - - - - - C O O L I N G - - - - - - - -     - - - - - - - - H E A T I N G - - - - - - - -     - - - E L E C - - -
                                           MAXIMUM                                          MAXIMUM      ELEC-     MAXIMUM
       COOLING    TIME    DRY-  WET-       COOLING    HEATING    TIME    DRY-  WET-         HEATING      TRICAL       ELEC
        ENERGY   OF MAX   BULB  BULB          LOAD     ENERGY   OF MAX   BULB  BULB            LOAD      ENERGY       LOAD
MONTH   (MBTU)   DY  HR   TEMP  TEMP     (KBTU/HR)     (MBTU)   DY  HR   TEMP  TEMP       (KBTU/HR)       (KWH)       (KW)

JAN    5.74185   18  16   29.F  25.F        44.863    -13.909    7   8   16.F  14.F         -50.986       4803.     18.992

FEB    5.40185   28  16   58.F  53.F        54.126    -13.234    3   5   -3.F  -4.F         -50.802       4173.     18.992

MAR    6.29780   19  16   65.F  51.F        52.738    -11.362   16  23   22.F  21.F         -44.945       4613.     18.992

APR   10.58069   26  16   88.F  62.F        63.598     -4.971   15   5   30.F  27.F         -23.329       4782.     18.992

MAY   13.57383   22  15   83.F  70.F        64.968     -2.466    5   5   41.F  37.F         -15.804       4803.     18.992

JUN   15.53150   12  17   90.F  70.F        69.735     -0.807    3   5   48.F  45.F         -10.113       4403.     18.992

JUL   19.55956    8  17   91.F  71.F        72.253     -0.110    7   5   59.F  54.F          -3.723       4803.     18.992

AUG   19.64659   23  15   94.F  75.F        73.079     -0.082   18   6   57.F  52.F          -3.771       4803.     18.992

SEP   15.80687    3  17   90.F  71.F        71.759     -0.494   29   6   42.F  41.F         -10.096       4403.     18.992

OCT   13.89180   17  15   82.F  69.F        66.361     -1.743   28   6   34.F  29.F         -14.248       4803.     18.992

NOV    7.49261    1  15   61.F  62.F        53.937     -7.898   30   7   13.F  12.F         -41.489       4214.     18.992

DEC    5.94738   10  15   56.F  49.F        53.576    -12.261   19   7    2.F   1.F         -45.149       4613.     18.992
      ---------                          ----------  ---------                           ----------    --------    -------

TOTAL  139.472                                        -69.337                                          55215.

MAX                                         73.079                                          -50.986                 18.992
```

REPORT LS–K -- SPACE INPUT FUELS SUMMARY

This report gives monthly summaries of the fuel inputs required by each space for lighting, equipment, and processes. Following the reports for each space is a separate building level report that gives the sum of the input fuels for the building as a whole.

Lighting, equipment, and process are the three major sections of this report, which is printed once for each space and once for the building as a whole.

1. TASK LIGHTING
   (kilowatt hours) is the electricity used by the space for all task lighting.

2. TOTAL LIGHTING
   (kilowatt hours) is the electricity used by the space for all lighting including task and overhead.

3. GENERAL EQUIPMENT
   (kilowatt hours) is the electricity used by the space for running all equipment (i.e., computers, typewriters, etc.). For the building report, this includes building equipment such as elevators which may not be included in any space.

4. PROCESS ELECTRIC
   (kilowatt hours) is all electricity used to maintain any of the processes in the space.

5. PROCESS GAS
   (millions of Btu) is all gas used to maintain any of the processes in the space.

6. PROCESS HOT WATER
   (millions of Btu) is the total hot water used in all processes in the space.

```
REPORT- LS-K  SPACE INPUT FUELS SUMMARY                    PLENUM-1                      WEATHER FILE- CHICAGO    WYEC
---------------------------------------------------------------------------------------------------------------------------
SPACE   PLENUM-1

          - - - - L I G H T I N G - - - -   E Q U I P M E N T - - - - - - - - - - - P R O C E S S - - - - - - - - - -

          TASK LIGHTING    TOTAL LIGHTING   GENERAL EQUIPMENT  PROCESS ELECTRIC   PROCESS GAS    PROCESS HOT WATER
              (KWH)            (KWH)              (KWH)             (KWH)            (MBTU)            (MBTU)
MONTH


JAN             0.00             0.00               0.00              0.00           0.0000            0.0000
FEB             0.00             0.00               0.00              0.00           0.0000            0.0000
MAR             0.00             0.00               0.00              0.00           0.0000            0.0000
APR             0.00             0.00               0.00              0.00           0.0000            0.0000
MAY             0.00             0.00               0.00              0.00           0.0000            0.0000
JUN             0.00             0.00               0.00              0.00           0.0000            0.0000
JUL             0.00             0.00               0.00              0.00           0.0000            0.0000
AUG             0.00             0.00               0.00              0.00           0.0000            0.0000
SEP             0.00             0.00               0.00              0.00           0.0000            0.0000
OCT             0.00             0.00               0.00              0.00           0.0000            0.0000
NOV             0.00             0.00               0.00              0.00           0.0000            0.0000
DEC             0.00             0.00               0.00              0.00           0.0000            0.0000
            -----------       ---------        ----------        ----------      -----------       -----------
ANNUAL          0.00             0.00               0.00              0.00           0.0000            0.0000
```

```
REPORT- LS-K  SPACE INPUT FUELS SUMMARY                 SPACE1-1                    WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------------------------------
SPACE   SPACE1-1

        ----LIGHTING----   EQUIPMENT ----------- PROCESS ----------

        TASK LIGHTING   TOTAL LIGHTING   GENERAL EQUIPMENT  PROCESS ELECTRIC   PROCESS GAS   PROCESS HOT WATER
           (KWH)            (KWH)              (KWH)             (KWH)            (MBTU)           (MBTU)
MONTH
JAN            0.00           804.02             210.31              0.00           0.0000           0.0000
FEB            0.00           699.04             182.25              0.00           0.0000           0.0000
MAR            0.00           772.83             201.46              0.00           0.0000           0.0000
APR            0.00           800.22             209.80              0.00           0.0000           0.0000
MAY            0.00           804.02             210.31              0.00           0.0000           0.0000
JUN            0.00           737.83             192.11              0.00           0.0000           0.0000
JUL            0.00           804.02             210.31              0.00           0.0000           0.0000
AUG            0.00           804.02             210.31              0.00           0.0000           0.0000
SEP            0.00           737.83             192.11              0.00           0.0000           0.0000
OCT            0.00           804.02             210.31              0.00           0.0000           0.0000
NOV            0.00           706.64             183.27              0.00           0.0000           0.0000
DEC            0.00           772.82             201.46              0.00           0.0000           0.0000
          ----------       ---------         ----------        ----------      -----------      -----------

ANNUAL         0.00          9246.93            2413.99              0.00           0.0000           0.0000
```

```
REPORT- LS-K  SPACE INPUT FUELS SUMMARY                      SPACE2-1                         WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------
SPACE  SPACE2-1

         - - - - L I G H T I N G - - - -   E Q U I P M E N T - - - - - - - - - - - P R O C E S S - - - - - - - - - -

        TASK LIGHTING   TOTAL LIGHTING  GENERAL EQUIPMENT  PROCESS ELECTRIC   PROCESS GAS   PROCESS HOT WATER
            (KWH)           (KWH)            (KWH)              (KWH)            (MBTU)           (MBTU)
MONTH
JAN           0.00          347.19            90.82              0.00            0.0000           0.0000
FEB           0.00          301.86            78.70              0.00            0.0000           0.0000
MAR           0.00          333.72            87.00              0.00            0.0000           0.0000
APR           0.00          345.55            90.60              0.00            0.0000           0.0000
MAY           0.00          347.19            90.82              0.00            0.0000           0.0000
JUN           0.00          318.61            82.96              0.00            0.0000           0.0000
JUL           0.00          347.19            90.82              0.00            0.0000           0.0000
AUG           0.00          347.19            90.82              0.00            0.0000           0.0000
SEP           0.00          318.61            82.96              0.00            0.0000           0.0000
OCT           0.00          347.19            90.82              0.00            0.0000           0.0000
NOV           0.00          305.14            79.14              0.00            0.0000           0.0000
DEC           0.00          333.72            87.00              0.00            0.0000           0.0000
          ----------      ---------        ----------         ----------       ----------       ----------
ANNUAL        0.00         3992.95          1042.47              0.00            0.0000           0.0000
```

```
REPORT- LS-K  SPACE INPUT FUELS SUMMARY                    SPACE3-1                   WEATHER FILE- CHICAGO    WYEC
-------------------------------------------------------------------------------------------------------------------------
SPACE   SPACE3-1

            - - - - L I G H T I N G - - - -   E Q U I P M E N T - - - - - - - - - - - P R O C E S S - - - - - - - - - -

            TASK LIGHTING   TOTAL LIGHTING   GENERAL EQUIPMENT  PROCESS ELECTRIC   PROCESS GAS   PROCESS HOT WATER
                (KWH)           (KWH)              (KWH)             (KWH)            (MBTU)           (MBTU)
MONTH
JAN               0.00          804.02            210.31              0.00           0.0000           0.0000
FEB               0.00          699.04            182.26              0.00           0.0000           0.0000
MAR               0.00          772.83            201.46              0.00           0.0000           0.0000
APR               0.00          800.22            209.80              0.00           0.0000           0.0000
MAY               0.00          804.02            210.31              0.00           0.0000           0.0000
JUN               0.00          737.83            192.11              0.00           0.0000           0.0000
JUL               0.00          804.02            210.31              0.00           0.0000           0.0000
AUG               0.00          804.02            210.31              0.00           0.0000           0.0000
SEP               0.00          737.83            192.11              0.00           0.0000           0.0000
OCT               0.00          804.02            210.31              0.00           0.0000           0.0000
NOV               0.00          706.64            183.27              0.00           0.0000           0.0000
DEC               0.00          772.82            201.46              0.00           0.0000           0.0000
            -----------      ---------        ----------        ----------     -----------      -----------
ANNUAL            0.00         9246.93           2413.99              0.00           0.0000           0.0000
```

```
REPORT- LS-K  SPACE INPUT FUELS SUMMARY                    SPACE4-1                  WEATHER FILE- CHICAGO    WYEC
----------------------------------------------------------------------------------------------------------------------
SPACE   SPACE4-1

          - - - - L I G H T I N G - - - -   E Q U I P M E N T - - - - - - - - - - - P R O C E S S - - - - - - - - - -

          TASK LIGHTING   TOTAL LIGHTING   GENERAL EQUIPMENT  PROCESS ELECTRIC   PROCESS GAS   PROCESS HOT WATER
              (KWH)           (KWH)              (KWH)              (KWH)           (MBTU)            (MBTU)
MONTH


JAN             0.00          347.19             90.82               0.00          0.0000            0.0000
FEB             0.00          301.86             78.70               0.00          0.0000            0.0000
MAR             0.00          333.72             87.00               0.00          0.0000            0.0000
APR             0.00          345.55             90.60               0.00          0.0000            0.0000
MAY             0.00          347.19             90.82               0.00          0.0000            0.0000
JUN             0.00          318.61             82.96               0.00          0.0000            0.0000
JUL             0.00          347.19             90.82               0.00          0.0000            0.0000
AUG             0.00          347.19             90.82               0.00          0.0000            0.0000
SEP             0.00          318.61             82.96               0.00          0.0000            0.0000
OCT             0.00          347.19             90.82               0.00          0.0000            0.0000
NOV             0.00          305.14             79.14               0.00          0.0000            0.0000
DEC             0.00          333.72             87.00               0.00          0.0000            0.0000
          ----------      ---------        ----------         ----------     -----------       -----------
ANNUAL          0.00         3992.95           1042.47               0.00          0.0000            0.0000
```

```
REPORT- LS-K  SPACE INPUT FUELS SUMMARY                     SPACE5-1                        WEATHER FILE- CHICAGO    WYEC
----------------------------------------------------------------------------------------------------------------------------
SPACE   SPACE5-1

          - - - - L I G H T I N G - - - -   E Q U I P M E N T - - - - - - - - - - P R O C E S S - - - - - - - - - -

          TASK LIGHTING    TOTAL LIGHTING   GENERAL EQUIPMENT  PROCESS ELECTRIC    PROCESS GAS     PROCESS HOT WATER
              (KWH)            (KWH)             (KWH)              (KWH)             (MBTU)             (MBTU)
MONTH

JAN            0.00          1504.48            393.53              0.00            0.0000             0.0000
FEB            0.00          1308.05            341.03              0.00            0.0000             0.0000
MAR            0.00          1446.12            376.98              0.00            0.0000             0.0000
APR            0.00          1497.37            392.59              0.00            0.0000             0.0000
MAY            0.00          1504.48            393.53              0.00            0.0000             0.0000
JUN            0.00          1380.64            359.48              0.00            0.0000             0.0000
JUL            0.00          1504.48            393.53              0.00            0.0000             0.0000
AUG            0.00          1504.48            393.53              0.00            0.0000             0.0000
SEP            0.00          1380.64            359.48              0.00            0.0000             0.0000
OCT            0.00          1504.48            393.53              0.00            0.0000             0.0000
NOV            0.00          1322.27            342.93              0.00            0.0000             0.0000
DEC            0.00          1446.12            376.98              0.00            0.0000             0.0000
          -----------      ---------        ----------        ----------       -----------       -----------
ANNUAL         0.00         17304.12           4517.27              0.00            0.0000             0.0000
```

```
REPORT- LS-K *BUILDING* INPUT FUELS SUMMARY                                          WEATHER FILE- CHICAGO    WYEC
-------------------------------------------------------------------------------------------------------------------
BUILDING

          - - - - L I G H T I N G - - - -  E Q U I P M E N T - - - - - - - - - - P R O C E S S - - - - - - - - -

          TASK LIGHTING  TOTAL LIGHTING  GENERAL EQUIPMENT  PROCESS ELECTRIC  PROCESS GAS  PROCESS HOT WATER
              (KWH)          (KWH)            (KWH)              (KWH)           (MBTU)          (MBTU)
MONTH
 JAN             0.00        3806.90           995.79              0.00          0.0000          0.0000
 FEB             0.00        3309.86           862.94              0.00          0.0000          0.0000
 MAR             0.00        3659.21           953.90              0.00          0.0000          0.0000
 APR             0.00        3788.91           993.39              0.00          0.0000          0.0000
 MAY             0.00        3806.90           995.79              0.00          0.0000          0.0000
 JUN             0.00        3493.53           909.62              0.00          0.0000          0.0000
 JUL             0.00        3806.89           995.79              0.00          0.0000          0.0000
 AUG             0.00        3806.90           995.79              0.00          0.0000          0.0000
 SEP             0.00        3493.53           909.62              0.00          0.0000          0.0000
 OCT             0.00        3806.89           995.79              0.00          0.0000          0.0000
 NOV             0.00        3345.86           867.74              0.00          0.0000          0.0000
 DEC             0.00        3659.22           963.91              0.00          0.0000          0.0000
          -----------      ---------       ----------        ----------     -----------     -----------
ANNUAL           0.00       43787.66         11431.60              0.00          0.0000          0.0000
```

REPORT SV–A -- SYSTEM DESIGN PARAMETERS

This report echoes the user's input to the program as interpreted by the SYSTEMS design routines. See Section IV.D of the *Reference Manual (2.1A)* for a discussion of SYSTEMS design calculations.

1. SYSTEM NAME
   in the first line after the header is the u-name (SYST–1) of the HVAC system assigned by the user.

2. SUPPLY FAN (CFM)
   is the calculated system design air flow rate. It should be equal to the user-input SUPPLY–CFM multiplied by the value of ALTITUDE MULTIPLIER. If not user-specified, the value will be calculated from the peak loads. For a constant volume system or if SIZING–OPTION = NON–COINCIDENT, the number will be the sum of the design/cfms for the zones on the system. If the system is a variable-air-volume system, SIZING–OPTION = COINCIDENT, and this is the only system in the PLANT–ASSIGNMENT, the value is calculated from the building coincident peak load.

3. ELEC (KW)
   is the electrical energy consumed by the central system supply fan at design flow. It will be calculated from the value in column 1 and the user input (or default) for SUPPLY–KW or from the ratio of SUPPLY–STATIC and SUPPLY–EFF.

4. DELTA–T (F)
   is the value of SUPPLY–DELTA–T, the rise in temperature of the air caused by the supply fan.

5. The next three entries, RETURN FAN (CFM), ELEC (KW), AND DELTA–T (F) are the corresponding values for the return air fan. In the sample report these are all zero because no return fan has been specified.

6. OUTSIDE AIR RATIO
   is the outside air ratio for central systems. Its value is either the user input value of MIN–OUTSIDE–AIR or is calculated by SYSTEMS from the ventilation or exhaust input at the zone level divided by the supply fan cfm in column 1. This is a design quantity and so does not reflect values entered through the MIN–AIR–SCH keyword. For zonal systems, this value will be zero.

   When OUTSIDE AIR RATIO is determined from zone ventilation rates, it is the sum of the values under OUTSIDE AIR CFM (in column 6 opposite the zone u-names) divided by the value under SUPPLY FAN. This outside air ratio is what the program will use as the minimum outside air ratio. It is assumed that the outside air is brought in at the main system fan and is distributed to the individual zones in proportion to the supply air to each zone.

   Note: The SYSTEMS design routine does not examine the values entered in schedules. Consequently, if the user specified the outside air ratio through the MIN–AIR–SCH but wants SYSTEMS to size the equipment, a value should be specified for MIN–OUTSIDE–AIR.

7. COOLING CAPACITY (KBTU/HR)
   is either the value entered by the user for the keyword COOLING–CAPACITY at the system level or is computed by SYSTEMS from the total cooling capacity (sensible plus latent) from the peak loads. If the cfm chosen for the system is different from the user-specified value of RATED–CFM, COOLING CAPACITY may reflect a correction for off-rated performance.

8. SENSIBLE (SHR)
is the sensible heat ratio, i.e., the fraction of the total cooling capacity that is sensible cooling capacity at the peak or design condition, adjusted for RATED–CFM. If the user has not entered COOL–SH–CAP at the system level for a central system, this value is calculated from a simulation of the conditions at peak loads, adjusted for RATED–CFM.

9. HEATING CAPACITY (KBTU/HR)
is the maximum value for heating and again it reflects either the user input or a calculation from peak loads. Like the COOLING CAPACITY, this value will be zero for zonal systems, where the capacity is shown at the zone level.

10. COOLING EIR and HEATING EIR (BTU/BTU)
are the electric input ratios for cooling and for heat pumps, respectively. Values are taken from user input or are default values. Values may be modified if the supply cfm differs from the RATED–CFM.

The remainder of the report shows zone-level design values:

11. SUPPLY FLOW
is the calculated or user-specified supply cfm for each zone. Only if the user has specified a value for the ASSIGNED–CFM keyword in the ZONE–AIR command will the value here correspond to the user input. The ZONE–AIR keywords,
AIR-CHANGES/HR and CFM/SQFT,
will be accepted by SYSTEMS only if they are consistent with the user-supplied HEATING–CAPACITY and COOLING–CAPACITY, and are equivalent to a cfm larger than that of the exhaust from or the ventilation to the zone. If so, the cfm-equivalent values of the keywords AIR-CHANGES/HR and CFM/SQFT will be rounded up to the nearest 10 cfm. In any case, the ALTITUDE MULTIPLIER will be applied.

12. FAN (KW)
is the total of the zone supply and exhaust fan electrical consumption at design conditions. In the example shown, this is zero, as there are no zone fans.

13. MINIMUM FLOW RATIO
reflects the user's input for MIN–CFM–RATIO, unless that input is in conflict with exhaust or ventilation requirements. In the absence of user input, SYSTEMS will calculate the minimum cfm ratio for VAV systems from the minimum cfm needed to meet the the minimum ventilation requirements and the required heating capacity.

14. OUTSIDE AIR FLOW
reflects the user-specified outside air quantity entered at the zone level. If OUTSIDE–AIR–CFM is specified, its value is multiplied by the ALTITUDE MULTIPLIER and reported here. Otherwise the reported value is the maximum of the cfm-equivalent values of OA–CHANGES and OA–CFM/PER, rounded upward to the nearest 10 cfm and then multiplied by the ALTITUDE MULTIPLIER. For the actual amount of outside air delivered to the zone for central systems, see OUTSIDE AIR RATIO above.

15. COOLING CAPACITY (KBTU/HR),
at the zone level, will be zero for central systems. For zonal systems it will either be the value specified by the user for COOLING–CAPACITY or it will be calculated by SYSTEMS to meet the peak loads at the rated conditions for HP, PTAC, TPFC, and FPFC systems or at any conditions for FPIU and TPIU systems. This is done similarly for HEATING CAPACITY for the

above-mentioned systems and for UVT and UHT systems.

16. SENSIBLE (SHR)
is the sensible part of the cooling capacity for zonal systems.

17. EXTRACTION RATE (KBTU/HR)
is the extraction rate (cooling) at design conditions. This is not the value used in the simulation; that value is recalculated hourly and depends upon the loads, the conditions, the thermostat type, and the thermostatic throttling range. ADDITION RATE (heating) is treated similarly.

18. MULTIPLIER
is the user-specified number of identical zones.

```
REPORT- SV-A   SYSTEM DESIGN PARAMETERS                    SYST-1                       WEATHER FILE- CHICAGO    WYEC
-------------------------------------------------------------------------------------------------------------------------
      SYSTEM        ALTITUDE
        NAME      MULTIPLIER

SYST-1                 1.020

    SUPPLY                        RETURN                           OUTSIDE     COOLING                 HEATING     COOLING     HEATING
       FAN      ELEC   DELTA-T       FAN        ELEC    DELTA-T        AIR    CAPACITY   SENSIBLE    CAPACITY         EIR         EIR
     (CFM )     (KW)       (F)     (CFM )       (KW)        (F)      RATIO   (KBTU/HR)      (SHR)   (KBTU/HR)   (BTU/BTU)   (BTU/BTU)

     5012.     5.768       3.6        0.       0.000        0.0      0.074     149.499      0.791       0.000        0.00        0.37

                                                        MINIMUM    OUTSIDE     COOLING              EXTRACTION     HEATING    ADDITION
        ZONE              SUPPLY   EXHAUST        FAN       FLOW        AIR    CAPACITY   SENSIBLE        RATE    CAPACITY        RATE
        NAME                FLOW      FLOW       (KW)      RATIO       FLOW   (KBTU/HR)      (SHR)   (KBTU/HR)   (KBTU/HR)   (KBTU/HR) MULTIPLIER

SPACE5-1                   1627.        0.      0.000      0.300       143.        0.00       0.00       31.62     -101.89      -84.32        1.0

SPACE1-1                   1077.        0.      0.000      0.300        79.        0.00       0.00       20.93      -67.45      -55.82        1.0

SPACE2-1                    567.        0.      0.000      0.300        36.        0.00       0.00       11.02      -35.51      -29.39        1.0

SPACE3-1                   1071.        0.      0.000      0.300        79.        0.00       0.00       20.83      -67.11      -55.54        1.0

SPACE4-1                    671.        0.      0.000      0.300        36.        0.00       0.00       13.04      -42.03      -34.78        1.0

PLENUM-1                      0.        0.      0.000      0.000         0.        0.00       0.00        0.00        0.00        0.00        1.0
```

REPORT SS–A -- SYSTEM MONTHLY LOADS SUMMARY

This report is always printed by the program for each HVAC system modeled. It shows monthly cooling, heating, and electrical loads. The loads shown are the sum of zone-level loads and central air-handling-unit loads. 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, and RESYS systems) but are not passed to the PLANT program.

1. The title of the report shows the user name of the HVAC system being summarized (SYST–1).

2. COOLING, HEATING, and ELEC
   are the three sections of this system-level report.

3. COOLING ENERGY
   (millions of Btu) is the monthly sum of energy (sensible and latent) extracted by the HVAC system during the operation hours of the system and passed as a load to PLANT.

4. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) includes sensible and latent space cooling loads, ventilation air, and fan heat. The peak cooling load shown here is often the start-up load after the system has been shut down overnight. Notice, however, that when the system size is inadequate to meet the start-up load there is no indication of this problem on the report. The user should first inspect the PLANT program BEPS report, which shows the "Percent of Hours Any System Zone Outside of Throttling Range", for a macro view, and Report SS–O for a zonal report of where "LOADS Not Met" conditions prevail.

   To the left of the MAXIMUM COOLING LOAD column are the day and hour of the peak cooling load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

5. HEATING ENERGY
   (millions of Btu) is the monthly sum of heat delivered by the secondary HVAC system during the operation hours of the system and passed as a load to PLANT.

6. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) includes space heating loads, ventilation, and humidification. Again, the peak heating load is often due to start-up conditions after the system has been shut down overnight. To the left of this column are the day and hour of the peak heating load along with the outside dry-bulb and wet-bulb temperatures at the time of the peak.

7. ELECTRICAL ENERGY (kWh)
   is the monthly electrical consumption for lights, convenience outlets, supply and return fans, and energy consumed by packaged HVAC units. The electrical consumption by the pumps is reported in the PLANT program.

8. MAXIMUM ELEC LOAD (kW)
   is the monthly peak electrical consumption in a one-hour period for lights, convenience outlets, energy consumed by packaged HVAC units, and fans for the zones served by the HVAC system.

```
REPORT- SS-A  SYSTEM MONTHLY LOADS SUMMARY FOR          SYST-1                        WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------------------------------
      - - - - - - - - C O O L I N G - - - - - - - -    - - - - - - - - H E A T I N G - - - - - - - -    - - - E L E C - - -

                                                MAXIMUM                                      MAXIMUM     ELEC-     MAXIMUM
          COOLING    TIME    DRY-   WET-        COOLING      HEATING    TIME    DRY-   WET-   HEATING     TRICAL      ELEC
           ENERGY   OF MAX   BULB   BULB           LOAD       ENERGY   OF MAX   BULB   BULB      LOAD     ENERGY      LOAD
MONTH      (MBTU)   DY  HR   TEMP   TEMP      (KBTU/HR)       (MBTU)   DY  HR   TEMP   TEMP (KBTU/HR)      (KWH)      (KW)

 JAN      0.00000                                 0.000      -14.837   28   8   24.F   23.F  -326.980      5014.    19.937

 FEB      0.00000                                 0.000      -12.802   25   8   11.F   11.F  -336.072      4357.    19.757

 MAR      0.09026   19  16   65.F   51.F         17.771       -8.824   18   8   27.F   24.F  -333.405      4784.    19.601

 APR      2.09777   26  17   87.F   62.F         80.260       -2.564   15   8   34.F   32.F  -202.321      4947.    21.409

 MAY      6.49387   22  18   78.F   72.F         87.580       -0.170   20   8   48.F   46.F   -72.549      5060.    21.364

 JUN     13.24104   13  17   85.F   74.F        112.120        0.000                            0.000      4846.    22.658

 JUL     20.60470   17  15   90.F   73.F        113.657        0.000                            0.000      5513.    22.912

 AUG     20.39339   20  17   90.F   77.F        122.824        0.000                            0.000      5497.    23.085

 SEP     10.49018    9  16   91.F   73.F        120.529        0.000                            0.000      4850.    23.216

 OCT      3.68348   17  16   82.F   69.F         88.442       -0.095   28   8   37.F   32.F   -68.152      5040.    21.866

 NOV      0.05012    1  14   62.F   53.F          9.753       -4.140   12   8   37.F   32.F  -201.337      4347.    19.976

 DEC      0.00000                                 0.000      -12.154   16   8    8.F    7.F  -334.756      4797.    19.712
        ---------                            ----------    ---------                        ---------   --------   -------
 TOTAL     77.145                                            -55.586                                      59058.
 MAX                                            122.824                                      -336.072               23.216
```

REPORT SS–D -- PLANT MONTHLY LOADS SUMMARY

In DOE-2, multiple central plants for serving the building's HVAC systems can be simulated. The PLANT–ASSIGNMENT command is used to assign HVAC systems to central plants. The name of the plant is reported in the title line. In this example, no u-name was specified, and so a default name (DEFAULT–PLANT) is printed. The cooling, heating, and electrical energy required by the system(s) and zones served by the plant are reported monthly along with the peak cooling, heating, and electrical loads for the combined systems, and the time of occurrence. Note that these peak loads may result from startup after the building has been shut down overnight. Cooling done in SYSTEMS by DX units is not included here in cooling loads but in electrical loads.

1. COOLING ENERGY
   (millions of Btu) is the sensible and latent monthly cooling required by the HVAC systems from the central plant specified in the PLANT–ASSIGNMENT command. For Unitary Heat Pumps (HP) the value reported here is the heat rejected to the plant's cooling tower.

2. TIME OF MAX
   gives the day and hour that the maximum cooling load occurs.

3. DRY–BULB TEMP and WET–BULB TEMP
   are the outside dry-bulb wet-bulb temperatures during the peak cooling load.

4. MAXIMUM COOLING LOAD
   (thousands of Btu/hr) gives the peak cooling load for each month and for the year.

5. HEATING ENERGY
   (millions of Btu) is the total monthly heating required by the HVAC systems from the specified central plant. For Unitary Heat Pumps (HP) the value reported here is the supplementary heat from the plant's hot water boiler.

6. TIME OF MAX
   gives the day and hour that the maximum heating load occurs.

7. DRY–BULB TEMP and WET–BULB TEMP
   are the outside dry-bulb wet-bulb temperatures during the peak heating load.

8. MAXIMUM HEATING LOAD
   (thousands of Btu/hr) gives the peak heating load for each month and for the year.

9. ELECTRICAL ENERGY
   (in kWh) is the monthly electrical requirement for lights and convenience outlets for the building *zones* served by the plant. In addition, the electrical energy contains the fan energy requirement for the HVAC system and electric energy for cooling and heating in packaged units. It does *not* include the electrical energy associated with pumps, cooling towers and chillers. These are reported in the PLANT program.

10. MAXIMUM ELEC LOAD
    (kW) gives the monthly peak electrical consumption in a one-hour period for the items in 9 (ELECTRICAL ENERGY).

```
REPORT- SS-D  PLANT MONTHLY LOADS SUMMARY FOR              DEFAULT-PLANT                      WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------------
         - - - - - - - - -C O O L I N G- - - - - - - - -     - - - - - - - - -H E A T I N G- - - - - - - - -    - - -E L E C- - -
                                                 MAXIMUM                                            MAXIMUM      ELEC-    MAXIMUM
           COOLING     TIME    DRY-   WET-       COOLING       HEATING    TIME    DRY-   WET-       HEATING     TRICAL       ELEC
            ENERGY    OF MAX   BULB   BULB          LOAD        ENERGY   OF MAX   BULB   BULB          LOAD     ENERGY       LOAD
MONTH       (MBTU)    DY  HR   TEMP   TEMP      (KBTU/HR)       (MBTU)   DY  HR   TEMP   TEMP     (KBTU/HR)      (KWH)       (KW)

JAN        0.00000                                  0.000      -14.837   28   8   24.F   23.F      -326.986      5014.     19.937

FEB        0.00000                                  0.000      -12.802   25   8   11.F   11.F      -336.072      4357.     19.757

MAR        0.09026    19  16   65.F   61.F         17.771       -8.824   18   8   27.F   24.F      -333.405      4784.     19.601

APR        2.09777    26  17   87.F   62.F         80.260       -2.564   15   8   34.F   32.F      -202.321      4947.     21.409

MAY        6.49387    22  18   78.F   72.F         87.580       -0.170   20   8   48.F   46.F       -72.549      5060.     21.364

JUN       13.24104    13  17   86.F   74.F        112.120        0.000                                0.000      4846.     22.658

JUL       20.60470    17  15   90.F   73.F        113.657        0.000                                0.000      5513.     22.912

AUG       20.39339    20  17   90.F   77.F        122.824        0.000                                0.000      5497.     23.085

SEP       10.49018     9  16   91.F   73.F        120.529        0.000                                0.000      4850.     23.216

OCT        3.68348    17  16   82.F   69.F         88.442       -0.095   28   8   37.F   32.F       -68.152      5040.     21.866

NOV        0.05012     1  14   62.F   53.F          9.753       -4.140   12   8   37.F   32.F      -291.337      4347.     19.976

DEC        0.00000                                  0.000      -12.164   16   8    8.F    7.F      -334.756      4797.     19.712
         ---------                             ----------    ---------                          ----------   --------   -------
TOTAL       77.145                                             -55.586                                        59058.
MAX                                               122.824                                         -336.072               23.216
MAXIMUM DAILY INTEGRATED COOLING LOAD (DES DAY )                 0.000 (KBTU)
MAXIMUM DAILY INTEGRATED COOLING LOAD (WTH FILE)              1179.734 (KBTU)
```

REPORT SS–H -- SYSTEM MONTHLY LOADS SUMMARY

This report gives monthly values of electrical energy for fans, gas/oil energy for heating and cooling, and electrical energy for heating and cooling for an HVAC system. The name of the system (SYST–1) is shown in the title.

1. FAN ELEC
   shows the total and maximum hourly electrical consumption of the supply, return, exhaust, and zonal fans.

2. FUEL HEAT
   shows the total oil and gas consumption by the system for heating, in Btu-equivalents. This will be zero unless the user has made at least one of the heat sources OIL–FURNACE or GAS–FURNACE.

3. FUEL COOL
   shows the total oil and gas consumption by the system for cooling, in Btu-equivalents.

4. ELEC HEAT
   shows the electrical consumption for heating. This will include electric baseboards and reheat coils as well as the electrical load attributable to the heating cycle of a heat pump.

5. ELEC COOL
   shows the electrical consumption and hourly maxima for cooling.

```
REPORT- SS-H  SYSTEM MONTHLY LOADS SUMMARY FOR          SYST-1                    WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------

      - -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         212.      5.503       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

FEB         185.      5.672       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

MAR         171.      5.567       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

APR         165.      2.611       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

MAY         258.      2.683       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

JUN         443.      3.807       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

JUL         711.      4.003       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

AUG         695.      4.248       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

SEP         447.      4.315       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

OCT         238.      3.032       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

NOV         133.      4.674       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000

DEC         184.      5.600       0.000       0.000       0.000       0.000          0.       0.000          0.       0.000
      ---------- ---------- ---------- ----------- ---------- ----------- ---------- ---------- ---------- ----------
0TOTAL     3839.                  0.000                   0.000                      0.                      0.
0MAX                  5.672                   0.000                   0.000                   0.000                   0.000
```

REPORT SS–L -- FAN ELECTRIC ENERGY FOR <system>

This report gives a breakdown of monthly fan electric energy for an HVAC system. The quantities are given for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours.

1. FAN ELECTRIC ENERGY DURING HEATING
   gives the total electric energy used by the fans in all hours when only heating is required.

2. FAN ELECTRIC ENERGY DURING COOLING
   gives the total electric energy used by the fans in all hours when only cooling is required.

3. FAN ELECTRIC ENERGY DURING HEATING-COOLING
   gives the total electric energy used by the fans in all hours when both heating and cooling are required.

4. FAN ELECTRIC ENERGY DURING FLOATING
   gives the total electric energy used by the fans when the system terminal is operating within the deadband range.

```
REPORT- SS-L   FAN ELECTRIC ENERGY                                SYST-1                                   WEATHER FILE- CHICAGO     WYEC
-----------------------------------------------------------------------------------------------------------------------------------
         FAN ELECTRIC   FAN ELECTRIC   FAN ELECTRIC     FAN ELECTRIC
         ENERGY DURING  ENERGY DURING  ENERGY DURING    ENERGY DURING
           HEATING        COOLING      HEATING-COOLING    FLOATING
MONTH      (KWH)          (KWH)           (KWH)            (KWH)
 JAN      211.573          0.000           0.000            0.000

 FEB      182.305          0.000           0.000            2.301

 MAR      164.858          4.027           0.000            1.726

 APR       80.397         58.672           0.000           25.482

 MAY        5.766        185.697           0.000           66.109

 JUN        0.000        436.615           0.000            6.589

 JUL        0.000        710.694           0.000            0.000

 AUG        0.000        694.574           0.000            0.000

 SEP        0.000        400.918           0.000           46.219

 OCT        4.027        131.419           0.575          102.740

 NOV      100.152          5.253           0.000           27.705

 DEC      181.250          0.000           0.000            2.301
         ------------   ------------   --------------   ------------
 ANNUAL   930.316       2627.870           0.575          281.171
```

REPORT SS--M -- FAN ELECTRIC ENERGY FOR PLANT

This report gives a breakdown of fan electric energy for each month passed to PLANT. The quantities are given for heating hours only, cooling hours only, simultaneous heating and cooling hours, and floating hours. The quantities are calculated by summing the individual space quantities.

1. FAN ELECTRIC ENERGY DURING HEATING
   gives the total electric energy used by the fans in all hours when only heating is required.

2. FAN ELECTRIC ENERGY DURING COOLING
   gives the total electric energy used by the fans in all hours when only cooling is required.

3. FAN ELECTRIC ENERGY DURING HEATING-COOLING
   gives the total electric energy used by the fans in all hours when both heating and cooling are required.

4. FAN ELECTRIC ENERGY DURING FLOATING
   gives the total electric energy used by the fans when the system terminal is operating within the deadband range.

```
REPORT- SS-M  FAN ELECTRIC ENERGY FOR PLANT                  DEFAULT-PLANT                  WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------------

         FAN ELECTRIC    FAN ELECTRIC    FAN ELECTRIC      FAN ELECTRIC
         ENERGY DURING   ENERGY DURING   ENERGY DURING     ENERGY DURING
            HEATING         COOLING      HEATING-COOLING      FLOATING
MONTH        (KWH)           (KWH)           (KWH)              (KWH)

 JAN        211.573          0.000           0.000             0.000

 FEB        182.305          0.000           0.000             2.301

 MAR        164.858          4.027           0.000             1.726

 APR         80.397         58.672           0.000            25.482

 MAY          5.766        185.697           0.000            66.109

 JUN          0.000        436.615           0.000             6.589

 JUL          0.000        710.694           0.000             0.000

 AUG          0.000        694.574           0.000             0.000

 SEP          0.000        400.918           0.000            46.219

 OCT          4.027        131.419           0.575           102.740

 NOV        100.152          5.253           0.000            27.705

 DEC        181.250          0.000           0.000             2.301
         ------------    ------------    --------------    ------------
 ANNUAL     930.316       2627.870           0.575           281.171
```

REPORT SS–O -- TEMPERATURE SCATTER PLOT

In this scatter plot, the ordinate, appearing in the left column, shows temperature bins. The abscissa, shown at the top, gives hours of the day. Entered in each cell of the plot is the number of hours during the RUN–PERIOD for which the zone air temperature was in the particular bin for this particular hour of the day. Hours when the fans are off do not show up in the plot.

The column at the far right is the sum of the entries in each row. It shows the frequency of temperature values for the RUN–PERIOD. (Because the temperature counts are only made for hours when the fans are on, summing the totals column will not sum to the number of hours in the run.)

Note: If fans are on due to NIGHT–CYCLE–CTRL, the hours will not be counted in the plot.

```
REPORT- SS-O  TEMPERATURE SCATTER PLOT  SYST-1          FOR SPACE5-1                        WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------------------------------------
                                        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

      81-85        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

      76-80        0   0   0   0   0   0   0 114 122 123 126 127 128 132 134 137 142  22   0   0   0   0   0   0   1307

      71-75        0   0   0   0   0   0   0  11 116 129 126 124 122 118 116 114 110 104   0   0   0   0   0   0   1190

      66-70        0   0   0   0   0   0   0   1  14   0   0   1   2   2   2   1   0   0   0   0   0   0   0   0     23

      61-65        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

      BELOW 60     0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0
                  === === === === === === === === === === === === === === === === === === === === === === === ===  =====
```

```
REPORT- SS-O  TEMPERATURE SCATTER PLOT  SYST-1            FOR SPACE1-1                        WEATHER FILE- CHICAGO    WYEC
------------------------------------------------------------------------------------------------------------------------------


                                  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

    81-85           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

    76-80           0   0   0   0   0   0   0 104 118 122 122 123 126 128 134 136 136  12   0   0   0   0   0   0   1261

    71-75           0   0   0   0   0   0   0  20 120 128 130 127 124 122 117 115 116 114   0   0   0   0   0   0   1233

    66-70           0   0   0   0   0   0   0   2  14   2   0   2   2   2   1   1   0   0   0   0   0   0   0   0     26

    61-65           0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

    BELOW 60        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

                  === === === === === === === === === === === === === === === === === === === === === === === ===  =====
```

```
REPORT- SS-O  TEMPERATURE SCATTER PLOT  SYST-1          FOR SPACE2-1                       WEATHER FILE- CHICAGO    WYEC
-------------------------------------------------------------------------------------------------------------------------

                              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

81-85              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

76-80              0   0   0   0   0   0   0  93 107 111 117 115 117 120 122 123 125   6   0   0   0   0   0   0   1156

71-75              0   0   0   0   0   0   0  31 128 138 135 134 133 130 128 127 126 119   0   0   0   0   0   0   1329

66-70              0   0   0   0   0   0   0   2  17   3   0   3   2   2   2   2   1   1   0   0   0   0   0   0     35

61-65              0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

BELOW 60           0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

                  === === === === === === === === === === === === === === === === === === === === === === === ===  =====
```

```
REPORT- SS-O  TEMPERATURE SCATTER PLOT  SYST-1            FOR SPACE3-1                        WEATHER FILE- CHICAGO     WYEC
---------------------------------------------------------------------------------------------------------------------------


                                       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

       81-85        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

       76-80        0   0   0   0   0   0   0 105 118 122 122 123 126 128 132 134 134  10   0   0   0   0   0   0   1254

       71-75        0   0   0   0   0   0   0  19 117 127 129 127 124 122 118 116 118 116   0   0   0   0   0   0   1233

       66-70        0   0   0   0   0   0   0   2  17   3   1   2   2   2   2   2   0   0   0   0   0   0   0   0     33

       61-65        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

       BELOW 60     0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

                  === === === === === === === === === === === === === === === === === === === === === === === ===  =====
```

```
REPORT- SS-O  TEMPERATURE SCATTER PLOT  SYST-1          FOR SPACE4-1                          WEATHER FILE- CHICAGO     WYEC
------------------------------------------------------------------------------------------------------------------------------


                                  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

      81-85        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

      76-80        0   0   0   0   0   0   0  98 113 117 120 120 125 127 132 133 135  10   0   0   0   0   0   0   1230

      71-75        0   0   0   0   0   0   0  26 134 134 132 130 125 123 119 118 117 116   0   0   0   0   0   0   1274

      66-70        0   0   0   0   0   0   0   2   5   1   0   2   2   2   1   1   0   0   0   0   0   0   0   0     16

      61-65        0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

      BELOW 60     0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

                  === === === === === === === === === === === === === === === === === === === === === === === ===  =====
```

```
REPORT- SS-O  TEMPERATURE SCATTER PLOT  SYST-1          FOR PLENUM-1                          WEATHER FILE- CHICAGO    WYEC
----------------------------------------------------------------------------------------------------------------------------


                               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

  81-85            0   0   0   0   0   0   0   0   0   3  21  29  41  53  65  68  68   2   0   0   0   0   0   0    350

  76-80            0   0   0   0   0   0   0  92  96  98  89  84  75  72  65  64  65   7   0   0   0   0   0   0    807

  71-75            0   0   0   0   0   0   0  27  31  30  25  29  35  32  35  39  43  45   0   0   0   0   0   0    371

  66-70            0   0   0   0   0   0   0   7  49  65  86 102 100  95  87  81  76  72   0   0   0   0   0   0    820

  61-65            0   0   0   0   0   0   0   0  76  56  31   8   1   0   0   0   0   0   0   0   0   0   0   0    172

  BELOW 60         0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0      0

                 === === === === === === === === === === === === === === === === === === === === === === === ===  =====
```

REPORT PV–A --

```
REPORT- PV-A  EQUIPMENT SIZES                                                        WEATHER FILE- CHICAGO    WYEC
--------------------------------------------------------------------------------------------------------------------

                       -------------  -------------  -------------  -------------  -------------  -------------
                              NUMBER         NUMBER         NUMBER         NUMBER         NUMBER         NUMBER
 E Q U I P M E N T     SIZE  INSTD    SIZE  INSTD    SIZE  INSTD    SIZE  INSTD    SIZE  INSTD    SIZE  INSTD
                       (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL (MBTU/H) AVAIL
 -----------------     ------ -- --   ------ -- --   ------ -- --   ------ -- --   ------ -- --   ------ -- --

 HW-BOILER              0.400  1  1

 HERM-REC-CHLR          0.180  1  1
```

REPORT PS–A -- PLANT ENERGY UTILIZATION SUMMARY

This report gives site and source energy use in MBtu(10^6 Btu). For electrical energy an entry followed by an E is the energy in MWh (thousands of kWh).

1. MONTH
2. TOTAL HEAT LOAD
   Total heating energy = load from SYSTEMS + load from PLANT (absorption chillers + steam turbines + heat dissipated from storage tanks + domestic hot water + heat stored in tanks but not used) + circulation loop losses. The values here are identical to those in the HEATING ENERGY column of the SYSTEMS SS–D report except that the heat energy delivered to an absorption chiller, steam turbine, domestic hot water, and circulation losses is included. Also included is the heat input to a storage tank from a boiler.
3. TOTAL COOLING LOAD
   This is the total of the values shown in the SS–D report plus tank and circulation loop losses; it represents the cooling energy needed each month.
4. TOTAL ELECTR LOAD
   This is the total electrical energy consumed by lights, equipment, and system fans plus the additional energy consumed by chiller motors, pumps, cooling towers, and any other electrical site use including energy entered into the program under BUILDING–RESOURCE.
5. RECVRED ENERGY
   These values are recovered heat used to reduce heating loads. This is waste heat from turbines, diesels, and double-bundle chillers, and solar energy delivered to the load via HEAT–RECOVERY.
6. WASTED RECVRABL ENERGY
   The values in this column represent the heat that *could* have been recovered, had there been a need for it.
7. FUEL INPUT COOLING
   The fuel used to drive engine chillers and gas fired absorption chiller/heaters, and regeneration fuel for desiccant cooling systems.
8. ELEC INPUT COOLING
   The electric energy used to drive chillers and to supply power for peripheral cooling equipment, such as circulation pumps, cooling towers, and cold storage tanks.
9. FUEL INPUT HEATING
   This column reports the fuel used for heating by boilers, furnaces, and hot water heaters.
10. ELEC INPUT HEATING
    The electrical energy used in association with supplying heating, including the electrical consumption by draft fans, circulation pumps, electric boilers, and hot water storage pumps.
11. FUEL INPUT ELEC
    The fuel used by diesel and gas turbine generators.
12. TOTAL FUEL INPUT
    The sum of fossil fuels use.
13. TOTAL SITE ENERGY
    The sum of purchased fossil fuel, electricity, chilled water and steam.
14. TOTAL SOURCE ENERGY
    The energy used at the source. For each RESOURCE, the energy consumption at the site is divided by the corresponding SOURCE–SITE–EFF to arrive at the energy consumed and transmitted by the generating station; the results are summed.

```
REPORT- PS-A  PLANT ENERGY UTILIZATION SUMMARY                                      WEATHER FILE- CHICAGO     WYEC
------------------------------------------------------------------------------------------------------------------------------
                                            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    TOTAL    TOTAL            WASTED     FUEL     ELEC     FUEL     ELEC     FUEL    TOTAL    TOTAL *    TOTAL
            HEAT  COOLING   ELECTR   RCVRED  RCVRABL    INPUT    INPUT    INPUT    INPUT    INPUT     FUEL     SITE *   SOURCE
MONTH       LOAD     LOAD     LOAD   ENERGY   ENERGY  COOLING  COOLING  HEATING  HEATING    ELECT    INPUT   ENERGY *   ENERGY
-----    -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  -------  ------- *  -------
  JAN       15.5      0.0     18.6      0.0      0.0      0.0      0.0     24.0      1.5      0.0     24.0     42.6 *     79.9
                              5.4E                                0.0E              0.4E                             *
  FEB       13.4      0.0     16.2      0.0      0.0      0.0      0.0     20.9      1.3      0.0     20.9     37.1 *     69.6
                              4.7E                                0.0E              0.4E                             *
  MAR        9.4      0.1     17.4      0.0      0.0      0.0      0.1     14.6      1.0      0.0     14.6     32.0 *     66.8
                              5.1E                                0.0E              0.3E                             *
  APR        2.9      2.2     18.3      0.0      0.0      0.0      1.1      4.5      0.4      0.0      4.5     22.9 *     59.6
                              5.4E                                0.3E              0.1E                             *
  MAY        0.2      6.8     20.3      0.0      0.0      0.0      3.0      0.3      0.0      0.0      0.3     20.7 *     61.4
                              6.0E                                0.9E              0.0E                             *
  JUN        0.0     13.7     22.2      0.0      0.0      0.0      5.6      0.0      0.0      0.0      0.0     22.2 *     66.5
                              6.5E                                1.6E              0.0E                             *
  JUL        0.0     21.2     26.8      0.0      0.0      0.0      8.0      0.0      0.0      0.0      0.0     26.8 *     80.5
                              7.9E                                2.3E              0.0E                             *
  AUG        0.0     21.0     26.7      0.0      0.0      0.0      7.9      0.0      0.0      0.0      0.0     26.7 *     80.1
                              7.8E                                2.3E              0.0E                             *
  SEP        0.0     10.9     20.9      0.0      0.0      0.0      4.3      0.0      0.0      0.0      0.0     20.9 *     62.8
                              6.1E                                1.3E              0.0E                             *
  OCT        0.1      3.9     18.9      0.0      0.0      0.0      1.7      0.2      0.0      0.0      0.2     19.1 *     57.0
                              5.5E                                0.5E              0.0E                             *
  NOV        4.5      0.1     15.4      0.0      0.0      0.0      0.0      7.0      0.5      0.0      7.0     22.4 *     53.3
                              4.5E                                0.0E              0.2E                             *
  DEC       12.7      0.0     17.6      0.0      0.0      0.0      0.0     19.7      1.2      0.0     19.7     37.3 *     72.6
                              5.2E                                0.0E              0.4E                             *
         =======  =======  =======  =======  =======  =======  =======  =======  =======  =======  =======  ======= *  =======
            58.6     80.0    239.4      0.0      0.0      0.0     31.8     91.3      6.0      0.0     91.3    330.7 *    810.2
                             70.1E                                9.3E              1.8E                             *
     NOTE-- ALL ENTRIES ARE IN MBTU EXCEPT ENTRIES FOLLOWED BY E ARE IN MWH (THOUSANDS OF KWH)
```

REPORT PS–B -- MONTHLY PEAK AND TOTAL ENERGY USE

This report shows the monthly total consumption and peak hourly consumption (demand) of up to five of the following purchased fuels:

ELECTRICITY
CHILLED-WATER
STEAM
NATURAL-GAS
LPG
FUEL-OIL
DIESEL-OIL
COAL
METHANOL
BIOMASS

To calculate the peak electrical demand in kW, the user should divide PEAK (kBtuh) by 3.413 kBtuh/kW.

The final section of the report gives, for each "fuel", the total energy use for the run period (ONE YEAR USE), and, below this, the peak hourly energy use (PEAK) for the run period.

```
REPORT- PS-B  MONTHLY PEAK AND TOTAL ENERGY USE                               WEATHER FILE- CHICAGO     WYEC
-------------------------------------------------------------------------------------------------------------

        MO       UTILITY-       ELECTRICITY      NATURAL-GAS
               TOTAL(MBTU)           18.600           24.023
        JAN     PEAK(KBTU)           78.120          424.617
                     DY/HR             2/11            28/ 8

               TOTAL(MBTU)           16.200           20.926
        FEB     PEAK(KBTU)           77.504          434.433
                     DY/HR             4/11            25/ 8

               TOTAL(MBTU)           17.388           14.626
        MAR     PEAK(KBTU)           76.888          431.557
                     DY/HR            19/15            18/ 8

               TOTAL(MBTU)           18.349            4.640
        APR     PEAK(KBTU)          106.917          285.794
                     DY/HR            26/16            15/ 8

               TOTAL(MBTU)           20.341            0.316
        MAY     PEAK(KBTU)          105.224          122.214
                     DY/HR            22/16            20/ 8

               TOTAL(MBTU)           22.157            0.000
        JUN     PEAK(KBTU)          121.111            0.000
                     DY/HR            12/15            30/ 1

               TOTAL(MBTU)           26.818            0.000
        JUL     PEAK(KBTU)          121.924            0.000
                     DY/HR            17/15            31/ 1

               TOTAL(MBTU)           26.686            0.000
        AUG     PEAK(KBTU)          125.569            0.000
                     DY/HR            23/15            31/ 1

               TOTAL(MBTU)           20.902            0.000
```

```
SEP     PEAK(KBTU)      124.635       0.000
            DY/HR          9/15       30/ 1

        TOTAL(MBTU)      18.937       0.181
OCT     PEAK(KBTU)      108.456     115.029
            DY/HR         18/15       28/ 8

        TOTAL(MBTU)      15.406       7.009
NOV     PEAK(KBTU)       75.219     385.706
            DY/HR         12/11       12/ 8

        TOTAL(MBTU)      17.606      19.710
DEC     PEAK(KBTU)       77.353     433.014
            DY/HR         16/11       16/ 8


         ONE YEAR       239.391      91.329
         USE/PEAK       125.569     434.433
```

REPORT PS–D -- PLANT LOADS SATISFIED

The intent of this report is to flag those situations where the plant is not able to meet the loads imposed by both systems and other plant equipment. This is of special importance in those cases where equipment is intentionally undersized in order to improve part load performance or to reduce costs.

MBTU supplied is the output energy from each piece of equipment.

PCT OF TOTAL LOAD is the following ratio (in percent): MBTU SUPPLIED divided by TOTAL LOAD ON PLANT. This will be 100% only if all of the load is satisfied.

When a hot or cold storage tank is included, additional entries are given at the bottom of the first page which describe the contribution to the heating and cooling demands made by the storage tank(s).

The TOTAL LOAD ON PLANT for heating (cooling) is the sum of the demand from SYSTEMS, the consumption by PLANT, the loss from the storage tank and the heat remaining in the storage tank at the end of the run. The last, of course, is still recoverable and is reported as RESIDUAL (not shown in this example; see the PS–D report for the 31-story Office Building, Run 2 in the Sample Run Book).

In the second part of this report, "SUMMARY OF LOADS MET", TOTAL OVERLOAD is that portion of a load that requires equipment to operate above its nominal rated capacity. PEAK OVERLOAD is the largest hourly OVERLOAD.

```
REPORT- PS-D  PLANT LOADS SATISFIED                                          WEATHER FILE- CHICAGO    WYEC
-----------------------------------------------------------------------------------------------------------

                    HEATING LOADS               MBTU SUPPLIED     PCT OF TOTAL LOAD
                    ---------------------       -------------     -----------------
                       HW-BOILER                         58.6               100.0
                                                =============     =================
                           LOAD SATISFIED                58.6               100.0
                       TOTAL LOAD ON PLANT               58.6


                    COOLING LOADS               MBTU SUPPLIED     PCT OF TOTAL LOAD
                    ---------------------       -------------     -----------------

                       HERM-REC-CHLR                     80.0               100.0
                                                =============     =================

                           LOAD SATISFIED                80.0               100.0
                       TOTAL LOAD ON PLANT               80.0


                    ELECTRICAL LOADS            MBTU SUPPLIED     PCT OF TOTAL LOAD
                    ---------------------       -------------     -----------------

                       ELECTRICITY                      239.4               100.0
                                                =============     =================

                           LOAD SATISFIED               239.4               100.0
                       TOTAL LOAD ON PLANT              239.4
```

```
REPORT- PS-D  PLANT LOADS SATISFIED                                                      WEATHER FILE- CHICAGO    WYEC
---------------------------------------------------------------------------------------------------(CONTINUED)-------


                                  SUMMARY OF LOADS MET

                               TOTAL       LOAD       TOTAL      PEAK       HOURS
          TYPE OF LOAD         LOAD      SATISFIED   OVERLOAD   OVERLOAD   OVERLOADED
                              (MBTU)      (MBTU)     (MBTU)     (MBTU)
      ------------------    ----------  ----------  ----------  ----------  ----------

      HEATING LOADS              58.6        58.6      0.000      0.000          0
      COOLING LOADS              80.0        80.0      0.000      0.000          0
      ELECTRICAL LOADS          239.4       239.4      0.000      0.000          0
```

REPORT PS–G -- ELECTRICAL LOAD SCATTER PLOT

In this scatter plot the ordinate, shown in the left-most column, is the electrical demand divided into 13 bins which range from zero to just above the peak electrical demand. The abscissa shown at the top is the hour of the day. Entered in each cell of the plot is the number of days during the year for which the electrical demand was less than the ordinate shown but larger than the next lower ordinate at that hour of the day.

The right-most column is the sum of the entries in each row and shows the frequency of the electrical demand throughout the run period.

The bottom row shows the distribution of electrical demand for each hour of the average day. The number here is the electrical consumption for the run period for a *particular* hour of the day divided by the total electrical consumption for *all hours of the day* for run period.

The chart at the bottom is a breakdown of the peak electrical demand into the contributing components. The SYSTEMS LOAD includes the lighting and equipment electrical loads from LOADS as well as that from system fans.

```
REPORT- PS-G  ELECTRICAL LOAD SCATTER PLOT                                              WEATHER FILE- CHICAGO    WYEC
-------------------------------------------------------------------------------------------------------------------
                                           TOTAL HOURS AT HOURLY DEMAND AND TIME OF DAY

              HOUR    1AM 2   3   4   5   6   7   8   9  10  11  12  1PM 2   3   4   5   6   7   8   9  10  11  12  TOTAL
                      --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- --- ---  -----

                  41   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
                  37   0   0   0   0   0   0   0   0   0   0   2   0   0   0  12  11   3   2   0   0   0   0   0   0     30
                  34   0   0   0   0   0   0   0   0   0  12  29  19   2  19  40  40  33  33   0   0   0   0   0   0    227
                  31   0   0   0   0   0   0   0   0  28  40  37  45  23  45  34  34  42  40   0   0   0   0   0   0    368
    D             28   0   0   0   0   0   0   0   0  33  24  20  23  46  23   9  11  14  18   0   0   0   0   0   0    221
    E             25   0   0   0   0   0   0   0   0  24  27  29  16  18  13  15  13  13   9   0   0   0   0   0   0    177
    M K           22   0   0   0   0   0   0   0   0 109 131 135 139  25  62 142 143  41  39   0   0   0   0   0   0    966
    A W           18   0   0   0   0   0   0   0   0  58  18   0  10 138  90   0   0 106 111   0   0   0   0   0   0    531
    N             15   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
    D             12   0   0   0   0   0   0   0  21   0   0   0   0   0   0   0   0   0   0 252   0   0   0   0   0    273
                   9   0   0   0   0   0   0   0  45   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0     45
                   6   4   5   4   5   4   5   3  98   1   2   1   2   1   2   1   2   1   2   1 254 254   4   4   4    664

                   3 361 360 361 360 361 360 362 201 112 111 112 111 112 111 112 111 112 111 112 111 111 361 361 361   5258
                     === === === === === === === === === === === === === === === === === === === === === === === ===  =====
         PERCENT
          TOTAL      0.5 0.5 0.5 0.5 0.5 0.5 0.5 1.7 8.1 8.5 8.9 8.6 7.8 8.4 9.1 8.9 8.5 8.5 3.9 1.8 1.6 0.8 0.8 0.8
         DEMAND
                                              PEAK ELECTRICAL LOAD BREAKDOWN
                                                 SOURCE               KW       PCT
                                             -------------------  ---------  -----
                                             SYSTEMS LOAD            23.085   62.8
                                             CIRCULATION PUMPS        0.400    1.1
                                             HERM-REC-CHLR           13.291   36.1
                                                                  =========
                                                            TOTAL    36.776
```

REPORT BEPS -- ESTIMATED BUILDING ENERGY PERFORMANCE

This report makes it possible to quickly review building energy performance. The breakdown of usage of up to five different types of energy sources is presented. These energy sources are user-specified through the ENERGY–RESOURCE command in PLANT.

HVAC auxiliary (shown as HVAC AUX) is defined as the energy required to operate non-solar fans, pumps, etc., which *transport* the conditioned air and water. AUX SOLAR is the energy required to operate the fans, pumps, etc. that *transport* the conditioned water or air associated with solar equipment. SPACE COOL and SPACE HEAT give the energy required to *produce* the conditioned water or air for SPACE heating or cooling.

Process and domestic hot water (shown as DOM HOT WTR) is the summation of the user input for hot water in the BUILDING–RESOURCE command and any entries for SOURCE–TYPE = HOT–WATER in the SPACE–CONDITIONS command.

Vertical transportation (shown as VERT TRANS) is the energy for elevators and escalators input through the BUILDING–RESOURCE command.

Loads that are input through SOURCE–TYPE = GAS or SOURCE–TYPE = ELECTRIC in the SPACE–CONDITIONS instruction will appear in this report as miscellaneous equipment (shown as MISC EQUIP). Loads entered as SOURCE–TYPE = PROCESS are assumed to have energy sources independent of the building utilities (e.g., wood stoves, acetylene welders, etc.) and are not reported in the BEPS report.

The distribution of ENERGY TYPE among the CATEGORY OF USE items is exact for every type of energy except electricity. Purchased electricity is apportioned correctly, but electricity generated on-site is apportioned on the basis of net yearly demands for electricity for each category of use.

It should also 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.

The report of TOTAL SITE ENERGY and TOTAL SOURCE ENERGY provides a distinction between the energy used per *gross* square foot of building area and that used per *net* square foot of building area. The report generator takes the gross area from the keyword GROSS–AREA in the BUILDING–LOCATION command in LOADS. The default for this keyword is the net area, i.e., the sum of the floor areas of the CONDITIONED ZONEs.

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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REPORT- BEPS  ESTIMATED BUILDING ENERGY PERFORMANCE                                    WEATHER FILE- CHICAGO    WYEC
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                   ENERGY TYPE
                   IN SITE MBTU -  ELECTRICITY     NATURAL-GAS

                  CATEGORY OF USE

                     SPACE HEAT          4.34            91.33

                     SPACE COOL         30.18             0.00

                     HVAC AUX           16.34             0.00

                     DOM HOT WTR         0.00             0.00

                     AUX SOLAR           0.00             0.00

                     LIGHTS            149.50             0.00

                     VERT TRANS          0.00             0.00

                     MISC EQUIP         39.03             0.00
                                    ----------       ----------
                      TOTAL            239.40            91.33

          TOTAL SITE ENERGY        330.72 MBTU     66.1 KBTU/SQFT-YR GROSS-AREA     66.1 KBTU/SQFT-YR NET-AREA
          TOTAL SOURCE ENERGY      810.22 MBTU    162.0 KBTU/SQFT-YR GROSS-AREA    162.0 KBTU/SQFT-YR NET-AREA

          PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE =  1.0
          PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED                =  0.0

          NOTE  ELECTRICITY AND/OR FUEL USED TO GENERATE ELECTRICITY IS APPORTIONED BASED
                ON THE YEARLY DEMAND.  ALL OTHER ENERGY TYPES ARE APPORTIONED HOURLY.
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REPORT ES–D -- SUMMARY OF FUEL AND UTILITY USE AND COSTS

This summary report lists the consumption, peak hourly demand, and total cost of each fuel and utility on a monthly and yearly basis. It is analogous to the PLANT summary report PS–B, but differs in that consumption and peak demand are reported in the units used for billing rather than MBtu. The unit, specified by the UNIT keyword in ENERGY–COST, is printed in the heading for each fuel or utility. In the example shown, the ELECTRIC UNIT (3412.97 Btu) is a kWh and the NTRL–GAS UNIT (100000.00 Btu) is a therm.

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REPORT- ES-D  SUMMARY OF FUEL AND UTILITY USE AND COSTS
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                                   ELECTRIC     NTRL-GAS
MONTH                                 UNIT=        UNIT=
                                    3412.97    100000.00
-------                            --------     --------
 JAN
   ENERGY CONSUMPTION (UNIT/MO)       6460.         240.
   PEAK DEMAND   (UNIT/HR)              23.           4.
   TOTAL COST ($)                    342.30       144.14
 FEB
   ENERGY CONSUMPTION (UNIT/MO)       4747.         209.
   PEAK DEMAND   (UNIT/HR)              23.           4.
   TOTAL COST ($)                    297.34       125.66
 MAR
   ENERGY CONSUMPTION (UNIT/MO)       5096.         146.
   PEAK DEMAND   (UNIT/HR)              23.           4.
   TOTAL COST ($)                    320.67        87.76
 APR
   ENERGY CONSUMPTION (UNIT/MO)       5376.          46.
   PEAK DEMAND   (UNIT/HR)              31.           3.
   TOTAL COST ($)                    340.93        27.24
 MAY
   ENERGY CONSUMPTION (UNIT/MO)       5960.           3.
   PEAK DEMAND   (UNIT/HR)              31.           1.
   TOTAL COST ($)                    379.38         1.89
 JUN
   ENERGY CONSUMPTION (UNIT/MO)       6492.           0.
   PEAK DEMAND   (UNIT/HR)              35.           0.
   TOTAL COST ($)                    414.43         0.00
 JUL
   ENERGY CONSUMPTION (UNIT/MO)       7858.           0.
   PEAK DEMAND   (UNIT/HR)              36.           0.
   TOTAL COST ($)                    500.53         0.00
 AUG
   ENERGY CONSUMPTION (UNIT/MO)       7819.           0.
   PEAK DEMAND   (UNIT/HR)              37.           0.
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  TOTAL COST ($)                 498.44          0.00
SEP
  ENERGY CONSUMPTION (UNIT/MO)   6124.             0.
  PEAK DEMAND  (UNIT/HR)           37.             0.
  TOTAL COST ($)                 390.19          0.00
OCT
  ENERGY CONSUMPTION (UNIT/MO)   5549.             2.
  PEAK DEMAND  (UNIT/HR)           32.             1.
  TOTAL COST ($)                 353.08          1.08
NOV
  ENERGY CONSUMPTION (UNIT/MO)   4514.            70.
  PEAK DEMAND  (UNIT/HR)           22.             4.
  TOTAL COST ($)                 284.35         42.05
DEC
  ENERGY CONSUMPTION (UNIT/MO)   5159.           197.
  PEAK DEMAND  (UNIT/HR)           23.             4.
  TOTAL COST ($)                 324.35        118.26
------                         --------      --------
TOTAL
  ENERGY CONSUMPTION (UNIT/YR)  70142.           913.
  PEAK DEMAND  (UNIT/HR)           37.             4.
  TOTAL COST ($)                4445.99        547.97
```

REPORT ES–E -- SUMMARY OF ELECTRICITY CHARGES

This report contains detailed, month-by-month information on the components of the electricity charges for each CHARGE–ASSIGNMENT in the month.

1. CHARGE–ASSIGNMENT
   The u-name of each CHARGE–ASSIGNMENT for each month in which the CHARGE–ASSIGNMENT has been assigned and in which electricity is consumed.

2. LENGTH
   The number of hours that the CHARGE–ASSIGNMENT was accruing electricity consumption for charges.

3. CONSUMPTION BY C–A
   The total amount of electricity consumed.

4. ENERGY CHARGE
   The charges assessed for the electricity consumed.

5. MEASURED DEMAND
   The highest demand measured in the hours that the CHARGE–ASSIGNMENT was in effect.

6. BILLING DEMAND
   The demand used for assessing demand charges. This quantity is the greater of the measured demand or the ratchet in effect, adjusted by the power factor correction (POWER–FAC–CORR).

7. DEMAND CHARGE
   The charges assessed for electricity demand.

8. TOTAL CHARGES
   For each month, the sum of the demand and energy charges of each charge assignment, plus any FIXED–MONTH–CHGs, adjusted for MIN–MONTH–CHG and RATE–LIMITATION (see ENERGY–COST command). For the year, the sum of the monthly total charges.

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REPORT- ES-E  SUMMARY OF ELECTRICITY CHARGES
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         CHARGE-                          CONSUMPTION    ENERGY     MEASURED    BILLING     DEMAND      TOTAL
MONTH    ASSIGNMENT         LENGTH        BY C-A         CHARGE     DEMAND      DEMAND      CHARGE      CHARGES
          (U-NAME)          (HR/MO)       (KWH)          ($)        (KW)        (KW)        ($)         ($)
-------  ---------------    -------     ----------    ----------   --------    --------   ----------   ----------

JAN
         NIGHT               400            595.         29.76        9.          9.         0.00
         SHD-P               234           2729.        163.77       23.         23.         0.00
         PEAK                110           2125.        148.78       22.         22.         0.00
                                                                                                       342.30
FEB
         NIGHT               370            571.         28.54        9.          9.         0.00
         SHD-P               207           2350.        141.02       23.         23.         0.00
         PEAK                 95           1826.        127.79       21.         21.         0.00
                                                                                                       297.34
MAR
         NIGHT               405            513.         25.67        9.          9.         0.00
         SHD-P               234           2569.        154.14       22.         22.         0.00
         PEAK                105           2012.        140.86       23.         23.         0.00
                                                                                                       320.67
APR
         NIGHT               376            401.         20.07        6.          6.         0.00
         SHD-P               234           2738.        164.27       30.         30.         0.00
         PEAK                110           2237.        156.60       31.         31.         0.00
                                                                                                       340.93
MAY
         NIGHT               400            385.         19.26        4.          4.         0.00
         SHD-P               234           3011.        180.63       30.         30.         0.00
         PEAK                110           2564.        179.49       31.         31.         0.00
                                                                                                       379.38
JUN
         NIGHT               395            407.         20.37       11.         11.         0.00
         SHD-P               225           3187.        191.21       34.         34.         0.00
         PEAK                100           2898.        202.85       35.         35.         0.00
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								414.43
JUL								
	NIGHT	400	544.	27.19	11.	11.	0.00	
	SHD-P	234	3863.	231.79	34.	34.	0.00	
	PEAK	110	3451.	241.55	36.	36.	0.00	
								500.53
AUG								
	NIGHT	391	526.	26.28	11.	11.	0.00	
	SHD-P	243	3839.	230.33	35.	35.	0.00	
	PEAK	110	3455.	241.83	37.	37.	0.00	
								498.44
SEP								
	NIGHT	404	415.	20.75	11.	11.	0.00	
	SHD-P	216	3021.	181.26	35.	35.	0.00	
	PEAK	100	2688.	188.18	37.	37.	0.00	
								390.19
OCT								
	NIGHT	400	382.	19.12	4.	4.	0.00	
	SHD-P	234	2767.	166.02	30.	30.	0.00	
	PEAK	110	2399.	167.94	32.	32.	0.00	
								353.08

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REPORT- ES-E  SUMMARY OF ELECTRICITY CHARGES
----------------------------------------------------------------------------------------------------CONTINUED----------

       CHARGE-                      CONSUMPTION   ENERGY     MEASURED   BILLING    DEMAND       TOTAL
MONTH  ASSIGNMENT         LENGTH    BY C-A        CHARGE     DEMAND     DEMAND     CHARGE       CHARGES
        (U-NAME)          (HR/MO)   (KWH)         ($)        (KW)       (KW)       ($)          ($)
-----  ---------------    -------   ----------    ---------  --------   --------   ----------   ----------

NOV
       NIGHT                400          439.        21.90         8.         8.       0.00
       SHD-P                216         2284.       137.05        22.        22.       0.00
       PEAK                  95         1791.       125.34        22.        22.       0.00
                                                                                                  284.35
DEC
       NIGHT                414          539.        26.96         9.         9.       0.00
       SHD-P                225         2596.       166.78        23.        23.       0.00
       PEAK                 105         2023.       141.61        21.        21.       0.00
                                                                                                  324.35
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TOTAL                                 70142.      4445.99                                  0.00      4445.99
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Appendix D

DOE-2 Materials Library

Table of Contents

1. Thermal Properties of Building Materials

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-$^\circ$F	Lb/ Ft^3	Btu/ Lb-$^\circ$F	Hr-Ft^2-$^\circ$F/ Btu
	Acoustic Tile					
AC01	3/8 inch	0.0313	0.0330	18.0	0.32	0.95
AC02	1/2 inch	0.0417	0.0330	18.0	0.32	1.26
AC03	3/4 inch	0.0625	0.0330	18.0	0.32	1.89
AS01	**Aluminum or Steel Siding**	0.0050	26.000	480.0	0.10	
	Asbestos-Cement					
AB01	1/8 inch Board	0.0104	0.3450	120.0	0.2	0.03
AB02	1/4 inch Board	0.0208	0.3450	120.0	0.2	0.06
AB03	Shingle					0.21
AB04	1/4 inch Lapped Siding					0.21
AV01	**Asbestos-Vinyl Tile**				0.3	0.05
	Asphalt					
AR01	Roofing Roll			70.0	0.35	0.15
AR02	Shingle and Siding			70.0	0.35	0.44
AR03	Tile				0.30	0.05
	Brick					
BK01	4 inch Common	0.3333	0.4167	120.0	0.20	0.80
BK02	8 inch Common	0.6667	0.4167	120.0	0.20	1.60
BK03	12 inch Common	1.0000	0.4167	120.0	0.20	2.40
BK04	3 inch Face	0.2500	0.7576	130.0	0.22	0.33
BK05	4 inch Face	0.3333	0.7576	130.0	0.22	0.44
	Building Paper					
BP01	Permeable Felt					0.06
BP02	2-Layer Seal					0.12
BP03	Plastic Film Seal					0.01
BR01	**Built-up Roofing** 3/8 inch	0.0313	0.0939	70.0	0.35	0.33
	Carpet					
CP01	With Fibrous Pad				0.34	2.08
CP02	With Rubber Pad				0.34	1.23

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity Btu-Ft/ Hr-Ft^2-°F	Density Lb/ Ft^3	Specific Heat Btu/ Lb-°F	Resistance Hr-Ft^2-°F/ Btu
	Cement					
CM01	1 inch Mortar	0.0833	0.4167	116.0	0.2	0.20
CM02	1.75 inch Mortar	0.1458	0.4167	116.0	0.2	0.35
CM03	1 inch Plaster with Sand Aggregate	0.0833	0.4167	116.0	0.2	0.20
	Clay Tile, Hollow					
CT01	3 inch 1 Cell	0.2500	0.3125	70.0	0.2	0.80
CT02	4 inch 1 Cell	0.3333	0.2999	70.0	0.2	1.11
CT03	6 inch 2 Cells	0.5000	0.3300	70.0	0.2	1.52
CT04	8 inch 2 Cells	0.6667	0.3600	70.0	0.2	1.85
CT05	10 inch 2 Cells	0.8333	0.3749	70.0	0.2	2.22
CT06	12 inch 3 Cells	1.0000	0.4000	70.0	0.2	2.50
	Clay Tile, Paver					
CT11	3/8 inch	0.0313	1.0416	120.0	0.2	0.03
	Concrete, Heavy Weight Dried Aggregate, 140 lbs.					
CC01	1.25 inch	0.1042	0.7576	140.0	0.2	0.14
CC02	2 inch	0.1667	0.7576	140.0	0.2	0.22
CC03	4 inch	0.3333	0.7576	140.0	0.2	0.44
CC04	6 inch	0.5000	0.7576	140.0	0.2	0.66
CC05	8 inch	0.6667	0.7576	140.0	0.2	0.88
CC06	10 inch	0.8333	0.7576	140.0	0.2	1.10
CC07	12 inch	1.0000	0.7576	140.0	0.2	1.32
	Concrete, Heavy Weight Undried Aggregate, 140 lbs.					
CC11	3/4 inch	0.0625	1.0417	140.0	0.2	0.06
CC12	1 3/8 inch	0.1146	1.0417	140.0	0.2	0.11
CC13	3 1/4 inch	0.2708	1.0417	140.0	0.2	0.26
CC14	4 inch	0.3333	1.0417	140.0	0.2	0.32
CC15	6 inch	0.5000	1.0417	140.0	0.2	0.48
CC16	8 inch	0.6667	1.0417	140.0	0.2	0.64
	Concrete, Light Weight, 80 lb.					
CC21	3/4 inch	0.0625	0.2083	80.0	0.2	0.30
CC22	1.25 inch	0.1042	0.2083	80.0	0.2	0.50
CC23	2 inch	0.1667	0.2083	80.0	0.2	0.80
CC24	4 inch	0.3333	0.2083	80.0	0.2	1.60
CC25	6 inch	0.5000	0.2083	80.0	0.2	2.40
CC26	8 inch	0.6667	0.2083	80.0	0.2	3.20

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-$^{\circ}$F	Lb/ Ft^3	Btu/ Lb-$^{\circ}$F	Hr-Ft^2-$^{\circ}$F/ Btu
	Concrete, Light Weight, 30 lb.					
CC31	3/4 inch	0.0625	0.0751	30.0	0.2	0.83
CC32	1.25 inch	0.1042	0.0751	30.0	0.2	1.39
CC33	2 inch	0.1667	0.0751	30.0	0.2	2.22
CC34	4 inch	0.3333	0.0751	30.0	0.2	4.44
CC35	6 inch	0.5000	0.0751	30.0	0.2	6.66
CC36	8 inch	0.6667	0.0751	30.0	0.2	8.88
	Concrete Block, 4 inch Heavy Weight					
CB01	Hollow	0.3333	0.4694	101.0	0.2	0.71
CB02	Concrete Filled	0.3333	0.7575	140.0	0.2	0.44
CB03	Perlite Filled	0.3333	0.3001	103.0	0.2	1.11
CB04	Partially Filled Concrete†	0.3333	0.5844	114.0	0.2	0.57
CB05	Concrete and Perlite††	0.3333	0.4772	115.0	0.2	0.70
	Concrete Block, 6 inch Heavy Weight					
CB06	Hollow	0.5000	0.5555	85.0	0.2	0.90
CB07	Concrete Filled	0.5000	0.7575	140.0	0.2	0.66
CB08	Perlite Filled	0.5000	0.2222	88.0	0.2	2.25
CB09	Partially Filled Concrete†	0.5000	0.6119	104.0	0.2	0.82
CB10	Concrete and Perlite††	0.5000	0.4238	104.0	0.2	1.18
	Concrete Block, 8 inch Heavy Weight					
CB11	Hollow	0.6667	0.6060	69.0	0.2	1.10
CB12	Concrete Filled	0.6667	0.7575	140.0	0.2	0.88
CB13	Perlite Filled	0.6667	0.2272	70.0	0.2	2.93
CB14	Partially Filled Concrete†	0.6667	0.6746	93.0	0.2	0.99
CB15	Concrete and Perlite††	0.6667	0.4160	93.0	0.2	1.60
	Concrete Block, 12 inch Heavy Weight					
CB16	Hollow	1.0000	0.7813	76.0	0.2	1.28
CB17	Concrete Filled	1.0000	0.7575	140.0	0.2	1.32
CB18	Partially Filled Concrete†	1.0000	0.7773	98.0	0.2	1.29
	Concrete Block, 4 inch Medium Weight					
CB21	Hollow	0.3333	0.3003	76.0	0.2	1.11
CB22	Concrete Filled	0.3333	0.4456	115.0	0.2	0.75
CB23	Perlite Filled	0.3333	0.1512	78.0	0.2	2.20
CB24	Partially Filled Concrete†	0.3333	0.3306	89.0	0.2	1.01
CB25	Concrete and Perlite††	0.3333	0.2493	90.0	0.2	1.34

† One filled and reinforced concrete core every 24 inches of wall length.

†† One filled and reinforced concrete core every 24 inches of wall length with the remaining cores filled with Perlite insulation.

1. Thermal Properties of Building Materials – Continued

			Thermal Properties			
DOE-2 Code-word	Description	Thickness Feet	Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-°F	Lb/ Ft^3	Btu/ Lb-°F	Hr-Ft^2-°F/ Btu
	Concrete Block, 6 inch Medium Weight					
CB26	Hollow	0.5000	0.3571	65.0	0.2	1.40
CB27	Concrete Filled	0.5000	0.4443	119.0	0.2	1.13
CB28	Perlite Filled	0.5000	0.1166	67.0	0.2	4.29
CB29	Partially Filled Concrete†	0.5000	0.3686	83.0	0.2	1.36
CB30	Concrete and Perlite††	0.5000	0.2259	84.0	0.2	2.21
	Concrete Block, 8 inch Medium Weight					
CB31	Hollow	0.6667	0.3876	53.0	0.2	1.72
CB32	Concrete Filled	0.6667	0.4957	123.0	0.2	1.34
CB33	Perlite Filled	0.6667	0.1141	56.0	0.2	5.84
CB34	Partially Filled Concrete†	0.6667	0.4348	76.0	0.2	1.53
CB35	Concrete and Perlite††	0.6667	0.2413	77.0	0.2	2.76
	Concrete Block, 12 inch Medium Weight					
CB36	Hollow	1.0000	0.4959	58.0	0.2	2.02
CB37	Concrete Filled	1.0000	0.4814	121.0	0.2	2.08
CB38	Partially Filled Concrete†	1.0000	0.4919	79.0	0.2	2.03
	Concrete Block, 4 inch Light Weight					
CB41	Hollow	0.3333	0.2222	65.0	0.2	1.50
CB42	Concrete Filled	0.3333	0.3695	104.0	0.2	0.90
CB43	Perlite Filled	0.3333	0.1271	67.0	0.2	2.62
CB44	Partially Filled Concrete†	0.3333	0.2808	78.0	0.2	1.19
CB45	Concrete and Perlite††	0.3333	0.2079	79.0	0.2	1.60
	Concrete Block, 6 inch Light Weight					
CB46	Hollow	0.5000	0.2777	55.0	0.2	1.80
CB47	Concrete Filled	0.5000	0.3819	110.0	0.2	1.31
CB48	Perlite Filled	0.5000	0.0985	57.0	0.2	5.08
CB49	Partially Filled Concrete†	0.5000	0.3189	73.0	0.2	1.57
CB50	Concrete and Perlite††	0.5000	0.1929	74.0	0.2	2.59
	Concrete Block, 8 inch Light Weight					
CB51	Hollow	0.6667	0.3333	45.0	0.2	2.00
CB52	Concrete Filled	0.6667	0.4359	115.0	0.2	1.53
CB53	Perlite Filled	0.6667	0.0963	48.0	0.2	6.92
CB54	Partially Filled Concrete†	0.6667	0.3846	68.0	0.2	1.73
CB55	Concrete and Perlite††	0.6667	0.2095	69.0	0.2	3.18

† One filled and reinforced concrete core every 24 inches of wall length.

†† One filled and reinforced concrete core every 24 inches of wall length with the remaining cores filled with Perlite insulation.

1. Thermal Properties of Building Materials -- Continued

			Thermal Properties			
DOE-2 Code-word	Description	Thickness Feet	Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ $Hr-Ft^2-{}^\circ F$	Lb/ Ft^3	Btu/ $Lb-{}^\circ F$	$Hr-Ft^2-{}^\circ F$/ Btu
	Concrete Block, 12 inch Light Weight					
CB56	Hollow	1.0000	0.4405	49.0	0.2	2.27
CB57	Concrete Filled	1.0000	0.4194	113.0	0.2	2.38
CB58	Partially Filled Concrete†	1.0000	0.4274	70.0	0.2	2.34
	Gypsum or Plaster Board					
GP01	1/2 inch	0.0417	0.0926	50.0	0.2	0.45
GP02	5/8 inch	0.0521	0.0926	50.0	0.2	0.56
GP03	3/4 inch	0.0625	0.0926	50.0	0.2	0.67
	Gypsum Plaster					
GP04	3/4 inch Light Weight Aggregate	0.0625	0.1330	45.0	0.2	0.47
GP05	1 inch Light Weight Aggregate	0.0833	0.1330	45.0	0.2	0.63
GP06	3/4 inch Sand Aggregate	0.0625	0.4736	105.0	0.2	0.13
GP07	1 inch Sand Aggregate	0.0833	0.4736	105.0	0.2	0.18
	Hard Board, 3/4 inch					
HB01	Medium Density Siding	0.0625	0.0544	40.0	0.28	1.15
HB02	Medium Density Others	0.0625	0.0608	50.0	0.31	1.03
HB03	High Density Standard Tempered	0.0625	0.0683	55.0	0.33	0.92
HB04	High Density Service Tempered	0.0625	0.0833	63.0	0.33	0.75
LT01	**Linoleum Tile**				0.30	0.05
	Particle Board					
PB01	Low Density 3/4 inch	0.0625	0.0450	75.0	0.31	1.39
PB02	Medium Density 3/4 inch	0.0625	0.7833	75.0	0.31	0.08
PB03	High Density 3/4 inch	0.0625	0.9833	75.0	0.31	0.06
PB04	Underlayment 5/8 inch	0.0521	0.1796	75.0	0.29	0.29

† One filled and reinforced concrete core every 24 inches of wall length.

1. Thermal Properties of Building Materials -- Continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity Btu-Ft/ Hr-Ft^2-°F	Density Lb/ Ft^3	Specific Heat Btu/ Lb-°F	Resistance Hr-Ft^2-°F/ Btu
	Plywood					
PW01	1/4 inch	0.0209	0.0667	34.0	0.29	0.31
PW02	3/8 inch	0.0313	0.0667	34.0	0.29	0.47
PW03	1/2 inch	0.0417	0.0667	34.0	0.29	0.63
PW04	5/8 inch	0.0521	0.0667	34.0	0.29	0.78
PW05	3/4 inch	0.0625	0.0667	34.0	0.29	0.94
PW06	1 inch	0.0833	0.0667	34.0	0.29	1.25
	Roof Gravel or Slag					
RG01	1/2 inch	0.0417	0.8340	55.0	0.4	0.05
RG02	1 inch	0.0833	0.8340	55.0	0.4	0.10
RT01	**Rubber Tile**					0.05
SL01	**Slate**, 1/2 inch	0.0417	0.8340	100.0	0.35	0.05
ST01	**Stone**, 1 inch	0.0833	1.0416	140.0	0.2	0.08
SC01	**Stucco**, 1 inch	0.0833	0.4167	166.0	0.2	0.20
TZ01	**Terrazzo**, 1 inch	0.0833	1.0416	140.0	0.2	0.08
	Wood, Soft					
WD01	3/4 inch	0.0625	0.0667	32.0	0.33	0.94
WD02	1.5 inch	0.1250	0.0667	32.0	0.33	1.87
WD03	2.5 inch	0.2083	0.0667	32.0	0.33	3.12
WD04	3.5 inch	0.2917	0.0667	32.0	0.33	4.37
WD05	4 inch	0.3333	0.0667	32.0	0.33	5.00
	Wood, Hard					
WD11	3/4 inch	0.0625	0.0916	45.0	0.30	0.68
WD12	1 inch	0.0833	0.0916	45.0	0.30	0.91
	Wood, Shingle					
WS01	For Wall	0.0583	0.0667	32.0	0.30	0.87
WS02	For Roof	0.0583	0.0667	32.0	0.30	0.94

2. Thermal Properties of Insulating Materials

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-°F	Lb/ Ft^3	Btu/ Lb-°F	Hr-Ft^2-°F/ Btu
	Mineral Wool/Fiber					
IN01	Batt, R-7‡	0.1882	0.0250	0.60	0.2	7.53
IN02	Batt, R-11	0.2957	0.0250	0.60	0.2	11.83
IN03	Batt, R-19	0.5108	0.0250	0.60	0.2	20.43
IN04	Batt, R-24	0.6969	0.0250	0.60	0.2	27.88
IN05	Batt, R-30	0.8065	0.0250	0.60	0.2	32.26
IN11	Fill, 3.5 inch, R-11	0.2917	0.0270	0.60	0.2	10.80
IN12	Fill, 5.5 inch, R-19	0.4583	0.0270	0.63	0.2	16.97
	Cellulose					
IN13	Fill, 3.5 inch, R-13	0.2917	0.0225	3.0	0.33	12.96
IN14	Fill, 5.5 inch, R-20	0.4583	0.0225	3.0	0.33	20.37
	Preformed Mineral Board					
IN21	7/8 inch, R-3	0.0729	0.0240	15.0	0.17	3.04
IN22	1 inch, R-3.5	0.0833	0.0240	15.0	0.17	3.47
IN23	2 inch, R-6.9	0.1667	0.0240	15.0	0.17	6.95
IN24	3 inch, R-10.3	0.2500	0.0240	15.0	0.17	10.42
	Polystyrene, Expanded					
IN31	1/2 inch	0.0417	0.0200	1.8	0.29	2.08
IN32	3/4 inch	0.0625	0.0200	1.8	0.29	3.12
IN33	1 inch	0.0833	0.0200	1.8	0.29	4.16
IN34	1.25 inch	0.1042	0.0200	1.8	0.29	5.21
IN35	2 inch	0.1667	0.0200	1.8	0.29	8.33
IN36	3 inch	0.2500	0.0200	1.8	0.29	12.50
IN37	4 inch	0.3333	0.0200	1.8	0.29	16.66
	Polyurethane, Expanded					
IN41	1/2 inch	0.0417	0.0133	1.5	0.38	3.14
IN42	3/4 inch	0.0625	0.0133	1.5	0.38	4.67
IN43	1 inch	0.0833	0.0133	1.5	0.38	6.26
IN44	1.25 inch	0.1042	0.0133	1.5	0.38	7.83
IN45	2 inch	0.1667	0.0133	1.5	0.38	12.53
IN46	3 inch	0.2500	0.0133	1.5	0.38	18.80
IN47	4 inch	0.3333	0.0133	1.5	0.38	25.06

‡ Nominal thickness is 2 inches to 2 3/4 inches. Resistance value is based on a thickness of 2.26 inches.

2. Thermal Properties of Insulating Materials -- continued

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-$^\circ$F	Lb/ Ft^3	Btu/ Lb-$^\circ$F	Hr-Ft^2-$^\circ$F/ Btu
	Urea Formaldehyde					
IN51	3.5 inch, R-19	0.2910	0.0200	0.7	0.3	14.55
IN52	5.5 inch, R-30	0.4580	0.0200	0.7	0.3	22.90
	Insulation Board					
IN61	Sheathing, 1/2 inch	0.0417	0.0316	18.0	0.31	1.32
IN62	Sheathing, 3/4 inch	0.0625	0.0316	18.0	0.31	1.98
IN63	Shingle Backer, 3/8 inch	0.0313	0.0331	18.0	0.31	0.95
IN64	Nail Base Sheathing, 1/2 inch	0.0417	0.0366	25.0	0.31	1.14
	Roof Insulation, Preformed					
IN71	1/2 inch	0.0417	0.0300	16.0	0.2	1.39
IN72	1 inch	0.0833	0.0300	16.0	0.2	2.78
IN73	1.5 inch	0.1250	0.0300	16.0	0.2	4.17
IN74	2 inch	0.1667	0.0300	16.0	0.2	5.56
IN75	2.5 inch	0.2083	0.0300	16.0	0.2	6.94
IN76	3 inch	0.2500	0.0300	16.0	0.2	8.33

3. Thermal Properties of Air Spaces

DOE-2 Code-word	Description	Thickness Feet	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
			Btu-Ft/ Hr-Ft^2-$^\circ$F	Lb/ Ft^3	Btu/ Lb-$^\circ$F	Hr-Ft^2-$^\circ$F/ Btu
	Air Layer, 3/4 inch or less					
AL11	Vertical Walls					0.90
AL12	Slope 45°					0.84
AL13	Horizontal Roofs					0.82
	Air Layer, 3/4 inch to 4 inches					
AL21	Vertical Walls					0.89
AL22	Slope 45°					0.87
AL23	Horizontal Roofs					0.87
	Air Layer, 4 inches or more					
AL31	Vertical Walls					0.92
AL32	Slope 45°					0.89
AL33	Horizontal Roofs					0.92

Note: A more extensive list of data can be found in the ASHRAE Handbook of Fundamentals, Chap. 23, 1985.

Appendix E

Index of Basic Commands and Keywords

This cross index of commands and keywords applies to the *DOE-2 Basics* manual only. A comprehensive cross index of all commands and keywords in DOE-2 is published once a year in the "User News". Please contact the Simulation Research Group at Lawrence Berkeley Laboratory for the comprehensive cross index.

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•COMPUTE LOADS			F.11
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NATURAL-VENT-SCH	N-V-SCH	SYSTEM-AIR	4.78, F.14
NEXT-TO	N-T	INTERIOR-WALL	3.22, F.10
NIGHT-CYCLE-CTRL	N-C-C	SYSTEM-FANS	4.83, F.14
NUMBER-OF-PEOPLE	N-O-P	SPACE-CONDITIONS	3.16, F.7
OA-CFM/PER	O-CFM/P	ZONE-AIR	4.67, F.13
OA-CHANGES	O-C	ZONE-AIR	4.66, F.13
OA-CONTROL	O-CTRL	SYSTEM-AIR	4.77, F.14
OUTSIDE-AIR-CFM	O-A-CFM	ZONE-AIR	4.66, F.13
OUTSIDE-HI	O-H	DAY-RESET-SCHED	4.61, F.12
OUTSIDE-LO	O-L	DAY-RESET-SCHED	4.62, F.12
OVERHANG-A	OH-A	DOOR	F.10
		WINDOW	3.28, F.9
OVERHANG-ANGLE	OH-ANG	DOOR	F.10

•COMMAND or Keyword	Abbrev.	Keyword refers to this COMMAND	*DOE-2 Basics* Page No.
		WINDOW	3.28, F.9
OVERHANG-B	OH-B	DOOR WINDOW	F.10 3.28, F.9
OVERHANG-D	OH-D	DOOR WINDOW	F.10 3.28, F.9
OVERHANG-W	OH-W	DOOR WINDOW	F.10 3.28, F.9
OVER-BLOCK-RANGE	O-B-R	CHARGE-ASSIGNMENT	6.6, F.20
PANES	P	GLASS-TYPE	3.13, F.6
•PART-LOAD-RATIO	**P-L-R**		5.9, F.16
PEOPLE-HEAT-GAIN	P-H-G	SPACE-CONDITIONS	3.16, F.7
PEOPLE-HG-LAT	P-H-L	SPACE-CONDITIONS	3.17, F.7
PEOPLE-HG-SENS	P-H-S	SPACE-CONDITIONS	3.17, F.7
PEOPLE-SCHEDULE	P-SCH	SPACE-CONDITIONS	3.16, F.7
•PLANT-EQUIPMENT	**P-E**		5.7, F.16
•PLANT-PARAMETERS	**P-P**		5.11, F.17
•PLANT-REPORT	**P-R**		5.17, F.18
POWER-FACT-CORR	P-F-C	COST-PARAMETERS	6.10, F.20
PREHEAT-SOURCE	PREHEAT	SYSTEM	4.87, F.15
PREHEAT-T	P-T	SYSTEM-CONTROL	4.75, F.14
RATE-LIMITATION	R-L	ENERGY-COST	6.3, F.19
RECOVERY-EFF	REC-E	SYSTEM-AIR	4.77, F.14
REHEAT-DELTA-T	R-D-T	SYSTEM ZONE	4.89, F.15 4.69, F.13
•RESET-SCHEDULE	**R-SCH**		4.61, F.12
RESOURCE	R	CHARGE-ASSIGNMENT ENERGY-COST ENERGY-RESOURCE	6.5, F.20 6.2, F.19 5.16F.18
RES-INF-COEF	R-I-C	SPACE-CONDITIONS	3.22, F.7
RETURN-DELTA-T	RET-D-T	SYSTEM-FANS	4.83, F.14
RETURN-KW	R-KW	SYSTEM-FANS	4.83, F.14
RIGHT-FIN-A	R-F-A	DOOR WINDOW	F.10 3.29, F.9
RIGHT-FIN-B	R-F-B	DOOR WINDOW	F.10 3.30, F.9
RIGHT-FIN-D	R-F-D	DOOR WINDOW	F.10 3.30, F.9
RIGHT-FIN-H	R-F-H	DOOR WINDOW	F.10 3.30, F.9
ROUGHNESS	RO	CONSTRUCTION	3.12, F.6
•RUN-PERIOD			3.3, F.3
•SCHEDULE	**SCH**		2.7, F.4, F.12, F.19
SEASON	S	CHARGE-ASSIGNMENT	6.6, F.20

•COMMAND or Keyword	Abbrev.	Keyword refers to this COMMAND	*DOE-2 Basics* Page No.
SETBACK	SETB	DOOR WINDOW	3.31, F.10 3.27, F.9
SHADING-COEF	S-C	GLASS-TYPE	3.13, F.6
SHADING-SCHEDULE	S-SCH	WINDOW	3.27, F.9
SIZE		PLANT-EQUIPMENT	5.7, F.16
SIZING-RATIO	S-R	SYSTEM	4.88, F.15
SOURCE-BTU/HR	S-B	SPACE-CONDITIONS	3.21, F.7
SOURCE-LATENT	S-L	SPACE-CONDITIONS	3.22, F.7
SOURCE-SCHEDULE	S-SCH	SPACE-CONDITIONS	3.21, F.7
SOURCE-SENSIBLE	S-S	SPACE-CONDITIONS	3.21, F.7
SOURCE-SITE-EFF	S-S-E	ENERGY-RESOURCE	5.16, F.18
SOURCE-TYPE	S-T	SPACE-CONDITIONS	3.20, F.7
•SPACE	**S**		3.24, F.8
•SPACE-CONDITIONS	**S-C**		3.16, F.7
SPACE-CONDITIONS	S-C	SPACE	3.24, F.8
STM-BOILER-HIR		PLANT-PARAMETERS	5.13, F.17
•STOP			F.20
SUMMARY	S	ECONOMICS-REPORT LOADS-REPORT PLANT-REPORT SYSTEMS-REPORT	F.20 F.11 F.18 F.15
SUPPLY-1	S-1	HEAT-RECOVERY	F.18
SUPPLY-CFM	S-CFM	SYSTEM-AIR	4.76, F.14
SUPPLY-DELTA-T	SUP-D-T	SYSTEM-FANS	4.82, F.14
SUPPLY-HI	S-H	DAY-RESET-SCHED	4.61, F.12
SUPPLY-KW	S-KW	SYSTEM-FANS	4.82, F.14
SUPPLY-LO	S-L	DAY-RESET-SCHED	4.61, F.12
•SYSTEM	**SYST**		F.15
•SYSTEM-AIR	**S-A**		4.76, F.14
SYSTEM-AIR	S-A	SYSTEM	4.87, F.15
•SYSTEM-CONTROL	**S-C**		4.71, F.14
SYSTEM-CONTROL	S-C	SYSTEM	4.87, F.15
•SYSTEM-FANS	**S-FANS**		4.81, F.14
SYSTEM-FANS	S-FANS	SYSTEM	4.87, F.15
•SYSTEM-FLUID	**S-FLU**		4.85, F.15
SYSTEM-FLUID	S-FLU	SYSTEM	4.87, F.15
SYSTEM-TYPE	S-TYPE	SYSTEM	4.87, F.15
•SYSTEMS-REPORT	**S-R**		F.15
TASK-LIGHTING-KW	T-L-KW	SPACE-CONDITIONS	3.19, F.7
TASK-LIGHT-SCH	T-L-SCH	SPACE-CONDITIONS	3.18, F.7
TASK-LT-W/SQFT	T-L-W	SPACE-CONDITIONS	3.19, F.7
TEMPERATURE	T	SPACE-CONDITIONS	3.16, F.7
TERMINAL-TYPE	TER-TYPE	ZONE	4.68, F.13
THERMOSTAT-TYPE	T-TYPE	ZONE-CONTROL	4.65, F.12

•COMMAND or Keyword	Abbrev.	Keyword refers to this COMMAND	*DOE-2 Basics* Page No.
THICKNESS	TH	LAYERS	3.8, F.6
THROTTLING-RANGE	T-R	ZONE-CONTROL	4.65, F.12
TILT		EXTERIOR-WALL or ROOF	3.26, F.8
TIME-ZONE	T-Z	BUILDING-LOCATION	3.4, F.3
•TITLE			F.3, F.12, F.16, F.19
TWR-DESIGN-WETBULB		PLANT-PARAMETERS	5.12, F.17
TWR-FAN-CONTROL		PLANT-PARAMETERS	5.12, F.17
TWR-PUMP-HEAD		PLANT-PARAMETERS	5.12, F.17
TWR-TEMP-CONTROL		PLANT-PARAMETERS	5.12, F.17
TWR-WTR-SET-POINT		PLANT-PARAMETERS	5.13, F.17
TYPE		CHARGE-ASSIGNMENT	6.6, F.20
		PART-LOAD-RATIO	5.9, F.16
		PLANT-EQUIPMENT	5.7, F.16
•UNDERGROUND-FLOOR	**U-F**		3.33, F.10
•UNDERGROUND-WALL	**U-W**		3.33, F.10
UNIFORM-CHARGE	U-C	CHARGE-ASSIGNMENT	6.6, F.20
UNIFORM-COST	U-C	ENERGY-COST	6.2, F.19
UNIT	U	ENERGY-COST	6.2, F.19
U-VALUE	U	CONSTRUCTION	3.9, F.6
VENT-TEMP-SCH	V-T-SCH	SYSTEM-AIR	4.78, F.14
VERIFICATION	V	LOADS-REPORT	F.11
VERT-TRANS-KW	V-T-KW	BUILDING-RESOURCE	3.35, F.10
VERT-TRANS-SCH	V-T-SCH	BUILDING-RESOURCE	3.35, F.10
VOLUME	V	SPACE	3.24, F.8
WARNINGS		DIAGNOSTIC	F.3
•WEEK-SCHEDULE	**W-SCH**		2.6, F.4, F.12, F.19
WIDTH	W	DOOR	3.31, F.10
		EXTERIOR-WALL or ROOF	3.25, F.8
		WINDOW	3.27, F.9
•WINDOW	**WI**		3.27, F.9
•ZONE	**Z**		4.68, F.13
•ZONE-AIR	**Z-A**		4.66, F.13
ZONE-AIR	Z-A	ZONE	4.68, F.13
•ZONE-CONTROL	**Z-C**		4.64, F.12
ZONE-CONTROL	Z-C	ZONE	4.68, F.13
ZONE-FAN-CFM	Z-F-CFM	ZONE-FANS	4.69, F.13
ZONE-FAN-KW	Z-F-KW	ZONE-FANS	4.69, F.13
ZONE-FAN-RATIO	Z-F-R	ZONE-FANS	4.69, F.13
ZONE-FAN-T-SCH	Z-F-SCH	ZONE-FANS	4.69, F.13
ZONE-HEAT-SOURCE	Z-H-S	SYSTEM	4.87, F.15
ZONE-NAMES	Z-N	SYSTEM	4.88, F.15

Appendix F

BASIC BDL SUMMARY

Table of Contents

INTRODUCTION

This *Basic BDL Summary* contains only a partial list of commands and keywords found in the DOE-2 Building Description Language (BDL). Information contained herein is considered appropriate for the beginning DOE-2 user. A complete list of all commands and keywords can be found in the *BDL Summary*, Version 2.1D. A discussion of commands and keywords can be found in the *Reference Manual (Rev.)* for Version 2.1A of the program, and the *Supplement*, Version 2.1D.

COMMAND(abbrev.,max allowed) [comments]
- • **KEYWORD**(abbrev.)(**default**;range and dimension)
  KEYWORD(abbrev.)(**default**;range and dimension)
  KEYWORD(abbrev.)(**default**;range and dimension)

About Commands and Keywords

•	indicates a required keyword
Suggested Inputs	To indicate their relative importance, we have bold-faced certain keywords that are suggested inputs.
=	in front of a command means that a u-name is mandatory
(=)	in front of a command means that a u-name is optional. Otherwise no u-name is permitted
LIKE	Unless otherwise noted, the **LIKE** keyword is permitted for each command.
Default Values	For easier reference, the default values of all keywords are bold-faced. Some keywords are shown with a long dash (—) as the default instead of a given value; in these cases, the user must define the value.
Terminator	A two-dot terminator, .. , is required to end each input. If a comment is to follow the terminator, put a space between the terminator and the comment.

LOADS SUMMARY

INPUT LOADS Required for Loads input

TITLE(5) LINE-*n* *Up to 40 characters enclosed by asterisks*
where n=1,2,...,5

[Note: In SYSTEMS, PLANT, and ECONOMICS, lines may be replaced, up to an *overall* total of 5. Also, any particular LINE-*n* may be substituted for lines input in LOADS by using TITLE command followed by LINE-*n* *changed text*, where *n* is the line to be changed.]

ABORT(**ERRORS**;ERRORS,WARNINGS,CAUTIONS)

DIAGNOSTIC(LIST) takes up to six optional code-words
WARNINGS;ERRORS,WARNINGS,CAUTIONS,DEFAULTS,COMMENTS
(**default**;options) is as follows:
ECHO;ECHO,NO-ECHO

RUN-PERIOD(1) Required for LOADS input

BUILDING-LOCATION(B-L,1)
LATITUDE(LAT)(*;-66.5 to 66.5°)
LONGITUDE(LON)(*;-180.0 to 180.0°)
ALTITUDE(ALT)(**0.0**;-1000.0 to 20000.0 ft)
TIME-ZONE(T-Z)(*;-12 to (all integers)
GROSS-AREA(G-A)(**;0.0 to 10^7ft^2)
AZIMUTH(AZ)(**0.0**;-360.0 to 360.0°)
HOLIDAY(HOL)(**YES**;YES,NO)
DAYLIGHT-SAVINGS(D-S)(**YES**;YES,NO)
GROUND-T(G-T)(***;-100.0 to 150.0°F)
CLEARNESS-NUMBER(C-N)(***;0.5 to 1.2)

[Note: HOL = YES ~ U.S. Holidays assumed; HOL = NO ~ no holidays assumed]
[Note: D-S = YES ~ Daylight Savings correction; D-S = NO ~ no Daylight Savings correction]
* Default is taken from the weather file
** Defaults to net area, i.e., the sum of areas of all conditioned SPACE's.
*** Takes a list of twelve values; one per month. Default is taken from the weather file.

= **DAY–SCHEDULE**(D-SCH,80)
(see example below)

[Note: All 24 hours must be accounted for]

In its simplest form, the input for DAY–SCHEDULE takes the form:

U–NAME = DAY–SCHEDULE (hours covered) (values for each hour) **..**

For example, for weekdays:

```
LTG–1 = DAY–SCHEDULE (1,24) (0,0,0,0,0,0,0,0,.3,.6,.8,1,1,1,1,1,1,1,0,0,0,0,0,0) ..
```

Optionally, this can be shortened by writing:

```
LTG–1 = DAY–SCHEDULE (1,8)(0) (9,11) (.3,.6,.8) (12,18) (1) (19,24) (0) ..
```

For week-ends and holidays:

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

= **WEEK–SCHEDULE**(W–SCH,60)
(see example below)

[Note: Code-word for days of week and holidays is first three letters of name.
ALL ~ Monday thru Sunday + Holidays; WEH ~ weekends + Holidays; and WD ~ weekdays]
[Note: Must preserve order of Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday, Holiday].
[Note: All days of week + Holiday must be accounted for]

In its simplest form, the input for WEEK–SCHEDULE takes the form:

U–NAME = WEEK–SCHEDULE (†) (**U–NAME** of **DAY–SCHEDULE** referenced) **..**
† days of week covered

Using the previously defined DAY–SCHEDULEs LTG–1 and LTG–2, the example can be carried forward with:

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

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

Optionally, NORMAL can be shortened to:

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

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

= **SCHEDULE**(SCH,60) [Note: **LIKE** keyword not allowed]
(see example below)

[Note: Every day of run period must be accounted for]
[Note: Code-word for month is first three letters of month name]
[Note: A maximum of 52 THRU's per command]

In its simplest form, the input for SCHEDULE takes the form:

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

† calendar period covered

To finalize the example:

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

Alternatively, explicit use of DAY–SCHEDULE and WEEK–SCHEDULE can be bypassed by writing:

```
LIGHTS = SCHEDULE    THRU JUN 10 (WD)(1,8)(0)(9,11)(.3,.6,.8)(12,18)(1)(19,24)(0)(WEH)(1,24)(0)
                     THRU SEP 5 (ALL)(1,24)(0)
                     THRU DEC 31 (WD) (1,8)(0)(9,11)(.3,.6,.8)(12,18)(1)(19,24)(0)(WEH)(1,24)(0)  ..
```

= **LAYERS**(LA,16) *
• **MATERIAL**(MAT) **
THICKNESS(TH) ***
INSIDE-FILM-RES(I-F-R)(0.68;0.0 to 40.0 hr-ft^{2}-°F/Btu)

* LIKE keyword not allowed

** Value must be a list of either the u-names of MATERIALs or code-words from the Material's Library; see Appendix D. Also, list the materials (a maximum of 9) from outside to inside; don't specify inside or outside air film as a material

*** THICKNESS must be specified if any thickness is different from those specified in MATERIAL commands or Materials Library. Order of list must correspond to list following MATERIALs

= **CONSTRUCTION**(CONS,32)
• **LAYERS**(LA) u-name or code-word
or
• U-VALUE(U)(—;0.0 to 20.0 Btu/hr-ft^{2}-°F)*
ABSORPTANCE(ABS)(**0.7**;0.0 to 1.0)**
ROUGHNESS(RO)(**3**;1 to 6) (all integers)**

* For interior surfaces, includes resistance of both air films;
for exterior surfaces, includes inside film resistance, but not outside film resistance.

** See pages 3.11-12 for ABSORPTANCE and ROUGHNESS values.
Not used for interior walls, underground walls, or underground floors

= **GLASS–TYPE**(G-T,32)
PANES(P)(**1**;1 to 3) (all integers)
• **SHADING–COEF**(S–C)(—;0.0 to 1.0)
GLASS–CONDUCTANCE(G–C)(*****;0.0 to 10.0 Btu/hr-ft^{2}-°F)

* See page 3.14 of this manual for GLASS–CONDUCTANCE defaults.
[For typical values, see Chapter 27 of the *ASHRAE* Handbook of Fundamentals, 1989.]

= **LAYERS**(LA,16) *
- **MATERIAL**(MAT) **

THICKNESS(TH) ***
INSIDE-FILM-RES(I-F-R)(0.68;0.0 to 40.0 hr-ft^2-°F/Btu)

* LIKE keyword not allowed

** Value must be a list of either the u-names of MATERIALs or code-words from the Materials Library; see Appendix D. Also, list the materials (a maximum of 9) from outside to inside; don't specify inside or outside air film as a material

*** THICKNESS must be specified if any thickness is different from those specified in MATERIAL commands or Materials Library. Order of list must correspond to list following MATERIALs

= **CONSTRUCTION**(CONS,32)
- **LAYERS**(LA) u-name or code-word

or
- U-VALUE(U)(—;0.0 to 20.0 Btu/hr-ft^2-°F)*

ABSORPTANCE(ABS)(**0.7**;0.0 to 1.0)**
ROUGHNESS(RO)(**3**;1 to 6) (all integers)**

* For interior surfaces, includes resistance of both air films;
for exterior surfaces, includes inside film resistance, but not outside film resistance.

** See pages 3.11-12 for ABSORPTANCE and ROUGHNESS values.
Not used for interior walls, underground walls, or underground floors

= **GLASS–TYPE**(G–T,32)
PANES(P)(**1**;1 to 3) (all integers)
- **SHADING–COEF**(S–C)(—;0.0 to 1.0)

GLASS–CONDUCTANCE(G–C)(*;0.0 to 10.0 Btu/hr-ft^2-°F)

* See page 3.14 of this manual for GLASS–CONDUCTANCE defaults.
[For typical values, see Chapter 27 of the *ASHRAE* Handbook of Fundamentals, 1989.]

= SPACE–CONDITIONS(S–C,32)

PEOPLE–SCHEDULE(P–SCH) u-name
NUMBER–OF–PEOPLE(N–O–P)(**0.0**;0.0 to 10000.0)
AREA/PERSON(A/P)(**100.0**;0.0 to 10000.0ft^2)[Used only if NUMBER–OF–PEOPLE not specified]
PEOPLE–HEAT–GAIN(P–H–G)(**0.0**;350.0 to 2000.0 Btu/hr-pers)†
or
PEOPLE–HG–LAT(P–H–L)(**0.0**;0.0 to 2000.0 Btu/hr-pers)†
and
PEOPLE–HG–SENS(P–H–S)(**0.0**;0.0 to 2000.0 Btu/hr-pers)†
LIGHTING–SCHEDULE(L–SCH) u-name
LIGHTING–TYPE(L–T)(**SUS–FLUOR**; Options are: SUS–FLUOR, REC–FLUOR–RV, REC–FLUOR–RSV, REC–FLUOR–NV, and INCAND.)
LIGHTING–W/SQFT(L–W)(**0.0**;0.0 to 10.0 W/ft^2) [If both specified, contribution is added]
or
LIGHTING–KW(L–KW)(**0.0**;0.0 to 200.0 kW)[If both specified, contribution is added.]
LIGHT–TO–SPACE(L–T–S)(*;0.0 to 1.0)
TASK–LIGHT–SCH(T–L–SCH) u-name
TASK–LT–W/SQFT(T–L–W)(**0.0**;0.0 to 10.0 W/ft^2)[If both specified, contribution is added.]
or
TASK–LIGHTING–KW(T–L–KW)(**0.0**;0.0 to 200.0 kW)[If both specified, contribution is added.]
EQUIP–SCHEDULE(E–SCH) u-name
EQUIPMENT–W/SQFT(E–W)(**0.0**;0.0 to 100.0 W/ft^2) [If both specified, contribution is added]
or
EQUIPMENT–KW(E–KW)(**0.0**;0.0 to 200.0 kW)[If both specified, contribution is added.]
EQUIP–SENSIBLE(E–S)(**1.0**;0.0 to 1.0)
EQUIP–LATENT(E–L)(**0.0**;0.0 to 1.0)
SOURCE–SCHEDULE(S–SCH) u-name
SOURCE–TYPE(S–T)(**GAS**;GAS,ELECTRIC,HOT–WATER,PROCESS)
SOURCE–BTU/HR(S–B)(**0.0**;-1000000.0 to 1000000.0 Btu/hr)
SOURCE–SENSIBLE(S–S)(**1.0**;-1.0 to 1.0)
SOURCE–LATENT(S–L)(**0.0**;0.0 to 1.0)
TEMPERATURE(T)((**70.0**);0.0 to 120.0°F) (list of 1)
FLOOR–WEIGHT(F–W)(**70.0**;0.0 to 200.0 lb/ft^2)
INF–SCHEDULE(I–SCH) u-name **
INF–METHOD(I–M)(**NONE**;NONE,CRACK,AIR–CHANGE,RESIDENTIAL,S–G) **
AIR–CHANGES/HR(A–C)(**0.0**;0.0 to 30.0) [If both specified, contribution is added.] **
or
INF–CFM/SQFT(I–CFM)(**0.0**;0.0 to 20.0 cfm/ft^2)[If both specified, contribution is added.] **
RES–INF–COEF(R–I–C)((**0.252,0.0251,0.0084**);0.0 to 20.0, mixed units) **

* See the table below, "Default Table for LIGHTING–TYPEs"

** See the table on the next page, "Default Table for INF–METHODs"

† If no value is input, there is no contribution from people. If all are specified, the contribution is cumulative.

Default Table for LIGHTING–TYPEs

KEYWORD	SUS–FLUOR	REC–FLUOR–RV	REC–FLUOR–RSV	INCAND	REC–FLUOR–NV
LIGHT–TO–SPACE	1.0	0.8	0.8	1.0	1.0

KEYWORD	Default Table for INF-METHODs				
	NONE	AIR-CHANGE		CRACK	RESI-DENTIAL
		With wind correction	Without wind correction		
AIR-CHANGES/HR	**not used**	**required**	**not used**	**not used**	**not used**
INF-CFM-SQFT	**not used**	**not used**	**required**	**not used**	**not used**
INF-SCHEDULE	**not used**	†	†	†	†
RES-INF-COEF	**not used**	**not used**	**not used**	**not used**	‡

† If not specified, always on ‡ If not specified, takes default value

* This keyword is input under the EXTERIOR-WALL, DOOR, and WINDOW commands. [Note: For INF-METHOD= RESIDENTIAL, wind and temperature dependence is given through the RES-INF-COEF keyword.]

= **SPACE**(S,64)
• **AREA**(A)(—;0.0+ to 100000.0 ft^2)
• **VOLUME**(V)(—;0.0 to 10^6 ft^3)
FLOOR-MULTIPLIER(F-M)(**1.0**;1.0 to 200.0)
SPACE-CONDITIONS(S-C) u-name §

§ Any keyword from this subcommand may be placed in the SPACE command.

(=)**EXTERIOR-WALL**(E-W) or **ROOF**(128)
• **HEIGHT**(H)(—;0.0 to 2000.0 ft)
• **WIDTH**(W)(—;0.0 to 2000.0 ft)
• **CONSTRUCTION**(CONS) u-name
AZIMUTH(AZ)(**0.0**;-360.0 to 360.0°)
TILT(**90.0**;0.0 to 180.0°) [Tilt for ROOF must be input, otherwise it will default to 90°]
MULTIPLIER(M)(**1.0**;0.0 to 99.0)
GND-REFLECTANCE(G-R)(**0.2**;0.0 to 1.0) [See page 3.25 for typical values.]

(=) **WINDOW**(WI)(200)

- **HEIGHT**(H)(—;0.0 to 40.0 ft)
- **WIDTH**(W)(—;0.0 to 1000.0 ft)
- **GLASS–TYPE**(G–T) u-name

SETBACK(SETB)(**0.0**;0.0 to 10.0 ft) [Unused for interior windows]
SHADING-SCHEDULE(S-SCH) u-name
MAX-SOLAR-SCH(M-S-SCH) u-name
CONDUCT-SCHEDULE(C-SCH) u-name
CONDUCT-TMIN-SCH(C-T-SCH) u-name
OVERHANG-A(OH-A)(**0.0**;no limits - ft) [Unused for interior windows]
OVERHANG-B(OH-B)(**0.0**;no limits - ft) [Unused for interior windows]

OVERHANG-W(OH-W)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*
and*
OVERHANG-D(OH-D)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*

OVERHANG-ANGLE(OH-ANG)(**90.0**;0.0 to 180°) [Unused for interior windows]
LEFT-FIN-A(L-F-A)(**0.0**;no limits - ft) [Unused for interior windows]
LEFT-FIN-B(L-F-B)(**0.0**;no limits - ft) [Unused for interior windows]

LEFT-FIN-H(L-F-H)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*
and*
LEFT-FIN-D(L-F-D)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*

RIGHT-FIN-A(R-F-A)(**0.0**;no limits - ft) [Unused for interior windows]
RIGHT-FIN-B(R-F-B)(**0.0**;no limits - ft) [Unused for interior windows]

RIGHT-FIN-H(R-F-H)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*
and*
RIGHT-FIN-D(R-F-D)(**0.0**;0.0 to no limits - ft) [Unused for interior windows]*

---

* Either both or neither of these should be specified. If not specifed, shading calculation will not be done.

(=) DOOR(64)
- HEIGHT(H)(—;0.0 to 40.0 ft)
- WIDTH(W)(—;0.0 to 1000.0 ft)
- CONSTRUCTION(CONS) u-name of a quick-type (U-value) CONSTRUCTION

SETBACK(SETB)(**0.0**;0.0 to 10.0 ft)
OVERHANG-A(OH-A)(**0.0**;no limits - ft)
OVERHANG-B(OH-B)(**0.0**;no limits - ft)

OVERHANG-W(OH-W)(**0.0**;0.0 to no limits - ft)*
and*
OVERHANG-D(OH-D)(**0.0**;0.0 to no limits - ft)*

OVERHANG-ANGLE(OH-ANG)(**90.0**;0.0 to 180°)
LEFT-FIN-A(L-F-A)(**0.0**;no limits - ft)
LEFT-FIN-B(L-F-B)(**0.0**;no limits - ft)

LEFT-FIN-H(L-F-H)(**0.0**;0.0 to no limits - ft)*
and*
LEFT-FIN-D(L-F-D)(**0.0**;0.0 to no limits - ft)*

RIGHT-FIN-A(R-F-A)(**0.0**;no limits - ft)
RIGHT-FIN-B(R-F-B)(**0.0**;no limits - ft)

RIGHT-FIN-H(R-F-H)(**0.0**;0.0 to no limits - ft)*
and*
RIGHT-FIN-D(R-F-D)(**0.0**;0.0 to no limits - ft)*

INSIDE-VIS-REFL(I-V-R)(**0.5**;0.0 to 1.0) [Used only for daylighting calculation.]
FUNCTION (*u-name*,*u-name*)

* Either both or neither of these should be specified. If not specified, shading calculation will not be done.

(=) **INTERIOR-WALL**(I-W,no limit)
- **AREA**(A)(—;0.0 to 100000.0 ft^2)
- **CONSTRUCTION**(CONS) u-name

NEXT-TO(N-T) u-name of adjacent SPACE

(=) **UNDERGROUND-WALL**(U-W) or **UNDERGROUND-FLOOR**(U-F)(64)
- **AREA**(A)(—;0.0 to 100000.0 ft^2)
- **CONSTRUCTION**(CONS) u-name

BUILDING-RESOURCE(B-R,1)
GAS-SCHEDULE(G-SCH) u-name
GAS-THERMS(G-T)(**0.0**;0.0 to 10.0 therms/hr)
HW-SCHEDULE(HW-SCH) u-name
HOT-WATER(H-W)(**0.0**;0.0 to 10^7 Btu/hr)
ELEC-SCHEDULE(E-SCH) u-name
ELEC-KW(E-KW)(**0.0**;0.0 to 1000.0 kW) [Use for outside lighting]
VERT-TRANS-SCH(V-T-SCH) u-name
VERT-TRANS-KW(V-T-KW)(**0.0**;0.0 to 1000.0 kW)

LOADS-REPORT(L-R,1)
    VERIFICATION(V)((—);LV-A,LV-B,...,LV-M)
    SUMMARY(S)((**LS-D**);LS-A,LS-B,...,LS-L)

END

Required at end of LOADS input and before FUNCTION command, if specified.

COMPUTE LOADS

Required to do Loads simulation

SYSTEMS SUMMARY

INPUT SYSTEMS Required for Systems input

TITLE(5)
See LOADS

= **DAY–SCHEDULE**(D-SCH,80)
See LOADS

= **WEEK–SCHEDULE**(W-SCH,60)
See LOADS

= **SCHEDULE**(SCH,60) [Note:LIKE keyword not allowed]
See LOADS

= **DAY–RESET–SCH**(D-R-SCH,60 minus the number of D-SCH's)
- SUPPLY–HI(S-H)(—;0.0 to 120.0°F) or (—;0.0 to 1.0)
- SUPPLY–LO(S-L)(—;0.0 to 120.0°F) or (—;0.0 to 1.0)
- OUTSIDE–HI(O-H)(—;-20.0 to 120.0°F)
- OUTSIDE–LO(O-L)(—;-20.0 to 120.0°F)

= **RESET–SCHEDULE**(R-SCH,40 minus the number of SCH's)
See LOADS [Note:**LIKE** keyword not allowed]

= **ZONE–CONTROL**(Z-C,20)
- DESIGN–HEAT–T(D-H-T)(—;0.0 to 80°F) *

  HEAT–TEMP–SCH(H-T-SCH) u-name **
- DESIGN–COOL–T(D-C-T)(—;0.0 to 90°F) *

  COOL–TEMP–SCH(C-T-SCH) u-name **

  BASEBOARD–CTRL(B-C)(**OUTDOOR–RESET**;OUTDOOR-RESET, THERMOSTATIC)

  THERMOSTAT–TYPE(T-TYPE)(**PROPORTIONAL**;PROPORTIONAL, REVERSE–ACTION,TWO–POSITION)

  THROTTLING–RANGE(T-R)(***;0.1 to 10.0°F)

* Required but not used in simulation of SUM system.

** If omitted, no heating or cooling, respectively, in zone.

*** Default is 2.0 if THERMOSTAT-TYPE = PROPORTIONAL or REVERSE-ACTION, 0.5 if TWO-POSITION.

= **ZONE–AIR**(Z–A,20)

ASSIGNED–CFM(A–CFM)(—;0.0 to 99999999.0 cfm)
or
CFM/SQFT(—;0.0 to 5.0 cfm/ft^2)
or
AIR–CHANGES/HR(A–C/HR)(—;0.0 to 10.0/hr)

OUTSIDE–AIR–CFM(O–A–CFM)(—;0.0 to 99999999.0 cfm)
or
OA–CFM/PER(O–CFM/P)(—;0.0 to 60.0 cfm/person)
or
OA–CHANGES(O–C)(—;0.0 to 10.0/hr)
EXHAUST–CFM(E–CFM)(—;0.0 to 99999999.0 cfm)
EXHAUST–STATIC(E–S)(—;0.0 to 10.0 in of WG)
EXHAUST–EFF(E–E)(**0.75**;0.1 to 1.0)
EXHAUST–KW(E–KW)(—;0.0 to 0.01)

= **ZONE**(Z,64)

ZONE–CONTROL(Z–C) u-name §
ZONE–AIR(Z–A) u-name §
MIN–CFM–RATIO(M–C–R)(—;0.0 to 1.0)
MIN–CFM–SCH(M–C–SCH) u-name
TERMINAL–TYPE(TER–TYPE)(**SVAV**;SVAV,SERIES–PIU,PARALLEL–PIU)*
INDUCED–AIR–ZONE(I–A–Z) u-name of ZONE*
REHEAT–DELTA–T(R–D–T)(—;0.0 to 100.0)*
BASEBOARD–RATING(B–R)(**0.0**;-99999999.0 to 0.0)
• **ZONE–FAN–RATIO**(Z–F–R)(**;0.0 to 10.0) ***
or
• **ZONE–FAN–CFM**(Z–F–CFM)(**;0.0 to 99999999.0 ft^3/min) ***
• **ZONE–FAN–T–SCH**(Z–F–SCH) u-name [Required if TERMINAL–TYPE = PARALLEL–PIU.] ***
ZONE–FAN–KW(Z–F–KW)(0.00033;0.0 to 0.01 kW/cfm) ***

* Used only for PIU system; I–A–Z required if TERMINAL–TYPE ≠ SVAV

** For series PIU, ZONE–FAN–RATIO defaults to 1.0. However, defaulting is not allowed for parallel PIU; therefore, user must input –RATIO or –CFM.

*** This keyword appears under the ZONE–FANS command in the (unabridged) BDL Summary, Version 2.1D, May, 1989.

§ Any keyword from these subcommands may be placed in the ZONE command

= **SYSTEM-CONTROL**(S-C,20)
MAX-SUPPLY-T(MAX-S-T)(—;50.0 to 200.0°F)
MIN-SUPPLY-T(MIN-S-T)(—;45.0 to 70.0°F)
COOL-CONTROL(C-C)(**CONSTANT**;CONSTANT,WARMEST,
RESET,SCHEDULED)
ECONO-LIMIT-T(E-L-T)(—;45.0 to 80.0°F)
BASEBOARD-SCH(B-SCH) u-name
HEATING-SCHEDULE(H-SCH) u-name
COOLING-SCHEDULE(C-SCH) u-name
HEAT-CONTROL(H-C)(**CONSTANT**;CONSTANT,COLDEST,RESET,SCHEDULED)
HEAT-SET-T(H-S-T)(—;50.0 to 200.0°F)
HEAT-RESET-SCH(H-R-SCH) u-name of RESET-SCHEDULE
HEAT-SET-SCH(H-S-SCH) u-name
COOL-RESET-SCH(C-R-SCH) u-name of RESET-SCHEDULE
COOL-SET-SCH(C-S-SCH) u-name
MAX-HUMIDITY(MAX-H)(**100.0**;30.0 to 80.0%)
MIN-HUMIDITY(MIN-H)(**0.0**;0.0 to 70.0%)
PREHEAT-T(P-T)(**45.0**;-50.0 to 70.0°F)

= **SYSTEM-AIR**(S-A,20)
OA-CONTROL(O-CTRL)(**TEMP**;TEMP,FIXED,ENTHALPY)
SUPPLY-CFM(S-CFM)(*;10.0 to 9999999.0 cfm) [* Calculated from ZONE-AIR input and zone loads.]
MIN-OUTSIDE-AIR(M-O-A)(*;0.0 to 1.0) [* Calculated from ZONE-AIR input and zone loads.]
MIN-AIR-SCH(M-A-SCH) u-name
RECOVERY-EFF(REC-E)(**0.0**;0.2 to 0.8 Btu/Btu)
NATURAL-VENT-AC(N-V-A)(—;0.0 to 100.0 air changes/hr)**
NATURAL-VENT-SCH(N-V-SCH) u-name**
VENT-TEMP-SCH(V-T-SCH) u-name**

** Used only for SYSTEM-TYPE = RESYS.

= **SYSTEM-FANS**(S-FANS,20)
FAN-SCHEDULE(F-SCH) u-name
FAN-CONTROL(F-C)(—;CONSTANT-VOLUME,SPEED,INLET,DISCHARGE,CYCLING,
TWO-SPEED,FAN-EIR-FPLR)

SUPPLY-DELTA-T(SUP-D-T)(—;0.0 to 30.0°F)
and
SUPPLY-KW(S-KW)(—;0.0 to 0.0 kW/cfm)

RETURN-DELTA-T(RET-D-T)(—;0.0 to 30.0°F)
and
RETURN-KW(R-KW)(—;0.0 to 0.01 kW/cfm)

NIGHT-CYCLE-CTRL(N-C-C)(—;STAY-OFF,CYCLE-ON-ANY,
CYCLE-ON-FIRST, ZONE-FANS-ONLY*) [*Used only for PIU systems]

= SYSTEM–FLUID(S-FLU,20)
MIN–FLUID–T(MIN-F-T)(—;40.0 to 80.0°F) [Required only for HP systems.]
MAX–FLUID–T(MAX-F-T)(—;60.0 to 150.0°F) [Required only for HP systems.]
FLUID–HEAT–CAP(F-H-C)(—;1.0 to 999999999.0 Btu/hr-°F) [Required only for HP systems.]

= SYSTEM(SYST,40)
SYSTEM–CONTROL(S-C)§
SYSTEM–AIR(S-A)§
SYSTEM–FANS(S-FANS)§
SYSTEM–FLUID(S-FLU)§
• **SYSTEM–TYPE**(S-TYPE)(—)
• **ZONE–NAMES**(Z-N) (list of zones in system,including plenum and unconditioned zones)
HEAT–SOURCE(HEAT-S)(—;HOT-WATER,ELECTRIC
GAS-FURNACE,OIL-FURNACE,HEAT-PUMP)
ZONE–HEAT–SOURCE(Z-H-S)(—;HOT-WATER,ELECTRIC
GAS-FURNACE,OIL-FURNACE)
PREHEAT-SOURCE(PREHEAT)(—;HOT-WATER,ELECTRIC
GAS-FURNACE,OIL-FURNACE)
BASEBOARD–SOURCE(BASEB-S)(—;HOT-WATER,ELECTRIC
GAS-FURNACE,OIL-FURNACE)
HUMIDIFIER-TYPE(H-TYPE)(—;HOT-WATER,ELECTRIC,GAS-FURNACE,
OIL-FURNACE)
SIZING–RATIO(S-R)(1.0;0.1 to 2.0)
REHEAT–DELTA–T(R-D-T)(—;0.0 to 100.0°F)*
MIN–CFM–RATIO(M-C-R)(—;0.0 to 10.0)*
HEATING-CAPACITY(H-CAP)(—;-99999999.0 to 0.0 Btu/hr)**
MAX-COND-RCVRY(M-C-R)(—;0.0 to 1.0)**

* This keyword appears under the SYSTEM-TERMINAL command in the (unabridged) BDL Summary, Version 2.1D May 1989.

** This keyword appears under the SYSTEM-EQUIPMENT command in the (unabridged) BDL Summary, Version 2.1D May 1989.

§ Any keyword from these subcommands may be placed in the ZONE command

SYSTEMS–REPORT(S-R,1) The total number of reports generated may not exceed 200.
SUMMARY(S)((SS-A);SS-A,SS-B,...,SS-O)

END
Required at end of Systems input

COMPUTE SYSTEMS
Required to do Systems simulation

PLANT SUMMARY

INPUT PLANT Required for Plant input

TITLE(5)
See LOADS

= **PLANT-EQUIPMENT**(P-E,60) [Six PLANT-EQUIPMENT instructions are allowed for each equipment type, so that up to six different sizes may be specified for each type. Exceptions are cooling towers, and hot and cold water tanks. Only one of each of these may be specified.]

- **TYPE**(—;†)

SIZE(**0.0**;-1000.0 to 100.0 MBtu/hr)
INSTALLED-NUMBER(I-N)(**1**;1 to 10) (all integers)
Note: For a cooling tower, INSTALLED-NUMBER is the number of cells.

[Note: At least one PLANT-EQUIPMENT command is required; TYPE must be the first keyword listed]

† Allowed TYPE code-words are:

ABSORG-CHLR
ABSOR1-CHLR
ABSOR2-CHLR
COOLING-TWR
DBUN-CHLR
DHW-HEATER
ELEC-DHW-HEATER
ELEC-HW-BOILER
ELEC-STM-BOILER
ENG-CHLR
HERM-CENT-CHLR
HERM-REC-CHLR
HW-BOILER
STM-BOILER

PART-LOAD-RATIO(P-L-R,25) [One PART-LOAD-RATIO instruction may be used for each equipment type.]

- TYPE(—;*) [* Takes same code-words as TYPE in PLANT-EQUIPMENT.]

ELEC-INPUT-RATIO(E-I-R)(‡;0.0 to 10.0) ‡ See RM Chap.V, Table V.4 for default values.

‡ See RM Chap.V, Table V.4 for default values.
For
DIESEL-GEN
GTURB-GEN
STURB-GEN
ABSORG-CHLR
ENG-CHLR
see the table below for revised default values.

Revised Default Values for PART-LOAD-RATIO

Plant-Equipment	MIN	MAX	OPT
DIESEL-GEN	0.15	1.1	0.95
GTURB-GEN	0.30	1.1	1.0
STURB-GEN	0.10	1.1	1.0

PLANT–PARAMETERS(P-P,1)

Boilers:
BOILER–FUEL(**FUEL–OIL**;†)
STM–BOILER–HIR(**1.3**;0.0 to 3.0)
HW–BOILER–HIR(**1.25**;0.0 to 3.0)

Domestic Hot Water Heaters:
DHW–HIR(**1.39**;0.0 to 3.0)
DHW–HEATER–FUEL(**NATURAL–GAS**;†)

Chillers:
HERM–CENT–COND–TYPE(**TOWER**;TOWER,AIR)
HERM–REC–COND–TYPE(**TOWER**;TOWER,AIR)
ABSOR1–HIR(**1.6**;0.0 to 3.0)
ABSOR2–HIR(**1.0**;0.0 to 3.0)
ABSORG–HIR(**1.0**; 0.0 to 3.0)
ABSORG–FUEL(**NATURAL–GAS**; †)
ABSORG–HEAT–XEFF(**0.8**; 0.1 to 1.0)
ENG–CH–COP(**1.4**; 0.1 to 3.0)
ENG–CH–FUEL(**NATURAL–GAS**; †)
ENG–CH–COND–TYPE(**TOWER**;TOWER,AIR)
DBUN–COND–T–REC(**105.0**;80.0 to 120.0°F)
MIN–COND–AIR–T(**65.0**;0.0 to 100.0°F)
CHILL–WTR–T(**44.0**;32.0 to 80.0°F)

Towers:
TWR–FAN–CONTROL(**ONE–SPEED**;ONE–SPEED,TWO–SPEED)
TWR–TEMP–CONTROL(**FLOAT**;FLOAT,FIXED)
TWR–WTR–SET–POINT(**80.0**;32.0 to 100.0°F)
MIN–TWR–WTR–T(**65.0**;32.0 to 100.0°F)
TWR–PUMP–HEAD(**60.0**;0.0 to 100.0 ft)
TWR–DESIGN–WETBULB(**75.0**;32.0 to 100.0°F)

Pumps:
HCIRC–HEAD(**60.0**;0.0 to 100.0 ft)
HCIRC–DESIGN–T–DROP(**30.0**;0.0 to 100.0°F)
HCIRC–LOSS(**0.01**;0.0001 to 1.0)
CCIRC–HEAD(**60.0**;0.0 to 100.0 ft)
CCIRC–DESIGN–T–DROP(**10.0**;0.0 to 20.0°F)
CCIRC–LOSS(**0.01**;0.0001 to 1.0)
CCIRC–SIZE–OPT(**SYSTEM–PEAK**;SYSTEM–PEAK,INST–PLANT–EQUIP)
HCIRC–SIZE–OPT(**SYSTEM–PEAK**;SYSTEM–PEAK,INST–PLANT–EQUIP)
CCIRC–PUMP–TYPE(**FIXED–SPEED**;FIXED–SPEED,VARIABLE–SPEED)
HCIRC–PUMP–TYPE(**FIXED–SPEED**;FIXED–SPEED,VARIABLE–SPEED)
CCIRC–MIN–PLR(**0.5**;0.0001 to 1.0)
HCIRC–MIN–PLR(**0.5**;0.0001 to 1.0)

---

† The options are: DIESEL–OIL,NATURAL–GAS,FUEL–OIL,LPG,COAL,METHANOL,BIOMASS.

HEAT-RECOVERY(HEAT-R;1)
SUPPLY-1(S-1)(DBUN-CHLR)
DEMAND-1(D-1)(SPACE-HEAT)

ENERGY-RESOURCE(E-R,5)
- RESOURCE(R)(—;ELECTRICITY,DIESEL-OIL,NATURAL-GAS, FUEL-OIL, STEAM,CHILLED-WATER,LPG,COAL,METHANOL,BIOMASS)

SOURCE-SITE-EFF(S-S-E)(†;0.0 to 1.0) [† See Supplement for default values.]

Default Values for ENERGY-RESOURCE

RESOURCE	SOURCE-SITE-EFF
CHILLED-WATER	1.5*
STEAM	0.60**
ELECTRICITY	0.333***
NATURAL-GAS	1.0
FUEL-OIL	1.0
COAL	1.0
DIESEL-OIL	1.0
METHANOL	1.0
LPG	1.0
BIOMASS	1.0

* Efficient electrically-driven chillers in a central chilled-water plant.

** Steam produced by heat-only boiler in a central steam generation plant.

*** California Energy Commission conversion factor for electricity: 10,239 Btu/kWh.

PLANT-REPORT(P-R,1)
SUMMARY(S)(**(PS-A,PS-B,PS-D)**;PS-A,PS-B,PS-C,PS-D,PS-G,BEPS

END
Required at end of Plant input

COMPUTE PLANT
Required to do Plant simulation

ECONOMICS SUMMARY

INPUT ECONOMICS

Required for Economics input

TITLE

See LOADS

= DAY-CHARGE-SCH(D-C-SCH,80)

[Note: Accepts a list of hourly values and up to two u-names of CHARGE-ASSIGNMENTs for each set of values.]

= WEEK-SCHEDULE(W-SCH,60)

See LOADS

= SCHEDULE(SCH,60)

See LOADS

ENERGY-COST(E-C,5)

- RESOURCE(R)(—;ELECTRICITY,DIESEL-OIL,NATURAL-GAS,FUEL-OIL, STEAM,CHILLED-WATER,LPG,COAL,METHANOL,BIOMASS)

UNIT(U)(†;0.+ to 10^8 Btu/unit)
UNIFORM-COST(U-C)(†;0.0 to 10^5 \$/unit)
ESCALATION(E)(†;0.0 to 100.0 %/yr)
MIN-MONTHLY-CHG(M-M-C)(**0.0**;0.0 to 10^5 \$/month)
FIXED-MONTH-CHG1(F-M-C1)(**0.0**;0.0 to 10^5 \$/month)
FIXED-MONTH-CHG2(F-M-C2)(**0.0**;0.0 to 10^5 \$/month)
RATE-LIMITATION(R-L)(**10000.0**;0.0 to 10^5 \$/units
ASSIGN-CHARGE(A-C) u-name of up to two CHARGE-ASSIGNMENTs††
ASSIGN-SCHEDULE(A-SCH) u-name of schedule

† see the table below for default values.

†† Maximum of two per ENERGY-COST command.

Default Values for ENERGY-COST

RESOURCE	UNIT	UNIFORM-COST ($/Unit)	ESCALATION (%/Year)
STEAM	1000000.00 Btu/unit	13.00	5.0
CHILLED-WATER	1000000.00 Btu/unit	13.4	5.0
ELECTRICITY	3412.97 Btu/kWh	0.0686	5.0
NATURAL-GAS	1031000.00 Btu/MCF	5.53	5.0
LPG	95500.00 Btu/gal.	1.50	5.0
FUEL-OIL	138700.00 Btu/gal.	1.186	5.0
DIESEL-OIL	138700.00 Btu/gal.	1.005	5.0
COAL	24580000.00 Btu/ton	30.00	5.0
METHANOL	63500.00 Btu/gal.	1.13	5.0
BIOMASS	1000000.00 Btu/unit	0.95	5.0

= CHARGE–ASSIGNMENT(C–A,10)
- **RESOURCE**(R)(—;ELECTRICITY,DIESEL–OIL,NATURAL–GAS, FUEL–OIL,STEAM,CHILLED–WATER,LPG,COAL, METHANOL,BIOMASS)

C–A–LINK(C–A–L) u-name of a different CHARGE–ASSIGNMENT†
SEASON(S)(**1**;1 or 2)
TYPE(ENERGY;ENERGY,DEMAND)††
UNIFORM–CHARGE(U–C)(—;0.0 to 1000.0 $/unit)
OVER–BLOCK–RANGE)(O–B–R)(**10^9**;0.0 to 10^9 units of TYPE)*
BLOCK–UNIT(B–U)(‡;ENERGY,DEMAND,KWH/KW)**

BLOCK–RANGE(B–R)((—);0.0 to 10^9) (list of up to ten)***
and
BLOCK–CHARGE(B–C)((—);-1000.0 to 1000.0 $/unit) (list of up to ten)***

* Maximum of three per CHARGE–ASSIGNMENT command.
** Maximum of two per OVER–BLOCK–RANGE keyword.
*** Maximum of two *sets* per OVER–BLOCK–RANGE keyword.
† Used only if RESOURCE = ELECTRICITY.
†† Maximum of two per CHARGE–ASSIGNMENT command.
‡ Defaults to previous value of BLOCK–UNIT, or to previous TYPE.

COST–PARAMETERS(C–P,1)
DEM–RATCHET–T1(D–R–T1)(**MEASURED**;MEASURED,HIGHEST,AVERAGE)
DEM–RATCHET–T2(D–R–T2)(†;MEASURED,HIGHEST,AVERAGE)
DEM–PERIOD–T1(D–P–T1)(**WHOLE–YEAR**;WHOLE–YEAR,SEASON)
DEM–PERIOD–T2(D–P–T2)(†;WHOLE–YEAR,SEASON)
DEM–AVERAGE–MON1(D–A–M1)(**2**;2 or 3)
DEM–AVERAGE–MON2(D–A–M2)(†;2 or 3)
DEM–RATCHET–FRC1(D–R–F1)(**1.0**;0.0 to 1.0)
DEM–RATCHET–FRC2(D–R–F2)(†;0.0 to 1.0)
POWER–FACT–CORR(P–F–C)(**1.0**;0.0 to 1.0)
KWH/KW–DEM–TYPE(K–D–T)(**RECORDED**;RECORDED,BILLING)

† Defaults to that specified (or defaulted) for first of pair.

ECONOMICS–REPORT(E–R,1)
SUMMARY(S)(ES–D,ES–E)(list)

END
Required at end of Economics input

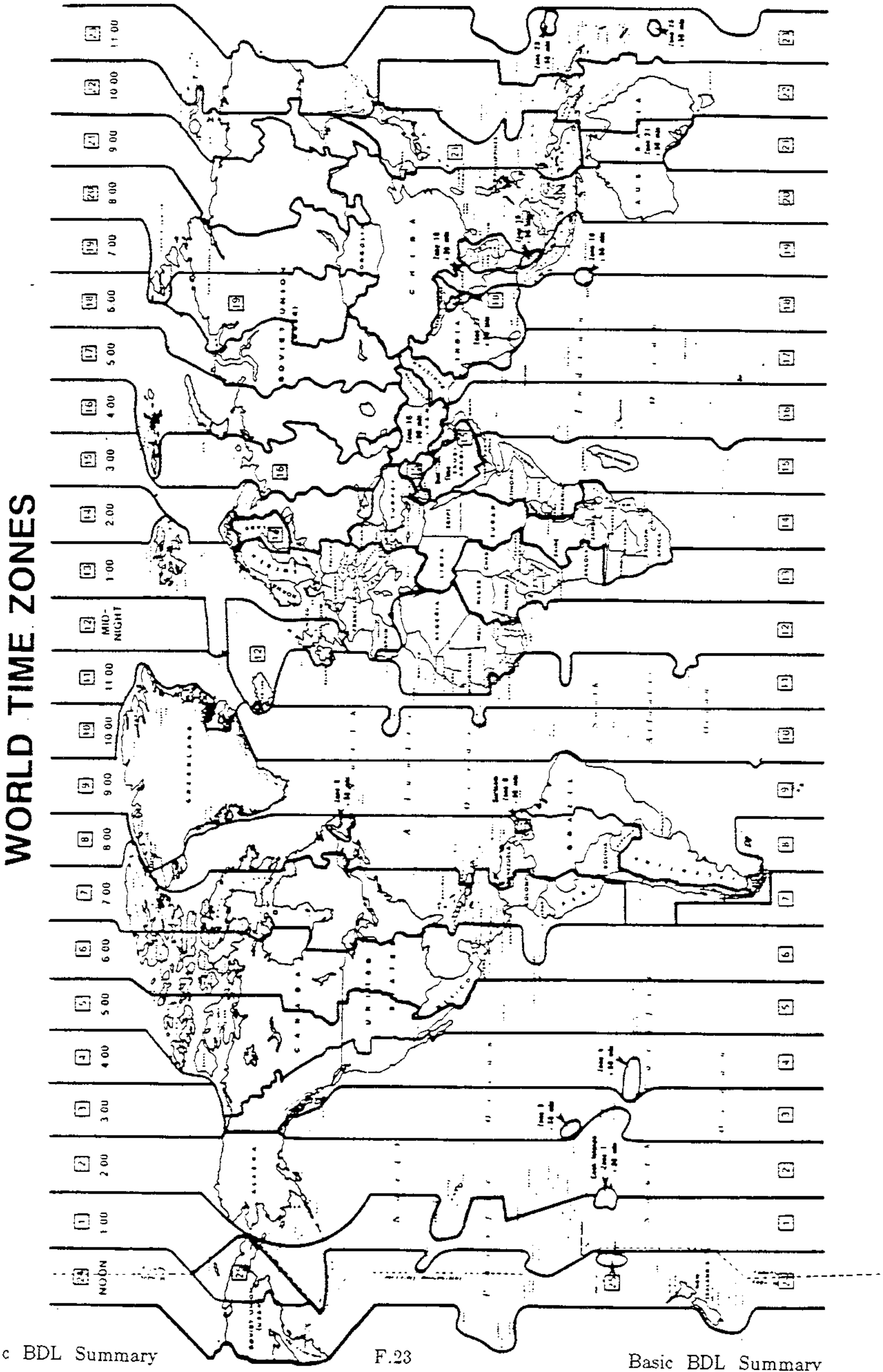
COMPUTE ECONOMICS
Required for Economics simulation

STOP
Use only if want BDL and simulation to stop here

Geographical Data for the 50 Largest U.S. Cities

State	City	Lat.	Long.	Time Zone
Arizona	Phoenix	33.45	112.07	7
	Tucson	32.13	110.58	7
California	Fresno	36.43	119.47	8
	Long Beach	33.78	118.18	8
	Los Angeles	34.07	118.25	8
	Oakland	37.82	122.27	8
	Sacramento	38.35	121.29	8
	San Diego	32.72	117.15	8
	San Francisco	37.78	122.42	8
	San Jose	37.33	121.88	8
Colorado	Denver	39.73	104.98	7
Florida	Jacksonville	30.33	81.65	5
	Miami	25.78	80.18	5
Georgia	Atlanta	33.75	84.38	5
Hawaii	Honolulu	21.32	157.87	10
Illinois	Chicago	41.88	87.63	6
Indiana	Indianapolis	39.77	86.15	5
Louisiana	New Orleans	29.97	90.07	6
Maryland	Baltimore	39.28	76.62	5
Massachusetts	Boston	42.37	71.07	5
Michigan	Detroit	42.33	83.00	5
Minnesota	Minneapolis	44.98	93.27	6
Missouri	Kansas City	39.10	94.58	6
	Saint Louis	38.62	90.20	6
Nebraska	Omaha	41.28	96.02	6
New Mexico	Albuquerque	35.05	106.39	6
New York	Buffalo	42.88	78.88	5
	New York	40.72	74.00	5
North Carolina	Charlotte	35.13	80.5	5
Ohio	Cincinnati	39.10	84.52	5
	Cleveland	41.50	81.70	5
	Columbus	39.97	83.00	5
	Toledo	41.65	83.55	5
Oklahoma	Oklahoma City	35.50	97.50	6
	Tulsa	36.17	95.92	6

Oregon	Portland	45.53	122.62	8
Pennsylvania	Philadelphia	39.95	75.17	5
	Pittsburgh	40.43	80.02	5
Tennessee	Memphis	35.13	90.05	6
	Nashville	36.17	86.78	6
Texas	Austin	30.16	97.44	6
	Dallas	32.78	96.82	6
	El Paso	31.75	106.48	7
	Fort Worth	32.75	97.30	6
	Houston	29.77	95.37	6
	San Antonio	29.42	98.50	6
Virginia	Virginia Beach	36.5	75.58	5
Washington	Seattle	47.60	122.33	8
Wisconsin	Milwaukee	43.03	87.92	6
D.C.	Washington	38.90	77.03	5


WORLD TIME ZONES
23 11:00
22 10:00
21 9:00
20 8:00
19 7:00
18 6:00
17 5:00
16 4:00
15 3:00
14 2:00
13 1:00
12 MID-NIGHT
11 11:00
10 10:00
9 9:00
8 8:00
7 7:00
6 6:00
5 5:00
4 4:00
3 3:00
2 2:00
1 1:00
24 NOON
CHINA
INDIA
SOVIET UNION
GREENLAND
CANADA
UNITED STATES
BRAZIL
AUSTRALIA

PERPETUAL CALENDAR

INDEX

1776	9	1801	5	1826	1	1851	4	1876	14	1901	3	1926	6	1951	2	1976	12
1777	4	1802	6	1827	2	1852	12	1877	2	1902	4	1927	7	1952	10	1977	7
1778	5	1803	7	1828	10	1853	7	1878	3	1903	5	1928	8	1953	5	1978	1
1779	6	1804	8	1829	5	1854	1	1879	4	1904	13	1929	3	1954	6	1979	2
1780	14	1805	3	1830	6	1855	2	1880	12	1905	1	1930	4	1955	7	1980	10
1781	2	1806	4	1831	7	1856	10	1881	7	1906	2	1931	5	1956	8	1981	5
1782	3	1807	5	1832	8	1857	5	1882	1	1907	3	1932	13	1957	3	1982	6
1783	4	1808	13	1833	3	1858	6	1883	2	1908	11	1933	1	1958	4	1983	7
1784	12	1809	1	1834	4	1859	7	1884	10	1909	6	1934	2	1959	5	1984	8
1785	7	1810	2	1835	5	1860	8	1886	5	1910	7	1935	3	1960	13	1985	3
1786	1	1811	3	1836	13	1861	3	1886	6	1911	1	1936	11	1961	1	1986	4
1787	2	1812	11	1837	1	1862	4	1887	7	1912	9	1937	6	1962	2	1987	5
1788	10	1813	6	1838	2	1863	5	1888	8	1913	4	1938	7	1963	3	1988	13
1789	5	1814	7	1839	3	1864	13	1889	3	1914	5	1939	1	1964	11	1989	1
1790	6	1815	1	1840	11	1865	1	1890	4	1915	6	1940	9	1965	6	1990	2
1791	7	1816	9	1841	6	1866	2	1891	5	1916	14	1941	4	1966	7	1991	3
1792	8	1817	4	1842	7	1867	3	1892	13	1917	2	1942	5	1967	1	1992	11
1793	3	1818	5	1843	1	1868	11	1893	1	1918	3	1943	6	1968	9	1993	6
1794	4	1819	6	1844	9	1869	6	1894	2	1919	4	1944	14	1969	4	1994	7
1795	5	1820	14	1845	4	1870	7	1895	3	1920	12	1945	2	1970	5	1995	1
1796	13	1821	2	1846	5	1871	1	1896	11	1921	7	1946	3	1971	6	1996	9
1797	1	1822	3	1847	6	1872	9	1897	6	1922	1	1947	4	1972	14	1997	4
1798	2	1823	4	1848	14	1873	4	1898	7	1923	2	1948	12	1973	2	1998	5
1799	3	1824	12	1849	2	1874	5	1899	1	1924	10	1949	7	1974	3	1999	6
1800	4	1825	7	1850	3	1875	6	1900	2	1925	5	1950	1	1975	4	2000	14

```
|                          Year 1                              |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
| 1  2  3  4  5  6  7|          1  2  3  4|          1  2  3  4|
| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11| 5  6  7  8  9 10 11|
|15 16 17 18 19 20 21|12 13 14 15 16 17 18|12 13 14 15 16 17 18|
|22 23 24 25 26 27 28|19 20 21 22 23 24 25|19 20 21 22 23 24 25|
|29 30 31            |26 27 28            |26 27 28 29 30 31   |
|-------APRIL--------|--------MAY---------|--------JUNE--------|
|                   1|    1  2  3  4  5  6|             1  2  3|
| 2  3  4  5  6  7  8| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10|
| 9 10 11 12 13 14 15|14 15 16 17 18 19 20|11 12 13 14 15 16 17|
|16 17 18 19 20 21 22|21 22 23 24 25 26 27|18 19 20 21 22 23 24|
|23 24 25 26 27 28 29|28 29 30 31         |25 26 27 28 29 30   |
|30                  |                    |                    |
|--------JULY--------|-------AUGUST-------|-----SEPTEMBER------|
|                   1|       1  2  3  4  5|                1  2|
| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9|
| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|10 11 12 13 14 15 16|
|16 17 18 19 20 21 22|20 21 22 23 24 25 26|17 18 19 20 21 22 23|
|23 24 25 26 27 28 29|27 28 29 30 31      |24 25 26 27 28 29 30|
|30 31               |                    |                    |
|------OCTOBER-------|------NOVEMBER------|------DECEMBER------|
| 1  2  3  4  5  6  7|          1  2  3  4|                1  2|
| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11| 3  4  5  6  7  8  9|
|15 16 17 18 19 20 21|12 13 14 15 16 17 18|10 11 12 13 14 15 16|
|22 23 24 25 26 27 28|19 20 21 22 23 24 25|17 18 19 20 21 22 23|
|29 30 31            |26 27 28 29 30      |24 25 26 27 28 29 30|
|____________________|____________________|31__________________|
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|                          Year 2                              |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|    1  2  3  4  5  6|             1  2  3|             1  2  3|
| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10| 4  5  6  7  8  9 10|
|14 15 16 17 18 19 20|11 12 13 14 15 16 17|11 12 13 14 15 16 17|
|21 22 23 24 25 26 27|18 19 20 21 22 23 24|18 19 20 21 22 23 24|
|28 29 30 31         |25 26 27 28         |25 26 27 28 29 30 31|
|-------APRIL--------|--------MAY---------|-------JUNE---------|
| 1  2  3  4  5  6  7|       1  2  3  4  5|                1  2|
| 8  9 10 11 12 13 14| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9|
|15 16 17 18 19 20 21|13 14 15 16 17 18 19|10 11 12 13 14 15 16|
|22 23 24 25 26 27 28|20 21 22 23 24 25 26|17 18 19 20 21 22 23|
|29 30               |27 28 29 30 31      |24 25 26 27 28 29 30|
|--------JULY--------|-------AUGUST-------|-----SEPTEMBER------|
| 1  2  3  4  5  6  7|          1  2  3  4|                   1|
| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8|
|15 16 17 18 19 20 21|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|
|22 23 24 25 26 27 28|19 20 21 22 23 24 25|16 17 18 19 20 21 22|
|29 30 31            |26 27 28 29 30 31   |23 24 25 26 27 28 29|
|-------OCTOBER------|------NOVEMBER------|30---DECEMBER-------|
|    1  2  3  4  5  6|             1  2  3|                   1|
| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10| 2  3  4  5  6  7  8|
|14 15 16 17 18 19 20|11 12 13 14 15 16 17| 9 10 11 12 13 14 15|
|21 22 23 24 25 26 27|18 19 20 21 22 23 24|16 17 18 19 20 21 22|
|28 29 30 31         |25 26 27 28 29 30   |23 24 25 26 27 28 29|
|____________________|____________________|30_31_______________|
```

Note: The program and the weather files use a 365 day year even for leap years. Therefore, in leap years, the calendar and the program get one day out of step with regard to days of the week after February 29. When using the perpetual calendar for leap years, shift back one day of the week for dates after February 29.

PERPETUAL CALENDAR

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 ______________________________________________________________
|                            Year 3                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|       1  2  3  4  5|                1  2|                1  2|
| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9| 3  4  5  6  7  8  9|
|13 14 15 16 17 18 19|10 11 12 13 14 15 16|10 11 12 13 14 15 16|
|20 21 22 23 24 25 26|17 18 19 20 21 22 23|17 18 19 20 21 22 23|
|27 28 29 30 31      |24 25 26 27 28      |24 25 26 27 28 29 30|
|-------APRIL--------|--------MAY---------|31-----JUNE---------|
|    1  2  3  4  5  6|          1  2  3  4|                   1|
| 7  8  9 10 11 12 13| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8|
|14 15 16 17 18 19 20|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|
|21 22 23 24 25 26 27|19 20 21 22 23 24 25|16 17 18 19 20 21 22|
|28 29 30            |26 27 28 29 30 31   |23 24 25 26 27 28 29|
|-------JULY---------|------AUGUST--------|30---SEPTEMBER------|
|    1  2  3  4  5  6|             1  2  3| 1  2  3  4  5  6  7|
| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14|
|14 15 16 17 18 19 20|11 12 13 14 15 16 17|15 16 17 18 19 20 21|
|21 22 23 24 25 26 27|18 19 20 21 22 23 24|22 23 24 25 26 27 28|
|28 29 30 31         |25 26 27 28 29 30 31|29 30               |
|-------OCTOBER------|------NOVEMBER------|-----DECEMBER-------|
|       1  2  3  4  5|                1  2| 1  2  3  4  5  6  7|
| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9| 8  9 10 11 12 13 14|
|13 14 15 16 17 18 19|10 11 12 13 14 15 16|15 16 17 18 19 20 21|
|20 21 22 23 24 25 26|17 18 19 20 21 22 23|22 23 24 25 26 27 28|
|27 28 29 30 31      |24 25 26 27 28 29 30|29 30 31            |
|____________________|____________________|____________________|
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 ______________________________________________________________
|                            Year 4                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|          1  2  3  4|                   1|                   1|
| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8| 2  3  4  5  6  7  8|
|12 13 14 15 16 17 18| 9 10 11 12 13 14 15| 9 10 11 12 13 14 15|
|19 20 21 22 23 24 25|16 17 18 19 20 21 22|16 17 18 19 20 21 22|
|26 27 28 29 30 31   |23 24 25 26 27 28   |23 24 25 26 27 28 29|
|-------APRIL--------|--------MAY---------|30-31--JUNE---------|
|       1  2  3  4  5|             1  2  3| 1  2  3  4  5  6  7|
| 6  7  8  9 10 11 12| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14|
|13 14 15 16 17 18 19|11 12 13 14 15 16 17|15 16 17 18 19 20 21|
|20 21 22 23 24 25 26|18 19 20 21 22 23 24|22 23 24 25 26 27 28|
|27 28 29 30         |25 26 27 28 29 30 31|29 30               |
|-------JULY---------|------AUGUST--------|-----SEPTEMBER------|
|       1  2  3  4  5|                1  2|    1  2  3  4  5  6|
| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13|
|13 14 15 16 17 18 19|10 11 12 13 14 15 16|14 15 16 17 18 19 20|
|20 21 22 23 24 25 26|17 18 19 20 21 22 23|21 22 23 24 25 26 27|
|27 28 29 30 31      |24 25 26 27 28 29 30|28 29 30            |
|-------OCTOBER------|31----NOVEMBER------|-----DECEMBER-------|
|          1  2  3  4|                   1|    1  2  3  4  5  6|
| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8| 7  8  9 10 11 12 13|
|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|14 15 16 17 18 19 20|
|19 20 21 22 23 24 25|16 17 18 19 20 21 22|21 22 23 24 25 26 27|
|26 27 28 29 30 31   |23 24 25 26 27 28 29|28 29 30 31         |
|____________________|30__________________|____________________|
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 ______________________________________________________________
|                            Year 5                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|             1  2  3| 1  2  3  4  5  6  7| 1  2  3  4  5  6  7|
| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14| 8  9 10 11 12 13 14|
|11 12 13 14 15 16 17|15 16 17 18 19 20 21|15 16 17 18 19 20 21|
|18 19 20 21 22 23 24|22 23 24 25 26 27 28|22 23 24 25 26 27 28|
|25 26 27 28 29 30 31|                    |29 30 31            |
|-------APRIL--------|--------MAY---------|-------JUNE---------|
|          1  2  3  4|                1  2|    1  2  3  4  5  6|
| 5  6  7  8  9 10 11| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13|
|12 13 14 15 16 17 18|10 11 12 13 14 15 16|14 15 16 17 18 19 20|
|19 20 21 22 23 24 25|17 18 19 20 21 22 23|21 22 23 24 25 26 27|
|26 27 28 29 30      |24 25 26 27 28 29 30|28 29 30            |
|-------JULY---------|31----AUGUST--------|-----SEPTEMBER------|
|          1  2  3  4|                   1|       1  2  3  4  5|
| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12|
|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|
|19 20 21 22 23 24 25|16 17 18 19 20 21 22|20 21 22 23 24 25 26|
|26 27 28 29 30 31   |23 24 25 26 27 28 29|27 28 29 30         |
|                    |30 31               |                    |
|-------OCTOBER------|------NOVEMBER------|-----DECEMBER-------|
|             1  2  3| 1  2  3  4  5  6  7|       1  2  3  4  5|
| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14| 6  7  8  9 10 11 12|
|11 12 13 14 15 16 17|15 16 17 18 19 20 21|13 14 15 16 17 18 19|
|18 19 20 21 22 23 24|22 23 24 25 26 27 28|20 21 22 23 24 25 26|
|25 26 27 28 29 30 31|29 30               |27 28 29 30 31      |
|____________________|____________________|____________________|
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 ______________________________________________________________
|                            Year 6                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|                1  2|    1  2  3  4  5  6|    1  2  3  4  5  6|
| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13| 7  8  9 10 11 12 13|
|10 11 12 13 14 15 16|14 15 16 17 18 19 20|14 15 16 17 18 19 20|
|17 18 19 20 21 22 23|21 22 23 24 25 26 27|21 22 23 24 25 26 27|
|24 25 26 27 28 29 30|28                  |28 29 30 31         |
|31-----APRIL--------|--------MAY---------|-------JUNE---------|
|             1  2  3|                   1|       1  2  3  4  5|
| 4  5  6  7  8  9 10| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12|
|11 12 13 14 15 16 17| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|
|18 19 20 21 22 23 24|16 17 18 19 20 21 22|20 21 22 23 24 25 26|
|25 26 27 28 29 30   |23 24 25 26 27 28 29|27 28 29 30         |
|                    |30 31               |                    |
|-------JULY---------|------AUGUST--------|-----SEPTEMBER------|
|             1  2  3| 1  2  3  4  5  6  7|          1  2  3  4|
| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11|
|11 12 13 14 15 16 17|15 16 17 18 19 20 21|12 13 14 15 16 17 18|
|18 19 20 21 22 23 24|22 23 24 25 26 27 28|19 20 21 22 23 24 25|
|25 26 27 28 29 30 31|29 30 31            |26 27 28 29 30      |
|-------OCTOBER------|------NOVEMBER------|-----DECEMBER-------|
|                1  2|    1  2  3  4  5  6|          1  2  3  4|
| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13| 5  6  7  8  9 10 11|
|10 11 12 13 14 15 16|14 15 16 17 18 19 20|12 13 14 15 16 17 18|
|17 18 19 20 21 22 23|21 22 23 24 25 26 27|19 20 21 22 23 24 25|
|24 25 26 27 28 29 30|28 29 30            |26 27 28 29 30 31   |
|31__________________|____________________|____________________|
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 ______________________________________________________________
|                            Year 7                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|                   1|       1  2  3  4  5|       1  2  3  4  5|
| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12| 6  7  8  9 10 11 12|
| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|13 14 15 16 17 18 19|
|16 17 18 19 20 21 22|20 21 22 23 24 25 26|20 21 22 23 24 25 26|
|23 24 25 26 27 28 29|27 28               |27 28 29 30 31      |
|30 31               |                    |                    |
|30-31--APRIL--------|---------MAY--------|--------JUNE--------|
|                1  2| 1  2  3  4  5  6  7|          1  2  3  4|
| 3  4  5  6  7  8  9| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11|
|10 11 12 13 14 15 16|15 16 17 18 19 20 21|12 13 14 15 16 17 18|
|17 18 19 20 21 22 23|22 23 24 25 26 27 28|19 20 21 22 23 24 25|
|24 25 26 27 28 29 30|29 30 31            |26 27 28 29 30      |
|--------JULY--------|-------AUGUST-------|-----SEPTEMBER------|
|                1  2|    1  2  3  4  5  6|             1  2  3|
| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10|
|10 11 12 13 14 15 16|14 15 16 17 18 19 20|11 12 13 14 15 16 17|
|17 18 19 20 21 22 23|21 22 23 24 25 26 27|18 19 20 21 22 23 24|
|24 25 26 27 28 29 30|28 29 30 31         |25 26 27 28 29 30   |
|31-----OCTOBER------|------NOVEMBER------|------DECEMBER------|
|                   1|       1  2  3  4  5|             1  2  3|
| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12| 4  5  6  7  8  9 10|
| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|11 12 13 14 15 16 17|
|16 17 18 19 20 21 22|20 21 22 23 24 25 26|18 19 20 21 22 23 24|
|23 24 25 26 27 28 29|27 28 29 30         |25 26 27 28 29 30 31|
|30 31_______________|____________________|____________________|
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 ______________________________________________________________
|                            Year 8                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
| 1  2  3  4  5  6  7|          1  2  3  4|             1  2  3|
| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11| 4  5  6  7  8  9 10|
|15 16 17 18 19 20 21|12 13 14 15 16 17 18|11 12 13 14 15 16 17|
|22 23 24 25 26 27 28|19 20 21 22 23 24 25|18 19 20 21 22 23 24|
|29 30 31            |26 27 28 29         |25 26 27 28 29 30 31|
|-------APRIL--------|---------MAY--------|--------JUNE--------|
| 1  2  3  4  5  6  7|       1  2  3  4  5|                1  2|
| 8  9 10 11 12 13 14| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9|
|15 16 17 18 19 20 21|13 14 15 16 17 18 19|10 11 12 13 14 15 16|
|22 23 24 25 26 27 28|20 21 22 23 24 25 26|17 18 19 20 21 22 23|
|29 30               |27 28 29 30 31      |24 25 26 27 28 29 30|
|--------JULY--------|-------AUGUST-------|-----SEPTEMBER------|
| 1  2  3  4  5  6  7|          1  2  3  4|                   1|
| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8|
|15 16 17 18 19 20 21|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|
|22 23 24 25 26 27 28|19 20 21 22 23 24 25|16 17 18 19 20 21 22|
|29 30 31            |26 27 28 29 30 31   |23 24 25 26 27 28 29|
|-------OCTOBER------|------NOVEMBER------|30---DECEMBER-------|
|    1  2  3  4  5  6|             1  2  3|                   1|
| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10| 2  3  4  5  6  7  8|
|14 15 16 17 18 19 20|11 12 13 14 15 16 17| 9 10 11 12 13 14 15|
|21 22 23 24 25 26 27|18 19 20 21 22 23 24|16 17 18 19 20 21 22|
|28 29 30 31         |25 26 27 28 29 30   |23 24 25 26 27 28 29|
|____________________|____________________|30_31_______________|
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 ______________________________________________________________
|                            Year 9                            |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|    1  2  3  4  5  6|             1  2  3|                1  2|
| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10| 3  4  5  6  7  8  9|
|14 15 16 17 18 19 20|11 12 13 14 15 16 17|10 11 12 13 14 15 16|
|21 22 23 24 25 26 27|18 19 20 21 22 23 24|17 18 19 20 21 22 23|
|28 29 30 31         |25 26 27 28 29      |24 25 26 27 28 29 30|
|-------APRIL--------|---------MAY--------|31-----JUNE---------|
|    1  2  3  4  5  6|          1  2  3  4|                   1|
| 7  8  9 10 11 12 13| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8|
|14 15 16 17 18 19 20|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|
|21 22 23 24 25 26 27|19 20 21 22 23 24 25|16 17 18 19 20 21 22|
|28 29 30            |26 27 28 29 30 31   |23 24 25 26 27 28 29|
|--------JULY--------|-------AUGUST-------|30---SEPTEMBER------|
|    1  2  3  4  5  6|             1  2  3| 1  2  3  4  5  6  7|
| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14|
|14 15 16 17 18 19 20|11 12 13 14 15 16 17|15 16 17 18 19 20 21|
|21 22 23 24 25 26 27|18 19 20 21 22 23 24|22 23 24 25 26 27 28|
|28 29 30 31         |25 26 27 28 29 30 31|29 30               |
|-------OCTOBER------|------NOVEMBER------|------DECEMBER------|
|       1  2  3  4  5|                1  2| 1  2  3  4  5  6  7|
| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9| 8  9 10 11 12 13 14|
|13 14 15 16 17 18 19|10 11 12 13 14 15 16|15 16 17 18 19 20 21|
|20 21 22 23 24 25 26|17 18 19 20 21 22 23|22 23 24 25 26 27 28|
|27 28 29 30 31      |24 25 26 27 28 29 30|29 30 31            |
|____________________|____________________|____________________|
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 ______________________________________________________________
|                            Year 10                           |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|       1  2  3  4  5|                1  2|                   1|
| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9| 2  3  4  5  6  7  8|
|13 14 15 16 17 18 19|10 11 12 13 14 15 16| 9 10 11 12 13 14 15|
|20 21 22 23 24 25 26|17 18 19 20 21 22 23|16 17 18 19 20 21 22|
|27 28 29 30 31      |24 25 26 27 28 29   |23 24 25 26 27 28 29|
|                    |                    |30 31               |
|-------APRIL--------|---------MAY--------|--------JUNE--------|
|    1  1  2  3  4  5|             1  2  3| 1  2  3  4  5  6  7|
| 6  7  8  9 10 11 12| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14|
|13 14 15 16 17 18 19|11 12 13 14 15 16 17|15 16 17 18 19 20 21|
|20 21 22 23 24 25 26|18 19 20 21 22 23 24|22 23 24 25 26 27 28|
|27 28 29 30         |25 26 27 28 29 30 31|29 30               |
|--------JULY--------|-------AUGUST-------|-----SEPTEMBER------|
|       1  2  3  4  5|                1  2|    1  2  3  4  5  6|
| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13|
|13 14 15 16 17 18 19|10 11 12 13 14 15 16|14 15 16 17 18 19 20|
|20 21 22 23 24 25 26|17 18 19 20 21 22 23|21 22 23 24 25 26 27|
|27 28 29 30 31      |24 25 26 27 28 29 30|28 29 30            |
|-------OCTOBER------|31----NOVEMBER------|------DECEMBER------|
|          1  2  3  4|                   1|    1  2  3  4  5  6|
| 5  6  7  8  9 10 11| 2  3  4  5  6  7  8| 7  8  9 10 11 12 13|
|12 13 14 15 16 17 18| 9 10 11 12 13 14 15|14 15 16 17 18 19 20|
|19 20 21 22 23 24 25|16 17 18 19 20 21 22|21 22 23 24 25 26 27|
|26 27 28 29 30 31   |23 24 25 26 27 28 29|28 29 30 31         |
|____________________|30__________________|____________________|
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PERPETUAL CALENDAR

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                              Year 11                      |
___________________________________________________________|
 W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
ANUARY     |      FEBRUARY      |       MARCH        |
 1  2  3  4|                   1| 1  2  3  4  5  6  7|
 8  9 10 11| 2  3  4  5  6  7  8| 8  9 10 11 12 13 14|
15 16 17 18| 9 10 11 12 13 14 15|15 16 17 18 19 20 21|
22 23 24 25|16 17 18 19 20 21 22|22 23 24 25 26 27 28|
29 30 31   |23 24 25 26 27 28 29|29 30 31            |
PRIL-------|--------MAY---------|-------JUNE---------|
 1  2  3  4|                1  2|    1  2  3  4  5  6|
 8  9 10 11| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13|
15 16 17 18|10 11 12 13 14 15 16|14 15 16 17 18 19 20|
22 23 24 25|17 18 19 20 21 22 23|21 22 23 24 25 26 27|
29 30      |24 25 26 27 28 29 30|28 29 30            |
LY---------|31----AUGUST--------|-----SEPTEMBER------|
 1  2  3  4|                   1|       1  2  3  4  5|
 8  9 10 11| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12|
15 16 17 18| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|
22 23 24 25|16 17 18 19 20 21 22|20 21 22 23 24 25 26|
29 30 31   |23 24 25 26 27 28 29|27 28 29 30         |
           |30 31               |                    |
OBER-------|------NOVEMBER------|-----DECEMBER-------|
    1  2  3| 1  2  3  4  5  6  7|       1  2  3  4  5|
    8  9 10| 8  9 10 11 12 13 14| 6  7  8  9 10 11 12|
   15 16 17|15 16 17 18 19 20 21|13 14 15 16 17 18 19|
   22 23 24|22 23 24 25 26 27 28|20 21 22 23 24 25 26|
   29 30 31|29 30               |27 28 29 30 31      |
___________|____________________|____________________|
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|                         Year 12                              |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|             1  2  3| 1  2  3  4  5  6  7|    1  2  3  4  5  6|
| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14| 7  8  9 10 11 12 13|
|11 12 13 14 15 16 17|15 16 17 18 19 20 21|14 15 16 17 18 19 20|
|18 19 20 21 22 23 24|22 23 24 25 26 27 28|21 22 23 24 25 26 27|
|25 26 27 28 29 30 31|29                  |28 29 30 31         |
|-------APRIL--------|--------MAY---------|-------JUNE---------|
|             1  2  3|                   1|       1  2  3  4  5|
| 4  5  6  7  8  9 10| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12|
|11 12 13 14 15 16 17| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|
|18 19 20 21 22 23 24|16 17 18 19 20 21 22|20 21 22 23 24 25 26|
|25 26 27 28 29 30   |23 24 25 26 27 28 29|27 28 29 30         |
|                    |30 31               |                    |
|-------JULY---------|------AUGUST--------|-----SEPTEMBER------|
|             1  2  3| 1  2  3  4  5  6  7|          1  2  3  4|
| 4  5  6  7  8  9 10| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11|
|11 12 13 14 15 16 17|15 16 17 18 19 20 21|12 13 14 15 16 17 18|
|18 19 20 21 22 23 24|22 23 24 25 26 27 28|19 20 21 22 23 24 25|
|25 26 27 28 29 30 31|29 30 31            |26 27 28 29 30      |
|-------OCTOBER------|------NOVEMBER------|-----DECEMBER-------|
|                1  2|    1  2  3  4  5  6|          1  2  3  4|
| 3  4  5  6  7  8  9| 7  8  9 10 11 12 13| 5  6  7  8  9 10 11|
|10 11 12 13 14 15 16|14 15 16 17 18 19 20|12 13 14 15 16 17 18|
|17 18 19 20 21 22 23|21 22 23 24 25 26 27|19 20 21 22 23 24 25|
|24 25 26 27 28 29 30|28 29 30            |26 27 28 29 30 31   |
|31                  |                    |                    |
|____________________|____________________|____________________|
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                      Year 13                    |
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Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
Y       |      FEBRUARY      |       MARCH        |
    1  2|    1  2  3  4  5  6|       1  2  3  4  5|
 7  8  9| 7  8  9 10 11 12 13| 6  7  8  9 10 11 12|
   15 16|14 15 16 17 18 19 20|13 14 15 16 17 18 19|
   22 23|21 22 23 24 25 26 27|20 21 22 23 24 25 26|
   29 30|28 29               |27 28 29 30 31      |
        |                    |                    |
  ------|--------MAY---------|-------JUNE---------|
    1  2| 1  2  3  4  5  6  7|          1  2  3  4|
    8  9| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11|
   15 16|15 16 17 18 19 20 21|12 13 14 15 16 17 18|
   22 23|22 23 24 25 26 27 28|19 20 21 22 23 24 25|
   29 30|29 30 31            |26 27 28 29 30      |
   -----|------AUGUST--------|-----SEPTEMBER------|
    1  2|    1  2  3  4  5  6|             1  2  3|
    8  9| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10|
   15 16|14 15 16 17 18 19 20|11 12 13 14 15 16 17|
    2 23|21 22 23 24 25 26 27|18 19 20 21 22 23 24|
    9 30|28 29 30 31         |25 26 27 28 29 30   |
    ----|------NOVEMBER------|-----DECEMBER-------|
       1|       1  2  3  4  5|             1  2  3|
       8| 6  7  8  9 10 11 12| 4  5  6  7  8  9 10|
      15|13 14 15 16 17 18 19|11 12 13 14 15 16 17|
      22|20 21 22 23 24 25 26|18 19 20 21 22 23 24|
      29|27 28 29 30         |25 26 27 28 29 30 31|
        |                    |                    |
  ______|____________________|____________________|
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|                          Year 14                             |
|______________________________________________________________|
| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S| S  M Tu  W Th  F  S|
|      JANUARY       |      FEBRUARY      |       MARCH        |
|                   1|       1  2  3  4  5|          1  2  3  4|
| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12| 5  6  7  8  9 10 11|
| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|12 13 14 15 16 17 18|
|16 17 18 19 20 21 22|20 21 22 23 24 25 26|19 20 21 22 23 24 25|
|23 24 25 26 27 28 29|27 28 29            |26 27 28 29 30 31   |
|30 31               |                    |                    |
|-------APRIL--------|--------MAY---------|-------JUNE---------|
|                   1|    1  2  3  4  5  6|             1  2  3|
| 2  3  4  5  6  7  8| 7  8  9 10 11 12 13| 4  5  6  7  8  9 10|
| 9 10 11 12 13 14 15|14 15 16 17 18 19 20|11 12 13 14 15 16 17|
|16 17 18 19 20 21 22|21 22 23 24 25 26 27|18 19 20 21 22 23 24|
|23 24 25 26 27 28 29|28 29 30 31         |25 26 27 28 29 30   |
|30-----JULY---------|------AUGUST--------|-----SEPTEMBER------|
|                   1|       1  2  3  4  5|                1  2|
| 2  3  4  5  6  7  8| 6  7  8  9 10 11 12| 3  4  5  6  7  8  9|
| 9 10 11 12 13 14 15|13 14 15 16 17 18 19|10 11 12 13 14 15 16|
|16 17 18 19 20 21 22|20 21 22 23 24 25 26|17 18 19 20 21 22 23|
|23 24 25 26 27 28 29|27 28 29 30 31      |24 25 26 27 28 29 30|
|30 31               |                    |                    |
|-------OCTOBER------|------NOVEMBER------|-----DECEMBER-------|
| 1  2  3  4  5  6  7|          1  2  3  4|                1  2|
| 8  9 10 11 12 13 14| 5  6  7  8  9 10 11| 3  4  5  6  7  8  9|
|15 16 17 18 19 20 21|12 13 14 15 16 17 18|10 11 12 13 14 15 16|
|22 23 24 25 26 27 28|19 20 21 22 23 24 25|17 18 19 20 21 22 23|
|29 30 31            |26 27 28 29 30      |24 25 26 27 28 29 30|
|____________________|____________________|31__________________|
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