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DOE-2 REFERENCE MANUAL

PART 1

Version 2.1

Group WX-4, Program Support
Los Alamos Scientific Laboratory
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DOE-2 REFERENCE MANUAL

(Version 2.1A)

Part 1

Group Q-11, Solar Energy Group
Los Alamos National Laboratory
Los Alamos, NM 87545

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May 1981

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NOTICE

The explicit function of this computer program is to aid in the analysis of energy consumption in buildings. This program is not intended to be the sole source of information relied upon for the design of buildings. The basic authority that should be relied upon is the judgment and experience of the architect/engineer.

The technical information in this computer program has been compiled from the best available sources and is believed to be correct. Many of the equations and much of the methodology used are based on the algorithms published by the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE), described in Ref. 1. However, this edition of the Reference Manual does not reflect ASHRAE review comment.

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(Revised 5/81)

ENGINEERS MANUAL RELEASE

The DOE 2.1A Engineers Manual will not be released at the same time as the DOE 2.1A Reference Manual, BDL Summary, Users Guide, and Sample Run Book. The DOE-2.1A Engineers Manual is currently estimated to be released in the spring of 1982.

Often throughout this manual, the user will be referred to the Engineers Manual, which will not exist until later. We apologize for this inconvenience.

USER EVALUATION
DOE-2.1 REFERENCE MANUAL

The editors of the DOE-2.1 Reference Manual would appreciate your comments as a user of the manual. Please take a few minutes to answer these questions and return this sheet to Bruce D. Hunn, Los Alamos National Laboratory, Group Q-11, MS 571, P. O. Box 1663, Los Alamos, NM 87545 (telephone: commercial (505) 667-6441; FTS 843-6441).

1. Are you, as a user of this manual, serving as ___ an engineer, ___ a computer programmer, ___ other ______________________________?

   Do you find that the manual contains
   ___ too much ___ not enough ___ the right amount
   of user-instruction detail?

   Do you find that the manual contains
   ___ too much ___ not enough ___ the right amount
   of program and data-structure detail?

2. What is the date of the last revision to your manual? ____________

3. Does the manual largely provide the information you need?
   ___ yes ___ no ___ partially

   If your answer is not "yes," would you briefly describe the information you find lacking?

4. If you feel that the organization, format, or presentation clarity could be improved, what suggestions can you give us?

5. Have you found any errors? If so, would you please indicate them?

   Error in Chapter _______, page _________
   Nature of error:

   Chapter _______, page _________
   Nature of error:

Please feel free to continue your comments on the back of this page.

Thank you.

(Revised 5/81)

NOTE TO THE BEGINNING DOE-2 USER

The beginning user should not be overwhelmed by the size of this Reference Manual. A large portion of this manual will never by used by you as an individual user; however, all the material has been included because some user, somewhere, will need it eventually.

It is not recommended that you attempt to read this manual as if it were a "novel". Rather, this manual should be read as if it were an "encyclopedia". Look for what you need and, for the moment, ignore the rest. Only after you have an application, or a problem to solve, will this manual become truly useful.

It is recommended that you, as a beginning user, follow the following steps in getting started with DOE-2:

1. Read the Introduction (Chap. I).

2. Review BDL (Chap. II), but do not attempt to memorize it.

3. Find a real problem or application and then acquire (or originate):

   a. Site layout
   b. Floor plan of each floor, elevations, construction details
   c. Mechanical schematic or drawing
   d. Equipment specs.

4. Read the Introduction to LOADS (Chap. III) and then make a LOADS run (using the appropriate User Worksheets).

5. Read the Introduction to SYSTEMS (Chap. IV), determine your SYSTEM-TYPE, and then make a SYSTEMS run (using the appropriate Applicability Table and User Worksheets).

6. Read the Introduction to PLANT (Chap. V) and then make a PLANT run (using the appropriate User Worksheets).

7. Read the Introduction to ECONOMICS (Chap. VI) and then make an ECONOMICS run (using the appropriate User Worksheets).

8. Conduct PARAMETRIC-INPUT runs on LOADS, SYSTEMS, PLANT, and ECONOMICS.

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ABSTRACT

This document describes the DOE-2 computer program, which is capable of rapid and detailed analysis of energy consumption in buildings. A new, user-oriented language, the Building Description Language, has been written to allow simplified manipulation of the many variables used to describe a building and its operation. DOE-2 includes:

1. a Building Description Language (BDL) program to analyze the input instructions, perform data assignments and data retrieval, and control the operation of the LOADS, SYSTEMS, PLANT, ECONOMICS, and REPORT programs;

2. a LOADS analysis program, which calculates peak, or design, loads and hourly space loads imposed by ambient weather conditions and internal occupancy, lighting, and equipment, as well as by variations in the size, location, orientation, construction, and materials for walls, roofs, floors, fenestrations, attachments (e.g., awnings or balconies), and the shape of a building;

3. a SYSTEMS program capable of simulating the operation of secondary Heating, Ventilating, and Air-Conditioning (HVAC) components, including fans, coils, economizers, and humidifiers, which may be arranged in various user-selected configurations and may be operated according to various temperature schedules;

4. a PLANT program, which models the operation of primary HVAC components (e.g., boilers, chillers); electrical generation equipment (e.g., diesel engines or turbines), energy storage and solar heating and/or cooling systems;

5. an ECONOMICS analysis program, which calculates life-cycle costs,

6. a REPORT program that generates the output reports, and

7. a set of WEATHER ANALYSIS programs capable of manipulating, summarizing, and plotting weather data.

A library of weather data has been prepared, which includes temperature, barometric pressure, wind, and cloud data for sixty locations in the United States. These data are used to calculate the thermal response of a building for each hour of a year. A preliminary library of schedule data has also been prepared to illustrate typical hourly conditions that can be used to specify desired temperature variations, occupancy patterns, lighting, and equipment operation. The construction library contains data on the properties of walls, roofs, and floors. The materials library contains data on the common building materials. The Constructions, Materials, and Weather libraries are available in machine-addressable form; the other library data are available only in printed form. Finally, input and output samples are included to illustrate the use of DOE-2.

FOREWORD

Approximately one-third of the total energy consumed in the United States is used to operate buildings. Only by the efficient use of energy in each building will we reduce our energy consumption at local and, eventually, national levels. Saving energy in buildings will require new public policies, new building codes, and innovations in the design of buildings and communities. It will also require new design procedures and tools for engineers and architects, correct operation of building energy systems, and careful attention to the quality of materials and construction.

Until recently, building designers lacked the necessary tools for the comprehensive calculation of dynamic heating and cooling loads, the simulation of heating and cooling distribution systems, the modeling of equipment supplying the required energy, and the calculation of the life-cycle costs of owning and operating building energy systems. Calculation of the response of building envelopes and systems to time-dependent variations of heat and moisture resulting from the weather outside and human activity inside is practical only with the aid of an electronic computer. Earlier energy analysis programs have had limitations: they have been expensive to run, difficult to use, or limited in scope. Furthermore, differences in algorithms and assumptions may cause different programs to give widely differing results.

There was, therefore, need for an easy-to-use, fast-running, well-documented, widely available computer program for the analysis of energy use in buildings. Furthermore, the Energy Resources Conservation and Development Commission of the State of California needed a program that could be used to establish and enforce codes and standards for energy use. At the same time, the Facilities and Construction Management Division of the Energy Research and Development Administration (ERDA) needed a program that would assist in many different energy conservation efforts at ERDA facilities.

In response to these needs, Argonne National Laboratory organized and held, in fall of 1975, a meeting to create a National Laboratories collaboration in the development of a new computer program for design, research, and code compliance. Lawrence Berkeley Laboratory was selected as the lead laboratory, with Professor Arthur H. Rosenfeld as the project director. Initial support was provided by the State of California (Cal) and the US Energy Research and Development Administration (ERDA); hence, the program was called Cal-ERDA. After its formation in October of 1977, the US Department of Energy (DOE) took over the funding of the project. In June 1978, the program was renamed DOE-1, and in February 1979, an updated version was issued as DOE-2.

The predecessors of DOE-2 in the public domain are the Post Office Program; NBSLD, developed by the National Bureau of Standards, and NECAP, developed for the National Aeronautics and Space Administration. The loads calculation is based on the Post Office and NECAP program algorithms, as modified by Consultants Computation Bureau (CCB). The secondary HVAC systems simulation program was originally formulated in DOE-1 by CCB, but has been extensively modified by Lawrence Berkeley Laboratory. The primary equipment simulation program of DOE-2 is based on a proprietary program developed by CCB, but has been extensively modified and enlarged in scope by Lawrence Berkeley Laboratory and Los Alamos National Laboratory. The DOE-2 language processors, solar simulator, and economics evaluation program are new.

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This Reference Manual was prepared by Group Q-11, Solar Energy Group, Energy Division, Los Alamos National Laboratory. The organization and text of this manual were derived from, and include portions of, the DOE-1 edition of the Reference Manual (ANL/ENG-78-01) by Robert M. Graven, Paul R. Hirsch, Krishna N. Patel, Walter J. Taylor, and George A. Whittington, all of the Argonne National Laboratory. This DOE-2.1A edition is a joint effort of the following people who have written major portions of the manual: Charlene C. Cappiello, John L. Peterson, Mark A. Roschke, Eva F. Tucker, Frederick C. Winkelmann, and Don A. York. In addition, W. Frederick Buhl, James J. Hirsch, and Steven D. Gates contributed information for the manual.

The DOE-2 computer program described by this Reference Manual is the result of the participation and cooperation of many persons. The combined efforts of many different laboratories, private companies, and individuals were essential to the success of this project. The participation of state and federal agencies, university personnel, representatives of professional societies, and many architects and engineers is gratefully acknowledged.

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STATUS AND AVAILABILITY

May 1981

This edition of the DOE-2 Reference Manual describes version 2.1A of the DOE-2 program and replaces the DOE-2.1 Reference Manual of May 1980.

The DOE-2 program will operate on any Control Data Corporation (CDC) computer with a FTN4 compiler or any International Business Machine (IBM) computer with a Level G compiler, or better.

The DOE-2 computer program is available from the:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161

Telephone: Commercial (703) 487-4650 or FTS 737-4650

To obtain a copy of the computer program tape and/or the documentation package ask for:

	NTIS No.		
	DOE-2.0A	DOE-2.1	DOE-2.1A
Program Tape (CDC)	PB-292 250	PB80-148398	PB81-152456
Program Tape (IBM)	-	PB80-215940	PB81-183212
Documentation Package	PB-292 251 (3 volumes)	PB80-148380 (3 volumes, one) of which is in two parts)	PB81-152464 (3 volumes, one of which is in two parts)

Interested persons should write or call NTIS for more detailed ordering information, including current price.

DOE-2 is installed and operating at Lawrence Berkeley Laboratory on a CDC 6600/7600. Any DOE contractor may access it through the Lawrence Berkeley Laboratory remote users network. DOE users may contact:

DOE-2 User Coordination Office
Lawrence Berkeley Laboratory
Building 90, Room 3147
Berkeley, California 94720

Telephone: Commercial (415) 486-5711 or FTS 451-5711

A document entitled "Using DOE-2.1 at Lawrence Berkeley Laboratory" is available.

Additional versions of DOE-2 are available at the Los Alamos National Laboratory in Los Alamos, New Mexico, for in-house use by Los Alamos National Laboratory personnel.

Any individual in the private sector who is interested in using DOE-2 is urged to investigate its availability through one of the computer service bureaus or consultants. As of March 1, 1981, the following computer service firms are expected to offer the program for private use. For information about the status of such plans, contact:

SERVICE BUREAU	CONTACT
CALIFORNIA Berkeley Solar Group 3140 Grove St. Berkeley, CA 94703	Grace Prez Commercial - (415) 843-7600 FTS - 8-415-843-7600
COLORADO Computer Sharing Services, Inc. 7535 East Hampdon Avenue, Suite 200 Denver, Colorado 80231	Tom Rallens, Customer Service Commercial - (303) 695-1500 FTS - 8-303-695-1500
Martin-Marietta Data Systems P. O. Box 179 Mail Stop I4100 Denver, Colorado 80201	O. Michael Antoun (Los Angeles) Commercial - (213) 552-9541 FTS - 8-213-552-9541
CONNECTICUT Arga Associates 1056 Chapel Street New Haven, Conn. 06510	Dr. Robert Frew, Consultant Commercial - (203) 789-0555 FTS Op 8-244-2000 IBM ONLY
KANSAS United Computing Systems, Inc. P. O. Box 8551 Kansas City, Kan. 64114	John C. Hicks Commercial - (913) 341-9161 FTS - 8-913-341-9161
MASSACHUSETTS University of Massachusetts Dept. of Mechanical Engineering Amhurst, Mass. 01003	Lawrence L. Ambs Associate Professor Commercial - (413)-545-0949 FTS - 8-413-545-0949 (University and local govt. clients only)
MICHIGAN Airflow Science Corporation/BACS, Inc. 352 North Main Street Plymouth, Michigan 48170	James C. Paul Coordinator of DOE-2 User Services Commercial - (313) 459-4000 FTS 8-313-459-4000 (Michigan area only)
MINNESOTA Cybernet User Service Control Data Corporation P. O. Box "O" Minneapolis, Minn. 55440	Jim Nail Mail Code HQW-05G Commercial - (612) 853-8858 FTS Op 8-725-4242

SERVICE BUREAU	CONTACT
MISSOURI McDonnell-Douglas Automation Co. P. O. Box 516 St. Louis, Mo. 63166	Charles Whitman Dept. K-242 Commercial - (314) 232-8570 FTS Op 8-279-4110
VIRGINIA Babcock and Wilcox P. O. Box 1260 Lynchburg, Va. 24505	Jim Lynch Commercial - (804) 384-5111 x 2081 FTS Op 8-937-6011
WASHINGTON Boeing Computer Services Co. P. O. Box 24346, M. S. 9C-02 Seattle, Wash. 98124	David W. Halstead Commercial - (206) 575-5009 FTS - 8-206-575-5009

I. INTRODUCTION

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I. INTRODUCTION

This Reference Manual describes the DOE-2 computer program that can be used to calculate hourly building heating and cooling loads, to simulate the operation of primary and secondary heating, ventilating, and air conditioning systems including solar energy systems, and to perform economic analyses. The major subprograms used for these computations are described in more detail in Chapters III, IV, V, and VI. This manual provides the detailed information needed to understand how to use the DOE-2 computer program; it is basically a step-by-step book of "how to input data" to the computer program.

This manual is also a reference book that contains library data and summaries of the Building Description Language (BDL) instructions, and is intended to be used primarily by engineers or architects with a background in the thermal performance of buildings.

This manual is produced in loose-leaf notebook form, so that it can be readily updated and expanded by the substitution of revised pages and the addition of new ones.

The user should not be overwhelmed, or overly concerned, by the size of this manual. Although the information is rather voluminous, the user will address only these portions of the manual that deal with the problem at hand. Much of the manual is reference tables, charts, systems, and examples from which the user will make a selection. Additionally, it is not necessary to input all the data, even within the area of concern. The program has a set of default values which are entered automatically by the program (and echoed back to the user) if data entry is omitted for selected keywords.

An introduction to the Building Description Language (BDL) is given in Chap. II. Chapters III, IV, V, and VI describe the BDL input for the LOADS, SYSTEMS, PLANT and ECONOMICS (LSPE) programs (LDL, SDL, PDL, and EDL, respectively). The use of each BDL instruction to provide the specific information required by these programs is described in these chapters. Examples are included to illustrate the use of the input instructions.

Chapter VII describes the standard preprogrammed report formats. A user may select one or more of the standard output report formats to print the results, or may design his own hourly reports.

Chapter VIII identifies four utility programs that are useful for examination and preparation of weather data for the DOE-2 weather library. However, these programs are not necessary to the ordinary use of the DOE-2 programs, but are provided for detailed analysis of weather data; they were used to prepare the weather data files. Test Reference Year (TRY) data for 60 cities are available in the DOE-2 weather library.

Chapter IX is a compact reference list of all DOE-2 commands, keywords, and code-words.

Chapter X summarizes the library data applicable to DOE-2. Occupancy, lighting, and internal heat generating equipment schedules are presented. Graphic representations of these schedules for daily (24-hour sequence), weekly (8-day sequence, including holidays), and yearly (365-day sequence) data groups for typical cases are presented. Any of these generalized schedules may be entered, using the SCHEDULE instructions. A table of the thermal properties of various materials and the code names used by DOE-2 is given. Construction details that may be entered to calculate the history of heat flow are given, including the layer-by-layer composition for walls, roofs, and floors. These preassembled constructions are machine addressable, that is, the thermal response factors for these constructions have been precalculated and stored and can be retrieved by entry of the appropriate construction code-word.

A selected list of references is given as Chap. XI.

The remainder of this first chapter contains a brief discussion of the documentation and source code of the DOE-2 program, and summaries of the major computer subprograms. Section D contains a short summary of how to use this energy analysis computer program. A list of acronyms is given in Sec. E.

A. DOCUMENTATION

1. Volume I - Users Guide/BDL Summary

BDL Summary - This document provides a summary of all commands, keywords, and code-words in the Building Description Language.

Users Guide - This guide explains the philosophy and interpretation of the DOE-2 code along with annotated examples.

2. Volume II - Sample Run Book

In this document are found numerous computer example runs which display both input data and output data.

3. Volume III - Reference Manual (Parts 1 and 2)

This manual as stated earlier presents detailed step-by-step instructions on "how to input data" to the DOE-2 program.

4. Volume IV - Engineers Manual (Scheduled for release in the winter, 1981)

This manual provides the information needed for understanding "what happens to the input data" to the DOE-2 computer program. It contains a summary of the equations and algorithms used to perform the calculations. The relationship of the DOE-2 algorithms to ASHRAE algorithms is also given and is traced to the ASHRAE documentation.

In addition, further user guidance is available in Site Manuals, which provide the necessary information for the use of DOE-2 at specific computing installations. These manuals are not provided by the National Technical Information Service, but rather are available from the computing installations.

B. PROGRAM PACKAGE

The DOE-2 program package for CDC and IBM computers is available in two parts: Magnetic tape FORTRAN source decks of the program and auxiliary routines, control and run information, sample problem decks, and weather file library data; printed documentation, and a National Energy Software Center note describing the transmittal tapes.

Listings of DOE-2 are available from the National Energy Software Center. If any problems arise with the magnetic tape copy, assistance is available by telephoning the Center. Punched card copies of the program are not available, because the program is too large.

C. EXECUTIVE SUMMARY

DOE-2 enables architects and engineers to compute energy consumption in buildings. The program can simulate hour-by-hour performance of a building for each of the 8760 hours in a year. A new computer language, the Building Description Language, has been written. It is a computer language for analysis of building energy consumption that permits the user to instruct a computer in familiar English terminology.

Building Description Language has been developed primarily to aid engineers and architects in the difficult and time-consuming task of designing energy-efficient buildings that have low life-cycle cost. The energy consumption of a building is determined by its shape; the thermal properties of materials; the size and position of walls, floors, roofs, windows, and doors; and the transient effects of shading, occupancy patterns, lighting schedules, equipment operation, ambient conditions, and temperature and humidity controls. Energy consumption is affected, also, by the operation of primary and secondary HVAC systems and by the type and efficiency of the fuel conversion (plant) equipment. Furthermore, the life-cycle cost of operating a building under different economic constraints can strongly influence basic design decisions.

DOE-2 also provides a means of performing the complicated analysis of energy consumption without the necessity of instructing the program correctly in every minor detail. A set of default values (numbers used for the value of a variable if the user does not assign one) is included, to reduce the amount of input that must be supplied in order to run the program.

Figure I.1 shows a brief organizational outline of the DOE-2 computer program.

1. Program Control

DOE-2 consists of more than 30 files, not including the weather data. Hence, assuring that the subprograms are properly executed requires a substantial number of bookkeeping functions, which are performed by a sequence of job control instructions. The job control instructions are unique to each site, because they interact with the particular operating system in use at that site. Local DOE-2 Site Manuals provide the site-specific instructions and procedures that are required for DOE-2 program control.

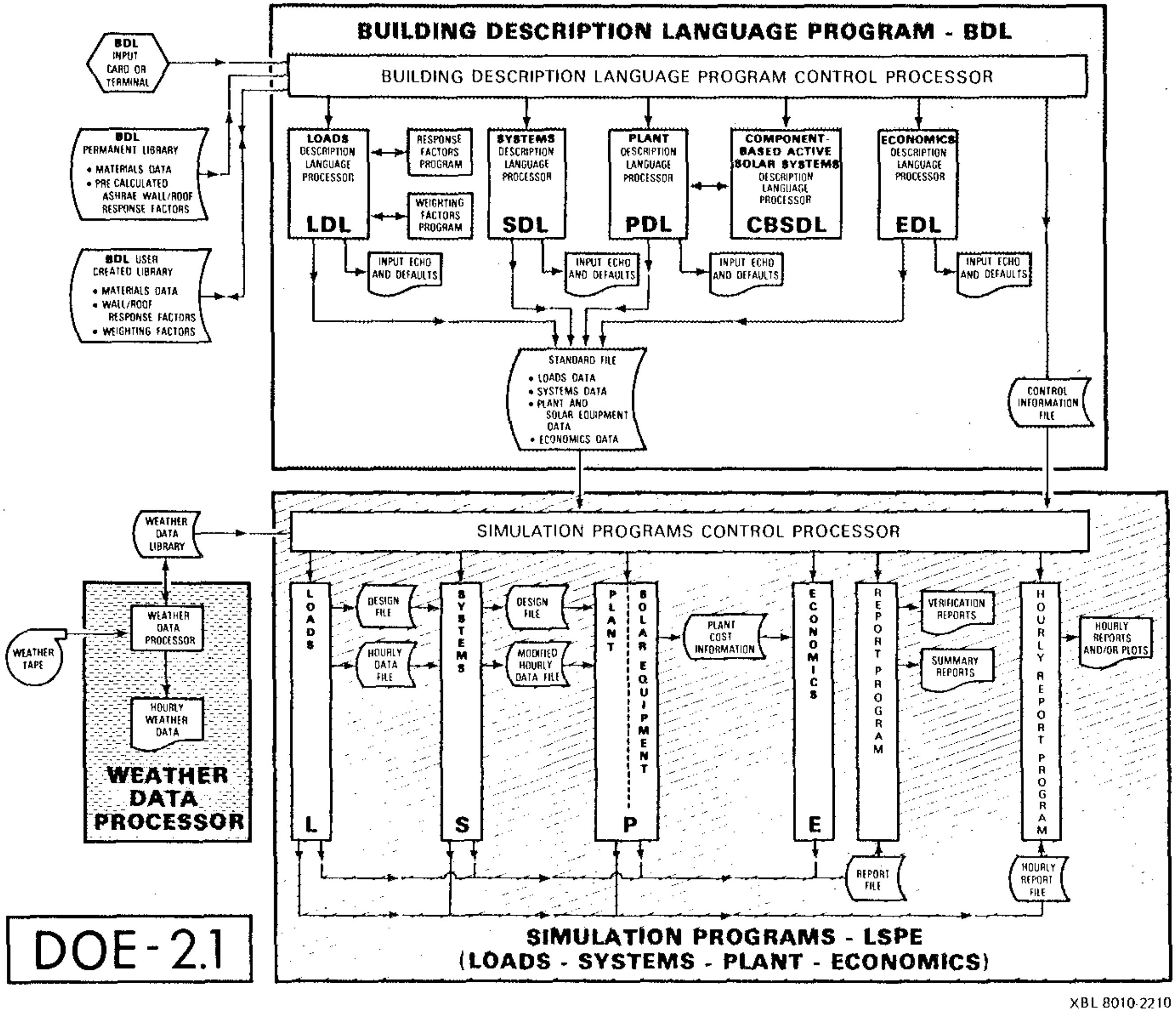

Fig. I.1. DOE-2 computer program configuration.

2. BDL Processor

The BDL Processor sequentially checks each BDL instruction for proper form, syntax, and content. The BDL Processor also checks for values that are beyond the expected range for input variables. As stated before, if a value is not specified, the BDL processor assigns an assumed (default) value, which will appear in the listing of input data. Sometimes the default value is actually a set of default values, such as a performance curve for a piece of equipment. It is possible for the user to override this set of default values (performance curve) with a different set of default values. The BDL Processor also collects whatever data the user desires from the various permanent libraries, e.g., data from the Materials Library. Response factors, numbers that are used to determine the transient flow of heat through exterior walls and roofs as they react to randomly fluctuating climatic conditions, are also calculated by the BDL Processor for use by the LOADS and SYSTEMS programs. The BDL processor will calculate, if desired, Custom Weighting Factors and build user-designed libraries of materials and walls. These factors are intended to account for the thermal lag in the heating and cooling of furnishings and structures. The BDL Processor also prepares the input data files for use by the LOADS, SYSTEMS, PLANT, or ECONOMICS (LSPE) simulators.

It is important to recognize that each of the LSPE simulators depends on the results of some or all of the previous simulators, and that many variations and combinations are allowed. Each of the LSPE simulators can be run repeatedly, to study the effect of design variations. Superior energy-efficient building design can result in greatly reduced energy consumption and significantly lower life-cycle cost.

3. LOADS Program

The LOADS program simulator calculates the hourly heating and cooling loads, using primarily the algorithms described in Ref. 1, "Procedure for Determining Heating and Cooling Loads for Computerizing Energy Calculations, Algorithms for Building Heat Transfer Subroutines," available from the American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (ASHRAE). DOE-2 provides a reorganization and reprogramming of many of these algorithms to increase execution speed. A description of the BDL input for the LOADS program (LDL) is presented in Chap. III, and a detailed description of the LOADS simulator is given in the Engineers Manual.

In the LOADS program (simulator), the heat gains and losses through walls, roofs, floors, windows, and doors are calculated separately. Heat transfer by conduction and radiation through the building skin is computed, using response factors, considering the effects of the thermal mass, placement of insulation, sun angle, cloud cover, and building location, orientation, and architectural features. Every set of response factors generated is placed in a file to be used by the LOADS and SYSTEMS programs. Infiltration loads can be calculated on the basis of the difference between the inside and outside conditions and on an assumed leak rate (crack method) or by an air-change method.

Internal use of energy for lighting and equipment is also computed according to schedules assigned by the user for each piece of equipment that affects the energy balance of each space. The latent and sensible heat given off by the building occupants is calculated as an hour-by-hour function of the occupancy of the building.

All the LOADS computations are performed on the basis of a fixed temperature for each space as specified by the user. Because the LOADS program calculates thermal loads on the basis of hourly weather data but artificial (fixed) space temperatures, the output may have little bearing on the actual thermal requirements of a building. It is, instead, a baseline profile of the thermal performance of a space, given a fixed internal temperature. The SYSTEMS program then modifies the output of the LOADS program, to produce actual thermal loads based on a hourly variable internal temperature.

The output of LOADS is useful to architects who wish to examine the thermal behavior of various combinations of materials used to make up alternative exterior walls and roofs. However, it is expected that engineers will be interested in the predicted thermal demands on the physical plant (chillers and heaters), obtained by running both the LOADS and SYSTEMS programs.

4. SYSTEMS Program

The SYSTEMS program contains algorithms for simulating performance of the secondary HVAC equipment used to control the temperature and humidity of each zone within the building. Many of the equations used to develop the SYSTEMS simulation procedure are given in Refs. 1 and 2. These algorithms have been organized and coded to allow selection of one of the preprogrammed space conditioning systems described in Chap. IV. The SYSTEMS program is used by choosing one of these preprogrammed systems and providing the necessary input data for the simulation calculations.

The SYSTEMS program uses the output information from the LOADS program and a list of user-defined system characteristics (e.g., air flow rates, thermostat settings, schedules of equipment operation, or temperature setback schedules) to calculate the hour-by-hour energy requirements of the secondary HVAC system. The SYSTEMS program calculates thermal loads based on variable temperature conditions for each zone.

5. PLANT Program

The PLANT program contains the equations necessary to calculate the performance of the primary energy conversion equipment. The operation of each plant component (e.g., boiler, absorption chiller, compression chiller, cooling tower, hot water storage tank, solar heater) is modeled on the basis of operating conditions and part-load performance characteristics. The user selects the type of plant equipment to be modeled (e.g., 2-stage absorption chiller), the size of each unit (e.g., 100 tons), the number of units, and the number of units simultaneously available. Values for equipment lifetime and maintenance may also be entered if preprogrammed values for these variables are not used. The sequence of equipment operation may be specified as a step function (e.g., from 0 to 500,000 Btu/hr, unit 1; from 500,001 to 10M Btu/hr, units 1 and 2). The user may schedule equipment operation by time (hourly or seasonally) or by peak load schedules. Additionally, the operating strategy between the various types of equipment may be specified. Energy storage may be specified. The PLANT program uses hourly results from the LOADS and SYSTEMS programs and the user's instructions to calculate the electrical and thermal energy consumption of the building. The DOE-2 PLANT program also contains subroutines for computing the life-cycle costs of plant equipment.

6. ECONOMICS Program

The ECONOMICS program may be used to compute the life-cycle costs of various building components and to generate investment statistics for economic comparison of alternative projects. The methodology used is similar to that recommended by DOE for evaluation of proposed energy conservation projects (Ref. 4).

7. REPORT Program

A REPORT program is used to collect information from the output files of the LSPE programs. The output data are then arranged in lists or tables according to the format of a standard output report. If a user wishes to examine a particular variable that is not available in a standard output report, he may select the variable and print its hourly values through the REPORT program.

8. WEATHER Programs

Manipulation of weather data is a separate activity, independent of the LSPE programs. Customary use of the LSPE programs to calculate the energy consumption of a building does not require use of the WEATHER analysis programs. The WEATHER analysis programs may be run to examine and prepare weather data not already in the DOE-2 library. (A table of weather stations for which data are available in the DOE-2 library is given in Chap. VIII.) Each meteorological variable may be changed or printed, and most may be plotted as desired, through these programs.

9. Libraries

Schedules Library data include graphs of various schedules that may be entered to calculate the hour-by-hour heat input to a space from lighting, equipment, or occupants. Various changes may be made in the schedule data, to customize it to particular requirements. Schedule data however are not machine readable.

Both the Materials Library and the Constructions Library are directly addressable by the DOE-2 program. The Materials Library contains data on the thermal properties of materials, to be used in the calculation of heat transfer through space boundaries. Thermal performance of a wall or roof may be modeled 1) by selecting and mathematically laminating various materials or 2) by specifying the desired construction from the Constructions Library by code-word. Each of the ASHRAE constructions is listed in Ref. 5. Other surfaces may be added by the user.

Weather data are accessed by using control card statements. The Weather Library contains Test Reference Year (TRY) data for the locations listed in Chap. VIII, weather data for the National Laboratory sites, and data for various climate regions in California.

In summary, the DOE-2 library consists of machine-readable weather, construction, and materials data. Schedule data are available but are not machine-readable. Private data files may be created by the user for individual use.

D. SUMMARY OF ENERGY ANALYSIS TASKS

The tasks required for performing a DOE-2 building energy analysis include: preparing the building description from conceptual or as-built drawings; in the case of an existing building, visiting the site to note actual building conditions and use; preparing the input deck using drawings and notes of operation, and the user worksheets given in this manual; examining results. A detailed discussion of these tasks is given in the DOE-2 Users Guide, with an annotated, step-by-step example.

E. ACRONYMS

ANL	Argonne National Laboratory
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc.
BDL	Building Description Language
BNL	Brookhaven National Laboratory
CBS	Component Based Simulator
CERL	Construction Engineering Research Laboratory of the Army Corps of Engineers
DOE	United States Department of Energy
EDL	ECONOMICS Description Language
ERCDC	State of California Energy Resources Conservation and Development Commission (now California Energy Commission)
ERDA	United States Energy Research and Development Administration (now DOE)
HVAC	Heating, Ventilating, and Air Conditioning
LASL	Los Alamos Scientific Laboratory (recently renamed Los Alamos National Laboratory - no acronym)
LBL	Lawrence Berkeley Laboratory
LDL	LOADS Description Language

LLNL	Lawrence Livermore National Laboratory
NBSLD	National Bureau of Standards Loads Determination Program
NECAP	NASA's Energy Cost Analysis Program
NOAA	National Oceanic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory
PDL	PLANT Description Language
SDL	SYSTEMS Description Language
SOLMET	Solar Meteorological Observations
TMY	Typical Meteorological Year
TRY	Test Reference Year

II. BUILDING DESCRIPTION LANGUAGE

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II. BUILDING DESCRIPTION LANGUAGE

A. LANGUAGE CONCEPTS

1. Introduction

The Building Description Language (BDL) allows the user to easily enter the information required to determine the energy consumption of a building. Through the use of BDL, the user can describe the appropriate physical parameters of a building with familiar English words.

The BDL Processor consists of five computer programs: BDLCTL (the control processor), and LDL, SDL, PDL, and EDL (the input processors for the LOADS, SYSTEMS, PLANT, and ECONOMICS programs, respectively). Each program processes the instructions directed to it, which involves checking for errors, issuing diagnostic messages, and preparing the input data for the appropriate simulation program.

Several features of BDL may be used to reduce input preparation time. The user may omit data entry for many variables, which allows BDL to assign values by default. These default values are described with each instruction and, if the user so desires, are listed on various verification reports, and may be printed along with the input instructions.

All instructions are processed before any simulation takes place. If any errors are detected that are considered fatal, no simulation occurs. The user may designate what severity of errors will be allowed before simulation is prohibited.

BDL input is free-format; the user is not required to enter data in a rigid column format. However, experienced users will recognize the advantage of having the instructions in a format that is organized for quick reference and that is easily understood by others.

Many examples of BDL instructions are given in this manual, and in the Sample Run Book.

2. BDL Instructions

Data are input to BDL using statements called instructions. There are two classes of instructions: control instructions and input instructions. Control instructions are recognized and processed only by the control processor, BDLCTL. Input instructions are recognized and processed only by the appropriate input processor; that is LDL for LOADS, SDL for SYSTEMS, etc.

BDL instructions take the form

```
U-name = Command
    Keyword = Value
    Keyword = Value
        .
        .
        . ..
```

where U-name is a user-specified name assigned to a particular instruction. Command indicates the type of instruction (and therefore the type of data to follow). Keyword = Value is one set of data for an instruction. The instruction terminator is defined to be two successive periods preceded and followed by a blank character. The use and details of each instruction are described in the appropriate chapter, LOADS, SYSTEMS, PLANT, or ECONOMICS. For example, the instruction

```
AIR-LAYER = MATERIAL
    RESISTANCE = 0.90 ..
```

defines a construction layer in a wall or roof, assigns it the user-specified name of AIR-LAYER, and sets its thermal resistance to 0.90 hr-ft^2-°F/Btu.

Rules:

1. One or more blanks must separate each element of an instruction.
2. The equals sign between a U-name and a command is optional.
3. A U-name may be required, optional, or not allowed, depending upon the particular command.
4. A valid command (or command abbreviation) must be the second item, or the first if no U-name is specified.
5. If a U-name is present, the U-name and the command must appear on the same line.
6. Commands may not be misspelled or contain embedded blanks.
7. Every instruction must end with the instruction terminator, defined to be two successive periods preceded and followed by a blank character.

3. U-Names

Multiple instructions of the same type must be distinguishable, one from the other, by the computer; thus, U-names are employed. A U-name is a unique name, assigned by the user to identify a particular BDL instruction. The user should define a U-name to be whatever word most appropriately describes the data to follow. Some instructions require a U-name, other instructions permit an optional U-name, and still others do not allow a U-name at all. Optional U-names should be entered in an instruction only if that instruction is referred to in another instruction.

Rules: 1. Although a U-name may be longer than 16 characters, only the first 16 characters are significant to the program. In the DOE-2 Library of MATERIALs, LAYERS, and CONSTRUCTIONs, only the first 8 characters are of significance.

2. A U-name must be unique, that is, one of a kind.

3. A U-name may not be a DOE-2 defined command, keyword, or code-word for the current input processor.

4. A U-name may not contain any of the following characters: ( ) [ ] , = or a blank.

Examples:

Valid U-names: WALL-4, FAN-3.6, BOILER-G1

Invalid U-names:

U-name	Reason
WALL,D	Contains a comma
END	Is a DOE-2 command
FAN(3.6)	Contains parentheses

4. Instruction Data

With very few exceptions, all data entered after the command word, and before the instruction terminator, take one of the following forms:

Keyword = Value

or

Keyword = (Value, Value,...)

where Keyword is a valid keyword, or keyword abbreviation, for the instruction being processed, and Value is a value to be assigned to the keyword. Keywords are external names for actual program variables.

Rules: 1. An equals sign following the keyword is optional.

2. If the keyword does not require a list of values, the value must not appear in parentheses.

3. If the keyword requires a list of values, the value(s) must appear within parentheses and all values must be separated by commas and/or one or more blanks. Normally, a list contains two or more values but occasionally a list will contain only one value (this will be noted in the text when it occurs.)

4. Keywords not entered will be set to their default values, if such default values exist. If default values do not exist for a mandatory keyword, a diagnostic message will be printed.

5. A keyword may not be misspelled or contain embedded blanks.

5. Keyword Types

There are several different types of keywords. Most keywords are of the numeric type and must be assigned numeric values. However, if a keyword is of the code-word, U-name, subcommand, or literal type, it must be assigned the corresponding type of value. Code-words are symbolic values (YES, NO, ON, OFF, etc.) assigned to keywords of the code-word type. U-names and subcommands are described in the U-Name and Subcommand sections in this chapter. Literals are values that are interpreted "literally" by the program, such as the values assigned in the TITLE command.

Rules: 1. Numeric values may be input as integers, decimal fractions, or exponential numbers. The following three values are equivalent and may be used interchangeably: 600, 600.0, and 6E+2.

a. Blanks may not occur after a minus sign or be embedded in the number.

b. Plus signs (+) may appear only in an exponent.

2. Code-word values must be selected from the list of valid code-words as described with the instruction.

3. U-name values must be defined (appear in the U-name field of an instruction) before the END instruction is reached.

4. Subcommand values are U-names that must have appeared in the U-name field of an instruction entered before the current instruction.

5. Literal values must begin and end with an asterisk (*) and may not be continued to the next line.

6. Code-words, U-names, and subcommands must not be misspelled or contain embedded blanks.

6. LIKE

The LIKE keyword is used to duplicate the user-supplied data input in a previous instruction (default values are not taken from the previous instruction but are recalculated by the program for the current instruction). The value entered for LIKE is the U-name of a previous instruction of the same type. Any data that differ from the data of the previous instruction may be specified in the normal manner. For example, the instruction

```
BLUE-ROOM = SPACE
     LIKE RED-ROOM EXCEPT
     WIDTH = 30.0
     LENGTH  = 50.5 ..
```

defines a new space named BLUE-ROOM that has all the attributes of a previously defined space named RED-ROOM, but with different values for its width and length.

The LIKE command will duplicate only user input keywords and keyword values, not program-calculated values. For example, in the instruction

```
BROWN-ROOM = SPACE
     LIKE BLUE-ROOM ..
```

the BROWN-ROOM will be assigned a WIDTH of 30.0 and an LENGTH of 50.5, not an AREA of 1515, the product of 30.0 and 50.5.

Rules: 1. The LIKE keyword may be used only in those instructions having LIKE listed as a valid keyword.

2. If the LIKE keyword is used, it must be the first keyword used in an instruction.

3. The instruction, whose name is used as the value for LIKE, must be entered before the instruction containing the LIKE keyword.

4. The word EXCEPT, after the value for LIKE, is optional.

5. Only instructions of the same type of command may use the LIKE keyword. Example: A DOOR instruction cannot use the U-name of WINDOW as a LIKE keyword value.

6. The code-words, which identify materials and walls in the DOE-2 Library of MATERIALs, LAYERS and CONSTRUCTIONs (BDLLIB), are not U-names. Therefore, these code-words cannot be used in a LIKE keyword.

If the user has specified an incorrect value in an instruction, which is subsequently referenced in other instructions with a LIKE keyword, the error diagnostics will not be repeated in the subsequent instructions.

For example:

```
WINDOW-1 = WINDOW
    HEIGHT = 5
    WIDTH  = 3
    DEPTH  = 4 ..
---------------------------------------------
   ERROR                          DEPTH          UNKNOWN KEYWORD
---------------------------------------------

WINDOW-2 = WINDOW
  LIKE WINDOW-1 ..
WINDOW-3 = WINDOW
  LIKE WINDOW-1 ..
```

DEPTH is not a valid keyword for WINDOW, therefore, it was rejected for WINDOW-1 and an error diagnostic was printed. Although WINDOW-2 and WINDOW-3 included the LIKE WINDOW-1 keyword and value, DEPTH = 4 in both cases will be rejected, but the error diagnostic will not be repeated.

7. Subcommands

Use of a subcommand is a way of grouping and naming a particular subset of keywords to be easily referred to in one or more commands. Keywords of the subcommand type are used in a manner similar to the LIKE keyword (see section on LIKE keyword). Subcommand keywords refer to an instruction of a different type than the current instruction. In addition, the keywords in the referenced instruction are only a subset of the keywords in the current instruction. As a result, only the values of the keywords in the referenced instruction are effectively "LIKEd" for the corresponding keywords in the current instruction.

Example:

```
ZAIR-1 = ZONE-AIR
     ASSIGNED-CFM = 500
     EXHAUST-CFM = 200
     EXHAUST-EFF = 0.6
     EXHAUST-STATIC = 5.0 ..

FLOOR-1 = ZONE
     ZONE-AIR = ZAIR-1
          Keyword = Value ..
```

The first instruction defines a set of supply and exhaust air parameters named ZAIR-1. The second instruction defines a zone named FLOOR-1 and assigns to it the supply and exhaust parameters as defined in the first instruction. The sequence Keyword = Value represents one or more keyword assignments used to fully describe the zone.

8. Comments

Comments may be inserted in or between the instructions to aid in the documentation of the input data. Comments are not processed in any way by the program, other than to print them along with the instructions.

Rules:

1. A comment must begin with a dollar sign ($).
2. If the dollar sign is not in column 1, the dollar sign must be preceded by a blank.
3. A comment is terminated by the end of the current line, or by a second dollar sign, whichever occurs first.
4. A comment may not occur within a literal value (see section on keywords).

Example:

```
$EXECUTIVE SUITE
BIG-GLASS = WINDOW $IN EXECUTIVE SUITE $ HEIGHT = 7   WIDTH = 30 ..
```

9. Typical Run Instruction Sequence

Instructions may be entered in any of several sequences, depending upon the type of execution desired. The following sequence should be used for a complete run of all the programs.

```
INPUT FOR LOADS ..
........................
........................      LDL instructions for
........................      the LOADS program
........................
END ..
COMPUTE LOADS ..

INPUT FOR SYSTEMS ..
........................
........................      SDL instructions for
........................      the SYSTEMS program
........................
END ..
COMPUTE SYSTEMS ..

INPUT FOR PLANT ..
........................
........................      PDL instructions for
........................      the PLANT program
........................
END ..
COMPUTE PLANT ..

INPUT FOR ECONOMICS ..
........................
........................      EDL instructions for
........................      the ECONOMICS program
........................
END ..
COMPUTE ECONOMICS ..

STOP ..
```

Note that the input instructions for each program are entered, followed by the COMPUTE instruction for that program. Also note that each input sequence in terminated by an END instruction.

If the user desires only to have the instructions checked for errors, all COMPUTE instructions should be omitted. The following example is an instruction sequence in which the input instructions for the SYSTEMS program are to be checked for errors.

```
INPUT FOR SYSTEMS ..
.......................
.......................      SDL instructions for
.......................      the SYSTEMS program
.......................
END ..
STOP ..
```

For more details concerning the INPUT, END, and STOP instructions, see instruction descriptions later in this chapter.

10. Parametric Run Instruction Sequences

When evaluating the results of variations in the input data, two approaches are available to the user. The first approach involves complete re-entry of all input instructions (along with the desired modifications) for program resimulation with different conditions. The following sequences illustrate a run in which the LOADS program is executed once, the hourly output from the LOADS program is used as input to two executions of the SYSTEMS program using different distribution systems, and the SYSTEMS hourly output data are in turn used as hourly input data to two PLANT simulations of the same plant.

```
INPUT FOR LOADS ..
........................
...
END ..
COMPUTE LOADS ..

INPUT FOR SYSTEMS ..
...
...
END ..
COMPUTE SYSTEMS ..

INPUT FOR PLANT ..
...
...
END ..
COMPUTE PLANT ..

INPUT FOR SYSTEMS ..
...
...
END ..
COMPUTE SYSTEMS ..

COMPUTE PLANT ..
STOP ..
```

Note that the input instructions for the PLANT program need not be re-entered for the second PLANT simulation.

The second approach involves the use of the PARAMETRIC-INPUT and PARAMETER instructions (see Sec. B.2 and Sec. B.6 of this chapter). This approach may be used when the variations involve only the values of one or more keywords entered in a previous INPUT sequence for the same program. In this case, these values are defined using the PARAMETER instruction during the first INPUT sequence, and are assigned to the proper keywords. Then, in place of subsequent INPUT sequences to that program, the user enters PARAMETRIC-INPUT sequences, which include only PARAMETER instructions to modify the parametric values assigned to the proper keywords. Thus, if the previously illustrated instruction sequence had involved only variations on a single keyword value (in this case, MAX-HUMIDITY), the sequence might also have been input as follows.

```
INPUT FOR LOADS ..
......................         LDL instructions for
......................         the LOADS program
END ..
COMPUTE LOADS ..

INPUT FOR SYSTEMS ..
PARAMETER                      One or more PARAMETER
      MAXHUM = 60       ..     instructions (MAXHUM is the
.....................          U-name of the parameter
                               keyword; 60 is the first value
                               for MAXHUM)
.....................
SC1 = SYSTEM-CONTROL           SDL instructions
    MAX-HUMIDITY = MAXHUM      for the SYSTEMS program
.....................
END ..
COMPUTE SYSTEMS  ..

INPUT FOR PLANT  ..
...                               PDL instructions
...                               for the PLANT program
END  ..
COMPUTE PLANT  ..

PARAMETRIC-INPUT FOR SYSTEMS ..
PARAMETER
      MAXHUM = 50     ..          One or more PARAMETER
                                  instructions (50 is the
                                  second value for MAXHUM)
END ..
COMPUTE SYSTEMS ..

COMPUTE PLANT  ..

PARAMETRIC-INPUT FOR SYSTEMS  ..
PARAMETER
      MAXHUM = 40  ..             One or more PARAMETER
                                  instructions (40 is the
                                  third value for MAXHUM)
END  ..
COMPUTE SYSTEMS ..
```

```
COMPUTE PLANT ..
STOP ..
```

The previous example would demonstrate the effect (on the loads calculated by the SYSTEMS and PLANT programs) caused by lowering the maximum relative humidity from 60 per cent to 50 per cent to 40 per cent, an effect that can be rather drastic, especially in humid climates. The PARAMETRIC-INPUT run is normally not attempted until the first run (INPUT run) is debugged and verified. This being the case, the user can specify DIAGNOSTIC = NO-ECHO in the PARAMETRIC-INPUT runs, to suppress the printing of the redundant input data; however, if a problem is detected, a diagnostic message will be printed, along with the data entry that caused the problem.

Rules: 1. A COMPUTE instruction is always associated with the last INPUT or PARAMETRIC-INPUT instruction. Thus, in the following sequence, the first set of INPUT instructions is not simulated.

```
INPUT FOR LOADS ..
......................
......................
END ..

INPUT FOR LOADS ..
......................
......................
END ..
COMPUTE LOADS ..
STOP ..
```

2. A COMPUTE instruction causes the referenced program to use, as hourly input data, the hourly output data as generated by the <u>last</u> COMPUTE instruction referring to the immediately "upstream" program. In the following sequence, the hourly output from the <u>second</u> LOADS simulation is used as hourly input data for the <u>SYSTEMS</u> program.

```
INPUT FOR LOADS ..
........................
........................
END ..
COMPUTE LOADS ..

INPUT FOR LOADS ..
........................
........................
END ..
COMPUTE LOADS ..

INPUT FOR SYSTEMS ..
...
...
END ..
COMPUTE SYSTEMS ..
STOP ..
```

3. It is not possible, in one run, to have two PARAMETRIC-INPUT instructions that have an INPUT instruction (for the same simulation program) between them. That is, given

```
INPUT LOADS ..
PARAMETRIC-INPUT LOADS ..
INPUT LOADS ..
PARAMETRIC-INPUT LOADS ..
```

the first PARAMETRIC-INPUT LOADS instruction will use the nonparametric data from the first INPUT LOADS run, and the second INPUT LOADS instruction will operate properly. However, the second PARAMETRIC-INPUT instruction will not operate properly because the program has no way to determine which INPUT LOADS data are to be used.

Example

Suppose a user wishes to change the LOADS input, but run the same SYSTEMS and PLANT input. The following sequence of instructions would do this.

```
INPUT FOR LOADS  ..
PARAMETER                        One or more PARAMETER
     AZIM = 90  ..               instructions
. . . . . . . . . . .            LDL instructions for the
BUILDING-LOCATION                LOADS program
     AZIMUTH = AZIM  ..
. . . . . . . . . . .
END  ..
COMPUTE LOADS  ..

INPUT FOR SYSTEMS  ..
. . . . . . . . . . .            SDL instructions for
. . . . . . . . . . .            the SYSTEMS program
END  ..
COMPUTE SYSTEMS  ..

INPUT PLANT  ..
. . . . . . . . . . .            PDL instructions for
. . . . . . . . . . .            the PLANT program
END  ..
COMPUTE PLANT  ..

PARAMETRIC-INPUT FOR LOADS  ..
PARAMETER
     AZIM = 180  ..              PARAMETER instructions
END  ..
COMPUTE LOADS  ..
COMPUTE SYSTEMS  ..
COMPUTE PLANT  ..
STOP  ..
```

The COMPUTE instructions for SYSTEMS and PLANT will cause the previously input data to be used with the results from the new LOADS run.

11. Scheduling Concepts

Schedules are used to define specific conditions on an hour-by-hour basis for the entire simulation. Schedules serve many functions, such as defining thermostat set points, indicating whether a piece of equipment is on or off, whether it is allowed to be on during a given hour, what fraction of its maximum capacity is permitted, etc.

Schedules of varying complexity may be defined according to the requirements of the user. In the normal mode, the three instructions used to define a schedule are the SCHEDULE, WEEK-SCHEDULE, and DAY-SCHEDULE instructions. (Advanced scheduling techniques are described in the Advanced Scheduling Concepts section.)

The schedule definition process may be thought of as having three steps. The first step is to define one or more 24-hour schedules, using one or more DAY-SCHEDULE instructions. These daily schedules are then assigned to particular days of the week using the WEEK-SCHEDULE instruction. Finally, one or more weekly schedules are assigned to particular times of the year, using the SCHEDULE instruction.

To illustrate this process, a schedule describing the occupancy of a school building will be defined. The school is to be occupied from 8:00 AM to 5:00 PM on weekdays during the school year. The school is to be unoccupied all other times, including holidays during the school year.

The following instructions define such a schedule.

Example 1:

```
DS-YES = DAY-SCHEDULE  HOURS = (1,8)    VALUES = (0.)
                       HOURS = (9,17)   VALUES = (1.)
                       HOURS = (18,24)  VALUES = (0.) ..
DS-NO  = DAY-SCHEDULE  HOURS = (1,24)   VALUES = (0.) ..
WS-YES = WEEK-SCHEDULE  DAYS = (WD)   DAY-SCHEDULE = DS-YES
                        DAYS = (WEH)  DAY-SCHEDULE = DS-NO ..
WS-NO  = WEEK-SCHEDULE  DAYS = (ALL)  DAY-SCHEDULE = DS-NO ..
SCHOOL-SCHED = SCHEDULE   THRU  MAY 31,  WEEK-SCHEDULE = WS-YES
                          THRU  AUG 31,  WEEK-SCHEDULE = WS-NO
                          THRU  DEC 31,  WEEK-SCHEDULE = WS-YES ..
```

The day-schedule named DS-YES is entered to define a daily occupancy schedule for days when school is in session. The day-schedule named DS-NO is entered to define a daily occupancy schedule to be used on days when school is not in session. The week-schedule named WS-YES is then entered to define which of the day-schedules is in effect for a given day of the week, and WS-NO is entered as a week-schedule indicating no occupancy for weeks when school is out. Finally, the schedule named SCHOOL-SCHED indicates that, during the school year week-schedule WS-YES is to be used, but during the summer week-schedule WS-NO is to be used.

The individual instructions are described in more detail in their respective sections later in this chapter.

Example 2:

```
DS1 = DAY-SCHEDULE   HOURS = (1,24)   VALUES = (68.) ..
WS1 = WEEK-SCHEDULE   DAYS = (ALL)  DAY-SCHEDULE = DS1 ..
S1  = SCHEDULE        THRU DEC 31,  WEEK-SCHEDULE = WS1 ..
```

The above instructions define a schedule having a value of 68. for every hour of the year.

Although the user may not originally intend to run the simulation for the maximum period of time, one year (JAN 1 THRU DEC 31), it is often wise to specify schedules for the entire year. The reason for this statement is that the RUN-PERIOD instruction determines the simulation interval and should this interval be subsequently extended beyond the range of the schedules, trouble is almost certain to occur.

12. Advanced Scheduling Concepts

Once the user has become familiar with the basic concepts of scheduling, as presented in the previous section, he may begin to take advantage of some of the more powerful features of the scheduling instructions. To facilitate the data entry for the simpler schedules, the concept of "schedule nesting" may be used. When entering a WEEK-SCHEDULE instruction, the nesting feature allows a DAY-SCHEDULE = U-Name sequence to be replaced with the actual day-schedule data normally entered in a DAY-SCHEDULE instruction, with the exception that no keywords are entered, only their value(s). For example, the week-schedule defined in Example 2 (in the previous section Scheduling Concepts) could also be defined using the nesting feature with the following instruction.

```
WS1 = WEEK-SCHEDULE (ALL) (1,24) (68.) ..
```

The nesting feature is also available with the SCHEDULE instruction. In this instructon the WEEK-SCHEDULE = U-Name sequence may be replaced with the data normally entered in a WEEK-SCHEDULE instruction, with the exception that no keywords are entered, only their value(s) are entered. For example, the SCHEDULE instruction in Example 2 of the previous section, Scheduling Concepts, could also be entered using the nesting feature with the following instruction.

```
S1 = SCHEDULE THRU DEC 31, (ALL) DS1 ..
```

As a further extension, double nesting could result in the following instruction which would define the same schedule for an entire year using only one instruction.

```
S1 = SCHEDULE THRU DEC 31, (ALL) (1,24) (68.) ..
```

The user is urged, however, to become familiar with the concepts described in the Scheduling Concepts section before attempting extensive use of the concepts of advanced scheduling.

ADVANCED SCHEDULING

____________________ =SCHEDULE or SCH (User Worksheet)

U-name*

Key-word	User Input: Month	Day-of-Month	Day-of-Week Code-word(s)	Hour(s)-of-Day	Number
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______)
THRU	________		(____, ____)	(___, ___)	(______) ..

*Mandatory entry, if SCHEDULE is specified.

Notes:

1. Acceptable code-words for Month are JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC.
2. Acceptable entries for Day-of-Month are 1 thru the number of days in the month.
3. Acceptable Day-of-Week Code-word(s) are MON, TUE, WED, THU, FRI, SAT, SUN, HOL, WD, WE, WEH and ALL. All <u>eight</u> days of the week must be specified before the terminator.
4. Acceptable entries for Hour(s)-of-Day are 1 thru 24. All hours must be specified.
5. All user input for this instruction must be in chronological order.

B. INSTRUCTION DESCRIPTIONS

In the previous section of this chapter it was necessary to use some of the legal commands, keywords, and code-words just to explain the concepts of BDL. It was not intended that the user understand the exact meanings of these words. Rather, the user should now understand the concepts of commands, keywords, terminators, input sequences, etc.

In this section the user's attention will be redirected from the concepts underlying BDL to the meanings of certain commands, keywords, and code-words. There exists a selected set of commands, keywords, and code-words that are appropriate to all the simulators (LOADS, SYSTEMS, PLANT, and ECONOMICS). To avoid redundancy they are listed and defined here, in the order in which they are normally input, and will not appear in each simulator chapter. All the following instructions are input instructions and, as such, must appear between an INPUT instruction and an END instruction (or between a PARAMETRIC-INPUT instruction and an END instruction). Exceptions to this rule will be noted with the appropriate instruction description.

1. INPUT

The INPUT instruction indicates that the instructions to follow contain data for a particular program (see Typical Run Instruction Sequences section).

The instruction takes the form

```
INPUT  Program-Name ..
```

where Program-Name is a code-word indicating the simulation program for which subsequent instructions are intended.

Rules:
1. The code-word must be one of the following: LOADS, SYSTEMS, PLANT, or ECONOMICS.
2. The INPUT instruction must precede any instruction for a particular program.
3. In a parametric run, the INPUT instruction should appear on a separate line.

Example:

```
INPUT LOADS ..
```

The above instruction indicates that subsequent instructions pertain to the LOADS program and should be processed by the LOADS input processor.

2. PARAMETRIC-INPUT

The PARAMETRIC-INPUT instruction indicates that the following instructions consist only of parametric modifications to data entered following the previous INPUT instruction for the same program (see Parametric Run Instruction Sequences section).

The instruction takes the form

PARAMETRIC-INPUT FOR Program ..

where Program is the name of the simulation program (LOADS, SYSTEMS, PLANT or ECONOMICS) for which subsequent instructions are intended.

Rules:

1. This instruction must have been preceded by one, and only one, corresponding INPUT instruction for the same program.

2. The command may be abbreviated to PAR-INPUT.

3. The word FOR is optional.

4. The name of the program must be one of the following: LOADS, SYSTEMS, PLANT, or ECONOMICS.

5. The only instructions that may be entered between a PARAMETRIC-INPUT instruction and the next END instruction are ABORT, PARAMETER, and additional TITLE instructions (beyond those used in the original simulation run). The only exception to this rule is that the PLANT-ASSIGNMENT instruction may be entered during a PLANT parametric run.

Example:

PARAMETRIC-INPUT FOR LOADS ..

The above instruction indicates that subsequent input instructions contain only parametric data and are to be used to generate a new parametric set of input data for the LOADS Program.

See also Sec. A.10 and Sec. B.6 of this chapter.

3. DIAGNOSTIC

The DIAGNOSTIC instruction is used to specify various options available when printing instructions and diagnostic messages.

The instruction takes the form

DIAGNOSTIC Option ..

where Option is one or more code-words that specify desired DIAGNOSTIC options.

Rules:

1. The DIAGNOSTIC instruction may be used as a control instruction (i.e., it need not occur between an INPUT instruction and an END instruction).

2. The DIAGNOSTIC instruction may be entered more than once. That is, the user may desire to change DIAGNOSTIC options to deliberately avoid COMMENT messages for certain instructions. The last option specified overrides any previously specified associated options.

3. The option(s) must be chosen from each group shown in the following table.

Option	Result
ERRORS	Only ERRORS messages are printed.
WARNINGS	ERRORS and WARNINGS messages are printed.
CAUTIONS	ERRORS, WARNINGS, and CAUTIONS messages are printed.
DEFAULTS	Same as CAUTIONS, plus all default values used are printed.
COMMENTS	Same as DEFAULTS, plus informative messages are printed. (This is the default value.)
WIDE	Messages are formatted for line printers and wide carriage terminals. (This is the default value.)
NARROW	Messages are formatted for printers and terminals having only 80 characters.
SINGLE-SPACED	Instructions are echoed single-spaced. (This is the default value.)
DOUBLE-SPACED	Instructions are echoed double-spaced.
ECHO	All instructions are echoed to the output listing. (This is the default value.)
NO-ECHO	Input instructions are not echoed. However, when diagnostic messages are printed, the previous line of input is also printed. All control instructions are echoed.
NO-LIMITS	The program ignores the keyword maximum and minimum allowable values in its data editing procedure and does not print CAUTIONS messages for specified values beyond its normal range. The user should be <u>extremely careful</u> when specifying NO-LIMITS because (1) erroneous data can escape this important editing process and (2) some algorithms are not accurate beyond their allowable ranges, which are built into the program.
LIMITS	The program uses its built-in ranges for editing user-specified keyword values. (This is the default value.)

. . . .

LIBRARY-CONTENTS	The contents of the user's library will be printed. This library, if specified, contains information on materials and layers (with response factors) and Custom Weighting Factors. No diagnostics are printed with the contents of the library.
-	The contents of the user's library are suppressed from printing. (This is the default value.)

The level chosen from the first five DIAGNOSTICs above must be equal to or less than the level specified for the ABORT command. That is, ABORT = CAUTIONS and DIAGNOSTIC = ERRORS are not compatible inputs. Also, if DIAGNOSTIC is input as ERRORS (or WARNINGS) and then ABORT is allowed to default to CAUTIONS (a lower level than ERRORS and WARNINGS), the DIAGNOSTIC instruction will get a WARNING message and the program will abort. This message can be avoided by entering an ABORT instruction before the DIAGNOSTIC instruction.

ERRORS messages deal with problems in the data that must be corrected before the simulation programs are capable of execution. WARNINGS messages are concerned with input data that are capable of being simulated, but that are probably input errors (such as TEMP = 700 instead of TEMP = 70.0). CAUTIONS messages are much less severe than WARNINGS messages and deal with questionable data that do not significantly affect the numerical results of the simulation. DEFAULTS messages indicate what values are assigned to unreferenced keywords and the units of those values. COMMENTS messages include all other informative messages such as echoing all entered keyword data, along with the units of those values, response factors calculated for delayed surfaces, and coefficients calculated for any CURVE-FIT instruction.

Examples:

```
DIAGNOSTIC WARNINGS ..
```

The above instruction will result in only ERRORS and WARNINGS messages being printed. By default all instructions will be echoed, single-spaced, and the messages will be printed in a wide format.

```
DIAGNOSTIC ERRORS, NARROW, DOUBLE-SPACED  ..
```

This instruction will result in only ERRORS messages being printed (WARNINGS, CAUTIONS, DEFAULTS, and COMMENTS messages will not be printed). The printed output will be formatted for an 80-column printer and all instructions will be double-spaced (every other line). By default, all instructions will be echoed.

Note: Many user difficulties are masked by specifying a value for DIAGNOSTIC that is too high. The first step in debugging a problem, or questionable results, is to make sure that DIAGNOSTIC is set to COMMENTS, especially if the user is using new data. More often than not the user will find a comment that solves his problem. After data has been successfully edited, the level of DIAGNOSTIC may be raised from COMMENTS.

4. ABORT

The ABORT instruction is used to specify what level of DIAGNOSTIC in subsequent instructions is to be considered severe enough to prevent execution of the simulation program(s).

The instruction takes the form

    ABORT IF Level ..

where Level is a code-word indicating what level of DIAGNOSTIC is to be considered fatal.

The default value is CAUTIONS.

Rules:

1. The code-word must be from the following list: ERRORS — only error messages are fatal; WARNINGS—error and warning messages are fatal; or CAUTIONS—error, warning, and caution messages are fatal.
2. The word IF is optional.
3. The ABORT instruction may be entered more than once to change the abort level.
4. The ABORT instruction may be used as a control instruction (i.e., it need not appear between an INPUT instruction and an END instruction).
5. The ABORT level specified in any simulator automatically carries through to subsequent simulators unless changed.

Example:

    ABORT IF WARNINGS ..

The above instruction directs the program to prevent simulation if WARNINGS level messages are found.

5. TITLE

The TITLE instruction is used to describe up to five lines of title information to be placed at the top of each report page.

The instruction takes the form

    TITLE Line-N = *Literal* ..

where Line-N is one of five valid keywords (LINE-1, LINE-2, LINE-3, LINE-4, and LINE-5), and *Literal* is a series of characters placed between two asterisks. The sequence Line-N = *Literal* may be repeated as necessary to define a complete title.

Title data are placed at the top of each report page in the following format:

```
line-1                          line-2
line-3                          line-4                          line-5
```

and have the default value of blank lines.

Rules:

1. The TITLE instruction may be entered more than once. If entered only once, all reports will have the same title. If entered more than once, the last value entered when an END instruction is encountered, is the value that will appear at the top of that program's reports.

2. The TITLE instruction may be used as a control instruction (that is, need not appear between an INPUT instruction and and END instruction).

3. The limit for each line of title is 40 characters.

4. A literal value may not be continued on the following line.

Example

```
TITLE  LINE-1 = *ABC OFFICE BUILDING*
       LINE-2 = *JONES AND SMITH ENGINEERING*
       LINE-3 = *JERRY JONES - P.E.*              ..
```

The above instruction would cause

```
ABC OFFICE BUILDING             JONES AND SMITH ENGINEERING
JERRY JONES - P.E.
```

to appear at the top of all reports.

6. PARAMETER

The PARAMETER instruction is used to designate user-specified variables (maximum of 50) as parameters in parametric runs and to assign them values (see Parametric Run Instruction Sequences section).

The instruction takes the form

```
PARAMETER
   U-name = Value  ..
```

where U-name is the user-specified name of a parametric keyword, and Value is the value assigned to that variable in the current simulation.

Whenever the U-name of a parametric keyword is encountered, as a value for a subsequent keyword, the value of that parametric keyword is substituted as the value for the keyword. Note: Only keyword values can be changed with PARAMETER. U-names of commands cannot be changed with PARAMETER.

Two types of values may be assigned to a parametric keyword, the first of which is a numeric quantity. In addition to the direct substitution of the parametric value as the value for a keyword, a numeric parameter may also be multiplied by a second numeric quantity when assigned to a keyword. This is accomplished by entering the word TIMES immediately after the parametric keyword U-name, followed by a number.

Example:

```
INPUT LOADS  ..
    PARAMETER
       P1 = 10  ..
...................
...................
     W1 = WINDOW
       WIDTH = P1  ..

     W2 = WINDOW
        WIDTH = P1 TIMES 1.1  ..
...................
...................
END  ..
COMPUTE LOADS  ..
STOP  ..
```

The above instructions would cause the width of windows W1 and W2 to be 10.0 feet and 11.0 feet, respectively.

Parametric keywords may also be assigned non-numeric values. Whenever the value being input for a non-numeric keyword, such as U-name, subcommand, or code-word type keywords, is detected to be a parametric keyword U-name, the value of that parameter is used as the value for the keyword.

Example:

```
PARAMETER
    P2 = COLDEST
             P3 = WS1 ..
SYSTEM-CONTROL        HEAT-CONTROL = P2 ..
             S1 = SCHEDULE     THRU DEC 31, WEEK-SCHEDULE = P3 ..
```

The above instructions would cause the value COLDEST to be assigned to HEAT-CONTROL and week-schedule WS1 to be assigned to WEEK-SCHEDULE.

Rules: 1. Although a parametric keyword U-name may be longer than 16 characters, only the first 16 characters are significant to the program.

2. A parametric keyword U-name must be unique from all other parametric keyword U-names and non-parametric keyword U-names.

3. A parametric keyword must be defined with a PARAMETER instruction before its use in a keyword value assignment.

4. If the TIMES feature is used with the input for a numeric parametric keyword, the word TIMES must appear on the same line as the parametric keyword.

5. The value after the word TIMES may not be another parametric keyword and it must be a number.

See also Sec. A.10 and Sec. B.2 of this chapter.

7. SET-DEFAULT

The SET-DEFAULT instruction is used to assign a new default value to one or more keywords in a particular instruction.

The form of this instruction is

```
SET-DEFAULT FOR  Command
      Keyword = Value  ..
```

where Command is the name of an instruction, Keyword is the name of a keyword in that instruction, and Value is the new default value to be assigned that keyword.

Rules: 1. Whenever a new default value (maximum of 100) is specified for the keyword of an instruction, that value overrides the previous default value for that keyword, or creates a default value if the keyword previously had none.

2. The word FOR after SET-DEFAULT is required.

3. The sequence Keyword = Value may be repeated if the default for more than one keyword is to be changed.

4. Some keywords are also subcommands (such as SYSTEM-FANS, SPACE-CONDITIONS, etc. These keywords may not be specified in SET-DEFAULT.

5. Do not use SET-DEFAULT = n where n is already the default value for the keyword. This is because the program, in many cases, determines whether SET-DEFAULT has been used by comparing the SET-DEFAULT value with the program default value. If these are the same, the program concludes that SET-DEFAULT has not been input.

6. The SET-DEFAULT instruction is not applicable to SYSTEM-level instructions (that is, instructions that apply to more than one ZONE) and PLANT instructions. This includes the PLANT-ASSIGNMENT instruction. Using SET-DEFAULT with these instructions will produce an error message.

Example:

```
SET-DEFAULT FOR WINDOW
     WIDTH = 6.5  HEIGHT = 4
     GLASS-TYPE = WEST-GLASS ..
```

The above example would set the width and height defaults for windows to 6.5 feet and 4.0 feet respectively, and the GLASS-TYPE to that defined in a GLASS-TYPE instruction U-named WEST-GLASS.

8. DAY-SCHEDULE

The DAY-SCHEDULE instruction is used to define a sequence of 24 hourly values. The DAY-SCHEDULE instruction is used in conjunction with the WEEK-SCHEDULE and SCHEDULE instructions to define an hour-by-hour schedule for an entire year. (For information on how these instructions are coordinated, see Scheduling Concepts section.)

The instruction takes the form

```
U-name = DAY-SCHEDULE  HOURS = (h)  VALUES = (v) ..
```

where U-name is the user-assigned name of a particular DAY-SCHEDULE instruction, HOURS and VALUES are the keywords for the instruction, and h and v are the values assigned to the keywords. The sequence HOURS = (h) VALUES = (v) may be repeated as many times as necessary to define values for all 24 hours of the day. The values of h assigned to HOURS vary from 1 to 24, where hour 1 is defined to end at 1:00 AM. The values of v can be 0 (indicating OFF, UNOCCUPIED, etc.), 1 (indicating ON, OCCUPIED, etc.), decimal fractions between 0 and 1 (meaning the fraction of a maximum capacity that is permitted), numbers greater than 1 (indicating temperature set points, etc.) or even +1, 0, or -1 (indicating window operating positions). The values input depend upon the type of schedule being specified. Care should be exercised in setting the value of v because a range check for maximum and minimum values is not performed.

Example 1:

```
DS1 = DAY-SCHEDULE  HOURS = (1,24)  VALUES = (68.) ..
```

The above instruction assigns the single value of 68.0 to all 24 hours of the DAY-SCHEDULE.

____________________ = DAY-SCHEDULE or D-SCH (User Worksheet)
U-name*

Keyword	User Input Hour(s)-of-Day	Keyword	User Input Number
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________)
HOURS	= (____, ____)	VALUES	= (________) ..

*Mandatory entry, if DAY-SCHEDULE is specified.

Notes:

1. Acceptable entries for Hour(s)-of-Day are 1 thru 24. All hours must be specified.
2. Acceptable entries for Number are explained in the keyword description of the item being scheduled.
3. The words "HOURS =" and "VALUES =" may be omitted.

____________________ = WEEK-SCHEDULE or W-SCH (User Worksheet)
U-name*

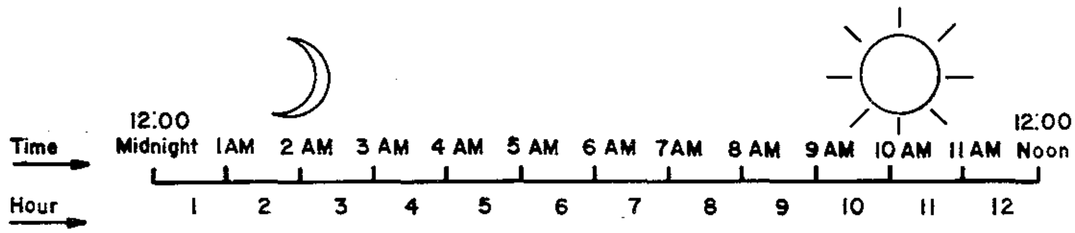
Keyword	User Input Day-of-Week Code-word(s)	Keyword	User Input U-name
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________
DAYS	= (______, ______)	DAY-SCHEDULE	= ____________ ..

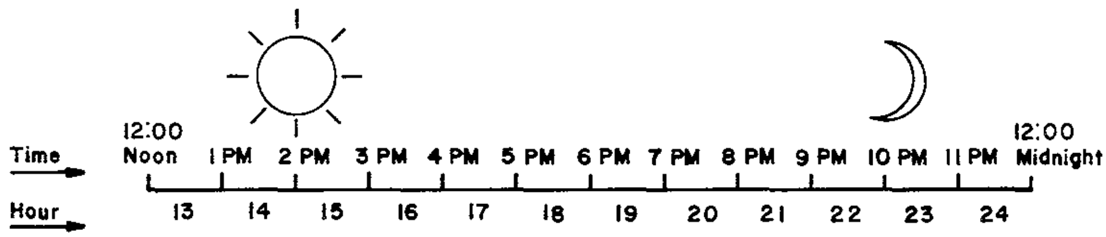
*Mandatory entry, if WEEK-SCHEDULE is specified.

Notes:

1. Acceptable Day-of-Week Code-word(s) are MON, TUE, WED, THU, FRI, SAT, SUN, HOL, WD, WE, WEH, and ALL. All <u>eight</u> days of the week must be specified before the terminator and must <u>be in</u> chronological order.
2. The words "DAYS =" and "DAY-SCHEDULE =" may be omitted.

TIME-TO-HOUR CONVERTER





Example 2:

```
DS2 = DAY-SCHEDULE  HOURS = (1,8)    VALUES = (0.)
                    HOURS = (9)      VALUES = (.5)
                    HOURS = (10,13)  VALUES = (.6,.7,.8,.9)
                    HOURS = (14,24)  VALUES = (0.) ..
```

The above instruction illustrates the various options available when entering data for the DAY-SCHEDULE instruction. If only one hour is assigned to an HOURS keyword, only one value may be assigned the next VALUES keyword. If a range of hours (specified by the starting and ending hours) is entered, then a single value may be assigned to the next VALUES keyword, or a series of values may be entered, one for each hour in the range.

Rules:

1. A U-name must appear before the DAY-SCHEDULE command.

2. All 24 hours must be assigned values. The first hour specified must be 1 and the last hour must be 24. It is not possible to specify hours through midnight.

3. The LIKE keyword may be used (see LIKE section).

4. All values assigned to the HOURS and VALUES keywords must be enclosed in parentheses.

5. A comma and/or one or more blanks must separate multiple values within parentheses.

6. The command may be abbreviated to D-SCH.

7. The keywords HOURS and VALUES may be omitted.

8. If two hour numbers are assigned to an HOURS keyword, the hour numbers must be in ascending order.

9. WEEK-SCHEDULE

The WEEK-SCHEDULE instruction is used to assign DAY-SCHEDULEs to the days of the week. The WEEK-SCHEDULE instruction is used in conjunction with the DAY-SCHEDULE and SCHEDULE instructions (see Scheduling Concepts section).

The instruction takes the form

U-name = WEEK-SCHEDULE   DAYS = (d)   DAY-SCHEDULE = D-S-Name ..

where U-name is the user-specified name of a particular WEEK-SCHEDULE instruction, and d is the day or days of the week that will be assigned the DAY-SCHEDULE named D-S-Name. The sequence DAYS = (d) DAY-SCHEDULE = D-S-Name may be repeated as necessary to define all 8 days of the program week, the first day being Monday and the eighth day signifying holidays.

Rules:

1. A U-name must appear before the command word.

2. The command may be abbreviated to W-SCH.

3. All eight days of the week must be assigned a DAY-SCHEDULE.

4. The keywords DAYS and DAY-SCHEDULE may be omitted.

5. The value(s) entered for the DAYS keyword must be selected from the following code-word table. If the list (of values for DAYS) is a one-element list, it may consist of any code-word in the table. To specify a sequence of days of the week, the list may be a two-element list, each element being taken from the first seven code-words in the table in chronological order (the DOE-2 program input processor assumes that the first day of the week is MON and the last is SUN).

Code-word	Day-of-the-week
MON	Monday
TUE	Tuesday
WED	Wednesday
THU	Thursday
FRI	Friday
SAT	Saturday
SUN	Sunday
HOL	Holiday
WD	Weekdays
WE	Weekend days
WEH	Weekends and holidays
ALL	All days of the week

National Holidays of the United States

New Years Day
    JAN 1 (unless on Saturday or Sunday)
    JAN 2 if a Monday
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 (continued)
    DEC 31 if a Friday

Example 1

```
WEEK-1 =  WEEK-SCHEDULE DAYS (ALL) DAY-SCHEDULE = DAY-1 ..
```

The above instruction defines a WEEK-SCHEDULE named WEEK-1 that uses the DAY-SCHEDULE named DAY-1 for all days of the week.

Example 2

```
WEEK-2 =  WEEK-SCHEDULE DAYS = (MON,WED)      DAY-SCHEDULE = D-1
                        DAYS = (THU,FRI)      DAY-SCHEDULE = D-2
                        DAYS = (WEH)          DAY-SCHEDULE = D-3 ..
```

The above instruction defines a week-schedule named WEEK-2. Day-schedule D-1 is to be used Monday, Tuesday, and Wednesday. Day-schedule D-2 is to be used Thursday and Friday, and day-schedule D-3 is to be used on weekends and holidays.

10. SCHEDULE

The SCHEDULE instruction is used to assign particular week-schedules to different times of the year. The SCHEDULE instruction is used in conjunction with the DAY-SCHEDULE and WEEK-SCHEDULE instructions. (See Scheduling Concepts section.)

The instruction takes the form

```
U-Name SCHEDULE THRU Month Day  WEEK-SCHEDULE =
                                   W-S-Name ..
```

where U-Name is the user-specified name for this instruction, and Month Day are the month and day through which the week-schedule named W-S-Name is to be used. The sequence THRU Month Day, WEEK-SCHEDULE = W-S-Name is repeated as necessary to define a schedule that must extend through the end of the simulation period, as specified in the RUN-PERIOD instruction. The initial date of every schedule is defined to be January 1. The keyword WEEK-SCHEDULE and the equal sign are optional.

Example 1

```
S-1 = SCHEDULE THRU DEC 31  WEEK-SCHEDULE = W-1 ..
```

The above instruction defines a schedule named S-1 and assigns week-schedule W-1 to be used all year.

Example 2

```
S-2 = SCHEDULE THRU MAY 31  IN-SCHOOL
               THRU AUG 31  ON-VACATION
               THRU DEC 31  IN-SCHOOL ..
```

The above instruction defines a schedule named S-2, and assigns week-schedule IN-SCHOOL to be used during the school year and week-schedule ON-VACATION to be used during the summer.

Rules: 1. A U-name must appear before the command word.

2. The command word may be abbreviated to SCH.

3. Dates given must be in chronological order.

4. All schedules must extend at least through the end of the simulation period as defined by the RUN-PERIOD instruction.

5. The value entered as the day-of-the-month must be between 1 and the number of days in the month.

6. The code-word entered as the value of the month must be the first three letters of the name of the month (e.g., JAN for January).

7. Commas are optional. Spaces are equivalent to commas.

8. There is a maximum of 12 THRUs (or intervals) permitted in each SCHEDULE instruction.

9. The LIKE keyword is not allowed.

10. The keyword WEEK-SCHEDULE is optional.

11. REPORT-BLOCK

The REPORT-BLOCK instruction is used to specify a group of variables to be printed in an hourly report (see HOURLY-REPORT instruction).

The instruction takes the form

```
U-Name = REPORT-BLOCK     VARIABLE-TYPE = v-t
                          VARIABLE-LIST = (v-l) ..
```

where U-Name is the user-specified name for a particular REPORT-BLOCK instruction, v-t is a code-word indicating the type of variables to be found in the VARIABLE-LIST data, and v-l is a list of one or more code-numbers indicating which variables of type v-t are to be used in an hourly report.

Rules: 1. The instruction U-name is required.

2. The command word REPORT-BLOCK and keywords VARIABLE-TYPE and VARIABLE-LIST may be abbreviated to R-B, V-T, and V-L, respectively.

3. The LIKE keyword may be used (see LIKE section).

4. The code-words that may be assigned to VARIABLE-TYPE and to VARIABLE-LIST must be selected from the table of acceptable values listed with the REPORT-BLOCK instruction description as given in the chapter in which the instruction is to be used.

____________________ =SCHEDULE or SCH (User Worksheet)

U-name*

Key-word	User Input: Month	User Input: Day-of-Month	Keyword	User Input: U-name
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	
THRU			WEEK-SCHEDULE =	..

*Mandatory entry, if SCHEDULE is specified.

Notes:

1. Acceptable code-words for Month are JAN, FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, and DEC.
2. Acceptable entries for Day-of-Month are 1 thru the number of days in the month.
3. The words "WEEK-SCHEDULE =" may be omitted.

5. The maximum number of code-numbers assigned to VARIABLE-LIST for <u>all</u> REPORT-BLOCKs is 60.

Example:

```
RB-1 = REPORT-BLOCK
    VARIABLE-TYPE = BUILDING
    VARIABLE-LIST = (1,19) ..
HR-1 = HOURLY-REPORT
    REPORT-SCHEDULE = RS-1
    REPORT-BLOCK  =  (RB-1) ..
```

The above instructions (as used in the LOADS program) would cause the building sensible heating load and building sensible cooling load to be printed every hour for which schedule RS-1 is nonzero.

12. HOURLY-REPORT

The HOURLY-REPORT instruction directs the program to print the hourly values of all variables specified in one or more REPORT-BLOCK instructions. These values are to be printed according to the schedule assigned to the keyword REPORT-SCHEDULE. (A plot option also exists. See Sec. B.21 in Chap. III.)

The instruction takes the form

```
U-Name =  HOURLY-REPORT
      REPORT-SCHEDULE = R-S-U-Name
      REPORT-BLOCK   = (R-B-U-Name)  ..
```

where U-Name is the user-specified name for an HOURLY-REPORT instruction, R-S-U-Name is the U-name of a schedule instruction, and R-B-U-Name is one or more U-names of report block instructions.

Rules:

1. The entry of a U-name for this instruction is required.

2. The command word may be abbreviated to H-R.

3. The LIKE keyword may be used (see LIKE section).

4. Report values will be printed every hour for which the hourly value of the assigned schedule is nonzero. Note that even if DAYLIGHT-SAVINGS = YES, summer hours will not reflect daylight saving time. Therefore, there will be one hour difference between times appearing in the LOADS Summary Reports and the LOADS Hourly Reports.

5. The U-name(s) assigned to the keyword REPORT-BLOCK must appear within parentheses, even if only one U-name is assigned.

6. The keywords REPORT-BLOCK and REPORT-SCHEDULE may be abbreviated to R-B and R-SCH, respectively.

Note: A DOE-2 weather year contains 365 days. When the DOE-2 Weather Processor is run on a weather tape for a leap year, the first 365 days it encounters become the DOE-2 weather year and February is assumed to have 28 days. As a result, the weather for all days after February 28 will be displaced by one day of the week, i.e., the weather for February 29 becomes the weather for March 1, and March 1 is assumed by DOE-2 to occur one day earlier in the week than the calendar for that year would indicate. The data for December 31 on the original weather file is ignored.

Example:

```
HR-1 = HOURLY-REPORT
    REPORT-SCHEDULE = RS-JAN
    REPORT-BLOCK    = (RS-1) ..
```

The above instruction defines an hourly report named HR-1 that will print values of the variables specified in report block RS-1 when the schedule named RS-JAN has an hourly nonzero value.

13. END

The END instruction indicates that all data for a particular program have been entered.

The instruction takes the form of simply

```
END ..
```

Once an END .. instruction is encountered, all final processing of the data for that program takes place, such as checking for undefined U-names, etc. Warning: If an END instruction is omitted, all subsequent instructions will be erroneously interpreted as further input instructions to the current program.

Rules:

1. Each END instruction must be preceded by an INPUT, LIBRARY-INPUT, or PARAMETRIC-INPUT instruction.
2. An END instruction must be encountered by the current input processor before instruction control is returned to the control processor.
3. The END instruction should appear as a separate instruction.

14. COMPUTE

The COMPUTE instruction directs the program to execute a particular simulation program, the data for which have been previously entered following an INPUT instruction for the same program.

The instruction takes the form

COMPUTE Program-Name ..

where Program-Name is a code-word indicating which simulation program is to be executed using previous input data.

Rules:

1. The code-word must be one of the following: LOADS, SYSTEMS, PLANT, ECONOMICS.

2. If no COMPUTE instruction is entered, only error checking of input data will occur--no simulation will take place.

3. All input data are processed before any simulation occurs. Thus, if a fatal error is detected in the PLANT instructions, the LOADS and SYSTEMS programs are not executed.

4. A COMPUTE instruction for the immediately "upstream" program must have been previously entered. (A COMPUTE SYSTEMS .. must be preceded by a COMPUTE LOADS .. , etc.) (See Typical Run Instruction Sequences section). If one is saving files from a previous run, this may not be true; see SAVE-FILES.

5. A COMPUTE instruction is always associated with the last INPUT or PARAMETRIC-INPUT instruction for the same program.

6. The hourly input data used by a program, specified in a COMPUTE instruction, is always the hourly output data generated by the last COMPUTE instruction for the immediately "upstream" program. (A COMPUTE PLANT .. instruction causes the PLANT program to use hourly data generated by the last COMPUTE SYSTEMS .. instruction.)

7. A COMPUTE instruction may not occur between an INPUT instruction and an END instruction.

15. SAVE-FILES

The SAVE-FILES instruction is used when the simulation program sequence is to be continued in a subsequent job.

The instruction takes the form of simply

SAVE-FILES ..

The SAVE-FILES instruction may be used only as a control instruction, that is, it must not occur between an INPUT instruction and an END instruction.

The control processor examines all COMPUTE instructions to determine if the intermediate output files of a program are needed as input files to a subsequent program. If not, the writing of those files is suppressed. However, if the user desires to save these intermediate files for use in a subsequent job to avoid re-execution of one or more of the programs, the SAVE-FILES instruction must be used.

For example, if the user desires to execute the LOADS and SYSTEMS programs during one job, and save the intermediate output files from SYSTEMS to be used in an extensive analysis using the PLANT program, the SAVE-FILES instruction would cause the SYSTEMS intermediate output files to be written even though no COMPUTE PLANT .. instruction was encountered.

The appropriate intermediate output files must be saved using the appropriate control cards or JCL for a particular installation, and must be likewise retrieved at the beginning of subsequent runs.

16. STOP

The STOP instruction indicates that the end of all input data for all simulation programs has been reached.

The instruction takes the form of simply

STOP ..

and directs the control processor to terminate data input and begin simulation, assuming COMPUTE instructions were entered and no fatal errors were detected.

Rules: 1. The STOP instruction may be used only as a control instruction, that is, it may not occur between an INPUT instruction and an END instruction.

III. LOADS PROGRAM

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III. LOADS PROGRAM

A. INTRODUCTION

The LOADS program calculates the heating and cooling loads for each space within a building based on the ASHRAE algorithms described in Ref. 1. For the load calculations it is assumed that no HVAC equipment is operating and each space remains at an individual constant temperature. Therefore, the hourly load calculated by the LOADS program is the energy required to maintain the space temperature without the effects of the ventilation air.

The building hourly loads are a function of the following parameters.

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 wind speed
Hourly wind direction
Hourly insolation
Size of external shading surfaces
Opacity of external shading surfaces
Location of external shading surface
Thickness of construction layers
Conductivities of construction layers
Densities of construction layer materials
Specific heats of construction layer materials
Sequence of layers in construction
Thermal lag of furnishings and structure
Schedules for occupants
Schedules for lighting
Schedules for equipment
Infiltration
Position of spaces within the building
Position of spaces with respect to other spaces
Size of exterior, interior, and underground surfaces
Construction of exterior, interior, and underground surfaces
Position of exterior, interior, and underground surfaces.

The user's problem is to determine these parameters and put them into a form usable by the LOADS program. To do this, each of the parameters must be described by a sequence of Loads Description Language (LDL) instructions.

1. Preparation of Input

a. Prepare Building Drawings

(1) Draw a simplified floor plan and elevation view of each unique floor.

(2) Identify and outline on these floor plans the individually controlled thermal zones or spaces. Usually a core zone, perimeter zone, computer rooms, cafeterias, unconditioned spaces and so on are each identified as separate thermal zones. Each SPACE in LOADS must be identical to a thermal ZONE in the SYSTEMS program. Therefore, it would be a good idea to read applicable sections of Chap. IV to determine the recommended way of defining the thermal zones from a secondary HVAC system (distribution system) viewpoint.

(3) Label each separate thermal zone with a unique "user name" (U-name) on the floor plan.

b. Prepare the LDL Instruction

(1) Make one copy of each user worksheet.

(2) Duplicate as many additional copies of each worksheet as is necessary for the building being modeled. For instance, if the building has 10 thermal zones, 10 SPACE worksheets should be filled out.

(3) Arrange the worksheets in the order described in the section, "LDL Input Sequence," and enter the appropriate data by keypunched cards or at a terminal, depending upon the hardware available at your site.

(4) Familiarity with the LDL instructions will probably allow the user to dispense with the worksheets. Instead the user will code the LDL instructions directly from a list of commands, keywords, code-words, and values.

c. Submit Input Deck

Every computer site or organization has certain requirements for user job and cost account information (or log-on instructions). Local site manuals should contain the necessary information on user passwords, cost algorithms, telephone numbers, and so on.

(1) Prepare the site-specific job, password, and account instructions, and place them at the beginning of the deck.

(2) Attach the job control language (JCL) deck for accessing the DOE-2 computer programs.

(3) Attach the LDL instructions, beginning with an "INPUT LOADS .. " instruction and ending with a "STOP .. " instruction.

(4) Submit the deck for processing.

2. LDL Input Sequence

This section describes the input sequence of the LDL instructions for the LOADS program. A detailed description of each instruction is in Chap. III, Sec B.

To begin the input data for the LOADS program, the user must first enter

INPUT LOADS ..

which informs the LDL processor that data in the following instructions will apply to the LOADS program. This instruction may be followed by any of the BDL control instructions described in Chap. II that define variables, set default values, select schedules, etc. The sequence of instructions is arbitrary except when the data hierarchy referencing features are used. The instruction sequence of the following examples illustrates the preferred sequence to minimize errors.

The identification and control instructions are

TITLE
ABORT
DIAGNOSTIC
RUN-PERIOD

The TITLE instruction is used to define the name of the building, the date, the name of the architect/engineer or any other identifying information. ABORT sets the error level that will cause the program to terminate after processing the language. The DIAGNOSTIC instruction establishes a message level for printing diagnostic information. The RUN-PERIOD instruction identifies the time interval(s) for the computations.

The next instruction

BUILDING-LOCATION

is used to specify the building location on the surface of the earth.

If an object shades an exterior surface of the building, this object must be described by the

BUILDING-SHADE

instruction. This instruction will direct the program to properly account for the reduction of direct solar radiation. Any surface that intercepts solar radiation (such as a hill, tree, nearby building, or other surfaces of the building being simulated) should be included.

It is strongly recommended that the instructions that specify the building envelope, along with the schedule and assignment instructions, be entered at the beginning of the LOADS input. This practice will preclude such common errors as referencing U-names not previously defined. Therefore, enter the following instructions next.

MATERIAL
LAYERS
CONSTRUCTION

As an alternative to the entry of one or more of the above instructions, a selection may be made from the DOE-2 Library of MATERIALs, LAYERS, and CONSTRUCTIONs, BDLLIB. In this case, proper code-words must be entered in a LAYERS, CONSTRUCTION, or EXTERIOR-WALL instruction.

Occupancy, lighting, infiltration, and equipment schedules are entered next.

DAY-SCHEDULE
WEEK-SCHEDULE
SCHEDULE

After all the schedules have been specified, each thermal zone* within the building should be specified. The selection of thermal zone boundaries should be done with consideration of the secondary HVAC systems. Every space in the LOADS program must be physically identical to every zone in the SYSTEMS program.

Common space conditions can be specified by the following instruction.

SPACE-CONDITIONS

This instruction simplifies input, because it can be referenced in several spaces. Thus the values under it do not have to be repeated.

The next instruction is required to define each space.

SPACE

indicates to the LDL Processor that the following instructions will define a thermal zone. Thus, immediately following each SPACE instruction, the appropriate thermal boundaries for that space must be entered. To do this, use the following commands.

EXTERIOR WALL (or ROOF)
INTERIOR WALL
UNDERGROUND-WALL (or UNDERGROUND-FLOOR)

as appropriate. Any fenestration or entryway should be defined using the

*In this text, the words "thermal zone," "zone," and "space" are synonymous and are interchangeable.

WINDOW
DOOR

instructions. The WINDOW and/or DOOR instructions must immediately follow the instruction for the EXTERIOR-WALL, or ROOF, upon which the fenestration or entryway occurs. The program will then locate the openings appropriately and subtract their area from the appropriate exterior wall or roof.

After all the spaces and their thermal boundaries have been specified, desired standard output reports are selected using the

LOADS-REPORT

instruction. Hourly reports of many variables calculated by LOADS are also available and may be selected by using the

REPORT-BLOCK
HOURLY-REPORT

instructions. These instructions also define the time periods for which hourly reports are desired. Then enter the instructions

END ..
COMPUTE LOADS ..

This concludes the input and initiates the LOADS simulation. If SYSTEMS, PLANT, and ECONOMICS runs are not involved enter

STOP ..

Note: If the user wishes to conduct parametric runs (successive simulations with one or more parameters being changed for each simulation), selected user-defined variables can be redefined by using the

PARAMETER

instruction. One common use of this instruction is to specify a "user-defined variable" and assign it an initial value. Then parametric studies can be easily run by changing the value of the "user-defined variable" instead of making several variable changes, using the PARAMETRIC-INPUT instruction (see Chap.II).

Also, if any preprogrammed default values for keywords are to be changed, this should be done, by using the

SET-DEFAULT

instruction. The default values will be over-written by a new user-specified default value each time the SET-DEFAULT instruction is encountered. Repeated use of this instruction may reduce the input data task but risks errors caused by incorrect defining of defaults.

3. Limitations

For DOE-2, the maximum number of LDL instructions that can be used for specifying the required data for the LOADS program is as follows:

Instruction	Maximum Number
DAY-SCHEDULE	60
WEEK-SCHEDULE	40
SCHEDULE	40
RUN-PERIOD	1 (1 command, specifying up to 12 periods)
BUILDING-LOCATION	1
BUILDING-SHADE	64
MATERIAL	128
LAYERS	16
CONSTRUCTION	32
GLASS-TYPE	32
SPACE-CONDITIONS	32
SPACE	64
EXTERIOR-WALL/ROOF	128
INTERIOR-WALL	128
WINDOW	128
DOOR	64
UNDERGROUND-WALL/UNDERGROUND-FLOOR	64
DESIGN-DAY	3
BUILDING-RESOURCE	1
SET-DEFAULT	100*
DESIGN-DAY	3
LOADS-REPORT	1
TITLE	5*
PARAMETER	50*
HOURLY-REPORT	16
REPORT-BLOCK	64
U-names	352**

4. Coordinate Systems

The LOADS program uses a hierarchy of three right-handed Cartesian coordinate systems (see Fig. III.1): the building coordinate system, the space coordinate system, and the surface coordinate system. These systems are related to each other by simple translation and rotation. The location

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

** The use of the advanced scheduling technique (described in Chapter II) 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.).

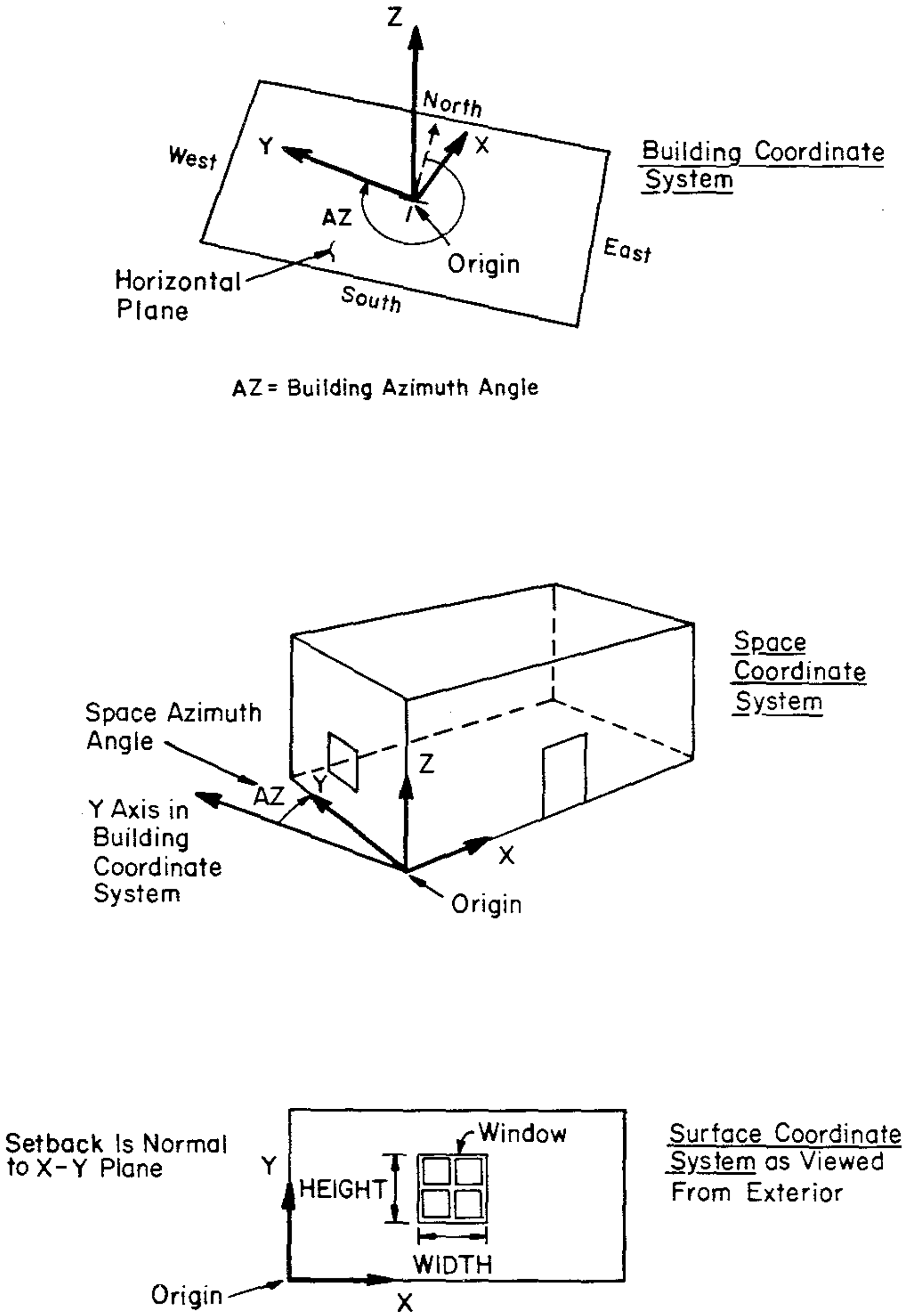

Fig. III.1. Three relative coordinate systems.

of the space coordinate system is defined relative to the origin of the building coordinate system, and the surface coordinate system is located relative to the origin of the space coordinate system. There is only one building coordinate system, but there is one space coordinate system for each space defined by the user, and one surface coordinate system for each exterior wall or roof defined by the user. The user need not keep track of the overall position of each surface and window/door relative to the building as a whole. Instead, the position of walls and roofs is specified relative to the space in which they occur, and the positions of windows and doors are specified relative to the wall on which they occur. The program then automatically transforms the walls and windows to the overall building coordinate system.

The building coordinate system is defined in the BUILDING-LOCATION instruction by assigning values to the keywords AZIMUTH, LATITUDE, LONGITUDE, and ALTITUDE. A space and its coordinate system are located within the building coordinate system by assigning values to the keywords X, Y, Z, and AZIMUTH in the SPACE instruction. The wall or roof is located within the <u>space</u> coordinate system by giving values to the keywords X, Y, Z, AZIMUTH, and TILT in the EXTERIOR-WALL (or ROOF) instruction. Each exterior wall or roof has a surface coordinate system associated with it. Windows are located relative to a surface coordinate system by assigned values to X, Y, and SETBACK in the WINDOW instruction.

BUILDING-SHADEs form a special class of surfaces in that, unlike exterior walls or roofs, they must be located in the building coordinate system. If the user <u>does not</u> use the BUILDING-SHADE instruction, there is no need to keep track of the <u>location</u> (X, Y, and Z keywords) of spaces, walls, and windows. All that is needed is that the <u>orientation</u> (AZIMUTH and TILT) of the walls be correctly specified. The user can allow the X, Y, and Z keywords to default to zero.

a. <u>Building Coordinate System</u>

SPACEs and BUILDING-SHADEs are specified relative to the building coordinate system. The coordinate system is defined in the BUILDING-LOCATION instruction. The location of the origin is fixed by values assigned to the keywords LATITUDE, LONGITUDE, and ALTITUDE. The orientation of the coordinate system is such that the z-axis is vertical and the x-y plane horizontal (right-hand Cartesian coordinate system). The user may rotate the coordinate system about the z-axis by using the AZIMUTH keyword. The AZIMUTH is defined as the clockwise angle between true north and the building y-axis. Thus AZIMUTH = 0 means that the y-axis points north, AZIMUTH = 90 means that the y-axis points east, and so forth.

It is recommended that, for a simple rectangular building, the user orient the building coordinate system so that the x-axis runs along the front of the building, and the origin is located at the lower left-hand corner of the front wall, as viewed from the outside (see Fig. III.2). For more complicated building shapes, any convenient location of the origin and orientation of the AZIMUTH may be chosen.

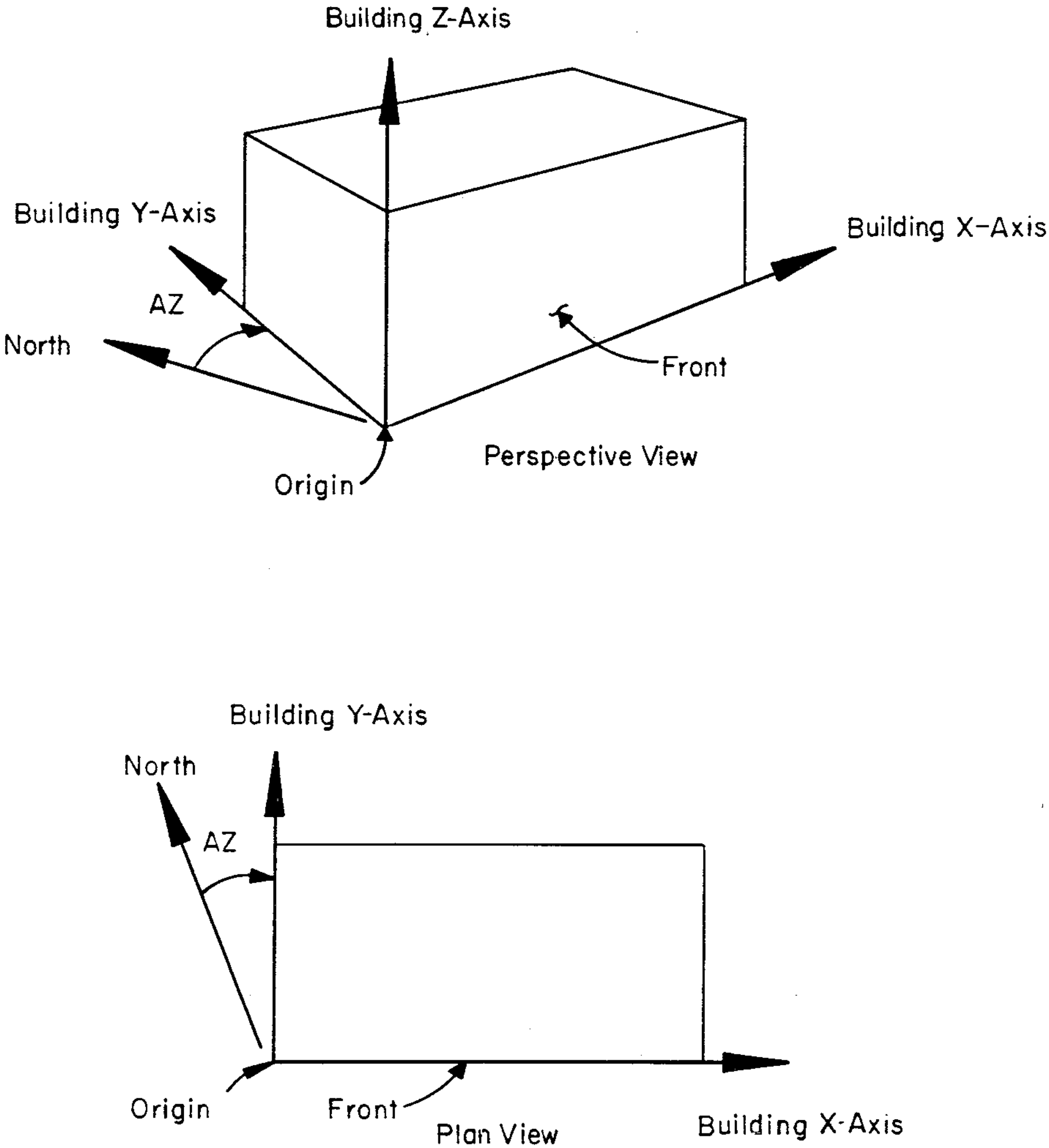

Fig. III.2. Example of building coordinate system.

b. Space Coordinate System

The location of a space and its associated space coordinate system are defined relative to the building coordinate system by the keywords X, Y, Z, and AZIMUTH in the SPACE instruction (see Figs. III.3 and III.4). The location of the origin of the space coordinate system is specified by assigning values to X, Y, and Z. The orientation of the space coordinate system is such that its z-axis is vertical and x-y plane is horizontal (right-hand cartesian coordinate system). The space and its coordinate system may be rotated about the z-axis by giving a value to the keyword AZIMUTH. The AZIMUTH is defined as the clockwise angle between the building y-axis and the space y-axis. If the user does not specify X, Y, Z, and AZIMUTH, the keyword value will default to zero and the space coordinate system becomes identical with the building coordinate system.

c. Surface Coordinate System

A surface and its surface coordinate system are located relative to the space coordinate system by the keywords X, Y, Z, AZIMUTH, and TILT in the EXTERIOR-WALL or ROOF instruction. Windows are located relative to the surface coordinate system. The location of the origin of the surface coordinate system relative to the origin of the space coordinate system is specified by assigning values to X, Y, and Z. The origin of the surface coordinate system is the lower left-hand corner of the wall, as seen by an observer viewing the surface in the direction opposite to the surface outward normal. The orientation of the coordinate system is fixed by the keywords AZIMUTH and TILT. The AZIMUTH is the clockwise angle between the space coordinate system y-axis and the horizontal projection of the outward normal of the wall or roof associated with the surface coordinate system (see Fig. III.5). To specify azimuth for a horizontal surface, see the discussion of Fig. III.9.

The surface coordinate system should be regarded as embedded in its associated exterior wall or roof. The x-axis runs along the width of the wall, the y-axis points along the height of the wall, and the z-axis is parallel to the surface outward normal. The TILT is then the angle between the vertical and the surface outward normal, and the AZIMUTH is the clockwise angle between the space coordinate system y-axis and the projection of the surface outward normal on the horizontal plane.

5. Use of the Coordinate Systems

a. Quick Method for Locating Walls, Ceilings, and Floors (in Box-shaped SPACEs)

For box-shaped SPACEs (rectangular parallelepipeds) only, there is an easy method of locating and orienting its walls. The user inputs SHAPE = BOX and assigns values to HEIGHT, WIDTH, and DEPTH in the SPACE instruction. For the walls, he may then simply assign

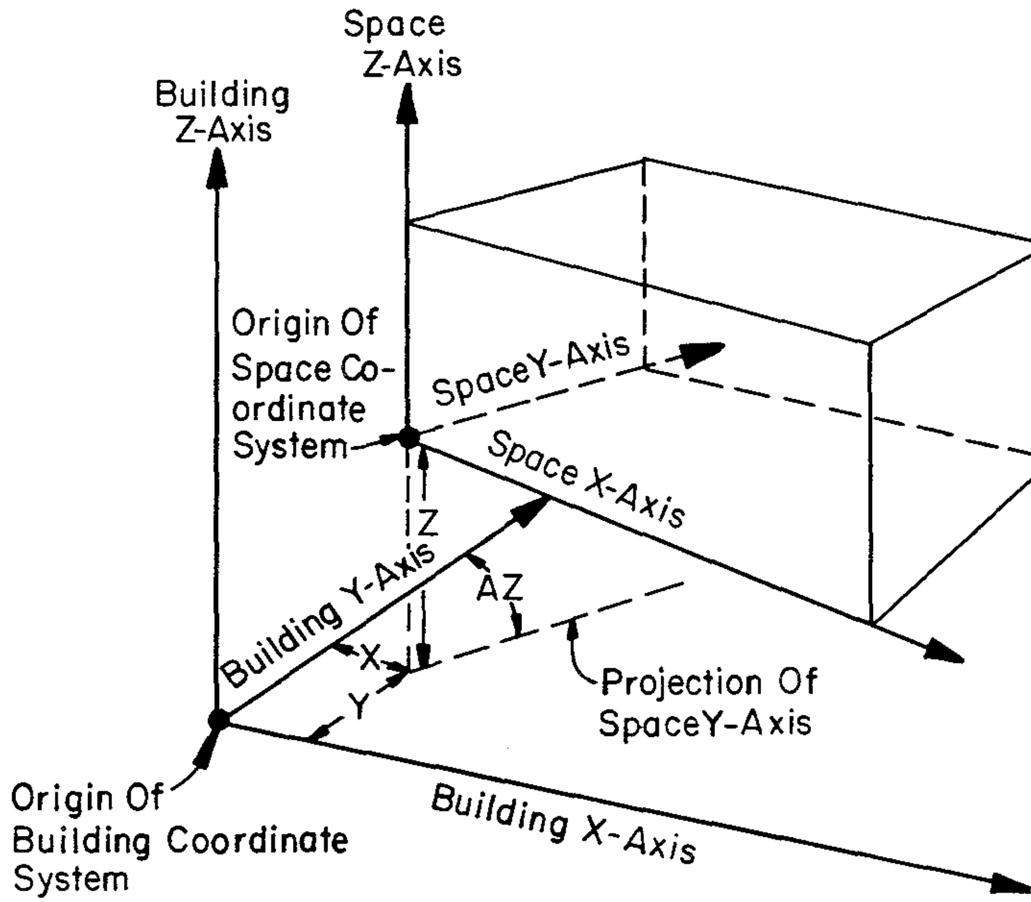

Fig. III.3. Example of a space coordinate system located in a building coordinate system.

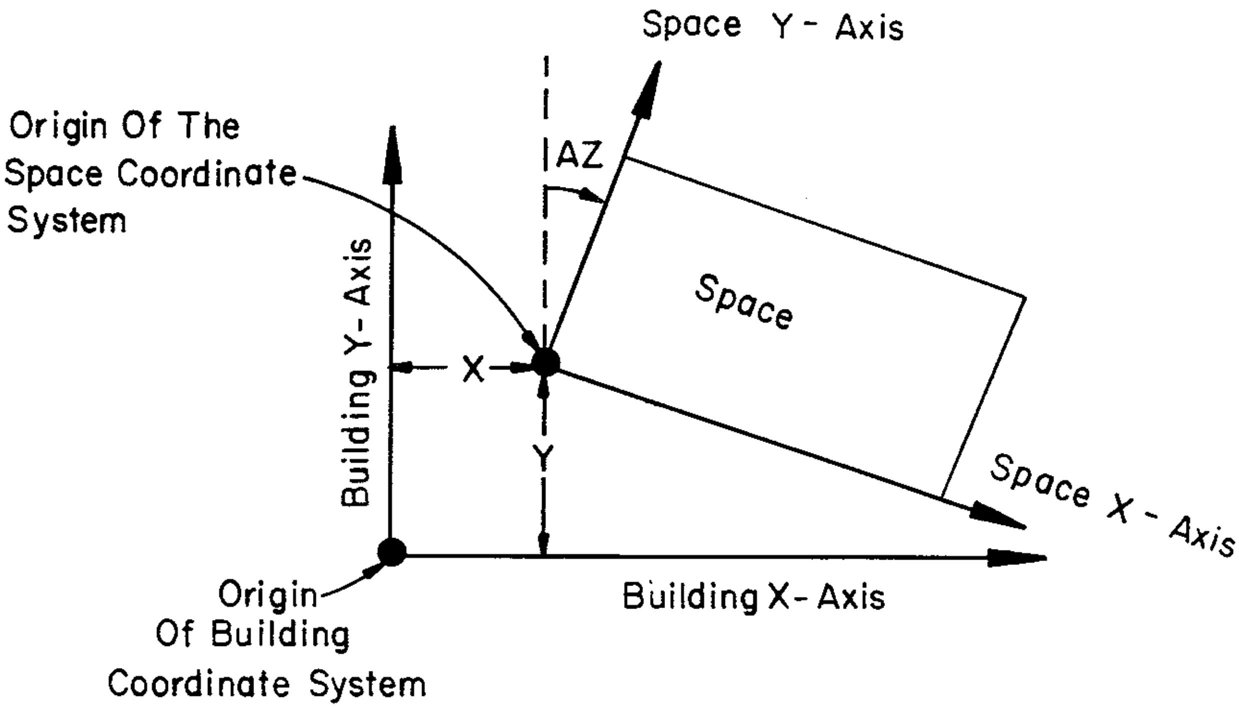

Fig. III.4. Plan view of Fig. III.3.

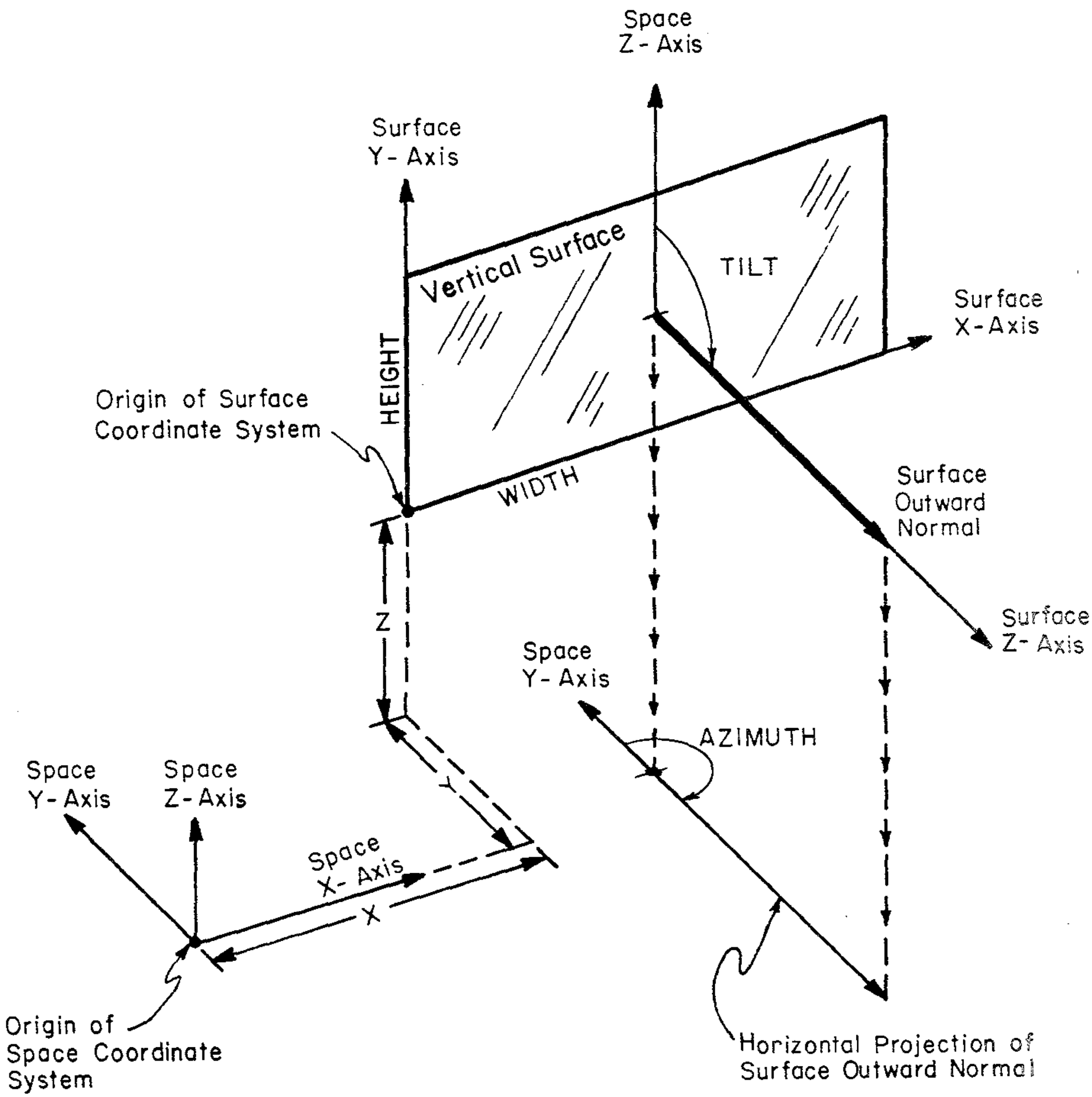

Fig. III.5. Example of a surface located within a space coordinate system.

$$
\text{LOCATION} = \begin{Bmatrix} \text{LEFT} \\ \text{RIGHT} \\ \text{FRONT} \\ \text{BACK} \\ \text{TOP} \\ \text{BOTTOM} \end{Bmatrix}
$$

in the EXTERIOR-WALL (ROOF), INTERIOR-WALL, UNDERGROUND-WALL, or UNDERGROUND-FLOOR instructions. The program will then automatically assign the correct X, Y, Z, AZIMUTH, and TILT for the wall, ceiling, or floor. The SPACE must be viewed by looking along the Y-axis in the positive direction. See Fig. III.6.

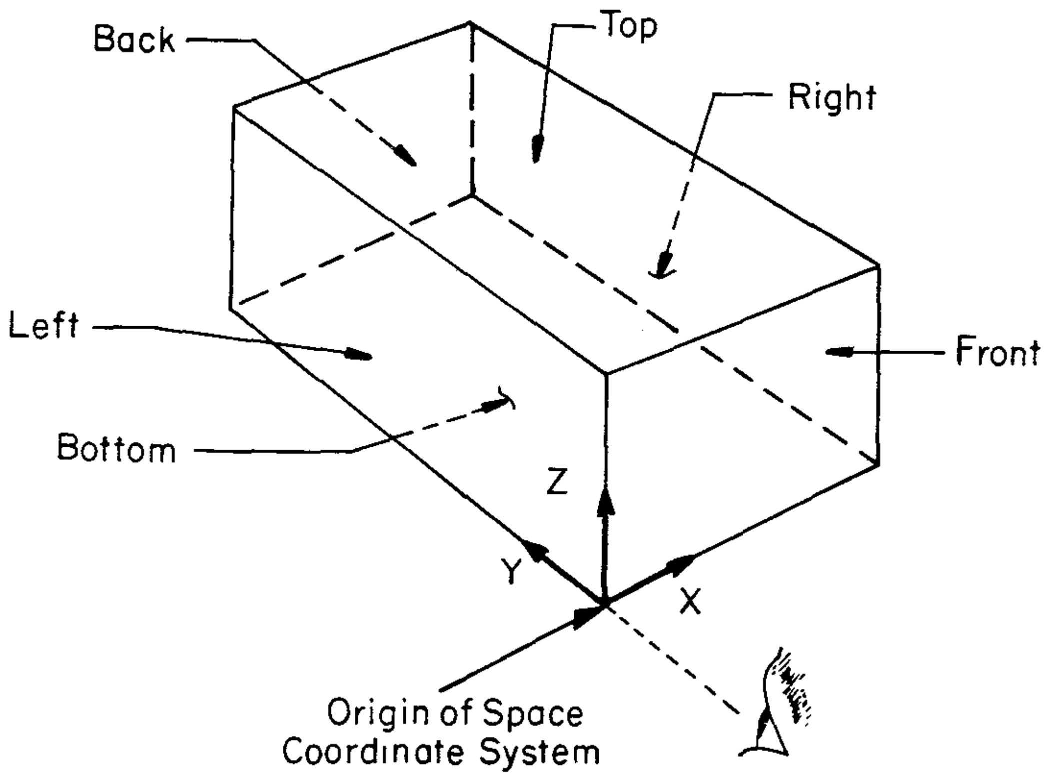

Fig. III.6. Illustration of BOX faces as they are located in the Space Coordinate System.

b. Locating and Orienting Building Shades, Roofs, and Exterior Walls

The method for locating and orienting building shades and exterior walls is similar to the SPACE locating method, although building shades are specified relative to the building coordinate system and roofs and exterior walls are specified relative to the space coordinate system. In both cases, X, Y, Z, AZIMUTH, and TILT must be input. TILT is simply the angle between the vertical (the building z-axis or the SPACE z-axis) and the surface outward normal. Vertical surfaces have TILT = 90; surfaces with the surface outward normal pointing straight up (horizontal) have TILT = 0 (see Fig. III.7).

For vertical surfaces, AZIMUTH is the clockwise angle between the y-axis (SPACE y-axis for exterior walls; building y-axis for shades) and the surface outward normal (see Fig. III.8). X, Y, and Z are the coordinates (relative to the space coordinate system for exterior walls; relative to the building coordinate system for building shades) of the lower left-hand corner of the surface as viewed from outside (i.e., in a direction opposite to the surface outward normal). Horizontal or nonvertical surfaces are trickier. The TILT is determined as before. Choose the origin of the surface and specify values for X, Y, and Z. Next, mentally rotate the surface to a vertical position such that the origin does not move (see Fig. III.9). Specify AZIMUTH, which is again the clockwise angle between the relevant y-axis and the outward normal of the surface in its new position. The values of HEIGHT and WIDTH are the height and width of the surface in its new, or vertical, position. Of course, the program will not see the surface in the vertical position because the TILT, which was specified before mentally rotating the surface to vertical, was already established at its true value.

CAUTION: The incorrect specification of AZIMUTH can result in coincident walls, inside out walls, outward protruding walls, bay windows instead of setback windows, direct sunlight through north facing windows, incorrect shading, and a whole host of other problems too numerous to mention. In complicated buildings these effects may not be readily noticeable in the simulation output.

If a building has exterior shading, either from itself or from other structures, X, Y, and Z should not be allowed to default to zero.

c. Locating Windows and Doors

Locating and orienting windows and doors is rather simple. The user needs to specify X and Y in the WINDOW or DOOR instructions. (Exception: if there is no exterior shading, X and Y may be allowed to default to zero.) The opening is regarded as lying in the plane (the x-y plane of the surface coordinate system) of its wall. Values for X and Y locate the lower left-hand corner of the opening, as viewed from outside, relative to the lower left-hand corner of the wall. See Fig. III.10. The x-dimension runs parallel to the width of the wall and opening; the y-dimension runs parallel to the height. Assigning a positive value to the keyword SETBACK will result in a window or door that is recessed into the wall by the amount specified. Local shading, resulting from the setback, will be done on the opening, so the keyword SHADING-DIVISION, in the EXTERIOR-WALL (ROOF), DOOR, and WINDOW instructions, should be given a value if the default value is inappropriate.

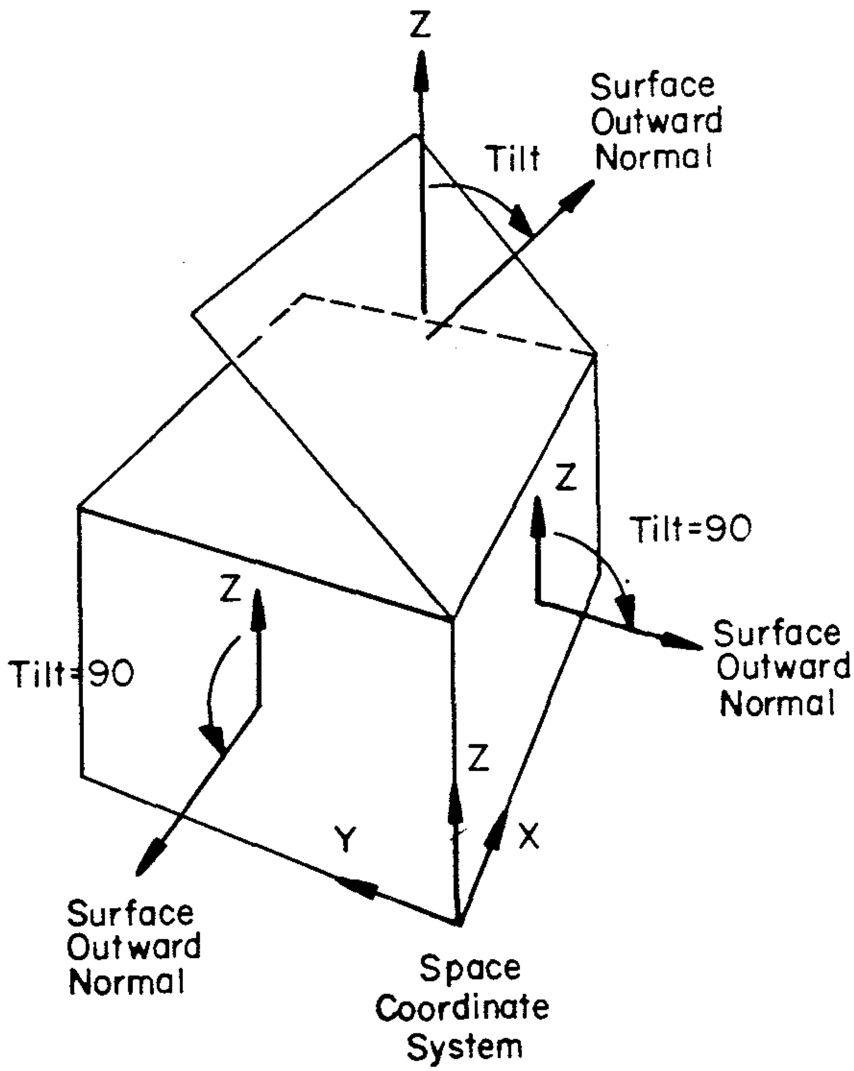

Fig. III.7. Several examples of the TILT keyword.

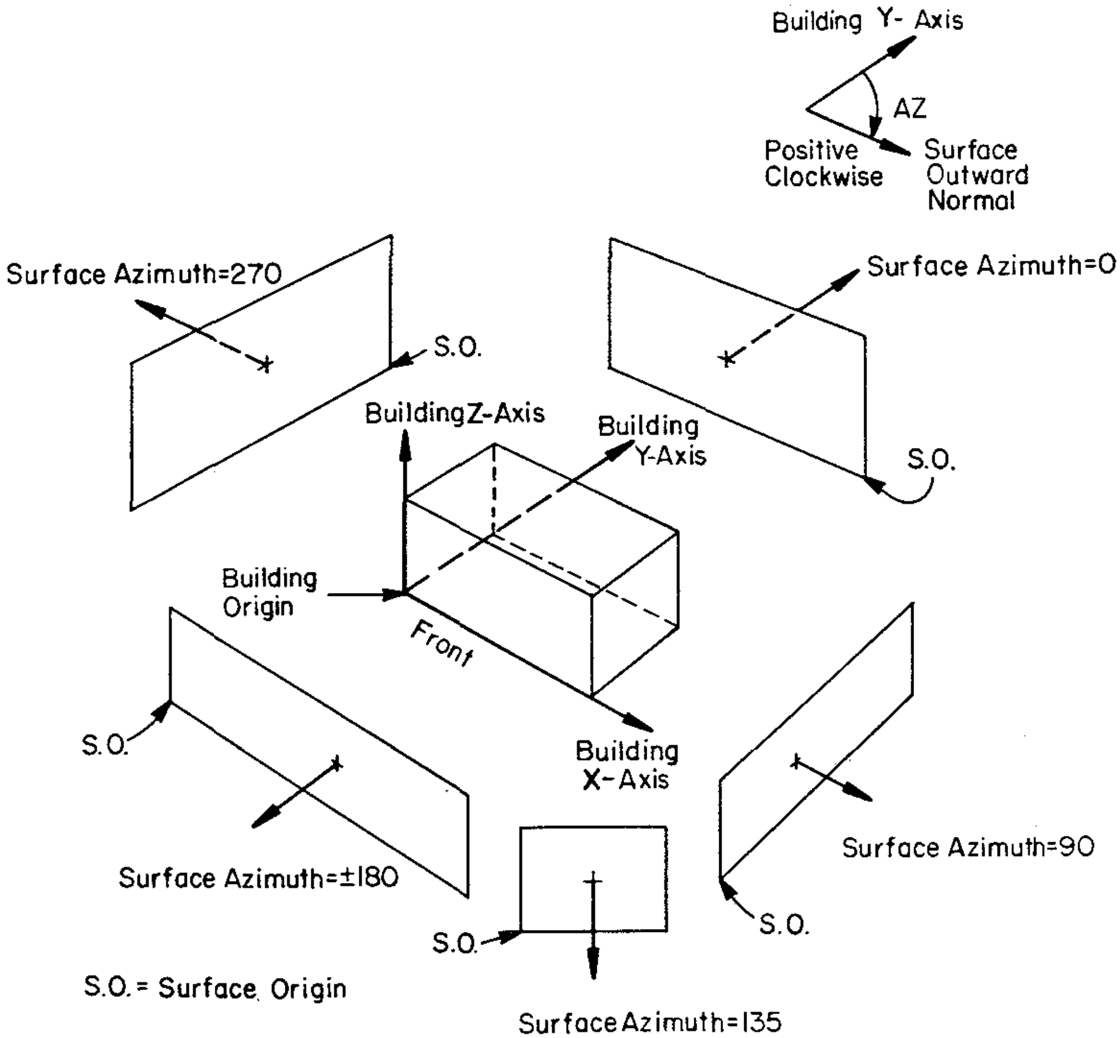

Fig. III.8. Several examples of the AZIMUTH keyword for surfaces.

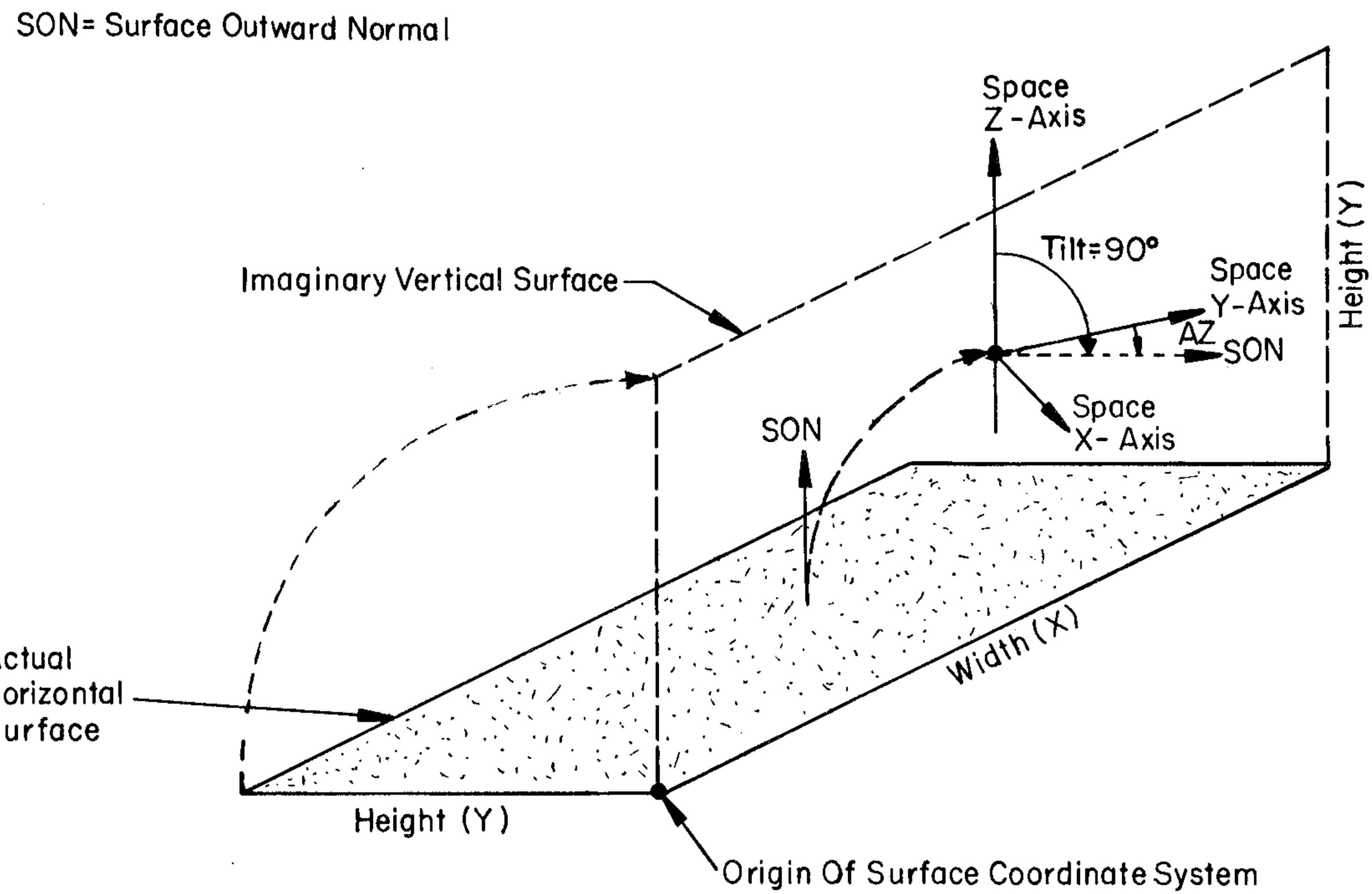

Fig. III.9. Example of method of describing a horizontal surface.

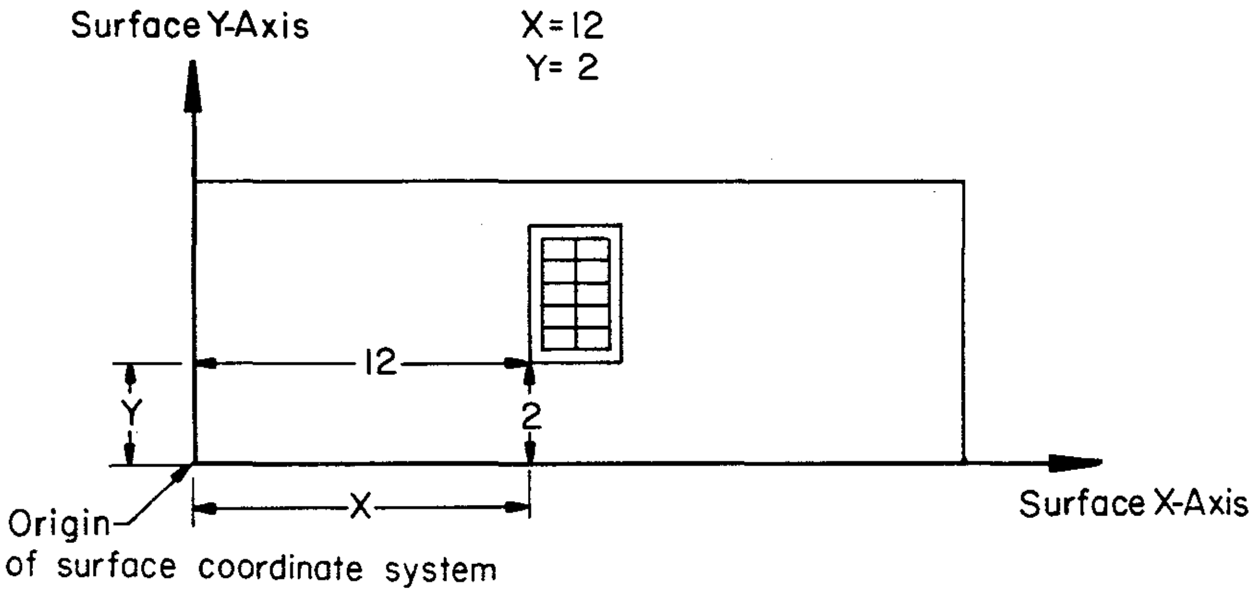

Fig. III.10. Example of window location in the surface coordinate system.

6. Data Hierarchy

LDL contains the following command hierarchy.

Level	Command
1	SPACE
2	EXTERIOR-WALL ROOF
3	WINDOW DOOR

All surfaces (level 2) are associated with the immediately preceding SPACE instruction. All apertures (DOORs and WINDOWs, level 3) are associated with the immediately preceding EXTERIOR-WALL (or ROOF) instruction. (see Fig. III.11).

Keywords always immediately follow the command they refer to. The LDL processor cannot check that all the necessary information has been entered. Care must be taken to avoid specifying common interior walls and floors twice for two adjacent spaces.

```
SPACE (1)
     EXTERIOR-WALL (1)
          WINDOW (1)
          WINDOW (2)
            :
          WINDOW (n)
          DOOR (1)
          DOOR (2)
            :
          DOOR (n)

     EXTERIOR-WALL (2)
          WINDOW (1)
          WINDOW (2)
            :
          WINDOW (n)
          DOOR (1)
          DOOR (2)
            :
          DOOR (n)

     EXTERIOR-WALL (3)
          WINDOW (1)
          WINDOW (2)
            :
          WINDOW (n)
          DOOR (1)
          DOOR (2)
            :
          DOOR (n)

     INTERIOR-WALL (1) thru (n)
     UNDERGROUND-WALL (1) thru (n)
     UNDERGROUND-FLOOR (1) thru (n)

SPACE (2)  (identical organization to above)

SPACE (n)  (identical organization to above)
```

Fig. III.11. Input hierarchy for a LOADS simulation.

B. LDL Input Instructions

This section contains descriptions of all LDL input instructions that are required to run the LOADS program. The order of presentation follows the hierarchy described in the last section of Chap. II, BDL.

1. INPUT (Alternative Forms)

As discussed in Chap. II, Sec. B, the input data for each of the main programs must begin with an INPUT Program-Name instruction.

INPUT LOADS ..

This instruction informs the LDL processor that LOADS program input data follow.

For the LOADS program only, an alternative form of the INPUT instruction exists that is used not to run the LOADS program itself but as a preprocessor to build a user-specified library of MATERIALs, LAYERS, and CONSTRUCTIONs. Normally, the DOE-2 Library will already contain all the MATERIALs, LAYERS, and CONSTRUCTIONs that a user will need, however, if the user wishes to add others, he should use the

LIBRARY-INPUT LOADS ..

instruction. More information on creating a library or adding to the existing DOE-2 Library can be found in Sec. C of this chapter. For conducting parametric studies, the user should specify the

PARAMETRIC-INPUT LOADS ..

instruction.

2. RUN-PERIOD

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

U-name	Command	Initial Date	Final Date	Terminator
	RUN-PERIOD	month day year	THRU month day year	
		⋮	⋮	
		month day year	THRU month day year	
		⋮	⋮	
		month day year	THRU month day year	..

U-name — is not allowed.

RUN-PERIOD — This command 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 first hour analyzed is the hour from midnight to 1:00 AM. 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 last hour analyzed is the hour from 11:00 PM to midnight for the last date using weather data recorded at midnight.

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 1 RUN-PERIOD instruction is permitted with up to 12 THRUs.

3. The number of RUN-PERIOD intervals must be greater than or equal to the number of DESIGN-DAY instructions. The first THRU applies to the first design day entered, the second THRU to the second design day, etc. Any THRUs in excess of the number of design days use the weather file (see DESIGN-DAY instruction).

4. A PLANT run is possible only if the number of RUN-PERIOD intervals is greater than the number of DESIGN-DAY instructions.

5. 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.

6. 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 (Chap. II).

Examples:

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 December, January, and February to study the winter heating peak, and for June, July, and August, 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  AUG 31 1979
             DEC 1 1979  THRU  DEC 31 1979 ..
```

Optionally, FROM can be used:

```
RUN-PERIOD FROM JAN 1 1979 THRU FEB 28 1979 ..
```

User Input: Initial Date		User Input: Final Date	Input Desc.	Default	Range Min.	Range Max.
______	THRU	______	two dates (month, day year)	–	See Text	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	
______	THRU	______	"	–	"	

..

3. DESIGN-DAY

Note: If the user wishes to use weather data from only the weather file, that is, no design day data, he may skip this section on DESIGN-DAY and go on to the next section.

It is possible for the user to supplement or even to override the weather file data by specifying up to 3 DESIGN-DAYs. This would be done (1) if the user feels that the one year of data contained on the weather file is not typical, or (2) if the user wishes to design the building for the most extreme weather conditions possible at its location. In this case, the peak cooling and heating loads used in the equipment sizing calculations in SYSTEMS and PLANT are the peaks generated during the DESIGN-DAY RUN-PERIOD intervals. If no DESIGN-DAYs have been specified, then the peak heating and cooling loads are calculated by the program, using the weather file for the RUN-PERIOD intervals.

Associated with each DESIGN-DAY instruction is one RUN-PERIOD interval. The DESIGN-DAY data apply to every day in the RUN-PERIOD interval, whether the RUN-PERIOD is one day long or longer.

The RUN-PERIOD and DESIGN-DAY instructions must be entered in a precise manner to get the desired results. The first RUN-PERIOD interval is associated with the first DESIGN-DAY instruction, the second RUN-PERIOD interval is associated with the second DESIGN-DAY instruction, and so on. Any RUN-PERIOD intervals in excess of the number of DESIGN-DAYs will be used for simulations that use data from the weather file. These extra RUN-PERIOD intervals should occur last in the RUN-PERIOD instruction. Therefore, if the user desires to use weather data in any situation, the number of RUN-PERIOD intervals must be greater than the number of DESIGN-DAY instructions.

Example:

```
RUN-PERIOD
   JAN 01 1979 THRU JAN 01 1979       $FIRST DESIGN-DAY    $
                                      $INTERVAL            $
   JUL 15 1979 THRU JUL 19 1979       $SECOND DESIGN-DAY   $
                                      $INTERVAL            $
   DEC 10 1979 THRU DEC 13 1979       $THIRD AND LAST      $
                                      $POSSIBLE DESIGN-DAY $
                                      $INTERVAL            $
   JAN 01 1979 THRU DEC 31 1979 ..    $USE WEATHER FILE    $
                                      $DATA FOR ENTIRE YEAR$
DD-1 = DESIGN-DAY                     $DATA FOR FIRST      $
         .                            $DESIGN-DAY          $
         .      ..                    $INTERVAL            $
```

```
DD-2 = DESIGN-DAY                      $DATA FOR SECOND      $
        .                              $DESIGN-DAY           $
        .        ..                    $INTERVAL             $
DD-3 = DESIGN-DAY                      $DATA FOR THIRD       $
        .                              $AND LAST POSSIBLE    $
        .                              $DESIGN-DAY           $
                 ..                    $INTERVAL             $
```

In the preceding example, the program will choose, for automatic equipment sizing, the largest loads (heating and cooling) based on DESIGN-DAY data rather than weather file data. If DESIGN-DAYs are input, the SYSTEMS program will size equipment based upon the DESIGN-DAY peaks, even if they are smaller than the yearly peaks calculated from the weather file. Had the fourth RUN-PERIOD interval been omitted, automatic equipment sizing in LOADS and SYSTEMS would be based on DESIGN-DAY data only. Furthermore, the subsequent loads in PLANT would be calculated to be zero because the PLANT simulator requires weather file data, and such data would not be available because all of the RUN-PERIOD intervals have been used. Had the fourth RUN-PERIOD interval been the only entry (no other intervals and no DESIGN-DAY instructions), automatic equipment sizing would be based on weather file data only.

The program attempts to account for the thermal mass of the structure and furnishings by iteratively calculating the first day of the RUN-PERIOD four times and then using the answers from the fourth iteration as the answers for the first day of the RUN-PERIOD.

Bear in mind, when using this instruction, that the building external loads will be imposed according to the DESIGN-DAY data (plus solar data) and the building internal loads will be imposed according to the scheduled SPACE-CONDITIONS data. Therefore, if a one-day RUN-PERIOD is chosen and that one day is a Saturday, Sunday or holiday, the internal loads may never be imposed in the calculations.

U-name — is optional for this instruction.

DESIGN-DAY — This command tells LOADS that the data to follow specify design-day-related variables.

LIKE — may be used to copy data from a previously U-named DESIGN-DAY instruction.

DRYBULB-HI — is the maximum ambient dry-bulb temperature (°F).

DRYBULB-LO — is the minimum ambient dry-bulb temperature (°F).

HOUR-HI — is the hour during which DRYBULB-HI occurs.

HOUR-LO — is the hour during which DRYBULB-LO occurs.

DEWPT-HI — is the maximum ambient dew-point temperature (°F).

DEWPT-LO — is the minimum ambient dew-point temperature (°F).

DHOUR-HI — is the hour during which DEWPT-HI occurs.

DHOUR-LO — is the hour during which DEWPT-LO occurs.

WIND-SPEED — is the local wind speed (knots).

WIND-DIR — is the local direction that the design condition wind comes from. It is entered by using a integer-code from the following table.

Wind Direction	Value	Wind Direction	Value
North	0	South	8
N by NE	1	S by SW	9
NE	2	SW	10
E by NE	3	W by SW	11
East	4	West	12
E by SE	5	W by NW	13
SE	6	NW	14
S by SE	7	N by NW	15

CLOUD-AMOUNT — is the cloud cover expressed on a "scale from zero to ten.". That is, 0 represents a clear day and 10 represents a completely overcast day.

CLEARNESS — is the local clearness number. (See ASHRAE Trans., Vol. 64, p. 67).

GROUND-T — is the local ground temperature (°F).

CLOUD-TYPE — is a integer-code to define the cloud type and therefore estimate the opacity of any clouds. The code numbers are 0 for cirrus, 1 for stratus, and 2 for halfway between cirrus and stratus.

Suggested values are:

0 for summer months
1 for winter months
2 for fall and spring months

Rules:

1. The user must make sure that he has included a RUN-PERIOD interval for each DESIGN-DAY in his input.

2. If the user desires any simulation that uses weather file data, the number of RUN-PERIOD intervals must be greater than the number of DESIGN-DAY instructions.

3. A PLANT run is possible only if the number of RUN-PERIOD intervals is greater than the number of DESIGN-DAY instructions.

4. Up to 3 DESIGN-DAY instructions can be entered. If more than one DESIGN-DAY instruction is entered, the instructions must be entered in chronological order.

5. Although weather conditions are not affected by holidays and weekends, internal building loads may be affected. Therefore, when choosing a DESIGN-DAY, especially if it is small, the user should be aware of the presence of holidays and weekends that fall within the interval.

6. If DRYBULB-HI = DRYBULB-LO or if DEWPT-HI = DEWPT-LO, the program will simulate a constant temperature throughout the day.

7. If DRYBULB-HI ≠ DRYBULB-LO, do not set HOUR-HI = HOUR-LO. If DEWPT-HI ≠ DEWPT-LO, do not set DHOUR-HI = DHOUR-LO.

Example:

A typical summer design day for Los Alamos, New Mexico, would be entered (note that the dew-point temperature frequently varies opposite to the dry-bulb temperature.):

```
SUMMER = DESIGN-DAY
   DRYBULB-HI          = 88.
   DRYBULB-LO          = 56.
   HOUR-HI             = 15
   HOUR-LO             =  5
   DEWPT-HI            = 65.
   DEWPT-LO            = 65.
   DHOUR-HI            =  5
   DHOUR-LO            = 15
   WIND-SPEED          =  5.
   WIND-DIR            = 15
   CLOUD-AMOUNT        =  5
   CLEARNESS           =  1.15
   GROUND-T            = 50.
   CLOUD-TYPE          = 0        ..
```

________________ = DESIGN-DAY or D-D (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	______	U-name	-	-	-
DRYBULB-HI	DB-H	=	______	°F	*	-100.	200.
DRYBULB-LO	DB-L	=	______	°F	*	-100.	200.
HOUR-HI	H-H	=	______	integer hour	*	1	24
HOUR-LO	H-L	=	______	integer hour	*	1	24
DEWPT-HI	DP-H	=	______	°F	*	-100.	200.
DEWPT-LO	DP-L	=	______	°F	*	-100.	200.
DHOUR-HI	DH-H	=	______	integer hour	*	1	24
DHOUR-LO	DH-L	=	______	integer hour	*	1	24
WIND-SPEED	W-S	=	______	knots	*	0.	200.
WIND-DIR	W-D	=	______	code-number	*	0	15
CLOUD-AMOUNT	C-A	=	______	integer	*	0	10
CLEARNESS	CL	=	______	number	*	.5	1.2
GROUND-T	G-T	=	______	°F	*	-100.	200.
CLOUD-TYPE	C-T	=	______	integer-code	*	0	2
			..				

*Mandatory entry, if DESIGN-DAY is specified.

4. 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 — This command 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. Chapter VIII, Table VIII.1. gives the latitudes for many U.S. cities.

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. Chapter VIII, Table VIII.1 gives the longitude for many U.S. cities.

ALTITUDE — is the distance of the origin of the building coordinate system above (positive) or below (negative) mean sea level. It is expressed in feet. Note that 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. The following table identifies the TIME-ZONE values within the US by common time zone names.

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

WARNING: If the user does not specify values for LATITUDE, LONGITUDE, TIME-ZONE, GROUND-T, and CLEARNESS-NUMBER, default values will be taken from the weather file. This should not be a problem if the user is employing one of the files provided with the DOE-2 program, because values for these five keywords have been defined on each of the DOE-2 weather files. However, if the user is employing other weather files, default values may not be defined.

This can produce very strange results. As an example, if TIME-ZONE does not exist on the weather tape, a value of 0., Greenwich Mean Time, will be used. The solar effect may occur at night, depending upon the building LONGITUDE, and may not be immediately noticeable in the output data. If, however, DIAGNOSTICS is set equal to COMMENTS or DEFAULTS, the output will state that TIME-ZONE=0. Generally speaking, it is not advisable to allow these BUILDING-LOCATION keywords to default.

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 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 gives the holidays; NO gives no holidays. The following table identifies the holiday list.

National Holidays of the United States

New Years Day
- JAN 1 (unless on Saturday or Sunday)
- JAN 2 if a Monday

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

It is not possible for the user to change the holiday list without modifying the FORTRAN code.

AZIMUTH — orients the building coordinate system relative to the direction of true north. This entry is the angle between true north and the Y-axis of the building coordinate system.

The azimuth is expressed in degrees from 0 to 360° (clockwise as seen from above) or 0 to -360° (counterclockwise as seen from above). Changing this angle has the effect of rotating the building about its z-axis (vertical axis).

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.

CLEARNESS-NUMBER — is a list of the local monthly clearness-numbers for each month of the year (see ASHRAE Trans., Vol. 64, p. 67). This is applicable when the clearness numbers on the weather file being used are not appropriate.

GROSS-AREA — is the gross floor area (outside dimensions) of the conditioned space of the building. Its default is the sum of the floor areas of all conditioned spaces. This keyword is appropriate only to the subsequent generation of the BEPS (Estimated Building Energy Performance) Report in PLANT. If a BEPS Report is not desired this keyword may be omitted.

HEAT-PEAK-PERIOD — allows the user to specify those hours in a day during which hourly peak heating loads will be calculated. Therefore, the user can choose to have the program ignore peaks that occur, for example, when the building is unoccupied. The input is a list of two values, (min. hour, max. hour). Between and including these two hour values, hourly heating peaks will be calculated. Min. hour must be less than max. hour. The default is (1,24), which means that hourly peaks will be calculated for all day and all night. If SYSTEMS is permitted to size the secondary HVAC equipment, it will use the peaks found within the stated hours.

COOL-PEAK-PERIOD — is analogous to HEAT-PEAK-PERIOD except that it concerns hourly peak cooling loads.

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 (i.e., SPACE or BUILDING-SHADE).

2. If the GROUND-T and CLEARNESS-NUMBER are not input, the values will be taken from the weather files. (See Chap. VIII for instructions on how to add these to a weather file if they were not in the user's original weather file.)

3. If LONGITUDE, LATITUDE, or TIME-ZONE are not specified, the values will be taken from the weather file.

Example:

The data entry below describes a building in Los Alamos, New Mexico, facing southeast. Daylight saving time and national holidays are in effect.

```
BUILDING-LOCATION
    LATITUDE = 35.8      LONGITUDE = 106.3
    ALTITUDE = 7200.0    TIME-ZONE = 7
    DAYLIGHT-SAVINGS = YES                (optional)
    HOLIDAY = YES                         (optional)
    AZIMUTH = -45.0                       (or 315.0)
    GROUND-T = (45, 45, 45, 50, 50, 55, 55, 55, 55,
                50, 50, 45)
    CLEARNESS-NUMBER  =  (1.05, 1,05, 1.08, 1.10, 1.13,
                          1.15, 1.15, 1.15, 1.13, 1.10,
                          1.08, 1.05)
    GROSS-AREA = 10500                    (optional)
    COOL-PEAK-PERIOD = (7,18)             (optional)
                                                ..
```

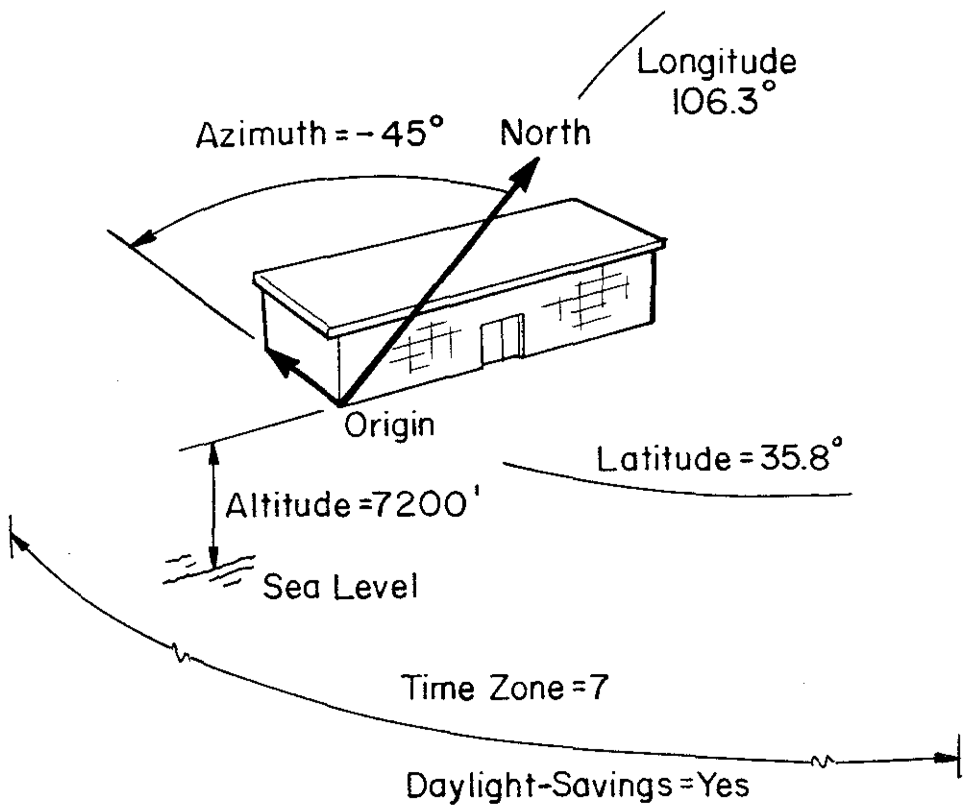

Fig. III.12. Example of BUILDING-LOCATION.

BUILDING-LOCATION or B-L* (User Worksheet)

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LATITUDE	LAT	=	________	degrees	Note 1	-90.	90.
LONGITUDE	LON	=	________	degrees	Note 1	-180.	180.
ALTITUDE	ALT	=	________	feet	0.	-1000.	20,000.
TIME-ZONE	T-Z	=	________	integer	Note 1	-12	12
DAYLIGHT-SAVINGS	D-S	=	________	code-word	YES	-	-
HOLIDAY	HOL	=	________	code-word	YES	-	-
AZIMUTH	AZ	=	________	degrees	0.	-360.	360.
GROUND-T	G-T	=	(________)	list of degrees	Note 2	-100.	150.
CLEARNESS-NUMBER	C-N	=	(________)	list of fractions	Note 2	0.5	1.2
GROSS-AREA	G-A	=	________	ft^2	Note 3	0.	$1.x10^7$
HEAT-PEAK-PERIOD	H-P-P	=	(________)	list of hours	(1,24)	1	24
COOL-PEAK-PERIOD	C-P-P	=	(________)	list of hours	(1,24)	1	24

*Mandatory entry.

Note 1: If defaulted, values are taken from the weather file.

Note 2: List format of 12 values. If defaulted, values are taken from the weather tape but will not be printed if the user uses DIAGNOSTIC = DEFAULTS.

Note 3: This entry is required only for the subsequent generation of the BEPS report (ESTIMATED BUILDING ENERGY PERFORMANCE) in PLANT. If allowed to default, the value used for generating the BEPS Report will be the net building area (sum of the area of the conditioned spaces) calculated by the LOADS program.

5. BUILDING-SHADE

The BUILDING-SHADE instruction is used to specify the opacity, position, size, and orientation of external surfaces that shade exterior surfaces of the building. Some typical surfaces that cast shadows on the exterior of a building are: a nearby building, tree, or hill, or an attached object, such as an overhang. It is also possible for a building to shade itself. The program will not calculate this type of shading unless the surface that causes the shadow is also specified under a BUILDING-SHADE command. That is, a wall may have to be specified twice; once as a BUILDING-SHADE, and once as an EXTERIOR-WALL. So that the shading surface does not shade the surface it represents, it should be placed slightly (about 0.01 ft) inside of the surface located in the related EXTERIOR-WALL or ROOF instruction. If the space and building coordinate systems are identical, the HEIGHT, WIDTH, AZIMUTH, and TILT keyword values in BUILDING-SHADE will be identical to the respective keywords in the related EXTERIOR-WALL or ROOF instruction.

Only the direct component of solar radiation is affected by BUILDING-SHADE. Diffuse solar radiation from the sky and ground is not affected by BUILDING-SHADE. To account for the shading of diffuse radiation, values for SKY-FORM-FACTOR and GND-FORM-FACTOR should be specified for the affected EXTERIOR-WALLs and WINDOWs (see EXTERIOR-WALL and WINDOW instructions).

Further description of the locating of building shades is in Sec. A of this chapter.

U-name	may be entered in the name field, but is not required.
BUILDING-SHADE	This command tells LOADS that the data to follow specify a shading surface.
HEIGHT	of a shading surface is expressed in feet.
WIDTH	of a shading surface is expressed in feet.
TRANSMITTANCE	is a decimal fraction expressing the ratio of the direct solar radiation that passes through a shading surface to the total insolation. The default value is 0.0, which means the surface is opaque. If the surface is transparent, the value to enter would be 1.0. Other values may be specifed as a decimal fraction between these limits. The diffuse component of the solar radiation is not affected by this entry.
X Y Z	are the coordinates of the lower left corner of the surface, as viewed from the opposite direction of the surface outward normal. These coordinates are in the building coordinate system and have units of feet.
AZIMUTH	is the angle (in degrees) between the Y-axis of the building coordinate system and the projection of the shading surface outward normal onto the X-Y plane of the building coordinate

system. Often, it is difficult to envision this angle, especially when the shading surface is horizontal, as shown in Figure III.13. This confusion can normally be avoided by the following procedure:

1. Choose the origin of the shading surface.

2. Mentally rotate the surface to a vertical position (keeping the origin in the same position and that position must be the lower left-hand corner as viewed in a direction opposite to the surface outward normal).

3. Specify the angle between the building Y-axis and the surface outward normal.

4. Mentally rotate the surface back to horizontal and specify TILT=0.

TILT — is the angle between the positive Z axis of the building coordinate system (vertical) and the surface outward normal. It is an angle between 0 degrees (horizontal) and 180 degrees (horizontal) with a default value of 90 degrees (vertical).

Example:

This example places a shading surface near the building located by the example in Sec. B of this chapter. The data entry below describes a horizontal shading surface (like a carport) located parallel to and 10 feet south of the building with its west edge aligned with the building west side. The shading surface is 30 by 15 (long dimension is parallel to the building) and 10 feet above the ground (see Fig. III.13).

```
CARPORT = BUILDING-SHADE
      HEIGHT           = 15.0
      WIDTH            = 30.0
      TRANSMITTANCE    = 0.0
      X                = 0.0
      Y                = -25.0
      Z                = 10.0
      AZIMUTH          = 180.0
      TILT             = 0.0       ..
```

Note:

Because X, Y, Z, AZIMUTH, and TILT of the shading surface are defined in the building coordinate system, a <u>rotation</u> of the building (accomplishing by changing AZIMUTH in the BUILDING-LOCATION command) will carry all building shading surfaces along with the building, even those which are detached, such as adjacent buildings and trees. Care must therefore be taken to adjust the X, Y, Z, AZIMUTH, and TILT of such detached shading surfaces each time the building is rotated, so that these surfaces stay fixed with respect to the global (earth) coordinate system.

Also, allowing X, Y, Z, AZIMUTH, or TILT to default will almost always produce a surface with a incorrect orientation and thus incorrect shading.

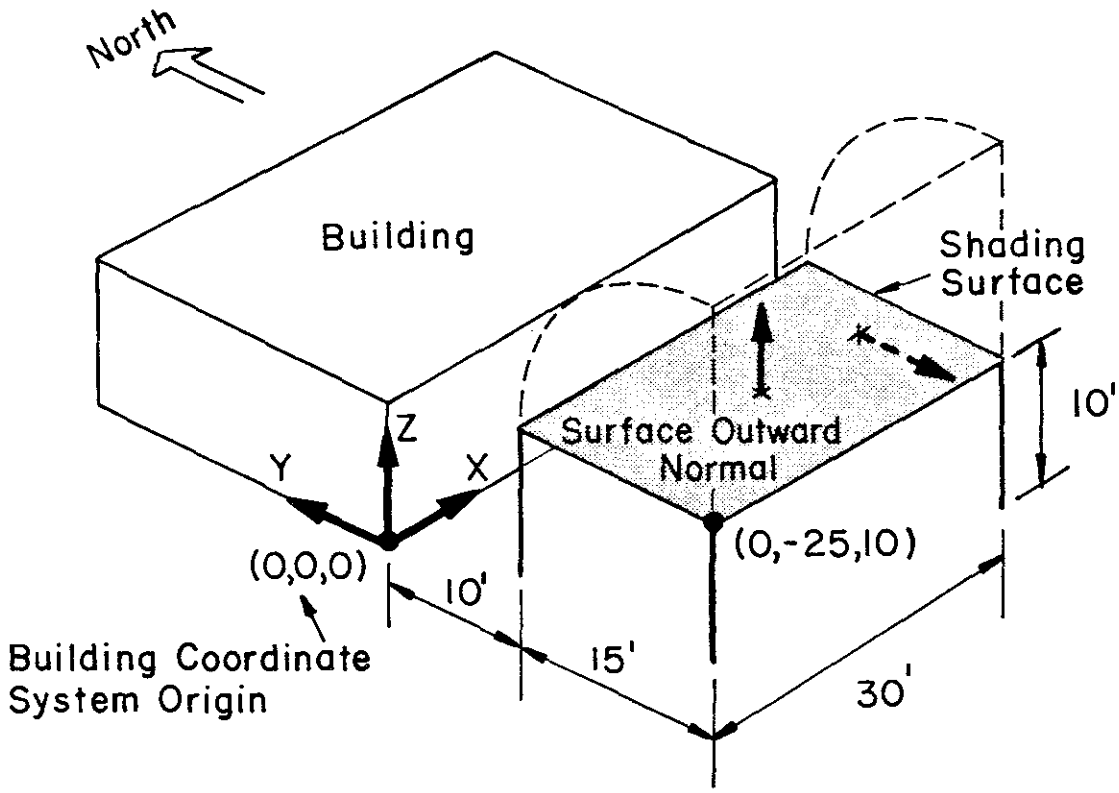

Fig. III.13. Example of a shading surface.

________________________ = BUILDING-SHADE or B-S (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	______	U-name	-	-	-
HEIGHT	H	=	______	feet	*	0.	2000.
WIDTH	W	=	______	feet	*	0.	2000.
TRANSMITTANCE	TR	=	______	fraction	0.	0.	1.
X	X	=	______	feet	0.	-	-
Y	Y	=	______	feet	0.	-	-
Z	Z	=	______	feet	0.	-	-
AZIMUTH	AZ	=	______	degrees	0.	-360.	360.
TILT	-	=	______	degrees	90.	0.	180.

..

*Mandatory entry, if BUILDING-SHADE is specified.

6. BUILDING-RESOURCE

The BUILDING-RESOURCE instruction is used to specify and schedule 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, 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. Energy use entered under this command does not contribute to space loads but does contribute to the utility load on the plant.

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, the schedule values will all default to zero and no gas usage will occur, regardless of the value specified for GAS-THERMS.

GAS-THERMS — is the maximum gas use at the building level. 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.

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, the schedule values will all default to zero and 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 (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. None of the load is added to the space heating or cooling loads. 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, the schedule values will all default to zero and no electrical usage will occur, regardless of the value specified for ELEC-KW.

ELEC-KW is the maximum building level electricity use (in kW). 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, the schedule values will all default to zero and 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 (in kW) for operating elevators and escalators. This electricity use is in addition to any electric use specified in the SPACE and SPACE-CONDITIONS instructions.

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
GAS-SCHEDULE	G-SCH	=	______	U-name	(Note 1)	-	-
GAS-THERMS	G-T	=	______	therms/hr	0.	0.	10.
HW-SCHEDULE	HW-SCH	=	______	U-name	(Note 1)	-	-
HOT-WATER	H-W	=	______	Btu/hr	0.	0.	$1.\times10^7$
ELEC-SCHEDULE	E-SCH	=	______	U-name	(Note 1)	-	-
ELEC-KW	E-KW	=	______	kW	0.	0.	1000.
VERT-TRANS-SCH	V-T-SCH	=	______	U-name	(Note 1)	-	-
VERT-TRANS-KW	V-T-KW	=	______	kW	0.	0.	1000.

Note 1: The schedule value will default to zero for all 24 hours of the day.

7. 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 overriden 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 (see Chap. II).

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 per cent of their energy to the SPACE.

1. All of the energy associated with people, task lighting, and infiltration is assumed to enter the SPACE. These energy sources contribute their entire energy consumption to the heating/cooling loads of that SPACE.

2. Only part of the energy associated with the other heat sources in the SPACE (overhead lighting, process equipment, and process utilities) escapes into the SPACE and thus contributes to the heating/cooling loads of the SPACE. That 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 escape into 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 escapes into 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 to the specifying of 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. The user should also remember that once the equipment is turned "on", it will not be turned "off", unless the user so specifies in the SCHEDULEs.

U-name — must be specified for this instruction.

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 to be used to specify the space air temperature to be used in the LOADS simulation. This is a list with only one value and it should be midway between the heating and cooling set points (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.

PEOPLE-SCHEDULE — identifies the schedule that will specify the 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 building with no people.

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).

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. An alternative method of specifying people heat gain is to use PEOPLE-HG-LAT and PEOPLE-HG-SENS.

PEOPLE-HG-LAT is the maximum latent heat gain per person to the space by the occupants.

PEOPLE-HG-SENS is the maximum sensible heat gain per person to the space by the occupants.

LIGHTING-SCHEDULE identifies the schedule that will specify the space overhead lighting schedule. 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 is used to specify the type of overhead lighting used in the space (see Fig. III.14). The following table identifies the code-words used.

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

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.

LIGHTING-KW is the maximum amount of electrical energy required to operate the main or overhead lights within the SPACE and is <u>not necessarily</u> 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). 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, not the amount of illumination produced.

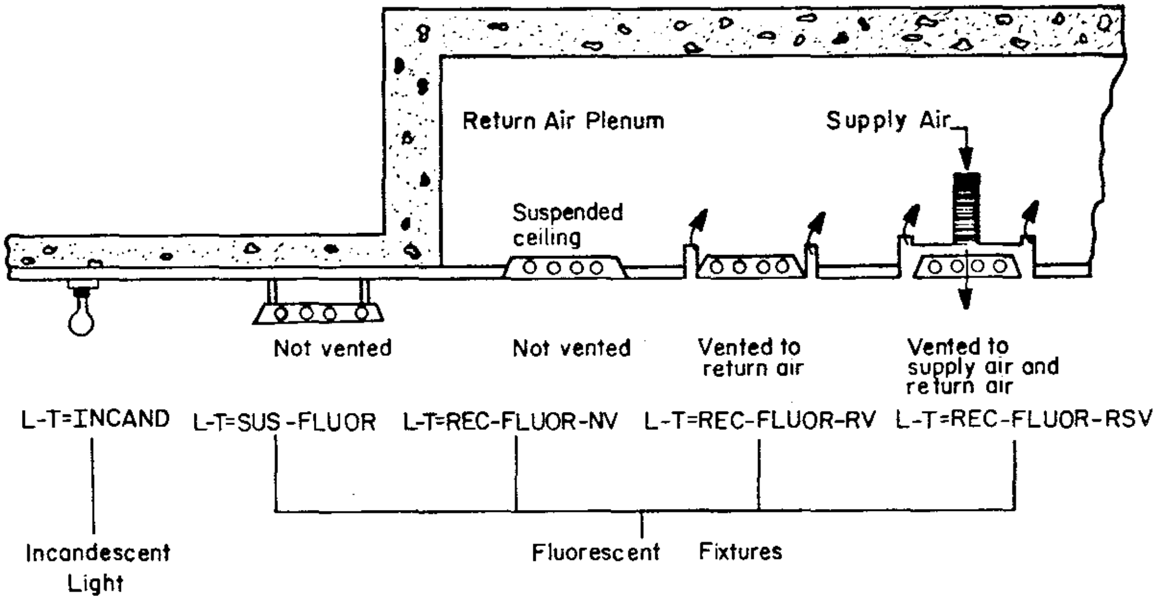

Fig. III.14. Examples of LIGHTING-TYPE.

LIGHTING-W/SQFT is an alternative method (to LIGHTING-KW) for specifying the maximum overhead lighting energy use. The dimensions are watts of lighting energy use per square foot of SPACE floor area. The actual overhead lighting energy required by the SPACE during any given hour is the value assigned to this keyword multiplied by the 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 flourescent 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 per cent	Incandescent per cent
Visible light	19	10
Infrared	31	72
Convection-conduction	36	18
Ballast	14	0

Eventually all the energy gets converted into SPACE load.

LIGHT-TO-SPACE 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 to the adjacent plenum if, in SYSTEMS, RETURN-AIR-PATH = PLENUM, or to the ductwork if RETURN-AIR-PATH = DUCT. Otherwise this energy is lost and is not accounted for.

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

TASK-LIGHT-SCH identifies the schedule that will specify the task lighting schedule for 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 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 per cent 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. LIGHT-TO-SPACE is not appropriate to this keyword because 100 per cent of task lighting energy goes to the SPACE.

EQUIP-SCHEDULE identifies the schedule that will specify the 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 <u>not necessarily</u> the sensible and/or latent heat added by the equipment to the SPACE (see EQUIP-SENSIBLE and EQUIP-LATENT). 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.

Before specifying a value for EQUIPMENT-KW, review SOURCE-TYPE = ELECTRIC. In EQUIPMENT-KW the user is specifying equipment. In SOURCE-TYPE the user is specifying a utility demand.

EQUIPMENT-W/SQFT is an alternative keyword for EQUIPMENT-KW and is based on watts of equipment energy per square feet of floor area of the SPACE.

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 1.00.

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. 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, means 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:

ELECTRIC - the load will contribute to electricity use budget in PLANT. Examples include electricity for electroplating, battery charging, etc.

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

HOT-WATER - the load will contribute to hot-water budget (natural gas or fuel oil) in PLANT. This load will be reported as a domestic 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.)

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, oxyactetylene welders, wood stoves, bottled gas equipment, etc. The user should sum up all the PROCESS loads in the zone, be they eléctrical, gas, hot water, solar, nuclear, etc. and express the total in Btu/hr. This total value should be expressed with the keyword SOURCE-BTU/HR. The portion of the total PROCESS load that enters the zone as a heating or cooling load is then specified by using the SOURCE-LATENT and 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 in Btu/hr 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 cooling load of the SPACE (see SOURCE-SENSIBLE and SOURCE-LATENT).

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 cooling load of the SPACE, if any, may be specified by SOURCE-LATENT and SOURCE-SENSIBLE.

SOURCE-SCHEDULE identifies 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 1.00 and is likely less than 1.00 since all such energy is not necessarily added to the space load.
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 1.00 and is likely less than 1.00 since all such energy is not necessarily added to the space load.
INF-SCHEDULE	identifies a schedule that will specify 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 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 the INF-SCHEDULE is not input, but the AIR-CHANGES/HR is, the schedule will default to one for all hours, and the full AIR-CHANGES/HR will be simulated for all 24 hours. Ordinarily, INF-SCHEDULE should not be used with the CRACK or RESIDENTIAL method of infiltration because the schedule will distort wind information from the weather tape.
INF-METHOD	Input for this keyword is the code-word that identifies the method used to calculate infiltration for the space. Air-change method calculations are made with <u>and/or</u> without wind velocity correction, depending upon the code-word chosen here and the keyword used to enter the value for infiltration.

Method	Code-Word
No-infiltration	NONE
Air-change	AIR-CHANGE
Crack	CRACK
Residential	RESIDENTIAL

The use of infiltration-related keywords for different types of calculation methods is summarized in the following table.

INF-METHOD

Keyword	NONE No Infiltration	AIR-CHANGE Air-Change Method With Wind Velocity Correction	 Without Wind Velocity Correction	CRACK Crack Method	RESIDENTIAL
AIR-CHANGES/HR	n/a	required	n/a	n/a	n/a
INF-CFM/SQFT	n/a	n/a	required	n/a	n/a
NEUTRAL-ZONE-HT	n/a	n/a	n/a	optional	n/a
INF-SCHEDULE	n/a	optional	optional	optional	optional
RES-INF-COEF	n/a	n/a	n/a	n/a	optional

In the case of the Crack Method, a value should be entered for the keyword INF-COEF in the EXTERIOR-WALL instruction, and for the keyword INF-COEF in the WINDOW instruction.

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 in knots (taken from the weather tape) and ΔT (absolute value of outdoor-indoor temperature differential) in °F. The keyword RES-INF-COEF is appropriate here in SPACE-CONDITIONS only if INF-METHOD = RESIDENTIAL.

AIR-CHANGES/HR* is the number of infiltration-caused air changes per hour at a wind speed of 10 mph for a space (see table under INF-METHOD). It has a correction for wind speed as shown by the following equation.

Infiltration in cfm = (AIR-CHANGES/HR) x (space volume)/(60 min/hr) x (wind-speed)/(10 mph)

(This keyword is not to be confused with a keyword of the same name in SYSTEMS.)

INF-CFM/SQFT* is the amount of infiltration into a space expressed as a ratio of air volume/floor area (see table under INF-METHOD). It does not correct for wind speed.

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

NEUTRAL-ZONE-HT should be assigned a value when the crack method is used to calculate infiltration (see table under INF-METHOD). It is used to compute a pressure difference between the inside and outside of a tall building caused by the "stack effect" or air density gradient. The calculated pressure difference is added to the pressure difference caused by wind velocity.

The value to be entered is calculated as follows. Let NPL (neutral pressure level) be the line on the building exterior where the pressure difference between the inside and outside resulting solely from the stack effect equals zero. The height of the NPL line is typically one-half the building height. The entry for the NEUTRAL-ZONE-HT keyword is the distance, in feet, from the center of the exterior wall of the space under consideration to the NPL line. This distance is positive if the space is below the NPL line and negative if the space is above the NPL line. Figure III.15, a modified version of Fig. 4 in Chap. 21 of Ref. 5, further explains this keyword entry.

If the SPACE-MULTIPLIER keyword of the SPACE instruction is used for spaces located on different floors, the value entered for NEUTRAL-ZONE-HT should be the average NEUTRAL-ZONE-HT for all the spaces. In general, NEUTRAL-ZONE-HT should be entered in the SPACE instruction, since it will be different for each space.

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. DOE-2 has two types of weighting factors, Precalculated Weighting Factors and Custom Weighting Factors.

Precalculated Weighting Factors:

If the user specifies FLOOR-WEIGHT = 30., 70., or 130., standard, precalculated ASHRAE weighting factors are used that represent respectively light, medium, and heavy construction. If values other than these three are input, DOE-2 interpolates between the ASHRAE weighting factors. At FLOOR-WEIGHTs less than .1 lb/ft^2 and greater than 200 lb/ft^2, the extrapolation of weighting factors is unreliable.

If an exterior wall is uninsulated or is insulated on its outside surface, the entire mass of the wall should be included in the composite weight. The composite weight is used to adjust the internal heat capacitance of the building and, hence, affects the transient thermal load calculations for the building.

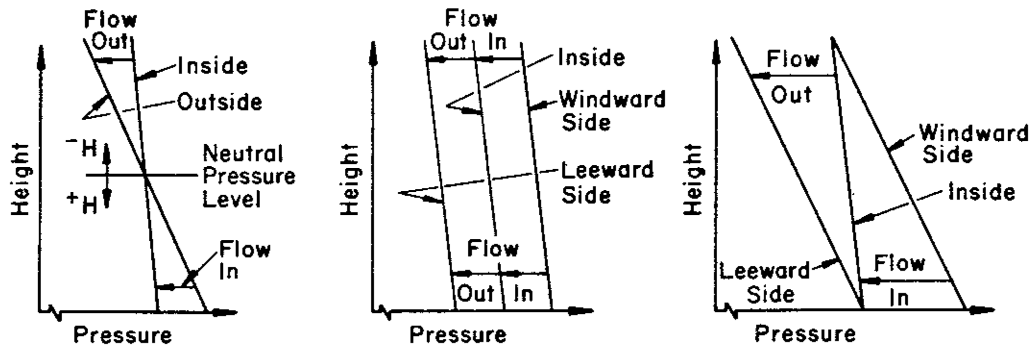

Fig. III.15. Explanation of NEUTRAL-ZONE-HT.

<u>Custom Weighting Factors</u>:

If the user elects to generate and use Custom Weighting Factors in an INPUT LOADS run, he should specify FLOOR-WEIGHT = 0 and he may specify values for FURN-FRACTION, FURNITURE-TYPE, FURN-WEIGHT, and SOLAR-FRACTION. This will cause the Custom Weighting Factors to be generated during the LDL run. The custom weighting factors that are generated are printed out in LOADS VERIFICATION report LV-K. (Hint: If the user elects to follow this approach, he should be aware that the Custom Weighting Factors will be calculated for each simulation run but they are not saved for subsequent runs. If the user specifies FLOOR-WEIGHT = 30., 70., or 130. for all but the final LOADS simulation run on a building, then sets FLOOR-WEIGHT equal to zero for the final run, computing costs can be reduced.)

Alternatively to get Custom Weighting Factors, the user may first create them and store them on the file named BDLLIB during a LIBRARY-INPUT LOADS run, as described in the back of this chapter and then use them in a subsequent INPUT LOADS simulation run. With the latter approach, the user should <u>not</u> specify a value for FLOOR-WEIGHT. By using a library, the user may experience a large computing savings, because both response factors and Custom Weighting Factors are saved for subsequent use.

In Sec. C.2 of this chapter is a set of guidelines for preparing input when using Custom Weighting Factors and in Sec. C.4 there is a list of WARNING and ERROR diagnostics printed by the Custom Weighting Factors Generation Program.

The user may specify both types of weighting factors in one simulation run; that is, some spaces may use Precalculated Weighting Factors and other spaces may use Custom Weighting Factors.

ZONE-TYPE — is used to identify whether the space is conditioned, unconditioned, or a plenum. For LOADS calculations, a plenum is identical to unconditioned space. The loads for an unconditioned space or a plenum will not appear in the building-level reports, LS-C, LS-D, and LS-F. The code-words are explained in the following table.

Description of Space	Code-word for ZONE-TYPE
The space is heated and/or cooled	CONDITIONED
The space is neither heated not cooled, but is adjacent to one or more conditioned spaces (such as false ceiling spaces not used as return air plenums, attics)	UNCONDITIONED
Return air plenums	PLENUM

The following keywords may be specified if the user elects to use Custom Weightings Factors:

WEIGHTING-FACTOR — accepts as input a U-name of eight or less alphanumeric characters. This U-name will be used to identify the Custom Weighting Factors for this space in the library that is being created in a LIBRARY-INPUT LOADS run. After the Custom Weighting Factors have been stored in the library, they may be assigned to any space in a DOE-2 simulation run by entering WEIGHTING-FACTOR = U-name in an INPUT LOADS run.

FURN-FRACTION — accepts a fraction that defines the fraction of floor area that is covered by the furniture. It determines the fraction of the incoming solar energy that is absorbed by the furniture.

FURNITURE-TYPE — accepts a code-word (LIGHT or HEAVY) describing the thermal response of the furniture in the space. "LIGHT" represents a furniture density of approximately 40 lb/ft^3 of furniture (like pine furniture). "HEAVY" represents items in a space like equipment weighing approximately 80 lb/ft^3.

FURN-WEIGHT — is the weight of furniture in pounds per square foot of floor area. The value of this keyword is the total weight of furniture in pounds divided by the total floor area of the space (not just the floor area covered by the furniture). For example, if the furniture weighs 1000 lb and the total floor area is 500 ft^2, then FURN-WEIGHT = 2.0.

Rules:

1. Infiltration method and required keywords should match.

2. SOURCE-BTU/HR, LIGHTING-KW, LIGHTING-W/SQFT, EQUIPMENT-KW and EQUIPMENT-W/SQFT all imply energy or fuel use, not necessarily heat-transferred to the space.

3. The heat transferred to the space is done via the keywords SOURCE-LATENT, SOURCE-SENSIBLE, LIGHT-TO-SPACE, TASK-LIGHTING-KW, TASK-LT-W/SQFT, EQUIP-LATENT, EQUIP-SENSIBLE.

Example:

A space is defined as follows. A conditioned zone: air temperature is maintained at 68°F, floor weight is 75 pounds per square foot, lighting is fluorescent overhead (3 watts/ft^2) with some task lighting (300 watts), there is a 1-hp motor (1 hp = .745 kW) in the space running at 80 per cent efficiency (thus 20 per cent of its energy consumption shows up as heat added to the space), infiltration is 2 air changes per hour, and six people occupy the space.

```
RM = SPACE-CONDITIONS
          TEMPERATURE           = (68)
          PEOPLE-SCHEDULE       = MANHR
          NUMBER-OF-PEOPLE      = 6
          PEOPLE-HG-LAT         = 200.
          PEOPLE-HG-SENS        = 250.
          LIGHTING-SCHEDULE     = HILITE
          LIGHTING-TYPE         = SUS-FLUOR
          LIGHTING-W/SQFT       = 3.
          LIGHT-TO-SPACE        = 1.0
          TASK-LIGHT-SCHED      = LOLITE
          TASK-LIGHTING-KW      = 0.3
          EQUIP-SCHEDULE        = MOTOR
          EQUIPMENT-KW          = 0.75
          EQUIP-SENSIBLE        = 0.2
          INF-METHOD            = AIR-CHANGE
          AIR-CHANGES/HR        = 2.
          FLOOR-WEIGHT          = 75.
          ZONE-TYPE             = CONDITIONED   ..
```

____________ = SPACE-CONDITIONS or S-C (User Worksheet)

U-name*

Keyword	Abbrev.		Input User Input	Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
TEMPERATURE	T	=	(________)	°F,list	70.	0.	120.
PEOPLE-SCHEDULE	P-SCH	=	________	U-name	(Note 7)	-	-
NUMBER-OF-PEOPLE	N-O-P	=	________	number	0.	0.	$1.x10^4$
PEOPLE-HEAT-GAIN	P-H-G	=	________	Btu/hr/ person	(Note 5)	350.	2000.
PEOPLE-HG-LAT	P-H-L	=	________	Btu/hr/ person	(Note 5)	0.	2000.
PEOPLE-HG-SENS	P-H-S	=	________	Btu/hr/ person	(Note 5)	0.	2000.
LIGHTING-SCHEDULE	L-SCH	=	________	U-name	(Note 7)	-	-
LIGHTING-TYPE	L-T	=	________	code-word	SUS-FLUOR	-	-
LIGHTING-KW	L-KW	=	________	kW	(Note 2)	0.	200.
LIGHTING-W/SQFT	L-W	=	________	W/ft^2	(Note 2)	0.	10.
LIGHT-TO-SPACE	L-T-S	=	________	fraction	1.(Note 6)	0.	1.
TASK-LIGHT-SCH	T-L-SCH	=	________	U-name	(Note 7)	-	-
TASK-LIGHTING-KW	T-L-KW	=	________	kW	(Note 3)	0.	200.
TASK-LT-W/SQFT	T-L-W	=	________	W/ft^2	(Note 3)	0.	10.
EQUIP-SCHEDULE	E-SCH	=	________	U-name	(Note 7)	-	-
EQUIPMENT-KW	E-KW	=	________	kW	(Note 4)	0.	200.
EQUIPMENT-W/SQFT	E-W	=	________	W/ft^2	(Note 4)	0.	100.
EQUIP-SENSIBLE	E-S	=	________	fraction	1.	0.	1.
EQUIP-LATENT	E-L	=	________	fraction	0.	0.	1.
SOURCE-SCHEDULE	S-SCH	=	________	U-name	(Note 7)	-	-
SOURCE-TYPE	S-T	=	________	code-word	GAS	-	-
SOURCE-BTU/HR	S-B	=	________	Btu/hr	0.	$-1x10^6$	$1.x10^6$
SOURCE-SENSIBLE	S-S	=	________	fraction	1.	0.	1.
SOURCE-LATENT	S-L	=	________	fraction	0.	0.	1.

Keyword	Abbrev.	Input User Input	Desc.	Default	Range Min.	Range Max.
INF-SCHEDULE	I-SCH	= ________	U-name	(Note 8)	-	-
INF-METHOD	I-M	= ________	code-word	NONE	-	-
RES-INF-COEF	R-I-C	= (________)	list of 3 numbers	(.252, .0251, .0084)	0.	20.
AIR-CHANGES/HR	A-C	= ________	number	0. (Note 1)	0.	30.
INF-CFM/SQFT	I-CFM	= ________	cfm/ft^2	0. (Note 1)	0.	20.
NEUTRAL-ZONE-HT	N-Z-H	= ________	ft	(Note 1)	-	-
FLOOR-WEIGHT	F-W	= ________	lb/ft^2	70.	0.	200.
ZONE-TYPE	Z-TYPE	= ________	code-word	CONDITIONED	-	-

The following keywords may be specified if the user elects to use Custom Weighting Factors.

WEIGHTING-FACTOR	W-F	= ________	U-name	(Note 9)	-	-
FURN-FRACTION	F-F	= ________	fraction	0.	0.	1.
FURNITURE-TYPE	F-TYPE	= ________	code-word	HEAVY	-	-
FURN-WEIGHT	F-WGT	= ________	lbs/ft^2	0.	0.	300.

..

* Mandatory entry, assuming SPACE-CONDITIONS is specified.

Note 1: Use one keyword only. There is no default.
Notes 2, 3, 4: Use either keyword, or both. There is no default.
Note 5: Use either PEOPLE-HG-LAT and PEOPLE-HG-SENS or PEOPLE-HEAT-GAIN. An entry of one of these two options is mandatory.
Note 6: Default is 1.0 for LIGHTING-TYPE = SUS-FLUOR, REC-FLUOR-NV, or INCAND, and is 0.8 for REC-FLUOR-RV or REC-FLUOR-RSV.
Note 7: The schedule value defaults to zero for all 24 hours of the day. This deactivates the possible source of heat to the SPACE, even if the related "sensible and latent" keywords have been specified.
Note 8: The schedule value defaults to one for all 24 hours of the day. The full AIR-CHANGES/HR will be simulated for all 24 hours.
Note 9: This U-name (eight or fewer alphanumeric characters) is used to first create and then later retrieve a set of Custom Weighting Factors from the DOE-2 Library. Do not specify a value for this keyword if automatic Custom Weighting Factors are being used; that is, FLOOR-WEIGHT has been set equal to zero.

8. SPECIFYING EXTERIOR WALLS, EXTERIOR FLOORS, AND ROOFS

Note: The following general discussion applies only to exterior walls, exterior floors, and roofs. For discussion of other surfaces, refer to the section in this chapter entitled "SPECIFYING INTERIOR WALLS, INTERIOR FLOORS, CEILINGS, UNDERGROUND WALLS, UNDERGROUND FLOORS, AND NON-GLASS DOORS."

Before specifying data for exterior walls, exterior floors, and roofs, it would be prudent to consider the following:

Entering a CONSTRUCTION instruction without a U-VALUE (but with a value for LAYERS) is done to specify a dynamic, or "delayed", type of construction. In this case, the calculation of heat transfer (by conduction and radiation) considers time and thermal mass. As such, computational time and cost can be greater than when specifying a CONSTRUCTION instruction with a U-VALUE. The latter approach is taken to specify a steady-state, or "quick", wall that has no heat capacitance and where heat flow is not delayed.

Specifying a wall by the dynamic, or "delayed", method (without a U-VALUE) tends to produce more accurate results, especially for massive exterior wall construction, but this is at the expense of additional computer time and cost.

Note: In the following discussion, the reader should pay particular attention to the use of the words "keyword" and "instruction".

The DOE-2 program treats exterior walls, exterior floors, and roofs in an identical manner. The only difference is the physical orientation of the surface. In the following discussion, all three surfaces will be referred to generically as "exterior wall".

Although there is only one DOE-2 instruction for specifying an exterior wall or roof (see EXTERIOR-WALL instruction), there are many possible methods of specifying the physical makeup of an exterior wall (see Fig. III.16). This physical makeup is specified through the CONSTRUCTION keyword in the EXTERIOR-WALL instruction. When the user tries to specify an EXTERIOR-WALL instruction, it will refer the user back to the CONSTRUCTION instruction, which in turn may refer the user back to either the LAYERS instruction or to tables of prespecified LAYERS in the DOE-2 Library. In short, this means that the user cannot define an exterior wall solely in the EXTERIOR-WALL instruction; certain other data items must also be specified first.

In order of increasing complexity, the common ways to specify an EXTERIOR-WALL are:

1. Specify a numerical value for the U-VALUE keyword in the CONSTRUCTION instruction (specify nothing for the LAYERS keyword). Then refer to the CONSTRUCTION instruction, by its U-name, in the CONSTRUCTION keyword of an EXTERIOR-WALL instruction. This will yield a steady-state, or "quick", exterior wall (see Fig. III.17).

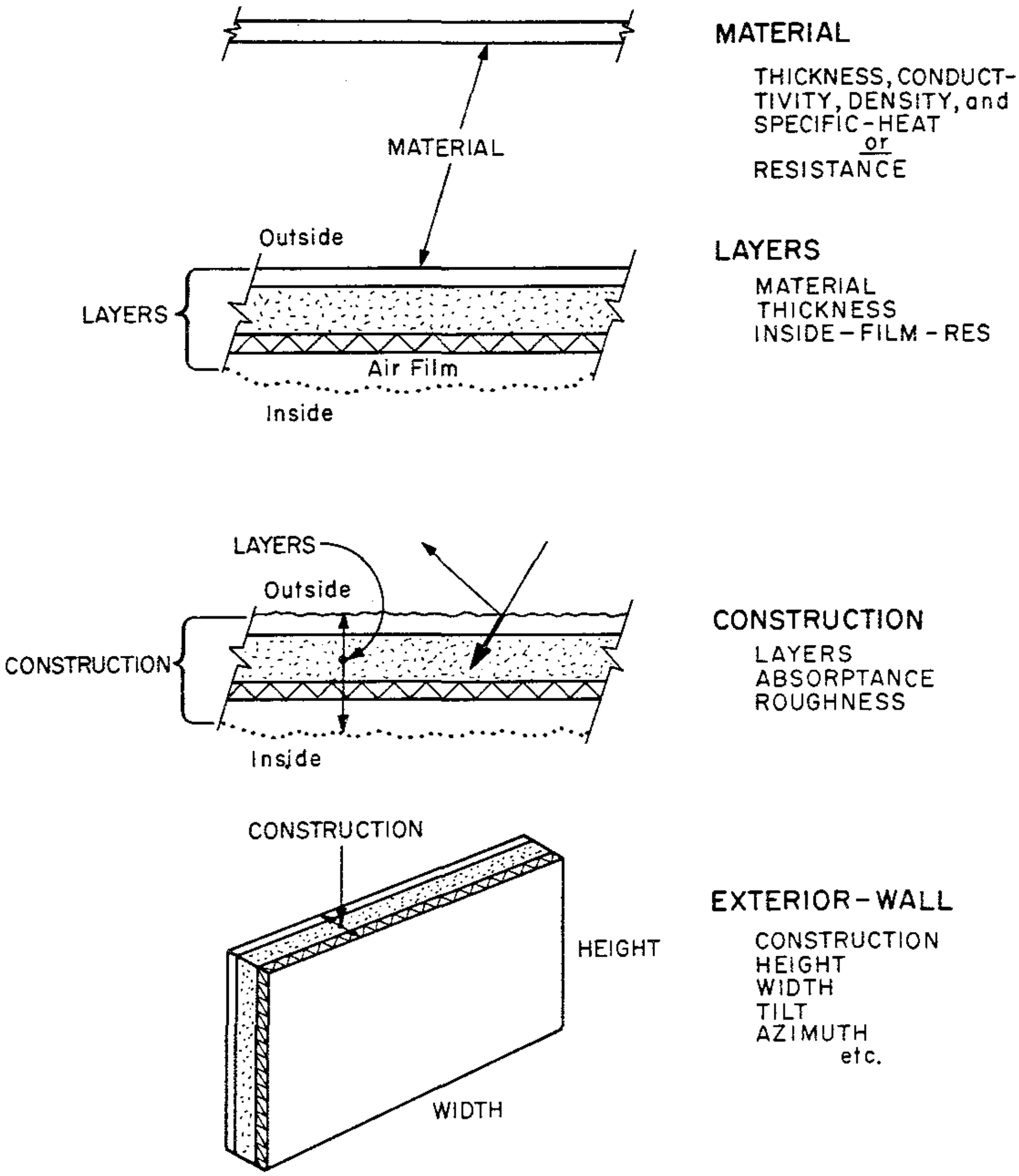

Fig. III.16. Physical makeup of a DOE-2 "delayed" EXTERIOR-WALL.

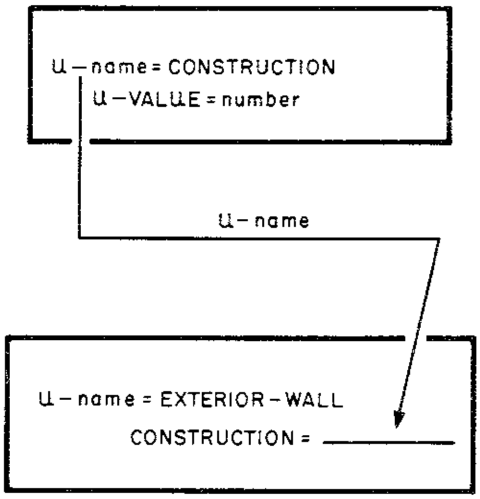

Fig. III.17 Specifying a "quick" EXTERIOR-WALL.

2. Specify an ASHRAE-type code-word for the LAYERS keyword in a CONSTRUCTION instruction (see Fig. III.18). This will yield a dynamic, or "delayed", exterior wall. This method utilizes ASHRAE prespecified LAYERS, stored in the DOE-2 LAYERS Library. This method allows the user to specify any one of 36 prespecified roof LAYERS and 96 prespecified exterior wall LAYERS. The roof LAYERS are described in the reprinted ASHRAE Table 26, entitled "Transfer Function Coefficients for Roofs (Time Interval = 1.0 h)". The exterior wall LAYERS are described in the reprinted ASHRAE Table 27, entitled "Transfer Function Coefficients for Exterior Walls (Time Interval = 1.0 h)". The code-words are ASHR-1, ASHR-2, etc., for roofs, and ASHW-1, ASHW-2, etc., for walls. This is the easiest and most commonly used method for specifying a dynamic, or "delayed", EXTERIOR-WALL. The MATERIAL and LAYERS instructions are not used with this method. If the user cannot find a suitable LAYERS in the ASHRAE prespecified LAYERS, he should then consider using one of the next three methods.

3. Specify a list of ASHRAE-type code-words for the MATERIAL keyword in a LAYERS instruction (see Fig. III.18). Then, refer to the LAYERS instruction, by its U-name, in the LAYERS keyword of a CONSTRUCTION instruction. Finally, refer to the CONSTRUCTION instruction, by its U-name, in the CONSTRUCTION keyword of an EXTERIOR-WALL instruction. This will yield a dynamic, or "delayed", exterior wall. This method utilizes prespecified ASHRAE materials stored in the DOE-2 MATERIALs Library. This method allows the user to specify a LAYERS instrucion with up to 9 ASHRAE materials from an available list of 39 materials. These materials are described in the ASHRAE reprinted Table 8, entitled "Thermal Properties and Code Numbers of Layers Used in Calculations of Coefficients for Roof and Wall". The code-words are HF- "Code Number in Table 8," i.e., HF-A1 gives the first material in Table 8.

4. Specify a list of DOE-2 code-words for the MATERIAL keyword in a LAYERS instruction (see Fig. III.18). Then refer to the LAYERS instruction, by its U-name, in the LAYERS keyword of a CONSTRUCTION instruction. Finally, refer to the CONSTRUCTION instruction, by its U-name, in the CONSTRUCTION keyword of an EXTERIOR-WALL instruction. This will yield a dynamic, or "delayed", exterior wall. This method utilizes DOE-2 prespecified materials stored in the DOE-2 MATERIALs Library. These materials are described in detail in Chap. X of this manual. This method allows the user to specify a LAYERS instruction with up to 9 materials. This method is identical to Method 3) except the materials are not ASHRAE-prespecified materials, but rather DOE-2-prespecified materials.

5. Specify each individual material (by THICKNESS, CONDUCTIVITY, DENSITY, and SPECIFIC-HEAT or by RESISTANCE) in a MATERIAL instruction (see Fig. III.19). Then refer to all the MATERIAL instructions, by a list of their U-names, in the MATERIAL keyword of a LAYERS instruction. Then, refer to the LAYERS instruction, by its U-name, in the LAYERS keyword of a CONSTRUCTION instruction. Finally, refer to the CONSTRUCTION instruction, by its U-name, in the CONSTRUCTION keyword of an EXTERIOR-WALL instruction. This will yield a dynamic, or "delayed", exterior wall. This method allows the user to specify unusual constructions.

6. The user may place additional MATERIALs, LAYERS, and CONSTRUCTIONs into the DOE-2 Library for subsequent simulation runs. For more information on creating, or adding information to the DOE-2 Library, see Sec. C of this chapter.

There is, of course, yet another but less obvious method for specifying an exterior wall. That is to use the LIKE keyword in an EXTERIOR-WALL instruction to repeat a previously specified exterior wall.

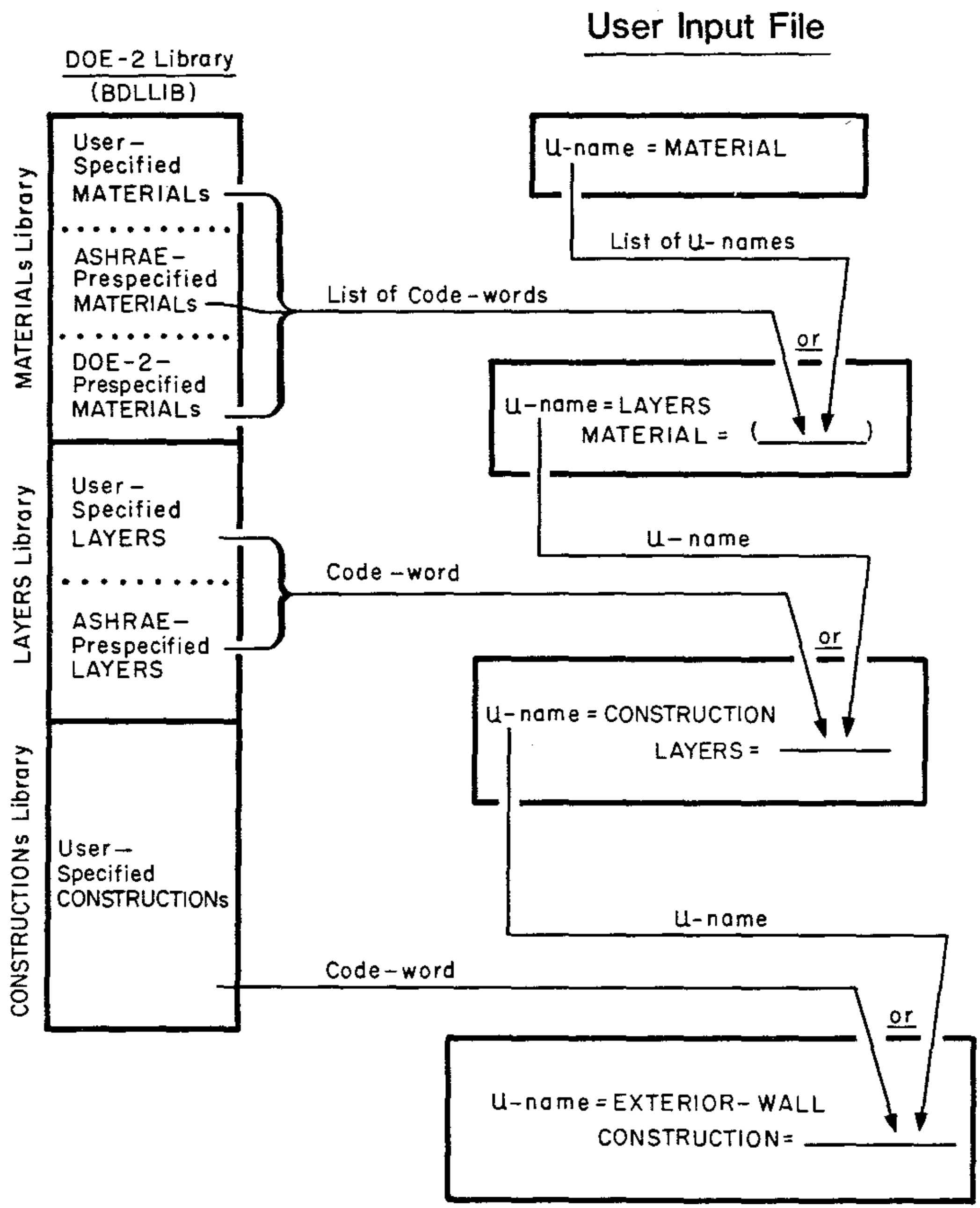

Fig. III.18 Specifying a "delayed" EXTERIOR-WALL (with a library).

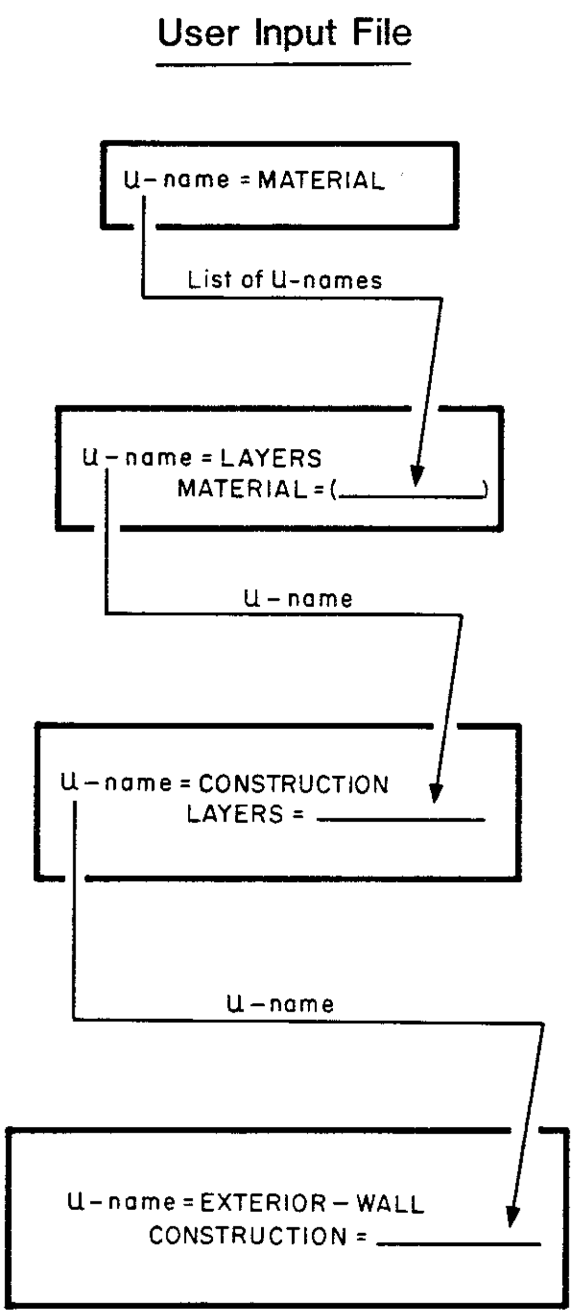

Fig. III.19 Specifying a "delayed" EXTERIOR-WALL (without a library).

Table 8 Thermal Properties and Code Numbers of Layers Used in Calculations of Coefficients for Roof and Wall

Description	Code Number	L	K	D	SH	R	WT
Outside surface resistance	AO					0.333	
1-in. Stucco (asbestos cement or wood siding plaster, etc.)	A1	0.0833	0.4	116	0.20	0.208	9.66
4-in. face brick (dense concrete)	A2	0.333	0.75	130	0.22	0.444	43.3
Steel siding (aluminum or other lightweight cladding)	A3	0.005	26.0	480	0.10	0.0002	2.40
Outside surface resistance						0.333	
0.5-in. slag, membrane	A4	0.0417	0.83	55	0.40		
0.375-in felt		0.0313	0.11	70	0.40		
Finish	A6	0.0417	0.24	78	0.26	0.174	3.25
4-in. face brick	A7	0.333	0.77	125	0.22	0.433	41.6
Air space resistance	B1					0.91	
1-in. insulation	B2	0.083	0.025	2.0	0.2	3.32	0.17
2-in. insulation	B3	0.167	0.025	2.0	0.2	6.68	0.33
3-in. insulation	B4	0.25	0.025	2.0	0.2	10.03	0.50
1-in. insulation	B5	0.0833	0.025	5.7	0.2	3.33	0.47
2-in. insulation	B6	0.167	0.025	5.7	0.2	6.68	0.95
1-in. wood	B7	0.0833	0.07	37.0	0.6	1.19	3.08
2.5-in. wood	B8	0.2083	0.07	37.0	0.6	2.98	7.71
4-in. wood	B9	0.333	0.07	37.0	0.6	4.76	12.3
2-in. wood	B10	0.167	0.07	37.0	0.6	2.39	6.18
3-in. wood	B11	0.25	0.07	37.0	0.6	3.58	9.25
3-in. insulation	B12	0.25	0.025	5.7	0.2	10.0	1.42
4-in. clay tile	C1	0.333	0.33	70.0	0.2	1.01	23.3
4-in. l.w. concrete block	C2	0.333	0.22	38.0	0.2	1.51	12.7
4-in. h.w. concrete block	C3	0.333	0.47	61.0	0.2	0.71	20.3
4-in. common brick	C4	0.333	0.42	120	0.2	0.79	40.0
4-in. h.w. concrete	C5	0.333	1.0	140	0.2	0.333	46.6
8-in. clay tile	C6	0.667	0.33	70	0.2	2.02	46.7
8-in. l.w. concrete block	C7	0.667	0.33	38.0	0.2	2.02	25.4
8-in. h.w. concrete block	C8	0.667	0.6	61.0	0.2	1.11	40.7
8-in. common brick	C9	0.667	0.42	120	0.2	1.59	80.0
8-in. h.w. concrete	C10	0.667	1.0	140	0.2	0.667	93.4
12-in. h.w. concrete	C11	1.0	1.0	140	0.2	1.00	140.0
2-in. h.w. concrete	C12	0.167	1.0	140	0.2	0.167	23.4
6.in. h.w. concrete	C13	0.5	1.0	140	0.2	0.50	70.0
4-in. l.w. concrete	C14	0.333	0.1	40	0.2	3.33	13.3
6-in. l.w. concrete	C15	0.5	0.1	40	0.2	5.0	20.0
8-in. l.w. concrete	C16	0.667	0.1	40	0.2	6.67	26.7
Inside surface resistance	E0					0.685	
0.75-in. plaster; 0.75-in. gypsum or other similar finishing layer	E1	0.0625	0.42	100	0.2	0.149	6.25
0.5-in. slag or stone	E2	0.0417	0.83	55	0.40	0.050	2.29
0.375-in. felt & membrane	E3	0.0313	0.11	70	0.40	0.285	2.19
Ceiling air space	E4					1.0	
Acoustic tile	E5	0.0625	0.035	30	0.20	1.786	1.88

Thickness and Thermal Properties[a]

[a] Units: L=ft.; SH=Btu/(lb·deg F); K=Btu/(h·ft·deg F); R=(h·ft^2·deg F)/Btu; D=lb/ft^3; WT=lb/ft^2.

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Table 26 Transfer Function Coefficients for Roofs (Time Interval=1.0 h)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] $n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$	$n=6$	U	$\sum_{n=0} c_n$
1	Roof terrace system	A0, C12, B1, B6, E2, E3,	b	0.00000	0.00008	0.00048	0.00039	0.00006			0.082	0.00101
		C5, E4, E5, E0	d	1.0000	−1.7304	0.8564	−0.1161	0.0024				
2	4-in. wood with 2-in. insulation	A0, E2, E3, B6, B9, E4,	b	0.000000	0.000000	0.000028	0.000155	0.000180	0.000055	0.000005	0.064	0.000423
		E5, E0	d	1.000000	−2.297995	1.866496	−0.659069	0.103380	−0.006350	0.000118		
3	2.5-in. wood with 2-in. insulation	A0, E2, E3, B6, B8, E4,	b	0.0000	0.0001	0.0008	0.0011	0.0003			0.076	0.0023
		E5, E0	d	1.0000	−1.6700	0.8423	−0.1499	0.0078	−0.0001			
4	1-in. wood with 2-in. insulation	A0, E2, E3, B6, B7, E4	b	0.0001	0.0034	0.0063	0.0014	0.0000			0.083	0.0112
		E5, E0	d	1.0000	−1.0856	0.2270	−0.0069	0.0000				
5	4-in. wood with 1-in. insulation	A0, E2, E3, B5, B9, E4,	d	0.0000	0.0000	0.0001	0.0003	0.0003	0.0001		0.085	0.0008
		E5, E0	d	1.0000	−2.2211	1.7256	−0.5741	0.0836	−0.0047	0.0001		
6	2.5-in. wood with 1-in. insulation	A0, E2, E3, B5, B8, E4,	b	0.0000	0.0002	0.0017	0.0017	0.0003			0.095	0.0039
		E5, E0	d	1.0000	−1.5931	0.7497	−0.1210	0.0056				

Table 26 Transfer Function Coefficients for Roofs (Time Interval=1.0 *h*) (Continued)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] n=0	n=1	n=2	n=3	n=4	n=5	n=6	U	$\sum_{n=0} c_n$
7	1-in. wood with 1-in. insulation	A0, E2, E3, B5, B7, E4,	b	0.0003	0.0082	0.0103	0.0014				0.115	0.0202
		E5, E10	d	1.0000	−1.0046	0.1845	−0.0046					
8	8-in. l.w. concrete	A0, E2, E3, C16, E4, E5,	b	0.00000	0.00002	0.00046	0.00133	0.00079	0.00011		0.092	0.00271
		E0	d	1.00000	−1.91091	1.22135	−0.31019	0.03001	−0.00095	0.00001		
9	6-in. l.w. concrete	A0, E2, E3, C15, E4, E5,	b	0.0000	0.0004	0.0034	0.0036	0.0007			0.109	0.0081
		E0	d	1.0000	−1.4904	0.6549	−0.0937	0.0037				
10	4-in. l.w. concrete	A0, E2, E3, C14, E4, E5,	b	0.0001	0.0055	0.0141	0.0045	0.0002			0.134	0.0244
		E0	d	1.0000	−1.0698	0.2665	−0.0143	0.0001				
11	6-in. h.w. concrete with 2 in. insulation	A0, E2, E3, B6, C13, E4,	b	0.00000	0.00015	0.00076	0.00050	0.00005			0.088	0.00146
		E5, E0	d	1.00000	−1.45612	0.53302	−0.06110	0.00082				
12	4-in. h.w. concrete with 2-in. insulation	A0, E2, E3, B6, C5, E4,	b	0.0000	0.0007	0.0016	0.0005				0.090	0.0028
		E5, E0	d	1.0000	−1.2437	0.2877	−0.0128					
13	2-in. h.w. concrete with 2-in. insulation	A0, E2, E3, B6, C12, E4,	b	0.0001	0.0025	0.0029	0.0003				0.091	0.0058
		E5, E0	d	1.0000	−1.1570	0.2229	−0.0022					
14	6-in. h.w. concrete with 1 in. insulation	A0, E2, E3, B5, C13, E4,	b	0.0000	0.0004	0.0016	0.0007				0.123	0.0027
		E5, E0	d	1.0000	−1.4117	0.4844	−0.0513	0.0006				
15	4-in. h.w. concrete with with 1-in. insulation	A0, E2, E3, B5, C5, E4,	b	0.0000	0.0017	0.0029	0.0006				0.126	0.0052
		E5, E0	d	1.0000	−1.1988	0.2503	−0.0103					
16	2-in. h.w. concrete with 1-in. insulation	A0, E2, E3, B5, C12, E4	b	0.0004	0.0057	0.0045	0.0003				0.131	0.0109
		E5, E0	d	1.0000	−1.1034	0.1885	−0.0018					
17	Steel sheet with 2-in. insulation	A0, E2, E3, B6, A3, E4	b	0.0025	0.0258	0.0156	0.0007				0.092	0.0446
		E5, E0	d	1.0000	−0.5996	0.0822	−0.0003					
18	Steel sheet with 1-in. insulation	A0, E2, E3, B5, A3, E4,	b	0.0085	0.0505	0.0179	0.0004				0.134	0.0773
		E5, E0	d	1.0000	−0.4700	0.0476						
19	Roof terrace system	A0, C12, B1, B6, E2, E3,	b	0.0000	0.0007	0.0025	0.0011	0.0001			0.106	0.0044
		C5, E0	d	1.0000	−1.6150	0.7406	−0.0848	0.0008				
20	4-in. wood with 2-in. insulation	A0, E2, E3,	b	0.0000	0.0000	0.0002	0.0006	0.0004	0.0001			
		B6, B9, E0	d	1.0000	−2.0606	1.4613	−0.4365	0.0550	−0.0023		0.077	0.0013
21	2.5-in. wood with 2-in. insulation	A0, E2, E3,	b	0.0000	0.0006	0.0034	0.0025	0.0003				
		B6, B8, E0	d	1.0000	−1.4326	0.5865	−0.0809	0.0023			0.090	0.0068
22	1-in. wood with 2-in. insulation	A0, E2, E3,	b	0.0012	0.0180	0.0150	0.0011					
		B6, B7, E0	d	1.0000	−0.8098	0.1357	−0.0007				0.109	0.0353
23	4-in. wood with 1-in. insulation	A0, E2, E3,	b	0.0000	0.0000	0.0005	0.0012	0.0006	0.0001			
		B5, B9, E0	d	1.0000	−1.9836	1.3387	−0.3742	0.0434	−0.0017		0.106	0.0024
24	2.5-in. wood with 1-in. insulation	A0, E2, E3,	b	0.0000	0.0017	0.0068	0.0035	0.0003				
		B5, B8, E0	d	1.0000	−1.3557	0.5121	−0.0634	0.0015			0.130	0.0123
25	1-in. wood with 1-in. insulation	A0, E2, E3,	b	0.0043	0.0385	0.0202	0.0007					
		B5, B7, E0	d	1.0000	−0.7314	0.1061	−0.0003				0.170	0.0637
26	8-in. l.w. concrete	A0, E2, E3,	b	0.0000	0.0002	0.0024	0.0038	0.0012	0.0001			
		C16, E0	d	1.0000	−1.6545	0.8775	−0.1734	0.0115	−0.0002		0.126	0.0077
27	6-in. l.w. concrete	A0, E2, E3,	b	0.0000	0.0031	0.0125	0.0067	0.0006				
		C15, E0	d	1.0000	−1.2340	0.4188	−0.0408	0.0007			0.158	0.0229
28	4-in. l.w. concrete	A0, E2, E3,	b	0.0013	0.0293	0.0336	0.0040					
		C14, E0	d	1.0000	−0.8134	0.1367	−0.0031				0.213	0.0682
29	6-in. h.w. concrete with with 2-in. insulation	A0, E2, E3,	b	0.0000	0.0014	0.0037	0.0013	0.0001				
		B6, C13, E0	d	1.0000	−1.3445	0.4428	−0.0434	0.0002			0.118	0.0065
30	4-in. h.w. concrete with 2-in. insulation	A0, E2, E3,	b	0.0002	0.0050	0.0063	0.0008					
		B16, C5, E0	d	1.0000	−1.1248	0.2344	−0.0065				0.119	0.0123
31	2-in. h.w. concrete with 2-in. insulation	A0, E2, E3,	b	0.0016	0.0151	0.0084	0.0003					
		B6, C12, E0	d	1.0000	−0.9605	0.1682	−0.0001				0.122	0.0254
32	6-in. h.w. concrete with 1-in. insulation	A0, E2, E3,	b	0.0001	0.0036	0.0068	0.0016					
		B5, C13, E0	d	1.0000	−1.3001	0.3991	−0.0361	0.0001			0.192	0.0121
33	4-in. h.w. concrete with 1-in. insulation	A0, E2, E3,	b	0.0008	0.0117	0.0100	0.0008					
		B5, C5, E0	d	1.0000	−1.0800	0.2015	−0.0051				0.200	0.0233
34	2-in. h.w. concrete with 1-in. insulation	A0, E2, E3,	b	0.0054	0.0314	0.0108	0.0001					
		B5, C12, E0	d	1.0000	−0.9091	0.1407					0.206	0.0477
35	Steel sheet with 2-in. insulation	A0, E2, E3,	b	0.0213		0.0642	0.0087					
		B6, A3, E0	d	1.0000	−0.2474	0.0026					0.125	0.0942
36	Steel sheet with 1-in. insulation	A0, E2, E3,	b	0.0601	0.1025	0.0055						
		B5, A3, E0	d	1.0000	−0.2124		0.0004				0.213	0.1681

[a] Construction is defined by code number for various layers. The thermal properties of layers designated by code numbers are given in Table 8.
[b] *U*, *b*'s and *c*'s are in Btu/(h · ft^2 · deg F), and *d* is dimensionless. Blank space represents zero.

Table 27 Transfer Function Coefficients for Exterior Walls (Time Interval=1.0 h)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] $n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$	$n=6$	U	$\sum_{n=0} c_n$
1	4-in. face brick, 2-in. insulation, and	A0, A2, B3	b	0.00000	0.00046	0.00225	0.00150	0.00016				
	4-in. l.w. concrete block	C2, E1, E0	d	1.00000	−1.73771	0.90936	−0.13373	0.00496	−0.00001		0.102	0.00437
2	4-in. l.w. concrete	A0, C14, E1,	b	0.0015	0.0299	0.0319	0.0034					
		E0	d	1.0000	−0.8364	0.1360	−0.0026				0.225	0.0667
3	4-in. face brick, air space, and	A0, A2, B1,	b	0.00000	0.00001	0.00017	0.00068	0.00058	0.00013	0.00001		
	8-in. common brick	C9, E1, E0	d	1.00000	−2.50273	2.25782	−0.88178	0.14098	−0.00804	0.00016	0.246	0.00158
4	4-in. face brick, air space, and	A0, A2, B1,	b	0.00000	0.00037	0.00302	0.00334	0.00069	0.00003			
	8-in. h.w. concrete block	C8, E1, E0	d	1.00000	−1.90941	1.16519	−0.24119	0.01264	−0.00017		0.275	0.00745
5	4-in. face brick, air space, and	A0, A2, B1,	b	0.00000	0.00030	0.00274	0.00344	0.00084	0.00004			
	8-in. l.w. concrete block	C7, E1, E0	d	1.00000	−1.89103	1.16153	−0.25248	0.01568	−0.00029		0.220	0.00736
6	4-in. face brick, air space, and	A0, A2, B1,	b	0.00000	0.00003	0.00058	0.00150	0.00082	0.00011			
	8-in. clay tile	C6, E1, E0	d	1.00000	−2.25069	1.76504	−0.56434	0.06627	−0.00257	0.00003	0.221	0.00304
7	4-in. face brick, air space, and	A0, A2, B1,	b	0.00003	0.00239	0.00757	0.00316	0.00018				
	2-in. h.w. concrete	C12, E1, E0	d	1.0000	−1.64772	0.74816	−0.06385	0.00147			0.350	0.01333
8	4-in. face brick, air space, and	A0, A2, B1,	b	0.00000	0.00086	0.00485	0.00378	0.00050	0.00001			
	4-in. common brick	C4, E1, E0	d	1.00000	−1.79201	0.98014	−0.16102	0.00609	−0.00003		0.301	0.01000
9	4-in. face brick, air space, and	A0, A2, B1,	b	0.00005	0.00387	0.01158	0.00460	0.00025				
	4-in. h.w. concrete block	C3, E1, E0	d	1.00000	−1.52669	0.64703	−0.05586	0.00128			0.309	0.02035
10	4-in. face brick, air space, and	A0, A2, B1,	b	0.00003	0.00286	0.01029	0.00504	0.00037				
	4-in. l.w. concrete block	C2, E1, E0	d	1.00000	−1.50943	0.65654	−0.07415	0.00212			0.248	0.01859
11	12-in. h.w. concrete	A0, A1, C11,	b	0.00000	0.00029	0.00303	0.00412	0.00105	0.00005			
		E1, E0	d	1.00000	−1.86853	1.09284	−0.21487	0.01094	−0.00009		0.421	0.00854
12	8-in. h.w. concrete with	A0, A1, C10,	b	0.00000	0.00028	0.00155	0.00118	0.00015				
	2-in. insulation	B6, E1, E0	d	1.00000	−1.71064	0.89735	−0.16643	0.00728	−0.00002		0.115	0.00316
13	8-in. h.w. concrete with	A0, A1, C10,	b	0.00000	0.00064	0.00303	0.00202	0.00023				
	1-in. insulation	B5, E1, E0	d	1.00000	−1.66125	0.83196	−0.14508	0.00613	−0.00002		0.187	0.00592
14	8-in. h.w. concrete with air space	A0, A1, C10,	b	0.00002	0.00199	0.00817	0.00467	0.00044	0.00001			
		B1, E1, E0	d	1.00000	−1.51622	0.64218	−0.08370	0.00288	−0.00001		0.339	0.01530
15	8-in. h.w. concrete	A0, A1, C10,	b	0.00009	0.00676	0.01821	0.00602	0.00024				
		E1, E0	d	1.00000	−1.37101	0.46271	−0.02787	0.00013			0.490	0.03132
16	4-in. face brick, 8-in. common brick	A0, A2, C9,	b	0.00000	0.00000	0.00008	0.00034	0.00035	0.00009	0.00001		
	with 1-in. insulation	B2, E1, E0	d	1.00000	−2.50527	2.30575	−0.97167	0.19281	−0.01643	0.00046	0.154	0.00087
17	4-in. face brick, 8-in. common brick	A0, A2, C9,	b	0.00000	0.00001	0.00022	0.00090	0.00080	0.00019	0.00001		
	with air space	B1, E1, E0	d	1.00000	−2.35214	1.98104	−0.73353	0.12178	−0.00859	0.00021	0.243	0.00213
18	Wall with 4-in. face brick, air space	A0, A7, B1,	b	0.0000	0.0008	0.0049	0.0040	0.0006				
	and 4-in. l.w. block	C14, E0	d	1.0000	−1.6216	0.7861	−0.1094	0.0038			0.175	0.0103
19	Wall with fiberglass insulation	A0, A6, B4	b	0.0158	0.0447	0.0065						
	and stucco outside finish	A6, E0	d	1.0000	−0.2480	0.0098					0.088	0.0670
20	Two-sided brick wall	A0, A7, B1,	b	0.0000	0.0024	0.0078	0.0034	0.0002				
		A2, E0	d	1.0000	−1.6620	0.7764	−0.0777	0.0019			0.358	0.0138
21	Brick wall, 8-in. concrete block and	A0, A7, C7,	b	0.0000	0.0013	0.0077	0.0064	0.0009				
	no air space	A6, E0	d	1.0000	−1.5966	0.7590	−0.1067	0.0037			0.274	0.0163
22	Brick wall with 4-in. concrete block	A0, A7, B1,	b	0.0000	0.0049	0.0130	0.0044	0.0002				
		C3, A6, E0	d	1.0000	−1.4750	0.5870	−0.0394	0.0007			0.307	0.0225
23	Brick wall with 8-in. concrete block	A0, A7, B1,	b	0.0000	0.0005	0.0034	0.0035	0.0006				
		C8, A6, E0	d	1.0000	−1.8688	1.1013	−0.2127	0.0095	−0.0001		0.274	0.0080
24	Brick wall with 6-in. concrete	A0, A7, B1,	b	0.000000	0.000033	0.000664	0.001650	0.000863	0.000106	0.000003		
		C15, A6, E0	d	1.000000	−2.080189	1.488946	−0.427814	0.045657	−0.001650	0.000017	0.133	0.003319
25	Frame wall with 4-in. brick veneer	A0, A7, B6,	b	0.00037	0.00823	0.00983	0.00125	0.00001				
		A6, E0	d	1.00000	−1.03045	0.20108	−0.00726				0.121	0.01969
26	Frame Wall	A0, A6, B6	b	0.01977	0.06317	0.01064	0.00006					
		A6, E0	d	1.00000	−0.25848	0.01072					0.124	0.09364
27	Metal curtain wall with	A0, A3, B12,	b	0.02704	0.05335	0.00337						
	3-in. insulation	A3, E0	d	1.00000	−0.07705	0.00013					0.091	0.08376
28	Metal curtain wall with	A0, A3, B6,	b	0.06695	0.06049	0.00077	0.00006					
	2-in. insulation	A3, E0	d	1.00000	−0.01493						0.130	0.12821
29	Metal curtain wall with	A0, A3, B5,	b	0.16228	0.06684	0.00008						
	1-in. insulation	A3, E0	d	1.00000	−0.00255						0.230	0.22920
30	Wall 12-in. concrete with	A0, A3, B6,	b	0.00000	0.00002	0.00030	0.00049	0.00015	0.00001			
	2-in. insulation on the outside	C11, A6, E0	d	1.00000	−1.91762	1.12612	−0.20839	0.00847	−0.00005		0.114	0.00097
31	Wall 8-in. concrete with	A0, A3, B6,	b	0.00001	0.00060	0.00205	0.00084	0.00004				
	2-in. insulation on the outside	C10, A6, E0	d	1.00000	−1.41996	0.47090	−0.02089	0.00006			0.118	0.00354
32	Wall 4-in. concrete with	A0, A3, B6,	b	0.00055	0.00735	0.00482	0.00021					
	2-in. insulation on the outside	C5, A6, E0	d	1.00000	−0.94420	0.05025	−0.00008				0.122	0.01293
33	Wall 12-in. concrete with	A0, C11, B6,	b	0.00000	0.00002	0.00039	0.00081	0.00034	0.00003			
	2-in. insulation on the inside	A6, E0	d	1.00000	−1.97154	1.28223	−0.32855	0.03282	−0.00087		0.113	0.00159
34	Wall 8-in. concrete with	A0, C10, B6,	b	0.00000	0.00072	0.00312	0.00183	0.00017				
	2-in. insulation on the inside	A6, E0	d	1.00000	−1.47387	0.60020	−0.07846	0.00197			0.117	0.00584

[a]Construction is defined by code number for various layers. The thermal properties of layers designated by code numbers are given in Table 8.
[b]U b's and c's are in Btu/(h · ft^2 · deg F) and d is dimensionless. Blank space represents zero.

Table 27 Transfer Function Coefficients for Exterior Walls (Time Interval=1.0 *h*) (Continued)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] $n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$	$n=6$	U	$\sum_{n=0} c_n$
35	Wall 4-in. concrete with	A0, C5, B6,	*b*	0.00058	0.01005	0.00982	0.00094	0.00001				
	2-in. insulation on the inside	A6, E0	*d*	1.00000	−0.99721	0.17610	−0.00367				0.122	0.02140
36	Frame wall with 3-in. insulation	A0, A1, B1,	*b*	0.00509	0.02644	0.00838	0.00010					
		B4, E1, E0	*d*	1.00000	−0.59602	0.08757	−0.00002				0.081	0.04001
37	Frame wall with 2-in. insulation	A0, A1, B1,	*b*	0.00984	0.03810	0.00869	0.00003					
		B3, E1, E0	*d*	1.00000	−0.57344	0.08074					0.112	0.05666
38	Frame wall with 1-in. insulation	A0, A1, B1,	*b*	0.02069	0.06369	0.01131	0.00001					
		B2, E1, E0	*d*	1.00000	−0.53187	0.06834					0.178	0.09570
39	Frame wall without insulation	A0, A1, B1,	*b*	0.07874	0.18185	0.02157	0.00001					
		E1, E0	*d*	1.00000	−0.37759	0.02246					0.438	0.28217
40	2-in. insulation with	A0, A1, B3,	*b*	0.00000	0.00001	0.00015	0.00035	0.00017	0.00002			
	12-in. h.w. concrete	C11, E1, E0	*d*	1.00000	−2.19085	1.64918	−0.51523	0.06550	−0.00241	0.00001	0.113	0.00070
41	2-in. insulation with 8-in. h.w.	A0, A1, B3,	*b*	0.00000	0.00025	0.000127	0.00090	0.00010				
	concrete	C10, E1, E0	*d*	1.00000	−1.69333	0.85832	−0.14902	0.00598	−0.00001		0.115	0.00252
42	2-in. insulation with	A0, A1, B3,	*b*	0.00000	0.00002	0.00029	0.00059	0.00025	0.00002			
	8-in. common brick	C9, E1, E0	*d*	1.00000	−2.09226	1.49037	−0.43637	0.05102	−0.00162	0.00001	0.105	0.00117
43	2-in. insulation with 8-in. h.w.	A0, A1, B3,	*b*	0.00001	0.00089	0.00317	0.00151	0.00010				
	concrete block	C8, E1, E0	*d*	1.00000	−1.50859	0.65148	−0.09296	0.00211			0.109	0.00568
44	2-in. insulation with 8-in. l.w.	A0, A1, B3,	*b*	0.00001	0.00081	0.00339	0.00196	0.00018				
	concrete block	C7, E1, E0	*d*	1.00000	−1.52490	0.69509	−0.11032	0.00399	−0.00001		0.099	0.00635
45	2-in. insulation with 8-in. clay tile	A0, A1, B3,	*b*	0.00000	0.00009	0.00088	0.00115	0.00029	0.00001			
		C6, E1, E0	*d*	1.00000	−1.86423	1.13568	−0.26957	0.02282	−0.00035		0.099	0.00242
46	2-in. insulation with 4-in. h.w.	A0, A1, B3	*b*	0.00017	0.00381	0.00465	0.00059					
	concrete	C5, E1, E0	*d*	1.00000	−1.21336	0.30574	−0.01507				0.119	0.00922
47	2-in. insulation with 4-in. common	A0, A1, B3,	*b*	0.00003	0.00178	0.00426	0.00130	0.00004				
	brick	C4, E1, E0	*d*	1.00000	−1.38159	0.50316	−0.05635	0.00038			0.113	0.00741
48	2-in. insulation with 4-in. h.w.	A0, A1, B3,	*b*	0.00032	0.00664	0.00794	0.00101	0.00001				
	concrete block	C3, E1, E0	*d*	1.00000	−1.13405	0.28947	−0.01615				0.114	0.01592
49	2-in. insulation with 4-in l.w.	A0, A1, B3,	*b*	0.00021	0.00593	0.00918	0.00168	0.00003				
	concrete block	C2, E1, E0	*d*	1.00000	−1.15325	0.34519	−0.02937	0.00004			0.105	0.01703
50	2-in. insulation with 4-in. clay tile	A0, A1, B3,	*b*	0.00010	0.00364	0.00662	0.00146	0.00003				
		C1, E1, E0	*d*	1.00000	−1.25692	0.40135	−0.03721	0.00010			0.110	0.01185
51	4-in. face brick 2-in. insulation and	A0, A2, B3,	*b*	0.00000	0.00000	0.00001	0.00007	0.00008	0.00002			
	12-in. h.w. concrete	C11, E1, E0	*d*	1.00000	−2.77682	2.82359	−1.27057	0.24210	−0.01709	0.00043	0.110	0.00018
52	4-in. face brick 2-in. insulation and	A0, A2, B3,	*b*	0.00000	0.00001	0.00017	0.00033	0.00013	0.00001			
	8-in. h.w. concrete	C10, E1, E0	*d*	1.00000	−2.27931	1.74119	−0.49535	0.04028	−0.00102		0.112	0.00065
53	4-in. face brick 2-in. insulation	A0, A2, B3,	*b*	0.00000	0.00000	0.00002	0.00012	0.00012	0.00003			
	and 8-in. common brick	C9, E1, E0	*d*	1.00000	−2.67788	2.60619	−1.10886	0.19586	−0.01264	0.00028	0.098	0.00029
54	4-in. face brick, air space	A0, A2, B1,	*b*	0.00000	0.00000	0.00009	0.00040	0.00040	0.00010	0.00001		
	and 12-in h.w. concrete	C11, E1, E0	*d*	1.00000	−2.62783	2.51419	−1.05796	0.18675	−0.01193	0.00027	0.287	0.00100
55	4-in. face brick, air space	A0, A2, B1,	*b*	0.00000	0.00010	0.00114	0.00180	0.00056	0.00004			
	and 8-in. h.w. concrete	C10, E1, E0	*d*	1.00000	−2.13032	1.50600	−0.39174	0.02828	−0.00062		0.314	0.00364
56	4-in. face brick, 2-in. insulation	A0, A2, B3,	*b*	0.00000	0.00051	0.00005	0.00071	0.00019	0.00001			
	and 8-in. h.w. concrete block	C8, E1, E0	*d*	1.00000	−2.09407	1.42522	−0.33797	0.02092	−0.00035		0.107	0.00147
57	4-in. face brick, 2-in. insulation	A0, A2, B3,	*b*	0.00000	0.00004	0.00051	0.00081	0.00023	0.00002			
	and 8-in. l.w. concrete block	C7, E1, E0	*d*	1.00000	−2.10971	1.47715	−0.37861	0.02866	−0.00067		0.096	0.00161
58	2-in. face brick, 2-in. insulation	A0, A2, B3,	*b*	0.00000	0.00000	0.00009	0.00030	0.00020	0.00003			
	and 8-in. clay tile	C6, E1, E0	*d*	1.00000	−2.44946	2.11710	−0.75882	0.10222	−0.00468	0.00006	0.097	0.00062
59	4-in. face brick, 2-in. insulation	A0, A2, B3	*b*	0.00000	0.00032	0.00131	0.00069	0.00005				
	and 4-in. h.w. concrete	C5, E1, E0	*d*	1.00000	−1.79933	0.90739	−0.09009	0.00250			0.116	0.00237
60	4-in. face brick 2-in. insulation	A0, A2, B3,	*b*	0.00000	0.00012	0.00084	0.00082	0.00014				
	and 4-in. common brick	C4, E1, E0	*d*	1.00000	−1.96722	1.20279	−0.22850	0.01033	−0.00006		0.111	0.00192
61	4-in. face brick, 2-in. insulation	A0, A2, B3,	*b*	0.00001	0.00057	0.00225	0.00117	0.00009				
	and 4-in. h.w. concrete block	C3, E1, E0	*d*	1.00000	−1.71940	0.84375	−0.09022	0.00268			0.111	0.00409
62	4-in. face brick with 8-in.	A0, A2, C9,	*b*	0.0000	0.0000	0.0007	0.0019	0.0012	0.0001			
	common brick	E1, E0	*d*	1.0000	−2.2097	1.6914	−0.5296	0.0632	−0.0024		0.302	0.0039
63	8-in. h.w. concrete block with	A0, A1, C8,	*b*	0.0000	0.0022	0.0070	0.0031	0.0002				
	1-in. insulation	B2, E1, E0	*d*	1.0000	−1.4583	0.6156	−0.0872	0.0022			0.173	0.0125
64	8-in. h.w. concrete block	A0, A1, C8,	*b*	0.0004	0.0171	0.0310	0.0065	0.0001				
		E1, E0	*d*	1.0000	−1.1621	0.3132	−0.0139				0.402	0.0551
65	8-in. l.w. concrete block with	A0, A1, C7,	*b*	0.0000	0.0019	0.0070	0.0037	0.0003				
	insulation	B2, E1, E0	*d*	1.0000	−1.4580	0.6409	−0.0996	0.0037			0.149	0.0130
66	8-in. l.w. concrete block	A0, A1, C7,	*b*	0.0002	0.0123	0.0271	0.0075	0.0002				
		E1, E0	*d*	1.0000	−1.1655	0.3509	−0.0245	0.0002			0.294	0.0473
67	4-in. face brick, 8-in. clay tile	A0, A2, C6,	*b*	0.0000	0.0000	0.0003	0.0008	0.0005	0.0001			
	and 1-in. insulation	B2, E1, E0	*d*	1.0000	−2.2886	1.8666	−0.6650	0.1043	−0.0061	0.0001	0.142	0.0016
68	4-in. face brick, 8-in. clay tile	A0, A2, C6,	*b*	0.0000	0.0000	0.0007	0.0019	0.0011	0.0001			
	and airspace	B1, E1, E0	*d*	1.0000	−2.1290	1.5667	−0.4781	0.0605	−0.0029		0.221	0.0038
69	4-in. face brick with 8-in. clay tile	A0, A2, C6,	*b*	0.0000	0.0001	0.0017	0.0034	0.0014	0.0001			
		E1, E0	*d*	1.0000	−1.9926	1.3232	−0.3341	0.0285	−0.0007		0.275	0.0067
70	8-in. clay tile with 1-in. insulation	A0, A1, C6,	*b*	0.0000	0.0002	0.0020	0.0024	0.0006				
		B2, E1, E0	*d*	1.0000	−1.8072	1.0721	−0.2513	0.0213	−0.0004		0.151	0.0052

Table 27 Transfer Function Coefficients for Exterior Walls (Time Interval=1.0 *h*) (Continued)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] $n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$	$n=6$	U	$\sum_{n=0} c_n$
71	8-in. clay tile with air space	A0, A1, C6,	*b*	0.0000	0.0007	0.0051	0.0052	0.0010				
		B1, E1, E0	*d*	1.0000	−1.6476	0.8490	−0.1597	0.0103			0.231	0.0120
72	8-in. clay tile	A0, A1, C6,	*b*	0.0000	0.0020	0.0107	0.0076	0.0009				
		E1, E0	*d*	1.0000	−1.5111	0.6712	−0.0910	0.0026			0.296	0.0212
73	4-in. h.w. concrete with 2-in.	A0, A1, C5,	*b*	0.0002	0.0045	0.0060	0.0009					
	insulation	B3, E1, E0	*d*	1.0000	−1.2260	0.3418	−0.0187				0.119	0.0116
74	4-in. h.w. concrete with 1-in.	A0, A1, C5,	*b*	0.0005	0.0094	0.0106	0.0013					
	insulation	B2, E1, E0	*d*	1.0000	−1.1763	0.3011	−0.0157				0.200	0.0218
75	4-in. h.w. concrete with air space	A0, A1, C5,	*b*	0.0017	0.0267	0.0252	0.0024					
		B1, E1, E0	*d*	1.0000	−1.0298	0.1837	−0.0071				0.381	0.0560
76	4-in. h.w. concrete	A0, A1, C5,	*b*	0.0078	0.0705	0.0355	0.0011					
		E1, E0	*d*	1.0000	−0.8789	0.0753	−0.0001				0.585	0.1149
77	4-in. face brick, 4-in. common	A0, A2, C4,	*b*	0.0000	0.0004	0.0024	0.0023	0.0004				
	brick and 1-in. insulation	B2, E1, E0	*d*	1.0000	−1.7939	1.0313	−0.2206	0.0151	−0.0002		0.174	0.0055
78	4-in. face brick, 4-in. common	A0, A2, C4,	*b*	0.0000	0.0011	0.0065	0.0053	0.0008				
	brick and air space	B1, E1, E0	*d*	1.0000	−1.6408	0.8149	−0.1359	0.0073			0.301	0.0137
79	4-in. face brick with 4-in.	A0, A2, C4,	*b*	0.0000	0.0035	0.0142	0.0075	0.0006				
	common brick	E1, E0	*d*	1.0000	−1.4987	0.6252	−0.0656	0.0012			0.415	0.0258
80	4-in. common brick	A0, A1, C4,	*b*	0.0015	0.0330	0.0381	0.0044					
		E1, E0	*d*	1.0000	−1.0401	0.2114	−0.0040				0.460	0.0770
81	4-in. h.w. concrete block	A0, A1, C3,	*b*	0.0101	0.0890	0.0457	0.0015					
		E1, E0	*d*	1.0000	−0.7809	0.0861	−0.0002				0.480	0.1463
82	4-in. face brick, 4-in. l.w. concrete	A0, A2, C2,	*b*	0.0000	0.0012	0.0052	0.0032	0.0003				
	block and 1-in. insulation	B2, E1, E0	*d*	1.0000	−1.5846	0.7760	−0.1323	0.0055			0.153	0.0099
83	4-in. face brick, 4-in. l.w. concrete	A0, A2, C2,	*b*	0.0000	0.0032	0.0118	0.0059	0.0005				
	block and air space	B1, E1, E0	*d*	1.0000	−1.4228	0.5787	−0.0713	0.0023			0.246	0.0214
84	4-in. face brick with 4-in. l.w.	A0, A2, C2,	*b*	0.0001	0.0072	0.0194	0.0066	0.0003				
	concrete block	E1, E0	*d*	1.0000	−1.3110	0.4487	−0.0329	0.0004			0.319	0.0336
85	4-in. l.w. concrete block and	A0, A1, C2,	*b*	0.0006	0.0129	0.0175	0.0028					
	1-in. insulation	B2, E1, E0	*d*	1.0000	−1.0784	0.3137	−0.0257				0.161	0.0338
86	4-in. l.w. concrete block and	A0, A1, C2,	*b*	0.0018	0.0319	0.0346	0.0042					
	air space	B1, E1, E0	*d*	1.0000	−0.9152	0.2013	−0.0105				0.263	0.0725
87	4-in. l.w. concrete block	A1, C2, E1,	*b*	0.0161	0.1223	0.0504	0.0012					
		E0	*d*	1.0000	−0.5447	0.0306					0.391	0.1900
88	4-in. face brick, 4-in. clay tile	A0, A2, C1,	*b*	0.0000	0.0008	0.0039	0.0029	0.0004				
	1-in. insulation	B2, E1, E0	*d*	1.0000	−1.6784	0.8825	−0.1650	0.0083			0.169	0.0080
89	4-in. face brick, 4-in. clay tile	A0, A2, C1,	*b*	0.0000	0.0022	0.0098	0.0060	0.0006				
	and air space	B1, E1, E0	*d*	1.0000	−1.5195	0.6769	−0.0950	0.0037			0.281	0.0186
90	4-in. face brick and 4-in. clay tile	A0, A2, C1,	*b*	0.0001	0.0060	0.0187	0.0075	0.0004				
		E1, E0	*d*	1.0000	−1.3861	0.5138	−0.0424	0.0006			0.381	0.0327
91	4-in. clay tile and 1-in. insulation	A0, A1, C1,	*b*	0.0003	0.0084	0.0137	0.0027	0.0001				
		B2, E1, E0	*d*	1.0000	−1.1988	0.3768	−0.0343	0.0001			0.175	0.0252
92	4-in. clay tile and air space	A0, A1, C1,	*b*	0.0010	0.0227	0.0305	0.0048	0.0001				
		B1, E1, E0	*d*	1.0000	−1.0394	0.2496	−0.0153				0.303	0.0591
93	4-in. clay tile	A0, A1, C1,	*b*	0.0035	0.0521	0.0445	0.0034					
		E1, E0	*d*	1.0000	−0.9042	0.1533	−0.0021				0.419	0.1035
94	Sheet metal with 1-in. insulation	A0, A3, B2,	*b*	0.1424	0.0479							
		B1, A3, E0	*d*	1.0000	−0.0013						0.191	0.1903
95	Sheet metal with 2-in. insulation	A0, A3, B3,	*b*	0.0770	0.0389	0.0001						
		B1, A3, E0	*d*	1.0000	−0.0028						0.116	0.1160
96	Sheet metal with 3-in. insulation	A0, A3, B4	*b*	0.0461	0.0369	0.0003						
		B1, A3, E0	*d*	1.0000	−0.0072						0.084	0.0833

It is not necessary for the user to crosscheck his chosen U-names against the code-words that have been reserved in the DOE-2 MATERIALs Library and CONSTRUCTIONs (ASHRAE) Library. Previously established U-names have precedence over code-words. Example: When a name is specified for the CONSTRUCTION keyword in an EXTERIOR-WALL instruction, the program first searchs its U-name list for the name. If the name is found on the list, it is used as a U-name. If the name is not found on the U-name list, the program then searchs the DOE-2 CONSTRUCTIONs Library to see if the name is a code-word. It is not wise, however, to deliberately choose U-names that are also code-words. This can make debugging or subsequent review of an input listing unnecessarily confusing.

9. SPECIFYING INTERIOR WALLS, INTERIOR FLOORS, CEILINGS, UNDERGROUND WALLS, UNDERGROUND FLOORS, AND NON-GLASS DOORS

Note: The following discussion applies only to interior walls, interior floors, ceilings, underground walls, underground floors, and doors. For discussion of other surfaces, refer to the section in this chapter entitled "SPECIFYING EXTERIOR WALLS, EXTERIOR FLOORS, AND ROOFS".

In the LOADS calculation, that is, calculating the flow of heat through interior walls, interior floors, ceilings, underground walls, underground floors, and doors, the program treats all these surfaces as steady-state, or "quick", constructions with little thermal capacitance. The heat flow is not delayed. One exception to the preceeding statement occurs when Custom Weighting Factors are generated for interior walls, interior floors, ceilings, underground walls, and underground floors.

The DOE-2 program treats interior walls, interior floors, and ceilings in an identical manner. The only difference is the physical orientation of the surface. All three of these surfaces are described in the INTERIOR-WALL instruction. See Fig. III.20.

The program treats underground walls and underground floors in the same manner as interior walls, except the underground surfaces have one surface covered (the outside surface) and no NEXT-TO SPACE. Underground walls and underground floors are described in the instructions by the same names.

Non-glass doors in exterior walls are specified in the DOOR instruction. Glass doors in exterior walls should be specified not in the DOOR instruction but rather in the WINDOW instruction. Doors in interior walls should not be specified in the DOOR instruction. Such doors, however, may be specified as interior walls.

When a user specifies any of the surfaces discussed in this section (except glass doors), one of two approaches must be followed: (1) if the user <u>is not</u> using Custom Weighting Factors, he will be referred back to a previously defined CONSTRUCTION instruction. In that referenced CONSTRUCTION instruction, a numerical value must be specified for the U-VALUE keyword (do not specify an entry for the LAYERS keyword), <u>or</u> (2) if the user <u>is</u> using Custom Weighting Factors, he will most likely have defined his interior walls as "delayed" for the purpose of the weighting factor calculation (see Sec. III.C). For the heat flow through the walls on an hourly basis, the program will use a calculated U-value and the user need not input one.

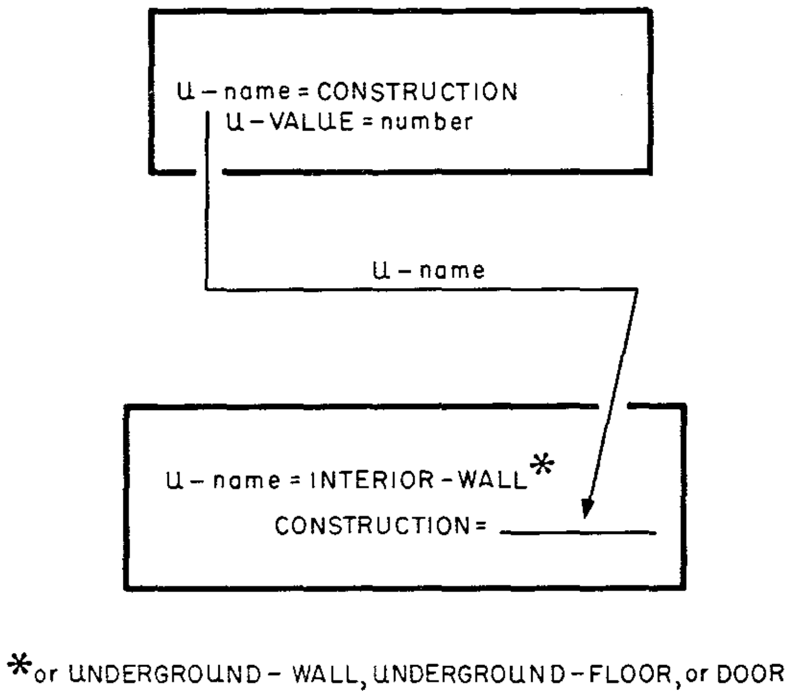

Fig. III.20 Specifying an interior wall, interior floor, ceiling, underground wall, underground floor, or non-glass door. The U-VALUE is either specified by the user or calculated by the program (see preceeding paragraph).

Table 29 Transfer Function Coefficients for Interior Partitions, Floors, and Ceilings (Time Interval=1.0 h)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] n=0	n=1	n=2	n=3	n=4	n=5	n=6	U	$\sum_{n=0} c_n$
1	4-in. clay tile with 0.75-in. plaster	E0, E1, C1,	b	0.0033	0.0424	0.0325	0.0021				0.374	0.0803
		E1, E0	d	1.0000	−0.9447	0.01613	−0.0017					
2	4-in. l.w. concrete block	E0, E1, C2,	b	0.0048	0.0514	0.0339	0.0018					
	with 0.75-in. plaster	E1, E0	d	1.0000	−0.8456	0.1397	−0.0015				0.314	0.0919
3	4-in. h.w. concrete block	E0, E1, C3	b	0.0092	0.0705	0.0318	0.0008					
	with 0.75-in. plaster	E1, E0	d	1.0000	−0.8203	0.0874	−0.0001				0.421	0.1123
4	4-in. common brick with	E0, E1, C4,	b	0.0014	0.0265	0.0272	0.0027					
	0.75-in. plaster	E1, E0	d	1.0000	−1.0753	0.2209	−0.0033				0.406	0.0578
5	4-in. h.w. concrete with	E0, E1, C5,	b	0.0068	0.0527	0.0226	0.0005					
	0.75-in. plaster	E1, E0	d	1.0000	−0.9083	0.0738					0.499	0.0826
6	8-in. clay tile with 0.75-in. plaster	E0, E1, C6,	b	0.0000	0.0018	0.0085	0.0056	0.0006				
		E1, E0	d	1.0000	−1.5522	0.7047	−0.0947	0.0025			0.274	0.0165
7	8-in. l.w. concrete block,	E0, E1, C7,	b	0.0002	0.0106	0.0214	0.0054	0.0001				
	plastered both sides	E1, E0	d	1.0000	−1.2098	0.3736	−0.0248	0.0001			0.271	0.0377
8	8-in. h.w. concrete block,	E0, E1, C8	b	0.0004	0.0141	0.0231	0.0043	0.0001				
	plastered both sides	E1, E0	d	1.0000	−1.1995	0.3293	−0.0132				0.360	0.0420
9	8-in. common brick,	E0, E1, C9,	b	0.0000	0.0005	0.0037	0.0040	0.0008				
	plastered both sides	E1, E0	d	1.0000	−1.7862	0.9878	−0.1802	0.0081	−0.0001		0.306	0.0090
10	8-in. heavy concrete	E0, E1, C10,	b	0.0001	0.0055	0.0131	0.0038	0.0001				
	plastered both sides	E1, E0	d	1.0000	−1.3984	0.4782	−0.0273	0.0001			0.430	0.0226
11	12-in. heavy concrete	E0, E1, C11,	b	0.0000	0.0002	0.0023	0.0029	0.0007				
	plastered both sides	E1, E0	d	1.0000	−1.8959	1.1220	−0.2203	0.0107	−0.0001		0.372	0.0061
12	4-in. clay tile	E0, C1	b	0.0906	0.2519	0.0279						
			d	1.0000	−0.3738	0.0018					0.590	0.3704
13	4-in. l.w. concrete block	E0, C2	b	0.1112	0.2189	0.0136						
			d	1.0000	−0.2440	0.0003					0.454	0.3437
14	4-in. h.w. concrete block	E0, C3	b	0.2080	0.3271	0.0128						
			d	1.0000	−0.2363	0.0001					0.717	0.5479
15	4-in. common brick	E0, C4	b	0.0516	0.2266	0.0484	0.0003					
			d	1.0000	−0.5275	0.0108					0.676	0.3269
16	4-in. h.w. concrete	E0, C5	b	0.2170	0.4082	0.0221						
			d	1.0000	−0.3411	0.0002					0.982	0.6473
17	8-in. clay tile	E0, C6	b	0.0008	0.0269	0.0413	0.0069	0.0001				
			d	1.0000	−0.9872	0.1962	−0.0049				0.372	0.0760
18	8-in. l.w. concrete block	E0, C7	b	0.0109	0.0955	0.0446	0.0013					
			d	1.0000	−0.6275	0.0395	−0.0001				0.370	0.1523
19	8-in. h.w. concrete block	E0, C8, E0	b	0.0036	0.0438	0.0309	0.0017					
			d	1.0000	−0.9441	0.1435	−0.0009				0.403	0.0800
20	8-in. common brick	E0, C9, E0	b	0.0000	0.0021	0.0091	0.0052	0.0005				
			d	1.0000	−1.5586	0.6889	−0.0821	0.0016			0.339	0.0169
21	8-in. h.w. concrete	E0, C10, E0	b	0.0006	0.0155	0.0203	0.0028					
			d	1.0000	−1.2467	0.3362	−0.0094				0.489	0.0392
22	12-in. h.w. concrete	E0, C11, E0	b	0.0000	0.0010	0.0053	0.0040	0.0005				
			d	1.0000	−1.7442	0.9050	−0.1395	0.0041			0.425	0.0108
23	Frame, partition with	E0, E1, B1,	b	0.0729	0.1526	0.0159						
	0.75-in. gypsum board	E1, E0	d	1.0000	−0.3986	0.0208					0.388	0.2414
24	1-in. wood	E0, B7, E0	b	0.0879	0.1653	0.0096						
			d	1.0000	−0.3276	0.004					0.391	0.2628
25	2-in. wood	E0, B10, E0	b	0.0044	0.0485	0.0300	0.0014					
			d	1.0000	−0.7656	0.0820	−0.0003				0.267	0.0843
26	3-in. wood	E0, B11, E0	b	0.0000	0.0060	0.0156	0.0051	0.0002				
			d	1.0000	−1.2012	0.3563	−0.0218	0.0001			0.202	0.0269
27	4-in. wood	E0, B9, E0	b	0.0000	0.0004	0.0035	0.0039	0.0008				
			d	1.0000	−1.6363	0.8198	−0.1362	0.0060			0.161	0.0086
28	Frame partition with 1-in. wood	E0, B7, B1,	b	0.0018	0.0281	0.0244	0.0018					
		B7, E0	d	1.0000	−0.9163	0.1789	−0.0009				0.214	0.0561
29	2-in. furniture	E0, B10, B1,	b	0.0000	0.0002	0.0020	0.0028	0.0008				
		B10, E0	d	1.0000	−1.7820	1.0138	−0.2044	0.0135	−0.0001		0.142	0.0058
30	3-in. furniture	E0, B11, B1,	b	0.00000	0.00000	0.00002	0.00015	0.00027	0.00014	0.00002		
		B11, E0	d	1.00000	−2.65321	2.63820	−1.22726	0.27415	−0.02738	0.00110	0.107	0.0006
31	2-in. h.w. concrete floor deck	E0, A5, C12	b	0.0505	0.0691	0.0011						
		E0	d	1.0000	−0.6662						0.362	0.1207
32	4-in. h.w. concrete floor deck	E0, A5, C5,	b	0.0111	0.0405	0.0072						
		E0	d	1.0000	−0.8507	0.0229					0.341	0.0588
33	4-in. l.w. concrete floor deck	E0, A5, C2,	b	0.0200	0.0710	0.0120						
		E0	d	1.0000	−0.5878	0.0116					0.243	0.1030
34	8-in. h.w. concrete floor deck	E0, A5, C10,	b	0.0002	0.0062	0.0084	0.0012					
		E0	d	1.0000	−1.3198	0.3840	−0.0118				0.305	0.0106
35	8-in. l.w. concrete floor deck	E0, A5, C7,	b	0.0013	0.0199	0.0167	0.0012					
		E0	d	1.0000	−0.9849	0.1677	−0.0016				0.216	0.0391
36	2-in. wood deck	E0, A5, B10,	b	0.0020	0.0245	0.0174	0.0010					
		E0	d	1.0000	−0.9025	0.1271	−0.0008				0.201	0.0449

Table 29 Transfer Function Coefficients for Interior Partitions, Floors, and Ceilings (Time Interval=1.0 h) (Continued)

No.	Construction[a] Description	Code Nos. of Layers		Coefficients b_n and d_n[b] $n=0$	$n=1$	$n=2$	$n=3$	$n=4$	$n=5$	$n=6$	U	$\sum_{n=0} c_n$
37	3-in. wood deck	E0, A5, B11	b	0.0000	0.0029	0.0083	0.0030	0.0001				
		E0	d	1.0000	−1.3381	0.4614	−0.0347	0.0003			0.161	0.0143
38	2-in. h.w. concrete deck with	E0, A5, C10,	b	0.0056	0.0191	0.0028						
	false ceiling	E4, E5, E0	d	1.0000	−0.8552	0.0084					0.180	0.0275
39	4-in. h.w. concrete deck with	E0, A5, C5,	b	0.0010	0.0083	0.0040	0.0001					
	false ceiling	E4, E5, E0	d	1.0000	−0.9694	0.0461	−0.0003				0.175	0.0134
40	4-in. l.w. concrete deck with	E0, A5, C2,	b	0.0020	0.0195	0.0104	0.0004					
	false ceiling	E4, E5, E0	d	1.0000	−0.8295	0.0534	−0.0003				0.144	0.0323
41	8-in. h.w. concrete deck with	E0, A5, C10,	b	0.00001	0.00081	0.00212	0.00068	0.00003				
	false ceiling	E4, E5, E0	d	1.00000	−1.43128	0.47458	−0.02140	0.00017			0.165	0.00365
42	8-in. l.w. concrete deck with	E0, A5, C7,	b	0.0001	0.0035	0.0065	0.0014					
	false ceiling	E4, E5, E0	d	1.0000	−1.2039	0.2980	−0.0085				0.134	0.0115
43	2-in. wood deck with	E0, A5, B10,	b	0.0001	0.0048	0.0078	0.0014					
	false ceiling	E4, E5, E0	d	1.0000	−1.1372	0.2530	−0.0061				0.129	0.0141
44	3-in. wood deck with false ceiling	E0, A5, B11,	b	0.00000	0.00039	0.00223	0.00169	0.00022				
		E4, E5, E0	d	1.00000	−1.57274	0.69111	−0.07957	0.00176			0.112	0.00453
45	12-in. h.w. concrete deck	E0, A5, C11,	b	0.00000	0.00004	0.00036	0.00048	0.00012	0.00001			
	with false ceiling	E4, E5 E0	d	1.00000	−1.92879	1.13565	−0.20935	0.00893	−0.00009		0.159	0.00101
46	4-in. wood deck with	E0, A5, B9,	b	0.00000	0.00002	0.00033	0.00074	0.00033	0.00003			
	false ceiling	E4, E5, E0	d	1.00000	−2.00785	1.31626	−0.31761	0.02445	−0.00050		0.098	0.00145
47	Steel deck with false ceiling	E0, A5, A3,	b	0.0749	0.0853	0.0022						
		E4, E5, E0	d	1.0000	−0.1257	0.0001					0.186	0.1624

[a]Construction is defined by code number for various layers. The thermal properties of layers designated by code numbers are given in Table 8.
[b]U, b's and c's are in Btu/(h · ft^2 · deg F) and d is dimensionless.

10. MATERIAL

The MATERIAL instruction is used to specify the heat transfer properties for one layer of a construction in an exterior wall, exterior floor, or roof. These properties will be subsequently used to calculate the thermal response factors of the composite wall (see LAYERS instruction). The response factors will then be used in the calculation of Custom Weighting Factors, if the user chooses that option. For interior floors, interior walls, underground walls, and underground floors, a MATERIAL instruction may be specified, but it will be used only for the calculation of the optional Custom Weighting Factors; heat flow for these surfaces is calculated as a "quick" surface.

This instruction is used when materials from the DOE-2 MATERIALs Library are not appropriate. The DOE-2-prespecified materials are described in Chap. X of this manual and are stored on the DOE-2 file named BDLLIB. The ASHRAE-prespecified materials are described in the 1977 ASHRAE Handbook of Fundamentals, Chap. 25, Table 8, p. 25.10 (Ref. 5) and are also stored on the DOE-2 file name BDLLIB. A reprint of Table 8 is included in the previous Section of the manual.

The user should review the discussion (immediately preceding this section) if he is not familiar with how to specify walls.

U-name	must be specified for this instruction. It identifies this MATERIAL in a subsequent LAYERS instruction.
MATERIAL	This command tells LOADS that the data to follow specify the properties of a material.
LIKE	may be used to copy data from a previously U-named MATERIAL instruction. It is not possible to use the LIKE keyword to specify a MATERIAL in the DOE-2 MATERIALs Library, such as AC01, CM01, CB17, A1, A2, etc. (these materials are identified and called by specifying code-words, not U-names, in the LAYERS instruction).
THICKNESS	specifies the thickness of the material in units of feet.
CONDUCTIVITY	is used to specify the thermal conductivity of the material in Btu-ft/hr-ft^2-°F. The entry for this keyword is expressed per foot of thickness, not per inch. Hence, values given per inch of thickness must be divided by 12 to obtain the correct entry.
DENSITY	specifies the material density in lb/ft^3.
SPECIFIC-HEAT	specifies the specific heat capacity of the material in Btu/lb-°F.

RESISTANCE — As an alternative to the preceding four keywords, this keyword may be entered. It is used to specify the thermal resistance for a material in hr-ft^2-°F/Btu. A RESISTANCE entry should be used for a material with no significant thermal capacitance, like an air gap.

Examples:

1. The following instruction enters the thermal properties of a four-inch-thick layer of brick:

```
BRICK-4IN = MATERIAL
     THICKNESS = 0.333
     CONDUCTIVITY = 0.4167
     DENSITY = 120.0
     SPECIFIC-HEAT = 0.2 ..
```

2. Because brick has fairly high heat capacitance, a RESISTANCE entry would not be appropriate for use in DOE-2. However, a one-inch-thick air gap would result in the following instruction:

```
AIR-LAYER = MATERIAL
     RESISTANCE = 0.90 ..
```

__________________ = MATERIAL or MAT (User Worksheet)

U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	__________	U-name	-	-	-
THICKNESS	TH	=	__________	feet	**	0.	10.
CONDUCTIVITY	COND	=	__________	Btu-ft/ hr-ft^2-°F	**	0.	30.
DENSITY	DENS	=	__________	lb/ft^3	**	0.	500.
SPECIFIC-HEAT	S-H	=	__________	Btu/lb-°F	**	0.	5.
RESISTANCE	RES	=	__________	hr-ft^2-°F/Btu	**	0.	40.

..

* Mandatory entry, if MATERIAL is specified.
**Either THICKNESS, CONDUCTIVITY, DENSITY, and SPECIFIC-HEAT, <u>or</u> RESISTANCE only must be entered. There are no default values.

11. LAYERS

The LAYERS instruction is used to specify the sequence of material layers of a construction; that is, it describes the cross section of a wall, roof, etc. It is used when no LAYERS code-word in the DOE-2 LAYERS Library is appropriate for a given exterior wall, exterior floor, roof, interior floor, interior wall, underground wall, or underground floor. The information in a LAYERS instruction for an interior floor, interior wall, underground wall, or underground floor will be used only for the calculation of Custom Weighting Factors; for heat flow, these surfaces are treated like "quick" surfaces.

U-name — is required for this instruction. It identifies this LAYERS in a subsequent CONSTRUCTION instruction.

LAYERS — This command 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. Note that the default of .68 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.

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

If the user cannot decide which is more important, cooling or heating, he can accept the default value of .68. For exterior walls and roofs, the outside-film-resistance is calculated by the program. 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). Do not input it as a MATERIAL.

MATERIAL — identifies a list of MATERIAL instruction U-names or a list of DOE-2-prespecified material code-words (see Chap. X) or a list of ASHRAE-prespecified material code-words from Table 8 on p. 25.10 of the 1977 ASHRAE Handbook of Fundamentals (Ref. 5). Do not include the code-words A0 or E0 from Ref. 5. When using the last approach, enter the code-word HF-x, where x is the "Code Number" of the material listed in Table 8 on p. 25.10 of Ref. 5 (Table 8 is reprinted earlier in this chapter).

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. For an interior wall, the sequence of elements in the list is the sequence of material layers in the interior-wall, starting with the layer on the opposite side of the wall and ending with the layer on the near side of the wall. 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. The list has the same number and order of elements as the immediately preceding MATERIAL instruction. If no thickness is specified, it will be taken from the MATERIAL instruction.

Rules:

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

2. The list identified by MATERIAL and THICKNESS must have a one-to-one correspondence. That is, 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 and proceed sequentially to end with the inside layer. For an interior wall, interior floor, ceiling, underground wall, or underground floor, both lists start with the layer on the opposite side and proceed sequentially to end with the layer on the near side.

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:

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

```
CBLOCK = LAYERS
     INSIDE-FILM-RES = 0.68
     MATERIAL        = (CM01, CB17)    $ From Chap. X $
     THICKNESS       = (.083, 1.00)   ..
```

____________________ = LAYERS or LA (User Worksheet)

U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
INSIDE-FILM-RES	I-F-R	=	__________	hr-ft^2-°F/Btu	0.68	0.	40.
MATERIAL	MAT	=	(__________)	U-name list or code-word list	*	-	-
THICKNESS	TH	=	(__________)	list of feet	**	0.	10.

* Mandatory entry, if LAYERS is specified.

**Default is the same THICKNESS as that specified in the appropriate MATERIAL instruction.

12. 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. This instruction may also be used to generate Custom Weighting Factors either (1) in a library during a LIBRARY-INPUT LOADS run or (2) in the current INPUT LOADS run.

A U-name must be specified for this instruction. It identifies this CONSTRUCTION in a subsequent EXTERIOR-WALL, ROOF, INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR, or DOOR instruction.

CONSTRUCTION — This command 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 either:

(1) a code-word from Chap. 25 of the 1977 ASHRAE Handbook of Fundamentals (Ref. 5); use Table 26 (pp. 25.28-25.29) for roofs, Table 27 (pp. 25.30-25.32) for exterior walls, and Table 29 (pp. 25.34-25.35) for interior walls, ceilings, and interior floors,

or

(2) a 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.

When using the former approach, enter code-words ASHW-x for exterior walls, ASHR-x for roofs, and, for Custom Weighting Factor generation, ASHI-x for interior walls, interior floors, or ceilings. In these code-words, x is the the "No." of the wall or roof in Table 26, Table 27, or Table 29 of Chap. 25 of Ref. 5.

U-VALUE — may be used as an alternative to LAYERS. The heat transfer calculation technique used here assumes that the construction has little heat capacitance, and the heat flow is not delayed. Thus 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; the outside film coefficient is calculated hourly as a function of surface roughness and wind speed. The following table shows typical U-values for some low-heat capacity walls.

EXAMPLE U-VALUES FOR SOME CONSTRUCTIONS WITH LOW HEAT CAPACITY

	U-Value
Exterior Walls*	
Wood sheathing, 1/2 in. on studs, 1/2 in. gypsum board	0.35
Metal siding on 1/2 in. plywood, studs, 1/2 in. gypsum board	0.38
Stucco on 3/4 in. pine, studs, 1/2 in. gypsum board	0.34
Roofs*	
Wood shingles on 1/2 in. plywood, 2 x 8 studs, 1/2 in. gypsum board	0.28
Built-up roof on plywood deck, 2 x 8 studs, 1/2 in. gypsum board with acoustical tile	0.27
Interior Walls and Floors**	
Gypsum board, 1/2 in., on either side of metal studs	0.32
Hardwood flooring on 1/2 in. 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.

COEFFICIENTS OF TRANSMISSION
(U-VALUES) FOR SLAB DOORS (Ref. 9)
($Btu/hr\text{-}ft^2\text{-}°F$)

Solid Wood Door			
Thickness	No Storm Door	With Wood Storm Door	With Metal Storm door
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 Door			
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.

Additional information on U-values may be obtained in Chap. X, however, bear in mind that the Chap. X, data are resistance (R) values. Therefore, use the reciprocal of these values; that is, U = 1/R.

ABSORPTANCE specifies, as a decimal fraction, 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 following table provides typical values for various exterior surfaces.

ABSORPTANCE for Various Exterior Surfaces*

Material	ABSORPTANCE	Paint	ABSORPTANCE
Black concrete	0.91	Optical flat black paint	0.98
Stafford blue brick	0.89	Flat black paint	0.95
Red brick	0.88	Black lacquer	0.92
Bituminous felt	0.88	Dark gray paint	0.91
Blue gray slate	0.87	Dark blue lacquer	0.91
Roofing, green	0.86	Black oil paint	0.90
Brown concrete	0.85	Dark olive drab paint	0.89
Asphalt pavement, weathered	0.82	Dark brown paint	0.88
Wood, smooth	0.78	Dark blue-gray paint	0.88
Uncolored asbestos cement	0.75	Azure blue or dark green lacquer	0.88
Uncolored concrete	0.65	Medium brown paint	0.84
Asbestos cement, white	0.61	Medium light brown paint	0.80
White marble	0.58	Brown or green lacquer	0.79
Light buff brick	0.55	Medium rust paint	0.78
Built-up roof, white	0.50	Light gray oil paint	0.75
Bituminous felt, aluminized	0.40	Red oil paint	0.74
Aluminum paint	0.40	Medium dull green paint	0.59
Gravel	0.29	Medium orange paint	0.58
White on galvanized iron	0.26	Medium yellow paint	0.57
White glazed brick	0.25	Medium blue paint	0.51
Polished aluminum reflector sheet	0.12	Medium Kelly green paint	0.51
Aluminized mylar film	0.10	Light green paint	0.47
Tinned surface	0.05	White semi-gloss paint	0.30
		White gloss paint	0.25
		Silver paint	0.25
		White lacquer	0.21
		Laboratory vapor deposited coatings	0.02

---

* This table is a compilation of data from several sources including Passive Solar Design Analysis by J. Douglas Balcomb (US Department of Energy, Office of the Assistant Secretary for Conservation and Solar Energy, December 1979) and Ref. 3.

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.

ROUGHNESS Code for Exterior Surface Finish

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

The following table summarizes the use of keywords for the CONSTRUCTION instruction to determine the heat transfer calculation method used.

Heat Transfer Calculation Method

	EXTERIOR-WALL or ROOF		INTERIOR-WALL, UNDERGROUND-WALL, or UNDERGROUND-FLOOR	
Keyword	Dynamic or "Delayed"	Steady-State or "Quick"	Dynamic or "Delayed"	Steady-State or "Quick"
LAYERS	Required	Not applicable	Required	Not applicable
U-VALUE	Not applicable	Required	Not applicable	Required
ABSORPTANCE	*	*	Not applicable	Not applicable
ROUGHNESS	*	*	Not applicable	Not applicable

*Used, but not required. The default will be used if no value is specified.

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 massive constructions.

3. If U-VALUE is specified, a steady-state heat transfer calculation is performed. It is recommended for lightweight constructions.

4. The U-VALUE is used to calculate heat transfer through interior walls, floors, underground walls, and underground floors. If delayed descriptions are input for these surfaces (for Custom Weighting Factors), LDL will calculated the U-value.

Examples:

1. An exterior wall is constructed of heavyweight concrete block with stucco exterior.

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

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

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

3. An equivalent brick-faced exterior wall is found in the Constructions Library.

```
WALL-1 = CONSTRUCTION
       LAYERS = WJ01-3
       ABSORPTANCE = 0.88
       ROUGHNESS = 2   ..
```

____________________ = CONSTRUCTION or CONS (User Worksheet)
U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	__________	U-name	-	-	-
LAYERS	LA	=	__________	U-name or code-word	**	-	-
U-VALUE	U	=	__________	Btu/hr-ft^2-°F	**	.001	20.
ABSORPTANCE	ABS	=	__________	fraction	0.7	0.	1.
ROUGHNESS	RO	=	__________	code-number	3	1	6

* Mandatory entry.

** Either entry is required. There are no default values. Non-glass doors on exterior walls must use U-VALUE. All other surfaces may use either.

13. 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.

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 respectively 1, 2, or 3 for single-, double-, or triple-pane.

GLASS-TYPE-CODE — is a code-number that identifies the type of glass used in the window. Two methods are available for calculating solar heat gain through windows. If GLASS-TYPE-CODE is specified, the program will use precalculated transmission and absorption coefficients to determine solar gain as a function of angle of incidence of solar radiation. Alternatively, if SHADING-COEF is entered, the ASHRAE shading coefficient technique will be used to calculate solar gain (see below).

To use GLASS-TYPE-CODE, refer to Table III.1. This table gives the overall transmittance and reflectance for solar radiation at normal incidence for different values of GLASS-TYPE-CODE and number of panes. For example, if GLASS-TYPE-CODE = 6 and PANES = 1, the normal transmittance is 50 per cent and the reflectance is 6 per cent. (The corresponding absorptance is 100 - 56 = 44 per cent; of the radiation absorbed, part is conducted into the space, and the rest is conducted back out of the window.) Note that the transmittance given in Table III. 1 is for the entire solar spectrum, not just the visible portion.

Also shown in Table III.1 is the default value of the conductance of the window, excluding outside air film (see GLASS-CONDUCTANCE keyword below), and the overall U-value, including outside air film, for 7.5 and 15 mph wind speed.

GLASS-TYPE-CODEs 1 through 8 are for uncoated glass, whereas values of 9, 10, and 11 correspond to clear, 1/4"-thick panes with a reflective coating (solar-control film) on the inside of the outer pane. This film acts to reflect a large fraction of the incident radiation. (At the present time, there is no GLASS-TYPE-CODE for reflective coatings on heat-absorbing glass; in this case, SHADING-COEF should be used).

To use Table III.1 the user should first determine, from manufacturer's literature, the transmittance and number of panes desired, and whether the window has a reflective coating. For uncoated windows, choose the GLASS-TYPE-CODE between 1 and 8 that gives a transmittance closest to the desired transmittance. For coated windows, choose GLASS-TYPE-CODE = 9, 10, or 11.

If SHADING-SCHEDULE is assigned to a window (see WINDOW command) the resultant solar heat gain calculated from the transmission/absorption coefficients will be multiplied by the schedule value.

SHADING-COEF is specified if the ASHRAE shading coefficient method is used. This keyword value is a number between 0.0 and 1.00 as specified in Chap. 26 of Ref. 5. If SHADING-COEF is entered, the program will first calculate the solar heat gain using transmission 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 venetian blinds, shades, draperies, etc., are used with the window. To simulate operable devices of this kind, 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.

<u>NOTE</u>: If SHADING-COEF is used, and PANES $\neq$ 1, the only effect of specifying the number of panes will be to change the default value for GLASS-CONDUCTANCE.

GLASS-CONDUCTANCE is used to specify the heat conductance of the total window except for the outside film coefficient.

If GLASS-CONDUCTANCE is not specified, a default value will be assigned that depends on number of panes and GLASS-TYPE-CODE. These default values, which are given in Table III.1, range from 1.47 (Btu/hr-ft^2-°F) for single pane, GLASS-TYPE-CODE = 1 through 8, to 0.232 (Btu/hr-ft^2-°F) for triple pane with reflective coating, GLASS-TYPE-CODE = 9 through 11.

The conductance given in glass manufacturers' data sheets usually includes the outside air film resistance for a wind speed of 7.5 mph (summer) or 15 mph (winter). The following equation can be used to obtain the corresponding value of GLASS-CONDUCTANCE:

$$\text{GLASS-CONDUCTANCE} = \left(\frac{1}{U} - R_{film}\right)^{-1},$$

where U is the overall conductance in Btu/ft^2-hr-°F and R_{film} is the outside air film resistance in (Btu/ft^2-hr-°F)$^{-1}$. R_{film} can be obtained from

$$R_{film} = 1/(-0.001661*V^2 + 0.302*V + 1.45),$$

where V is the wind speed in knots. For example, let U = 0.64 for a wind speed of 7.5 mph. Then V = 7.5/1.15 = 6.52 knots, and

$$R_{film} = 1/(-0.001661*42.51 + 0.302*6.52 + 1.45) = 0.30.$$

$$\text{GLASS-CONDUCTANCE} = \left(\frac{1}{0.64} - 0.30\right)^{-1} = 0.79.$$

TABLE III.1

TRANSMITTANCE, REFLECTANCE, DEFAULT CONDUCTANCE, AND U-VALUES FOR DIFFERENT GLASS-TYPE-CODE VALUES AND NUMBER OF PANES

	GLASS-TYPE-CODE	Transmittance(1) (per cent)	Reflectance(2) (per cent)	Default Conductance(3) (Btu/hr-ft^2-°F)	U-Value corresponding to default Cond. (Btu/hr-ft^2-°F)
SINGLE PANE					
un-coated	1	88	7	1.47	1.02 (4) (1.14) (5)
	2	83	7		
	3	79	7		
	4	75	7		
	5	61	6		
	6	50	6		
	7	41	6		
	8	34	5		
with reflective coating(6)	9	50	30	1.47	1.02 (1.14)
	10	20	45		
	11	10	50		
DOUBLE-PANE					
un-coated	1	75	16	0.574	0.49 (0.52)
	2	71	16		
	3	68	14		
	4	64	14		
	5	53	11		
	6	43	9		
	7	35	8		
	8	29	7		
with reflective coating (6)	9	45	31	0.311	0.285 (0.293)
	10	19	45		
	11	9	51		

(See notes at end of table.)

TABLE III.1 (cont)

	GLASS-TYPE-CODE	Transmittance(1) (per cent)	Reflectance(2) (per cent)	Default Conductance(3) (Btu/hr-ft^2-°F)	U-Value corresponding to default Cond. (Btu/hr-ft^2-°F)
TRIPLE PANE					
	1	68	18		
	2	64	16		
	3	61	15		
un-	4	58	14		0.279
coated	5	47	10	0.305	(0.288)
	6	39	7		
	7	32	6		
	8	26	5		
with	9	40	33		
reflec-	10	17	45	0.232	0.217
tive	11	8	51		(0.222)
coating (6)					

(1) Transmittance at normal incidence for overall solar spectrum (not just visible portion)

(2) Reflectance at normal incidence for overall solar spectrum

(3) Conductance includes inside air film, but excludes outside air film

(4) Overall U-value (including outside air film) for 7.5 mph wind speed

(5) Overall U-value (including outside air film) for 15 mph wind speed

(6) Coating is on inside of outer pane; all panes are clear glass

For glass doors treated as windows, the GLASS-CONDUCTANCE of the particular type of glass should be multiplied by the appropriate factor from the following table.

GLASS CONDUCTANCE ADJUSTMENT FACTORS FOR GLASS DOORS

	Single Glass	Double or Triple Glass
Wood Frame	G-C*0.95	G-C*1.0
Metal Frame	G-C*1.0	G-C*1.10

The following table illustrates the keyword entry differences for the two calculation methods of solar heat gain through windows.

	Method	
Keyword	ASHRAE Shading Coefficient	Transmission and Absorption Characteristics
GLASS-TYPE-CODE	no	yes
SHADING-COEF	yes	no

Rule:

1. Either GLASS-TYPE-CODE or SHADING-COEF may be entered, but not both.

Examples

1. Using GLASS-TYPE-CODE

   The window is double-pane, uncoated, insulating glass with heat absorbing outer pane. The transmittance at normal incidence is 55 per cent. The conductance is 0.63.

   From Table III.1, for double-pane, uncoated glass, the closest transmittance is 53 per cent, corresponding to GLASS-TYPE-CODE=5. The input is therefore:

```
SOUTHGLASS = GLASS-TYPE
             PANES = 2
             GLASS-TYPE-CODE = 5
             GLASS-CONDUCTANCE = 0.63 ..
```

2. Using SHADING-COEF

   The window is single-pane. The shading coefficient is 0.43. Default conductance is desired.

```
NORTHGLASS = GLASS-TYPE
             PANES = 1
             SHADING-COEF = 0.43 ..
```

__________________ = GLASS-TYPE or G-T (User Worksheet)

U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
PANES	P	=	________	integer	1	1	3
GLASS-TYPE-CODE	G-T-C	=	________	code-number	**	1	11
SHADING-COEF	S-C	=	________	fraction	**	0.	1.
GLASS-CONDUCTANCE	G-C	=	________	Btu/hr-ft^2-°F	***	0.	10.

* Mandatory entry, if GLASS-TYPE is specified.

** Either entry is mandatory. There are no default values.

*** See Table III.1 for default values.

14. 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.

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.

MULTIPLIER — may be used to specify the total number of identical spaces. This reduces the amount of required data entry. Using MULTIPLIER with SPACE doesn't actually create other SPACEs. MULTIPLIER does not duplicate the input data but rather the calculated answers.

The user should be aware of one subtlety of using the keyword MULTIPLIER in this instruction. Assume the user is attempting to simulate a multistory office building as in Fig. III.21.

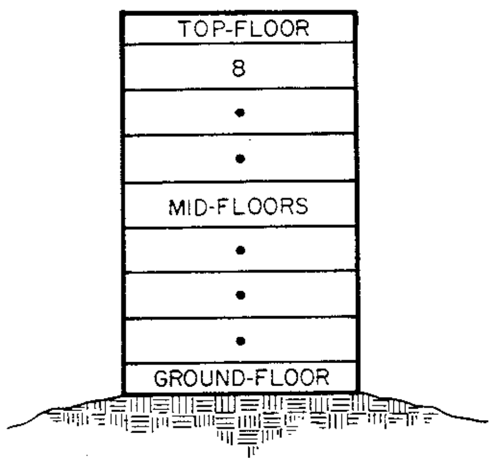

Fig. III.21. Simulating a multistory building by using MULTIPLIER in a SPACE instruction.

In an attempt to reduce the effort of specifying input data, the user chooses to use MULTIPLIER. The SPACEs named TOP-FLOOR and GROUND-FLOOR are truly both unique. Floors 2 through 8, designated MID-FLOORS, are identical enough to permit the user of MULTIPLIER. Therefore, the user specifies

```
TOP-FLOOR = SPACE
          .
          .
          .        ..
   FLOOR = INTERIOR-WALL      $FLOOR OF TOP-FLOOR$
     NEXT-TO = MID-FLOORS  ..

MID-FLOORS = SPACE
   MULTIPLIER = 7  ..          $FLOORS 2 THRU 8$

GROUND-FLOOR = SPACE
          .
          .
          .   ..
   CEILING = INTERIOR-WALL    $CEILING OF GROUND-FLOOR$
     NEXT-TO = MID-FLOORS
          .
          .
          .   ..
```

The program more closely simulates what is shown in Fig. III.22.

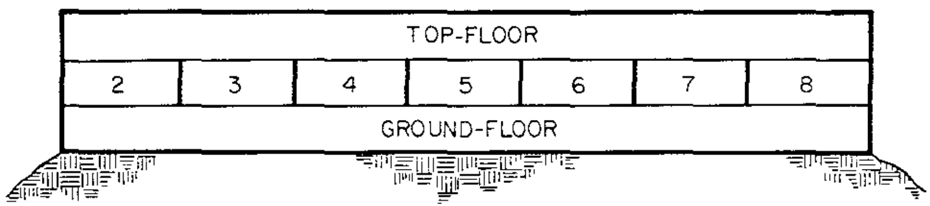

Fig. III.22. Actual simulation, incorrectly showing all floors (2 through 8) NEXT-TO both TOP-FLOOR and GROUND-FLOOR.

That is, floors 2 through 8 can be thought of thermally as operating in parallel between GROUND-FLOOR and TOP-FLOOR rather than in series. This may or may not be important to the user; only the user can decide. This may not be as serious as assuming that floors 2 through 8 are thermally identical, especially where internal loads are concerned.

A more appropriate application of the keyword MULTIPLIER in a SPACE instruction is shown in Fig. III.23.

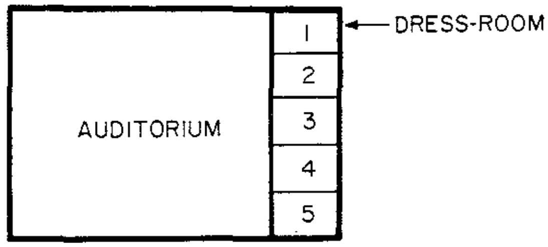

Fig. III.23. Multiple INTERIOR-WALLS all truly NEXT-TO a single SPACE.

DRESS-ROOMs 1 and 5 are truly both unique. DRESS-ROOMs 2, 3, and 4 are identical enough to permit the use of MULTIPLIER. Therefore, the user specifies

```
AUDITORIUM = SPACE
             .
             .
             .  ..

DRESS-ROOM2 = SPACE
             .
             .
             .
   AUDWALL = INTERIOR-WALL
     NEXT-TO = AUDITORIUM
     MULTIPLIER = 3  ..      $(2 thru 4)$
```

In this latter example, the DRESS-ROOMs are truly operating thermally in parallel with AUDITORIUM. Note that if all four vertical walls of DRESS-ROOM2 had been specified, the INTERIOR-WALL common to DRESS-ROOM 2 and 3 would be duplicated. The same is true for the INTERIOR-WALL common to 3 and 4. This is important only if these common walls are massive.

The point of this discussion is that the user should understand and use care when specifying MULTIPLIER in a SPACE instruction where INTERIOR-WALLs are involved.

When using Custom Weighting Factors for INTERIOR-WALLs, MULTIPLIER should not be used in any spaces that have INTERIOR-WALLs in common, especially massive walls. If this is done, the Custom Weighting Factors will not be correct and no diagnostic message will be printed. If the user is not using Custom Weighting Factors, this is no problem.

X Y Z	are the coordinates in the building coordinate system that locate the origin of the space coordinate system associated with this space. The walls and other boundaries will then be defined using the space coordinate system.
AZIMUTH	is the angle (in decimal degrees) between the Y-axis of the building coordinate system and the Y-axis of the space coordinate system. Note: X, Y, Z and AZIMUTH are more fully explained in Sec. A of this chapter.
AREA	is the floor area of the space.
VOLUME	is the space air volume, used to calculate the infiltration rate by the air-change method.
SHAPE	is an alternative method for defining a space. It is simpler than using the space coordinate system. At present there is only one shape -- BOX. This box is defined by the HEIGHT, WIDTH, and DEPTH keywords and the faces of the box are defined internally. The faces can then be referred to by instructions that define their nature (i.e. EXTERIOR-WALL). Fig. III.6 shows how a BOX and its faces are defined with respect to the space coordinate system.
HEIGHT	is the height (Z-dimension) of the space, used when SHAPE=BOX is specified.
WIDTH	is the dimension of the BOX, parallel to the X-axis.
DEPTH	is the dimension of the BOX, parallel to the Y-axis.
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 program.

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.

Examples:

1. Specify a SPACE that is box-shaped (10 by 20 by 8 ft) and located 15 ft east along the south wall of a building aligned in a N-S direction. SPACE-CONDITIONS are as in the example in the SPACE-CONDTIONS command.

```
OFFICE = SPACE
     X                   = 15.
     Y                   = 0.
     Z                   = 0.
     AZIMUTH             = 0.
     AREA                = 200.
     VOLUME              = 1600.
     SPACE-CONDITIONS    =  RM            ..
```

2. The following is an alternative method for Example 1.

```
OFFICE = SPACE
      X                  = 15
      SHAPE              = BOX
      HEIGHT             = 8.
      WIDTH              = 10.
      DEPTH              = 20.
      SPACE-CONDITIONS   = RM  ..
```

_________________________ = SPACE or S (User Worksheet)

U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	________	U-name	–	–	–
MULTIPLIER	M	=	________	number	1.	1.	50.
X	–	=	________	feet	0.	–	–
Y	–	=	________	feet	0.	–	–
Z	–	=	________	feet	0.	–	–
AZIMUTH	AZ	=	________	degrees	0.	-360.	360.
AREA	A	=	________	ft^2	–	0.00001	$1.x10^5$
VOLUME	V	=	________	ft^3	–	0.	$1.x10^6$
SHAPE	–	=	________	code-word	**	–	–
HEIGHT	H	=	________	feet	**	0.	50.
WIDTH	W	=	________	feet	**	0.	$1.x10^4$
DEPTH	D	=	________	feet	**	0.	$1.x10^4$
SPACE-CONDITIONS	S-C	=	________	U-name	–	–	–

plus any keyword listed under the SPACE-CONDITIONS instruction

* Mandatory entry.

** Mandatory entry only if SHAPE=BOX feature is used. AREA and VOLUME are in this case unused. There are no default values.

NOTE: Either SHAPE, HEIGHT, WIDTH, and DEPTH <u>or</u> the AREA and VOLUME keywords must be used, but not both.

15. 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 applies to the SPACE instruction immediately preceding it and describes one of the exterior walls of that space.

U-name — may be used to identify each wall. A logical naming convention minimizes errors of omission.

EXTERIOR-WALL — (or ROOF) This command word 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.

CONSTRUCTION — is used to identify, by U-name, the previously entered CONSTRUCTION instruction that defines the type of construction used in this wall. It can be used also to identify the code-word of a CONSTRUCTION in the DOE-2 CONSTRUCTIONs Library.

GND-REFLECTANCE — is the solar reflectance of the ground; that is, the fraction of sunlight incident on the ground that is reflected. The following table (see Ref. 5, Chap. 26) provides typical values for various surfaces.

Surface	GND-REFLECTANCE
Ocean	0.05
Bituminous Concrete	0.10
Wheat Field	0.07
Dark Soil	0.08
Green Field	0.12-0.25
Grass, Dry	0.24
Crushed Rock Surface	0.20
Concrete, Old	0.22
Concrete, Light Colored	0.32
Paved Asphalt	0.18

SKY-FORM-FACTOR — is the fraction of the hemisphere facing the wall that is subtended by the open sky.

GND-FORM-FACTOR — is the fraction of the hemisphere facing the wall that is subtended by the ground, adjacent buildings, trees, hills, etc.

Note: SKY-FORM-FACTOR and GND-FORM-FACTOR are used in the diffuse radiation calculation. If no entry is made for SKY-FORM-FACTOR and GND-FORM-FACTOR, they are calculated by the program by using the TILT angle of the wall and ignoring the presence of BUILDING-SHADEs. The user should specify his own values for SKY-FORM-FACTOR and GND-FORM-FACTOR if he wishes to account for the shading of diffuse radiation from sky and ground.

INF-COEF — specifies an infiltration flow coefficient used to compute the infiltration resulting from cracks in an exterior wall or roof. This entry is required if the crack method (INF-METHOD = CRACK) is specified in SPACE or SPACE-CONDITIONS.

For walls that use response factors to calculate heat flow and that use the crack method, the coefficient is used in the following equation for determining infiltration

$$\text{cfm} = (\text{INF-COEF}) * (P_w)^{0.8} * (A)$$

where

cfm = infiltration airflow (cfm)
P_w = pressure difference between outside and inside air (inches of water)
A = Wall surface area (ft^2)

Typical values for INF-COEF are in the following table (Refs. 3 and 5, Chap. 21).

Construction of Wall	$\frac{cfh}{ft^2}$	INF-COEF
13-in. brick with plastered surface	(0.01)	0.002
13-in. brick, furring, lath and plaster	(0.03)	0.005
Frame wall, lath and plaster	(0.09)	0.016
8.5-in. brick-plain	(5.0)	0.915
16-in. shingles on shiplap w/building paper	(0.5)	0.092
16-in. shingles on shiplap	(8.0)	1.465
16-in. shingles on 1 by 4 boards on 5-in. center	(40.0)	7.324

The values in parentheses are typical infiltration values in cfh/ft^2 for a 7.5 mph wind normal to the surface of the given walls (7.5 mph equals approximately .05 inches of water).

For walls using the steady-state (U-value) method for heat flow calculation and the crack method, the following equation is used:

$$\text{cfm} = (\text{INF-COEF}) * (P_w)^{0.5} * (L)$$

where now

L = crack length (ft).

Typical values for INF-COEF are in the following table (Refs. 3 and 5, Chap. 21).

Construction	INF-COEF
1/8-in. crack (0.3 cfm/ft)	1.342
1/4-in. crack (0.5 cfm/ft)	2.236
1/2-in. crack (1.1 cfm/ft)	4.919

SHADING-DIVISION — is an integer value that specifies the number of divisions by which an exterior wall is to be segmented for the shading calculations. The larger the number, the longer time the shading computations will require, but the more exact the result will be. Choosing the number of shading divisions for a specific surface requires some judgement. If the estimated effect of the shading on the overall building load is large, use more (20 to 40) divisions. Conversely, if the estimated effect of the shading on the overall building load is small, use fewer (1-10) divisions. The minimum number of shading divisions is one.

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.

X
Y
Z — locate the wall in the space-coordinate system. This is done by specifying the coordinates of the surface coordinate system origin associated with this wall. See also Sec. A.5 of this chapter.

HEIGHT — is the dimension of the exterior wall parallel to the Y axis in the surface coordinate system (see Sec. A.5 of this chapter).

WIDTH — is the dimension of the exterior wall parallel to the X axis in the surface coordinate system (see Sec. A.5 of this chapter).

AZIMUTH — is the azimuth of the exterior wall and the associated surface coordinate system (see Sec. A.5 of this chapter).

TILT — is the inclination of the exterior wall from the Z axis of the space coordinate system (see Sec. A.5 of this chapter).

LOCATION — is an alternative method for specifying the position of a surface. This is used in conjunction with the SHAPE = BOX keyword (Sec. B.14 of this chapter). The following code-words replace HEIGHT, WIDTH, X, Y, Z, AZIMUTH, and TILT entries thereby reducing input quantity.

FRONT
BACK
LEFT
RIGHT
TOP
BOTTOM

These code-words correspond to the boundaries that define the space. These code-words all assume that the user is looking forward (in the positive direction) along the Y-axis of the space coordinate system.

The following keyword may be used if the user elects to use Custom Weighting Factors:

SOLAR-FRACTION — accepts as input the fraction of the solar radiation, direct, diffuse, and reflected, coming through the glazings in the space that is absorbed by this exterior wall, exterior floor, or roof. Note that this is the fraction of radiation absorbed, not the fraction that actually enters the space. For example, in a given space, the floor may receive .55 of the radiation, each of the walls .1, and the ceiling .05. For exterior walls containing windows, SOLAR-FRACTION applies to the opaque part of the wall. For exterior walls containing doors, the program automatically apportions the SOLAR-FRACTION between wall and door according to their relative areas. A CAUTION message will be issued if the sum of the SOLAR-FRACTIONs for a given space is not within 10 per cent of 1.0, and the program will adjust the SOLAR-FRACTIONs so that their sum is 1.0. Each SOLAR-FRACTION will then be automatically multiplied by a factor that accounts for the amount of incoming solar radiation that is reflected back out of the space through the glazing.

If all SOLAR-FRACTIONs for a space are allowed to default, the program will assume that 60 per cent of the incoming solar radiation is absorbed by the floor; the remaining 40 per cent will be distributed to the other surfaces (excluding windows), according to their surface areas. If there is no floor, the full 100 per cent will be distributed to the surfaces (excluding windows), according to their surface areas. To override this default procedure, the user can explicitly specify SOLAR-FRACTION values for all the surfaces or part of the surfaces. If the latter approach is taken, the program will sum the values specified and distribute the balance (up to 1.0) to the other surfaces. Thus, if the user specified SOLAR-FRACTION = .7 for the floor only, the program will distribute the remaining .3 to the walls and ceiling, according to their surface areas.

The distribution of absorbed solar radiation depends, of course, on the space geometry and surface absorptances, as well as on the hourly varying position of the sun relative to the space. It also depends on the hourly varying proportions of direct and diffuse solar radiation entering the space.

Since the user can enter only one set of SOLAR-FRACTIONs for a SPACE, the SOLAR-FRACTIONs should be chosen to represent a time-average over the intended RUN-PERIOD of the analysis, with emphasis given to those times of day and seasons of the year when solar gain is greatest.

Note: SOLAR-FRACTION is not affected by MULTIPLIER. It applies to the surface area after multiplication.

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.

4. If a code-word is not chosen from Ref. 5, a CONSTRUCTION instruction must precede an EXTERIOR-WALL or ROOF instruction.

5. When the LOCATION keyword is used, the X, Y, Z, AZIMUTH, HEIGHT, and WIDTH keywords should not be used.

6. GND-FORM-FACTOR and SKY-FORM-FACTOR must be entered together or not at all. No entry results in program calculation of these values.

Example:

Using AREA and VOLUME in the SPACE instruction:

```
NWALL = EXTERIOR-WALL
        CONSTRUCTION      = BRICK
        GND-REFLECTANCE   = 0.3
        SKY-FORM-FACTOR   = 0.5
        GND-FORM-FACTOR   = 0.5
        INF-COEF          = 0.002
        SHADING-DIVISION  = 30
        MULTIPLIER        = 2
        HEIGHT            = 10.
        WIDTH             = 30.   ..
```

or if using SHAPE, HEIGHT, WIDTH, and DEPTH in the SPACE instruction:

```
NWALL = EXTERIOR-WALL
        CONSTRUCTION        = BRICK
        GND-REFLECTANCE     = 0.3
        SKY-FORM-FACTOR     = 0.5
        GND-FORM-FACTOR     = 0.5
        INF-COEF            = 0.002
        SHADING-DIVISION    = 30
        MULTIPLIER          = 2
        LOCATION            = BACK  ..
```

In the latter example the wall dimensions are taken from the SPACE instruction. If the SPACE is truly box-shaped, this approach to specifying walls will normally require fewer keyword values to be input.

______________________ = EXTERIOR-WALL or E-W (or ROOF)(User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
CONSTRUCTION	CONS	=	________	U-name or Code-word	*	-	-
GND-REFLECTANCE	G-R	=	________	fraction	0.2	0.	1.
SKY-FORM-FACTOR	S-F-F	=	________	fraction	**	0.	1.
GND-FORM-FACTOR	G-F-F	=	________	fraction	**	0.	1.
INF-COEF	I-C	=	________	number	0.	0.	160.
SHADING-DIVISION	S-D	=	________	integer	10	1	40
MULIPLIER	M	=	________	number	1.	0.	99.
X	-	=	________	ft	0.	-	-
Y	-	=	________	ft	0.	-	-
Z	-	=	________	ft	0.	-	-
HEIGHT	H	=	________	ft	*	0.	2000.
WIDTH	W	=	________	ft	*	0.	2000.
AZIMUTH	AZ	=	________	degrees	0.	-360.	360.
TILT	-	=	________	degrees	90.	0.	180.
LOCATION	LOC	=	________	code-word	***	-	-

The following keyword may be used if the user elects to use Custom Weighting Factors.

SOLAR-FRACTION	S-F	=	________	fraction	Note a	0.	1.

* Mandatory entry, if EXTERIOR-WALL is specified.

** Specify values for both keywords or neither keyword. Program calculates defaults based upon TILT of surface.

*** Replaces the HEIGHT, WIDTH, X, Y, Z, AZIMUTH, and TILT keyword values.

a For default procedure, see description of the keyword SOLAR-FRACTION.

16. 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 word 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.
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 changing 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, an appropriate matching SHADING-SCHEDULE should be used. If the CONDUCT-SCHEDULE is not input, the schedule value will default to one for all 24 hours.
SHADING-SCHEDULE	accepts as input the U-name of a previously entered schedule that defines hourly values of a multiplier on the SHADING-COEF (and the transmission and absorptance determined by GLASS-TYPE-CODE). This represents the shading effect of moveable devices such as blinds, curtains, or shutters. Note that items that change light transmission also affect conductance. If the SHADING-SCHEDULE is not input, the schedule value will default to one for all 24 hours.
SHADING-DIVISION SKY-FORM-FACTOR GND-FORM-FACTOR INF-COEF MULTIPLIER	are identical to the keywords in the EXTERIOR-WALL instruction.
X Y SETBACK	position the window in the surface coordinate system of the wall containing the window. See Sec. A.5 of this chapter, Locating Windows and Doors, for a detailed description.

HEIGHT is the window dimension parallel to the Y axis of the surface coordinate system.

WIDTH is the window dimension parallel to the X axis of the surface coordinate system.

Note: The WINDOW area (HEIGHT times WIDTH) is automatically removed from the associated wall area.

Rules:

1. An EXTERIOR-WALL or ROOF instruction must precede a WINDOW instruction.

2. A GLASS-TYPE instruction must precede a WINDOW instruction.

Example:

```
WNDO = WINDOW
    GLASS-TYPE          = GLASS1
    SHADING-SCHEDULE    = CURTAIN1
    CONDUCT-SCHEDULE    = CURTAIN2
    SHADING-DIVISION    = 4
    SKY-FORM-FACTOR     = 0.5
    GND-FORM-FACTOR     = 0.5
    INF-COEF            = 2.4
    MULTIPLIER          = 1          (default)
    X                   = 12.0
    Y                   =  3.0
    SETBACK             =  0.0       (default)
    HEIGHT              =  4.0
    WIDTH               =  4.0         ..
```

________________ = WINDOW or WI (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	________	U-name	–	–	–
GLASS-TYPE	G-T	=	________	U-name	*	–	–
CONDUCT-SCHEDULE	C-SCH	=	________	U-name	***	–	–
SHADING-SCHEDULE	S-SCH	=	________	U-name	***	–	–
SHADING-DIVISION	S-D	=	________	integer	10	1	40.
SKY-FORM-FACTOR	S-F-F	=	________	fraction	**	0.	1.
GND-FORM-FACTOR	G-F-F	=	________	fraction	**	0.	1.
INF-COEF	I-C	=	________	number	0.	0.	160.
MULTIPLIER	M	=	________	number	1.	0.	99.
X	–	=	________	ft	0.	–	–
Y	–	=	________	ft	0.	–	–
SETBACK	SETB	=	________	ft	0.	0.	10.
HEIGHT	H	=	________	ft	*	0.	40.
WIDTH	W	=	________	ft	*	0.	1000.

..

* Mandatory entry, if WINDOW is specified.
** Program uses the value provided for the exterior wall.
***The schedule values will default to one for all 24 hours.

17. 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.
<u>DOOR</u>	This command word 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 door dimension parallel to the Y axis of the surface coordinate system.
WIDTH	is the door dimension parallel to the X axis of the surface coordinate system.
CONSTRUCTION	identifies the U-name of a previously defined CONSTRUCTION instruction that describes the effective U-value of this door.
SETBACK	is the distance that the door is recessed into the wall, measured parallel to the Z axis of the surface coordinate system.
X and Y	position the door in the surface coordinate system of the wall containing the door (see Sec. A.5 of this chapter). X and Y are measured from the lower left-hand corner of the exterior wall to the lower left-hand corner of the door.
MULTIPLIER	is analogous to MULTIPLIER for INTERIOR-WALL.
SKY-FORM-FACTOR GND-FORM-FACTOR SHADING-DIVISION	see the discussion of these keywords in the previous section on the WINDOW instruction and in Sec. B.15 of this chapter.
INF-COEF	specifies an infiltration flow coefficient used to compute the infiltration through the door. See Sec. B.15 of this chapter for a discussion of this keyword. Typical values for INF-COEF for a door are in the following table (Refs. 3 and 5).

Construction	INF-COEF
1. Door-Residential (3 ft by 7 ft)	
closed, with weather stripping	2.4
average use without weather stripping	12.0
average use with weather stripping	9.8
2. Door-office (3.5 ft by 7 ft)	
closed	3.1
open 10 per cent of time	13.5
open 25 per cent of time	55.0
open 50 per cent of time	153.0
open 10 per cent of time and vestibule	9.3
3. Door-revolving	
average use	12.0
4. Garage or Shipping room door	
no use	6.0
average use	60.0

_______________ = DOOR (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	______________	U-name	–	–	–
HEIGHT	H	=	______________	ft	*	0.	40.
WIDTH	W	=	______________	ft	*	0.	1000.
CONSTRUCTION	CONS	=	______________	U-name	*	–	–
SETBACK	SETB	=	______________	ft	0.	0.	10.
X	–	=	______________	ft	0.	–	–
Y	–	=	______________	ft	0.	–	–
MULTIPLIER	M	=	______________	number	1.	0.	99.
SKY-FORM-FACTOR	S-F-F	=	______________	fraction	**	0.	1.
GND-FORM-FACTOR	G-F-F	=	______________	fraction	**	0.	1.
SHADING-DIVISION	S-D	=	______________	integer	10	1	40
INF-COEF	I-C	=	______________	number	0.	0.	500.

*Mandatory entry if DOOR is specified.
**Program uses the value provided for the exterior wall containing the door.
Specify both S-F-F and G-F-F, or neither.

18. 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 word 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.

HEIGHT — is the dimension of the interior wall parallel to the Y axis in the surface coordinate system (see Sec. A.5 of this chapter).

WIDTH — is the dimension of the interior wall parallel to the X axis in the surface coordinate system (see Sec. A.5 of this chapter).

LOCATION — is an alternative method for specifying the position of a surface. This is used in conjunction with the SHAPE = BOX keyword (Sec. B.14 of this chapter). The following code-words replace HEIGHT, WIDTH, and TILT entries thereby reducing input quantity.

FRONT
BACK
LEFT
RIGHT
TOP
BOTTOM

These code-words correspond to the boundaries that define the space.

CONSTRUCTION — is the U-name of a previously defined CONSTRUCTION instruction that describes the LAYERS (response factors) or the effective U-value of this interior wall, ceiling, or interior floor. A U-value may be used to represent the combined conductive and convective effects of the boundary between two spaces. For boundaries that are free air, the effective U-value must be approximated: U ≈ 0.01578 * Volume/(Area * Time). Volume is the mean volume of the two spaces between which heat is transferred; Area is the area of the "wall" between the spaces; and Time is the mean time for the heat transfer to occur. Any larger U-value will violate the second law of thermodynamics, that is, taking more heat energy from the air in the space than is available. For Time ≈ 5 minutes and for usual geometries, U ≈ 2.7. This is a maximum U-value for nonexistent partitions or open doors.

More complex boundaries such as walls with large areas of glass and with large openings require the user to estimate the effective U-value. However, the effective U-value cannot exceed the value for free air as discussed above.

For runs in which Custom Weighting Factors are to be created (LIBRARY-INPUT LOADS runs), the CONSTRUCTION defined by this keyword may be a delayed construction. In such a case, the delayed construction may be left in the input deck for the regular INPUT LOADS run; LDL will simply substitute the calculated U-value for the delayed construction.

NEXT-TO identifies the space that shares this interior wall, ceiling, or interior floor as a boundary with the space under consideration.

MULTIPLIER is used to specify the total number of identical interior wall panels. This reduces data input. It multiplies the area of the INTERIOR-WALL instruction.

Warning: The user should use care when specifying MULTIPLIER in an INTERIOR-WALL instruction. All multiplied INTERIOR-WALLs will be NEXT-TO the same SPACE, whether this is physically true or not.

The following keywords may be used if the user elects to use Custom Weighting Factors:

SOLAR-FRACTION accepts as input the fraction of the solar radiation, direct, diffuse, and reflected, coming through the glazings in the space that is absorbed by this interior wall, interior floor, or ceiling. Note that this is the fraction of radiation absorbed, not the fraction that actually enters the space. For example, in a given space, the floor may receive .55 of the radiation, each of the walls .1, and the ceiling .05. A CAUTION message will be issued if the sum of the SOLAR-FRACTIONs for a given space is not within 10 per cent of 1.0, and the program will adjust the SOLAR-FRACTIONs so that their sum is 1.0. Each SOLAR-FRACTION will then be automatically multiplied by a factor that accounts for the amount of incoming solar radiation that is reflected back out of the space through the glazing.

If all SOLAR-FRACTIONs for a space are allowed to default, the program will assume that 60 per cent of the incoming solar radiation is absorbed by the floor; the remaining 40 per cent will be distributed to the other surfaces (excluding windows), according to their surface areas. If there is no floor, the full 100 per cent will be distributed to the surfaces (excluding windows), according to their surface areas. To override this default procedure, the user can explicitly specify SOLAR-FRACTION values for all the surfaces or part of the surfaces. If the latter approach is taken, the program will sum the values specified and distribute the balance (up to 1.0) to the other surfaces. Thus, if the user specified SOLAR-FRACTION = .7 for the floor only, the program will distribute the remaining .3 to the walls and ceiling, according to their surface areas.

The distribution of absorbed solar radiation depends, of course, on the space geometry and surface absorptances, as well as on the hourly varying position of the sun relative to the space. It also depends on the hourly varying proportions of direct and diffuse solar radiation entering the space.

Since the user can enter only one set of SOLAR-FRACTIONs for a SPACE, the SOLAR-FRACTIONs should be chosen to represent a time-average over the intended RUN-PERIOD of the analysis, with emphasis given to those times of day and seasons of the year when solar gain is greatest.

Note: SOLAR-FRACTION is not affected by MULTIPLIER. It applies to the surface area after multiplication.

TILT is the inclination of the interior wall from the Z axis of the space coordinate system (see Sec. A.5 of this chapter). The program uses this value to determine if this surface is an interior floor, or not. If it is, the program uses the floor area to calculate the effects of furnishings on the Custom Weighting Factors. If the surface being described is truly a floor, the user should specify TILT = 180. If it is a ceiling, specify TILT = 0.

Rules:

1. The associated SPACE instruction must precede any INTERIOR-WALL instruction.

2. Before an INTERIOR-WALL instruction is specified, the user must specify either (a) Custom Weighting Factors or (b) a CONSTRUCTION instruction having a U-value keyword.

3. It is important not to input INTERIOR-WALLs twice. This is usually done by accidentally specifying the same interior wall under two adjacent SPACEs. If the user specifies the same U-name in both SPACEs for the same INTERIOR-WALL, the program will abort with a diagnostic message. If, however, different U-names are specified, in the two SPACEs for the same INTERIOR-WALL, the program will accept the data

with no diagnostic message. The heat transfer area is, however, now double that intended.

4. LOCATION is used only when SHAPE = BOX in the SPACE instruction. LOCATION may be used whether or not Custom Weighting Factors are being used. When specifying LOCATION, do not specify AREA or HEIGHT and WIDTH (this information is obtained by the program from the user input for the SPACE instruction).

Example:

```
WDFC     = INTERIOR-WALL
           AREA          = 120.0
           CONSTRUCTION  = FRAME
           NEXT-TO       = LOBBY      ..
```

_______________ = INTERIOR-WALL or I-W (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	____________	U-name	-	-	-
AREA	A	=	____________	ft^2	Note 1	0.	$1.x10^5$
HEIGHT	H	=	____________	ft	Note 1	0.	2000.
WIDTH	W	=	____________	ft	Note 1	0.	2000.
LOCATION	LOC	=	____________	code-word	Note 1	-	-
CONSTRUCTION	CONS	=	____________	U-name	*	-	-
NEXT-TO	N-T	=	____________	U-name	*	-	-
MULTIPLIER	M	=	____________	number	1.	0.	99.

The following keywords may be used if the user elects to use Custom Weighting Factors:

SOLAR-FRACTION	S-F	=	(__________)	list of 2 fractions	Note 2	0.	1.
TILT	-	=	____________	degrees	90. (Note 3)	0.	180.

*Mandatory entry, if INTERIOR-WALL is specified.

Note 1: Either AREA, or HEIGHT and WIDTH, or LOCATION is required. (see Rule 4)

Note 2: The first fraction is for the side of the wall that is in this SPACE. The second fraction is for the opposite side of the same wall, in the NEXT-TO SPACE. For default procedure, see description of the keyword SOLAR-FRACTION.

Note 3: If LOCATION keyword is not used, TILT should be input for all surfaces when using Custom Weighting Factors. If the walls are vertical, TILT may be allowed to default.

19. 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). It is essentially an INTERIOR-WALL without the NEXT-TO keyword as far as data entry is concerned. 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 judgement. Using the actual U-value of the floor construction and 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. Depending upon whether or not Custom Weighting Factors are being used, the user should specify either an effective (lower) U-value, or an effective (lower) area.

U-name — may be specified.

UNDERGROUND-WALL — (or UNDERGROUND-FLOOR) This command word tells LOADS that the data to follow specify an underground wall or underground floor.

LIKE — is analogous to LIKE for INTERIOR-WALL.

AREA — the definition of AREA for UNDERGROUND-WALL or UNDERGROUND-FLOOR depends upon whether or not the user is using Custom Weighting Factors.

If Custom Weighting Factors are being used, AREA is defined as the total surface area of the UNDERGROUND-WALL or UNDERGROUND-FLOOR. This total area will be used in the calculation of Custom Weighting Factors; however, a value must be specified for U-EFFECTIVE.

If Custom Weighting Factors are not being used, AREA is normally defined as the perimeter area (i.e., the linear perimeter expressed as ft^2) of the UNDERGROUND-WALL or UNDERGROUND-FLOOR. This definition may be interpreted as the effective (lower) heat transfer area, but it may vary according to engineering judgement. This effective area will be used with the numerical value specified for the keyword U-VALUE in the CONSTRUCTION instruction to calculate heat transfer through the UNDERGROUND-WALL or UNDERGROUND-FLOOR.

HEIGHT — is the dimension of the underground wall or underground floor parallel to the Y axis in the surface coordinate system (see Sec. A.5 of this chapter). It is suggested that this keyword be used only if Custom Weighting Factors are being used. If Custom Weighting Factors are not being used, it is suggested that the user specify instead AREA according to its second definition.

WIDTH — is the dimension of the underground wall or underground floor parallel to the X axis in the surface coordinate system (see Sec. A.5 of this chapter). It is suggested that this keyword be used only if Custom Weighting Factors are being used. If Custom Weighting Factors are not being used, it is suggested that the user specify instead AREA according to its second definition.

LOCATION — is an alternative method for specifying the position of a surface. This is used in conjunction with the SHAPE = BOX keyword (Sec. B.14 of this chapter). The following code-words replace HEIGHT, WIDTH, and TILT entries thereby reducing input quantity.

FRONT
BACK
LEFT
RIGHT
TOP
BOTTOM

These code-words correspond to the boundaries that define the space.

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.

For runs in which Custom Weighting Factors are to be created (LIBRARY-INPUT LOADS runs), the CONSTRUCTION defined by this keyword may be a delayed construction. In such a case, the delayed construction may be left in the input deck for the regular INPUT LOADS run; LDL will simply substitute the calculated U-value for the delayed construction.

MULTIPLIER — is analogous to MULIPLIER for INTERIOR-WALL.

The following keywords are used if the user elects to use Custom Weighting Factors:

SOLAR-FRACTION — accepts as input the fraction of the solar radiation, direct, diffuse, and reflected, coming through the glazings in the space that is absorbed by this UNDERGROUND-WALL or UNDERGROUND-FLOOR. Note that this is the fraction of radiation absorbed, not the fraction that actually enters the space. For example, in a given space, the floor may receive .55 of the radiation, each of the walls .1, and the ceiling .05. A CAUTION message will be issued if the sum of the SOLAR-FRACTIONs for a given space is not within 10 per cent of 1.0, and the program will adjust the SOLAR-FRACTIONs so that their sum is 1.0. Each SOLAR-FRACTION will then be automatically multiplied by a factor that accounts for the amount of incoming solar radiation that is reflected back out of the space through the glazing.

If all SOLAR-FRACTIONs for a space are allowed to default, the program will assume that 60 per cent of the incoming solar radiation is absorbed by the floor; the remaining 40 per cent will be distributed to the other surfaces (excluding windows), according to their surface areas. If there is no floor, the full 100 per cent will be distributed to the surfaces (excluding windows), according to their surface areas. To override this default procedure, the user can explicitly specify SOLAR-FRACTION values for all the surfaces or part of the surfaces. If the latter approach is taken, the program will sum the values specified and distribute the balance (up to 1.0) to the other surfaces. Thus, if the user specified SOLAR-FRACTION = .7 for the floor only, the program will distribute the remaining .3 to the walls and ceiling, according to their surface areas.

The distribution of absorbed solar radiation depends, of course, on the space geometry and surface absorptances, as well as on the hourly varying position of the sun relative to the space. It also depends on the hourly varying proportions of direct and diffuse solar radiation entering the space.

Because the user can enter only one set of SOLAR-FRACTIONs for a SPACE, the SOLAR-FRACTIONs should be chosen to represent a time-average over the intended RUN-PERIOD of the analysis, with emphasis given to those times of day and seasons of the year when solar gain is greatest.

Note: SOLAR-FRACTION is not affected by MULTIPLIER. It applies to the surface area after multiplication.

TILT — is the inclination of the UNDERGROUND-WALL or UNDERGROUND-FLOOR from the Z axis of the space coordinate system (see Sec. A.5 of this chapter). The program uses this value to determine if this surface is an UNDERGROUND-FLOOR, or not. If it is, the program uses the UNDERGROUND-FLOOR area to calculate the effects of furnishings on the Custom Weighting Factors. If the surface being described is truly an UNDERGROUND-FLOOR, the user should specify TILT = 180.

U-EFFECTIVE — is the effective coefficient of heat transfer of an UNDERGROUND-WALL or UNDERGROUND-FLOOR. This keyword is appropriate only when Custom Weighting Factors are used. U-EFFECTIVE, which is a lower U-value than normal, attempts to account for the effect of soil on the outside of the UNDERGROUND-WALL or below the UNDERGROUND-FLOOR. The selection of a value for U-EFFECTIVE requires good engineering judgement. More information can be found on this subject in Ref. 1 (1977 ASHRAE Handbook of Fundamentals, Chap. 24, pp. 24.3 through 24.5 and in Sec. C of this Chapter).

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 either (a) Custom Weighting Factors, or (b) a CONSTRUCTION instruction having a U-VALUE keyword.

3. LOCATION is used only when SHAPE = BOX in the SPACE instruction. LOCATION may be used whether or not Custom Weighting Factors are being used. When specifying LOCATION, do not specify AREA or HEIGHT and WIDTH (this information is obtained by the program from the user input for the SPACE instruction).

Example:

```
WBASEMENT    = UNDERGROUND-WALL
               AREA         = 120.0
               CONSTRUCTION = BLOCK
               MULTIPLIER   = 4           ..
```

(User Worksheet)

_________________ = UNDERGROUND-WALL or U-W (UNDERGROUND-FLOOR or U-F)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	____________	U-name	–	–	–
AREA	A	=	____________	ft^2	Note 1	0.	$1.x10^5$
HEIGHT	H	=	____________	ft	Note 1	0.	2000.
WIDTH	W	=	____________	ft	Note 1	0.	2000.
LOCATION	LOC	=	____________	code-word	Note 1	–	–
CONSTRUCTION	CONS	=	____________	U-name	*	–	–
MULTIPLIER	M	=	____________	number	1.	0.	99.

The following keywords may be used if the user elects to use Custom Weighting Factors:

SOLAR-FRACTION	S-F	=	____________	fraction	Note 2	0.	1.
TILT	–	=	____________	degrees	90. (Note 3)	0.	180.
U-EFFECTIVE	U-EFF	=	____________	Btu/ $hr-ft^2-°F$	(Note 4)	0.	20.0

..

*Mandatory entry, if UNDERGROUND-WALL or UNDERGROUND-FLOOR is specified.

Note 1: Either AREA, or HEIGHT and WIDTH, or LOCATION is required. (see Rule 3)

Note 2: For default procedure, see the description of the keyword SOLAR-FRACTION.

Note 3: If LOCATION keyword is not used, TILT should be input for all surfaces when using Custom Weighting Factors. If the walls are vertical, TILT may be allowed to default.

Note 4: This is a mandatory keyword if Custom Weighting Factors are being specified; otherwise, it is not allowed.

20. LOADS-REPORT

This instruction defines the type of standard report format that will be output. The VERIFICATION reports display the physical structure of the building that the user has specified in his input and the SUMMARY reports display the calculated loads.

The time period(s) covered in the LOADS-REPORTs are the RUN-PERIOD interval(s), see RUN-PERIOD instruction.

Format:

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

The code-words for the different VERIFICATION reports are given in the following table. These reports are used to verify the data entered by the user.

Code-word	VERIFICATION
LV-A	General Project and Building Input
LV-B	Summary of Spaces Occurring in the Project
LV-C	Details of Space
LV-D	Details of Exterior Surfaces Occurring in the Project
LV-E	Details of Underground Surfaces Occurring in the Project
LV-F	Details of Interior Surfaces Occurring in the Project
LV-G	Details of Schedules Occurring in the Project
LV-H	Details of Windows Occurring in the Project
LV-I	Details of Constructions Occurring in the Project
LV-J	Details of Building Shades Occurring in the Project
LV-K	Weighting Factor Summary

If all the VERIFICATION reports are desired, the user should enter the code-word ALL-VERIFICATION.

Examples of the VERIFICATION reports may be seen in Chap. VII.

The code-words for different SUMMARY reports are given in the following table. These reports summarize the results of the simulation.

Code-Word	SUMMARY
LS-A	Space Peak Loads Summary prints the peak heating and cooling loads for each SPACE and for the entire building; the day and hour at which each peak occurs, and the corresponding outdoor dry-bulb and wet-bulb temperatures.
LS-B	Space Peak Load Components provides a breakdown by "component" of the peak heating and cooling load for each SPACE. The components are: walls, roofs, glass

conduction, glass solar, interior surfaces, underground surfaces, occupants-to-space, light-to-space, equipment-to-space, source-to-space, infiltration, total load, and total load/area.

LS-C — Building Peak Load Components provides a breakdown of the heating and cooling load components for the entire building. These components are as described for report LS-B above.

LS-D — Building Monthly Loads Summary provides peak and total monthly summaries of heating and cooling loads, the time the peak occurs, and the outside dry-bulb and wet-bulb temperatures. Annual total heating and cooling loads are displayed. Also provided are peak and total monthly summaries of the electrical loads plus an annual total. This is the default report.

LS-E — Space Monthly Load Components provides a breakdown of the cumulative heating loads, sensible cooling loads, and latent cooling loads (for each SPACE) on a monthly basis, according to the source of the load. The components are walls, roofs, interior surfaces, underground surfaces, infiltration, glass conductance, glass solar, occupants-to-space, light-to-space, equipment-to-space, source-to-space, and total.

LS-F — Building Monthly Load Components provides a breakdown of the cumulative heating loads, sensible cooling loads, and latent cooling loads (for the entire building) on a monthly basis, according to the source of the load. Loads for UNCONDITIONED SPACEs are not included. The components are as described for report LS-E.

If all the SUMMARY reports are desired, the user should enter the code-word ALL-SUMMARY.

Examples of the SUMMARY reports may be seen in Chap. VII.

Example:

To get detailed data on schedules and windows plus a summary of loads for each space and a building monthly loads summary, enter the following.

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

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
VERIFICATION	V	= (__________)	list of code-words	-	-	-
SUMMARY	S	= (__________)	list of code-words	LS-D	-	-
		..				

NOTE:

The user should now seriously consider making parametric runs to minimize the consumption of energy by the building. Most of the cost of simulating the LOADS of the building has already been endured. For a slight additional expenditure, it is possible to make substantial reductions in energy consumption and costs. By using the parametric commands, PARAMETRIC-INPUT and PARAMETER, it is possible to vary user-selected building parameters in a simplified cost-effective manner. Exactly what LOADS parameters should be changed, and to what extent they should be changed, is beyond the scope of this manual. Bear in mind that merely simulating a building with DOE-2 does not necessarily reduce energy consumption. Only the proper use of this tool will reduce energy consumption.

See Chap. II (BDL) for more information on PARAMETRIC-INPUT and PARAMETER.

21. HOURLY-REPORT.

The HOURLY-REPORT instruction directs the program to print the hourly values of all variables specified in one or more REPORT-BLOCK instructions.

Examples of the HOURLY-REPORTs may be seen in Chap. VII.

HOURLY-REPORT — This command tells the program that the data to follow specify hourly output reports on the simulation data.

REPORT-SCHEDULE — is the U-name of a previously specified schedule which will be used here for report generation purposes.

REPORT-BLOCK — Input for this keyword is a code-word list of U-names that have been specified under one or more (maximum of 64) REPORT-BLOCK instructions. Note that REPORT-BLOCK is both a keyword (here) and a command (next topic.)

OPTION — Input for this keyword is the code-word which specifies the format to be used in presenting the HOURLY-REPORT data. The code-word PRINT, which is the default value, produces output report(s) with numerical data displayed in tabular form. The code-word PLOT produces graphic plot(s) of the same data. It is possible to plot up to 12 variables on 1 or 2 horizontal axes (abscissas). The variables can be taken from one or more REPORT-BLOCK instructions.

If PLOT is chosen, it is necessary to also specify the following keywords.

AXIS-ASSIGN — is a list of up to 12 integers (1 or 2), which represent axes numbers. One integer (axis number) should appear in the list for each VARIABLE-LIST value in the REPORT-BLOCK command. This assigns each variable to be plotted to a specific axis. The ordering of the axis numbers in this keyword list should match the ordering of the variables in the VARIABLE-LIST instruction.

AXIS-TITLES — is a list of up to two literal values that will appear on one or two horizontal axes (abscissas), one literal value per axis. The first title is assigned to axis 1; the second title is assigned to axis 2. The month, day, and hour automatically appear on the vertical (ordinate) axis. Remember that the literal values must be separated by a comma and each literal must be enclosed in asterisks (*'s).

AXIS-MAX — is a list of up to 2 values (one per axis) that specify the maximum value on the horizontal (abscissa) axis. The values are entered in the same order as the axes are numbered. Care should be exercised in choosing these values because it is possible to specify values below the data to be plotted, resulting in a blank plot. This also results in all data points appearing at the AXIS-MAX.

AXIS-MIN — is a list of up to 2 values (one per axis) that specify the minimum value on the horizontal (abscissa) axis. The values are entered in the same order as the axes are numbered. Care should be exercised in choosing these values because it is possible to specify values above the data to be plotted, resulting in a blank plot. This also results in all data points appearing at the AXIS-MIN.

DIVIDE — is a list of values (one per variable in the VARIABLE-LIST instruction) which scale the plot either up or down to present the most readable plot. The variable values are divided by these values.

Example: The following keyword assignments,

```
AXIS-MAX  =  100
AXIS-MIN  =  0
DIVIDE    =  1000000
```

would cause the value 5,000,000 to be plotted as 5 (1/20 of the distance from 0 to 100). It is the user's responsibility to assign the proper AXIS-TITLES to match the DIVIDE value (i.e., GBTU).

NOTE: The total number of VARIABLE-LIST variables in <u>all</u> REPORT-BLOCK instructions must not exceed 60 in <u>any single</u> HOURLY-REPORT. Also note that even if <u>DAYLIGHT-SAVINGS = YES</u>, summer hours will not reflect daylight saving time. Therefore, there will then be an hour difference between times in LOADS summary reports and hourly reports.

For more information on HOURLY-REPORT see Chap. II.

______________________ = HOURLY-REPORT or H-R (User Worksheet)
U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	______________	U-name	-	-	-
REPORT-SCHEDULE	R-SCH	=	______________	U-name	**	-	-
REPORT-BLOCK	R-B	=	(____________)	List of U-names	-	-	-
OPTION	O	=	______________	code-word	PRINT	-	-
AXIS-ASSIGN	A-A	=	(____________)	list of integers	1	1	2
AXIS-TITLES	A-T	=	(____________)	list of literals each within asterisks	-	-	-
AXIS-MAX	A-MAX	=	(____________)	list of numbers	-	-	-
AXIS-MIN	A-MIN	=	(____________)	list of numbers	-	-	-
DIVIDE	-	=	(____________)	list of numbers	1.00	-	-

* Mandatory entry, if HOURLY-REPORT is specified.
** If REPORT-SCHEDULE is not specified, the schedule values will default to zero and no HOURLY-REPORT(s) will be produced.

22. REPORT-BLOCK

The REPORT-BLOCK instruction is used to specify a group of variables for an hourly output report.

REPORT-BLOCK — This command tells the program that the data to follow specify the variables to be included in an HOURLY-REPORT.

VARIABLE-TYPE — Input for this keyword is a code-word or a U-name, depending upon which VARIABLE-TYPE is chosen. All variables are classified by VARIABLE-TYPE and appear in the following tables.

VARIABLE-LIST — is a list of code-numbers which designate which variables are to be included in the HOURLY-REPORT. (See tables of VARIABLE-TYPE.)

For more information on REPORT-BLOCK see Chap. II.

Note: After the input of all preceding data the following instructions are appropriate:

```
END ..

COMPUTE LOADS ..
```

____________________ = REPORT-BLOCK or R-B (User Worksheet)
U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	__________	U-name	–	–	–
VARIABLE-TYPE	V-T	=	__________	code-word or U-name	–	–	–
VARIABLE-LIST	V-L	=	(__________)	list of code-numbers	–	–	–

*Mandatory entry, if REPORT-BLOCK is specified.

VARIABLE-TYPE = GLOBAL

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	CLRNES	Clearness number
2	TGNDR	Ground temperature (Rankine)
3	WBT	Wet-bulb temperature (°F)
4	DBT	Dry-bulb temperature (°F)
5	PATM	Atmospheric pressure (in. Hg)
6	CLDAMT	Cloud amount, 0 to 10
7	ISNOW	Snow flag (unused)
8	IRAIN	Rain flag (unused)
9	IWNDDR	Wind direction (0-15) (see table, Sec. B.3 of this chapter)
10	HUMRAT	Humidity ratio (lb H_2O/lb air)
11	DENSTY	Density of air (lb/ft^3)
12	ENTHAL	Specific enthalpy of air (Btu/lb)
13	SOLRAD	Total horizontal solar radiation from the weather file (Btu/hr-ft^2)
14	DIRSOL	Total direct normal solar radiation from the weather file (Btu/hr-ft^2)
15	ICLDTY	Cloud type (0, 1, or 2) (see table, Sec. B.3 of this chapter)
16	WNDSPD	Wind speed (knots)
17	IRFCP	Unused
18	DPT	Dew-point temperature (°F)
19	WNDDRR	Wind direction in radians (clockwise from North)
20	CLDCOV	Cloud cover multiplier (fraction of sky covered by cloud) (0 to 1)
21	RDNCC	Clear day direct normal solar radiation times CLDCOV (Btu/hr-ft^2)
22	BSCC	Clear day diffuse solar radiation on a horizontal surface times CLDCOV (Btu/hr-ft^2)
23	SKYA	Heat lost by horizontal surface to sky (Btu/hr-ft^2)
24	DBTR	Dry-bulb temperature (Rankine)
25	ISUNUP	Sun-up flag (= 1 if sun is up; = 0 if down)
26	GUNDOG	Hour angle of sunrise for the day (radians)

VARIABLE-TYPE = GLOBAL (cont)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
27	HORANG	Current hour angle (radians)
28	TDECLN	Tangent of solar declination angle
29	EQTIME	Value of the solar equation of time (hr)
30	SOLCON	Direct normal extraterrestrial solar radiation (Btu/hr-ft^2)
31	ATMEXT	Atmospheric extinction coefficient
32	SKYDFF	Sky diffusivity factor
33	RAYCOS(1)	Solar direction cosine
34	RAYCOS(2)	Solar direction cosine
35	RAYCOS(3)	Solar direction cosine
36	RDN	Direct normal solar radiation intensity on a clear day (Btu/hr-ft^2)
37	BSUN	Diffuse solar intensity on a horizontal surface on a clear day (Btu/hr-ft^2)
38	IYR	Year
39	IMON	Month
40	IDAY	Day
41	IHR	Hour (local time; including Daylight Saving Time, if appropriate)
42	IDOY	Day of year (1-365)
43	IDOW	Day of week (1-7)
44	ISCHR	Schedule hour (DST corrected, IHR + IDSTF)
45	ISCDAY	Schedule day (Day of week; 1 = Sunday, 2 = Monday,..., 8 = Holiday)
46	IDSTF	Daylight saving time flag (1 if daylight saving is in effect, 0 if not)
47	PTWV	Pressure caused by wind velocity (inches of water)

VARIABLE-TYPE = BUILDING

For each hour, entries are summed for all spaces with a heating load that hour and appear in BLDDTH (1-18), VARIABLE-LIST numbers 1-18; similarly, entries are summed for all zones with a cooling load and appear in BLDDTC (1-18), VARIABLE-LIST numbers 19-36. For example, if a building has three spaces, S1, S2, and S3, and for a given hour, S1 and S2 each have a net heating load, and S3 has a net cooling load, then: (1) the sensible heating load for S1 and S2 appears in VARIABLE-LIST number 1, the latent heating load appears in VARIABLE-LIST number 2, etc.; (2) the sensible cooling load for S3 appears in VARIABLE-LIST number 19, the latent cooling load for S3 appears in VARIABLE-LIST number 20, etc. All values for VARIABLE-LIST = 1 through 36 are weighted values. All loads are in Btus.

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	BLDDTH(1)	Building heating load (sensible)
2	BLDDTH(2)	Building heating load (latent)
3	BLDDTH(3)	Building wall heating load
4	BLDDTH(4)	Building roof heating load
5	BLDDTH(5)	Building heating load from window conduction
6	BLDDTH(6)	Building heating load from solar radiation through windows
7	BLDDTH(7)	Building sensible heating load from infiltration
8	BLDDTH(8)	Building heating load from interior walls
9	BLDDTH(9)	Building heating load from conduction through underground walls and floors
10	BLDDTH(10)	Building lighting heating load
11	BLDDTH(11)	Building heating load from doors
12	BLDDTH(12)	Building equipment (electrical) heating load (sensible)
13	BLDDTH(13)	Building source heating load (sensible)
14	BLDDTH(14)	Building people heating load (sensible)
15	BLDDTH(15)	Building people heating load (latent)
16	BLDDTH(16)	Building equipment (electrical) heating load (latent)
17	BLDDTH(17)	Building source heating load (latent)
18	BLDDTH(18)	Building infiltration heating load (latent)
19	BLDDTC(1)	Building cooling load (sensible)
20	BLDDTC(2)	Building cooling load (latent)
21	BLDDTC(3)	Building wall cooling load
22	BLDDTC(4)	Building roof cooling load

VARIABLE-TYPE = BUILDING (cont)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
23	BLDDTC(5)	Building cooling load from window conduction
24	BLDDTC(6)	Building cooling load from solar radiation through windows
25	BLDDTC(7)	Building cooling sensible infiltration load
26	BLDDTC(8)	Building cooling load from conduction through interior walls
27	BLDDTC(9)	Building cooling load from conduction through underground walls and floors
28	BLDDTC(10)	Building lighting cooling load
29	BLDDTC(11)	Building cooling load from doors
30	BLDDTC(12)	Building equipment (electrical) cooling load (sensible)
31	BLDDTC(13)	Building source cooling load (sensible)
32	BLDDTC(14)	Building people cooling load (sensible)
33	BLDDTC(15)	Building people cooling load (latent)
34	BLDDTC(16)	Building equipment (electrical) load cooling (latent)
35	BLDDTC(17)	Building source cooling load (latent)
36	BLDDTC(18)	Building infiltration cooling load (latent)
37	QBELEC	Building electric total
38	QBGAS	Building gas total
39	QBHW	Building hot water total
40	QBEQEL	Building equipment electric total
41	QBLTEL	Building light electric total
42	QBELR	Building electric from BUILDING-RESOURCE command
43	QBGASR	Building gas from BUILDING-RESOURCE command
44	QBHWR	Building hot water from BUILDING-RESOURCE command
45	QBELV	Building elevator (included in No. 37, but not in No. 40)

VARIABLE-TYPE = U-name of SPACE

All space loads are in Btu/hr, including electric.

The walls below are exterior surfaces with tilt greater than or equal to 45°; roofs are exterior surfaces with tilt less than 45°.

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	QWALQ	Quick wall load, unweighted
2	QCELQ	Quick roof load, unweighted
3	QWINC	Window conduction load, unweighted
4	QWALD	Delayed wall load, unweighted
5	QCELD	Delayed roof load, unweighted
6	QINTW	Interior wall load, unweighted
7	QUGF	Underground floor load, unweighted
8	QUGW	Underground wall load, unweighted
9	QDOOR	Door load, unweighted
10	QEQPS	Equipment load, sensible, unweighted
11	QEQPS2	Source load, sensible, unweighted
12	QPPS	People load, sensible, unweighted
13	QTSKL	Task light load, unweighted
14	QSOL	Solar load, unweighted
15	QPLENUM	Plenum load, unweighted
16	QWALD	Quick wall load, weighted
17	QCELQ	Quick roof load, weighted
18	QWINC	Window conduction load, weighted
19	QWALD	Delayed wall load, weighted
20	QCELD	Delayed roof load, weighted
21	QINTW	Interior wall load, weighted
22	QUGF	Underground floor load, weighted
23	QUGW	Underground wall load, weighted
24	QDOOR	Door load, weighted
25	QEQPS	Equipment load, sensible, weighted
26	QEQPS2	Source load, sensible, weighted
27	QPPS	People load, sensible, weighted

VARIABLE-TYPE = U-name of SPACE (cont)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
28	QPPL	People load, latent, unweighted
29	QEQPL	Equipment load, latent, unweighted
30	QEQPL2	Source load, latent, unweighted
31	QINFL	Infiltration load, latent, unweighted
32	QTSKL	Task lighting load, weighted
33	QSOL	Solar load, weighted
34	QPLENUM	Plenum load, weighted
35	QLITE	Light load, unweighted
36	QLITEW	Light load, weighted
37	QINFS	Infiltration load, sensible, unweighted
38	QELECT	Electric load for space
39	CFMINF	Infiltration (ft^3/minute)
40	QSUMW	Sum of all weighted loads except infiltration and latent
41	ZCOND	Space conductance (Btu/hr-°F)
42	QZS	Space sensible load
43	QZL	Space latent load
44	QZTOT	Space total load
45	QZLTEL	Space electric from lights
46	QZEQEL	Space electric from equipment
47	QZGAS	Space gas
48	QZHW	Space hot water

VARIABLE-TYPE = U-name of EXTERIOR-WALL

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	SOLI	Solar radiation on wall after shading (Btu/hr)
2	XGOLGE	Fraction of the wall that is shaded
3	FILMU	Outside air film U-value (Btu/hr-ft^2-°F)
4	PCO	Pressure difference across wall caused by wind velocity and stack effect (psig)
5	Q	Heat transfer from the wall to the zone. (Btu/hr)
6	T	Outside surface temperature for delayed walls (Rankine)
7	CFM	Crack method air flow for wall (cfm)
8	C2	
9	C3	
10	SUMXDT	Used in response factor
11	SUMYDT	determination of Q and T
12	DT	for delayed walls
13	XSXCMP	
14	XSQCMP	
15	ETA	Cosine of the angle between the direction of the sun and the surface outward normal
16	BG	Solar radiation on the wall reflected from ground (Btu/hr-ft^2)
17	RDIR	Intensity of direct solar radiation on the surface, shading neglected (Btu/hr-ft^2)
18	RDIF	Intensity of diffuse solar radiation on the surface (Btu/hr-ft^2)
19	RTOT	Total solar radiation on the surface, shading neglected (Btu/hr-ft^2)

VARIABLE-TYPE = U-name of WINDOW

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	UW	Window U-value (includes inside and outside film coefficients) (Btu/hr-ft^2-°F)
2	TDIR	Direct radiation transmission coefficient
3	ADIRO	Direct radiation absorption coefficient (exterior pane)
4	TDIF	Diffuse radiation transmission coefficient
5	ADIFO	Diffuse radiation absorption coefficient (exterior pane)
6	ADIRI	Direct radiation absorption coefficient [interior pane(s)]
7	ADIFI	Diffuse radiation absorption coefficient [interior pane(s)]
8	FI	Inward flowing fraction of heat from solar radiation absorbed by inner pane(s)
9	FO	Inward flowing fraction of heat from solar radiation absorbed by outer pane
10	AGOLGE	Fraction of window area that is shaded
11	QDIR	Direct solar radiation incident on unshaded part of window, divided by total window area (Btu/hr-ft^2)
12	QDIF	Diffuse solar radiation incident on window divided by total window area (Btu/hr-ft^2)
13	QTRANS	Solar energy transmitted through glass divided by total window area, before multiplication by shading coefficient (Btu/hr-ft^2)
14	QABS	Solar energy absorbed by glass and conducted into the space divided by window area, before multiplication by shading coefficient (Btu/hr-ft^2)
15	QSOLG	Heat gain through window by solar radiation (QTRANS)*(window area)*(shading coefficient) (Btu/hr)
16	GSHACO	Shading coefficient
17	QCON	Heat through window by conduction (Btu/hr) QCON = UW * (window area) * (outside DBT - zone temp.) + QABS * (window area)
18	CFMW	Crack method infiltration air flow through window (Btu/hr)

VARIABLE-TYPE = U-name of DOOR

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	FILMU	Outside film U-value (Btu/hr-ft^2-°F)
2		Shadow ratio (fraction shaded)
3	SOLI	Solar energy (Btu/hr-ft^2)(after shading)
4	T	Outside surface temperature (°R)
5	Q	Heat flow through DOOR (Btu/hr-ft^2)
6	CFMINF	Crack method infiltration air flow (Btu/hr)

C. ALTERNATIVE LOAD CALCULATION METHODS

1. Load Calculation Methods

The purpose of the following discussion is to give the user enough of the DOE-2 load calculation theory to permit decision making. At the conclusion of this section the user will be asked to make a decision on which of two available load calculation methods he wishes to use. It is not necessary for the user to understand the theory in detail, only enough to make the decision.

In Heating, Ventilating and Air Conditioning (HVAC) calculations, four distinct heat flows, each varying with time, take place. These heat flows are:

1. Space Instantaneous Heat Gain (or Space Instantaneous Heat Loss)
2. Space Cooling Load (or Space Heating Load)
3. Space Heat Extraction Rate (or Space Heat Addition Rate)
4. Cooling Coil Load (or Heating Coil Load).

The following discussion speaks in terms of "heat gain and the associated necessary cooling" but the same discussion could be made for the reverse situation, that is, "heat loss and the associated necessary heating."

Space Instantaneous Heat Gain is the rate at which heat enters or is generated within a space at a given instant. The space instantaneous heat gain results from: (1) solar radiation through transparent surfaces; (2) heat conduction through exterior walls and roofs; (3) heat conduction through interior partitions, ceilings, and floors; (4) heat generated within the space by occupants, lights, and appliances; (5) energy transfer as a result of entering outside air; or (6) miscellaneous heat gains. Space instantaneous heat gain calculations may be done based on either transient (dynamic) or steady-state formulas, depending on the form of the space instantaneous heat gain. For example, transient formulas may be used in the calculation of the heat conduction through an exterior wall. Using transient calculations makes it possible to account for the storage of energy that is due to the thermal mass between the high and low temperature sides of the energy transmitting media.

Space Cooling Load is the rate at which heat must be removed from the space to maintain space air temperature at a constant value. It should be noted that the summation of all space instantaneous heat gains, at any given time, does not necessarily equal the cooling load for the space at that same time. For example, the space instantaneous heat gain by solar radiation is first partially absorbed by the surfaces (walls, floor, and ceiling) and the contents (furniture) of the space. Therefore, it does not affect the space air until these surfaces and contents become warmer than the space air; when this happens, some of the heat will be transferred to the space air by convection.

Space Heat Extraction Rate is the rate at which heat is removed from the conditioned space. It equals the space cooling load only when space air temperature is kept constant, which rarely occurs. Usually, the control system, in conjunction with intermittent operation of the HVAC equipment, will cause a "swing" in the space air temperature.

Cooling Coil Load is the rate at which energy is removed at the cooling coil, which serves one or more conditioned spaces in any central HVAC system. This load is equal to the instantaneous sum of the space cooling loads (or space heat extraction rates if the space temperature is assumed to "swing") for all spaces served by the system, plus any additional load imposed on the system external to the conditioned spaces. Such additional load components include heat gain into the HVAC distribution system in the ducting and piping between the individual spaces and the HVAC equipment, and outdoor hot and moist air introduced into the HVAC distribution system through the HVAC equipment. The following figure shows the heat transfer modes that take place among the space instantaneous heat gain, space cooling load, and space heat extraction rate.

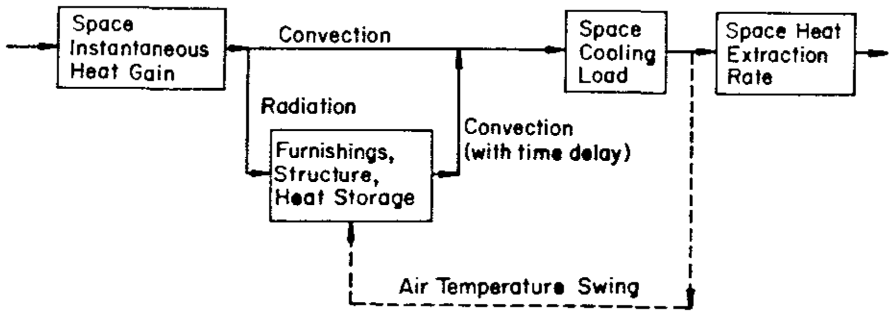

Fig. III.24. Heat transfer modes in a building.

The calculation of space instantaneous heat gains, space cooling loads, and space heat extraction rates can be accomplished by a number of methods. The most accurate technique involves a simultaneous solution of a set of energy balance equations for all the space surfaces and the space air (Ref. 1). It is called the "thermal balance method." The three space energy flows noted above, as well as the space air temperature, are calculated in one step at each time of interest (usually hourly). However, because of the simultaneous solution of the energy balance equations, this method requires considerable computer time.

In the "weighting factor method" the space energy flows and space air temperature are determined by a multistep calculation that eliminates the need for the simultaneous solution of a set of equations (Ref. 1). In the first step, the space instantaneous heat gains are calculated, for the same point in time, assuming that the space air temperature is held fixed at some reference value. These instantaneous heat gains must then be combined to yield a space cooling load. As noted previously, this combining procedure is not a simple addition because space instantaneous heat gains from different sources undergo different time delays before appearing as space cooling loads. These time delays are taken into account with the room weighting factors for the space, one set for each type of heat gain considered in the calculation. The cooling load for the space weighting factors are transfer functions relating the space cooling loads to the instantaneous space heat gains. The final step in this method is the calculation of the space heat extraction rate and the space air temperature. It should be noted that deviation of the space air temperature from the reference temperature, or design set-point, causes the actual rate of heat extraction from the space to be different from the calculated space cooling load. Thus, the calculation of the actual space air temperature and space heat extraction rate is very important. A set of room air weighting factors for the space, along with information about the performance characteristics of the thermostat temperature-control and HVAC systems, are used for this calculation. Whereas the previous steps in the weighting factor method are carried out in the LOADS portion of the DOE-2 program, this final step is done in SYSTEMS, where the information on the control and HVAC systems is available.

Decision on DOE-2 Weighting Factor Method:

Depending on the type of building and the application, the user must choose one of the two weighting factor methods available in DOE-2.

1. Precalculated Weighting Factor method:

   DOE-2 has available sets of ASHRAE precalculated weighting factors for typical constructions (Ref. 1). The only parameter that varies is the combined weight of floors, walls, and furniture, that is, the effective thermal mass of the space. The user can select the weighting factors that best describe his structure from the precalculated set. To use this option it is only necessary to use the INPUT LOADS command and the appropriate value for the FLOOR-WEIGHT keyword (see Sec. B.9 of this chapter).

2. Custom Weighting Factor* method:

   In DOE-2 it is possible for the user to specify weighting factors that are customized, or tailored, to the building (or to specific spaces within the building) under investigation. To input the necessary data to calculate these weighting factors, either (1) specify FLOOR-WEIGHT = 0 in the SPACE or SPACE-CONDITIONS instruction, or (2) refer to the LIBRARY-INPUT LOADS instruction discussed below.

The user may specify both types of weighting factors in one simulation run; that is, some spaces may use Precalculated Weighting Factors and other spaces may use Custom Weighting Factors.

To aid the user in deciding which of the above methods to use for HVAC calculations, the following can be stated. The Precalculated Weighting Factor method (1) requires the least computer time and produces the least accurate results. The Custom Weighting Factor method (2) is more accurate than the Precalculated Weighting Factor method, but requires more user-input effort and

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* The general theoretical basis for the Custom Weighting Factor calculations was developed by CCB/Cumali Associates (Refs. 6 and 7). The algorithms and their supporting analytical basis were developed by the Los Alamos National Laboratory (Ref. 8).

slightly more computer time. In the following cases use of the Custom Weighting Factors is suggested:

- Buildings with thermostat set-back and/or set-up
- All passive solar buildings (only direct-gain systems can currently be modeled)
- Masonry buildings
- Heavy construction buildings
- Any building in which it is necessary to define the distribution of the solar radiation within the building
- Buildings located in sunny locations with large amounts of solar energy entering the spaces.

Notes:

1. When using Custom Weighting Factors, specify all EXTERIOR-WALLs, INTERIOR-WALLs, and UNDERGROUND-FLOORs with "delayed-" or dynamic-type constructions. If a surface is of the "quick-" or steady-state-type construction, its thermal mass will not be accounted for in the Custom Weighting Factors (CWF) calculation. Because the response-factor calculation for delayed surfaces is expensive, users are advised to use library walls as much as possible, that is, specify wall LAYERS from the DOE-2 Library (BDLLIB).

2. Input all of the bounding surfaces of a space. This includes interior walls, floors, and ceilings across which there is negligible heat transfer. Such surfaces contribute to the radiation balance that is performed in calculating the CWFs. Also, interior surfaces, particularly floors, often contribute substantially to the space thermal mass.

3. Use the full area of underground walls and floors, not just the perimeter area (that is, an area equal in length to the perimeter and one foot wide). This is especially important for slab-on-grade structures where most of the thermal mass could well be in the slab. To avoid unrealistically high heat transfer to the ground when the full slab area is used, the keyword U-EFFECTIVE in the UNDERGROUND-FLOOR instruction should be used. It works as follows: if the UNDERGROUND-FLOOR is described as delayed (as it should be for CWFs) and if U-EFFECTIVE is input, then the response factors for this surface will be used in the CWF calculation, but the heat transfer (Q) in LOADS will be calculated as

$$Q = (\text{U-EFFECTIVE}) * A_T * (T_G - T_R),$$

where

A_T = total slab area
T_G = ground temperature
T_R = LOADS-calculated space temperature.

Therefore, if the user is starting from a LOADS input where the full U-value (U_T) of the UNDERGROUND-FLOOR was used, along with a perimeter area (A_P) then, A_P should be changed to A_T, a delayed-type of construction should be assigned, and an effective U-value should be input, as calculated from

$$\text{U-EFFECTIVE} = U_T \frac{A_P}{A_T}$$

4. Particular attention should be given to quick INTERIOR-WALLs where a U-value was chosen to be large ($U > 0.709$ Btu/ft^2-hr-°F) to account for heat exchange caused by air movement through openings in the wall. For CWFs, an additional INTERIOR-WALL should be specified if an actual wall (as opposed to an imaginary partition) separates the zones. The additional wall should be of the delayed type of construction and its area should be exclusive of openings.

   The result will be the following. The original wall will affect the air-temperature weighting factor calculation. The added wall will affect the detailed thermal balance calculation that produces the other weighting factors (i.e., the solar, lighting, people/equipment, and conduction weighting factors). Both walls will contribute to heat exchange (thermal conduction) in LOADS.

5. The WEIGHTING FACTOR SUMMARY REPORT shows the weighting factors for each space, whether CWF or Automatic Weighting Factors (AWF). To get this report, specify VERIFICATION = (LV-K) in the LOADS-REPORT instruction.

2. INPUT (Alternative Forms for LOADS)

As discussed in Chap. II, Sec. B, the input data for each of the main programs must begin with an INPUT Program-Name instruction. For the LOADS program only, this instruction can be modified to create certain libraries in which user-specified data or data calculated from user-specified input are stored. If libraries are to be created, the libraries must be created before the actual running of the DOE-2 program. Table III.2 summarizes the options available to the LOADS user.

The simplest method is to use the prespecified, or precalculated, libraries in the DOE-2 program. The DOE-2 Library, BDLLIB, contains the (1) DOE-2-prespecified MATERIALs described in Chap. X and (2) the ASHRAE prespecified MATERIALs and LAYERS (response factors). All are accessible to the program by Keyword = Code-word input. Most beginning users will choose this approach. In this method, no libraries need be created by the user and he simply uses an INPUT LOADS instruction to input his data for the DOE-2 calculational run. If he wishes to use entries from BDLLIB, he must attach it by job control statements to his run, unless it so defaults on his system.

The other option available to the user is to create libraries of MATERIALs, LAYERS, or weighting factors that are calculated specifically for the characteristics of his building or a particular space in his building.

Again, note that DOE-2 already contains precalculated libraries of these data. It is only when the user wishes to have libraries of data that are not in the precalculated sets that he will use this option. Some of the reasons for doing this might be as follow:

The user intends to make a number of parametric runs of DOE-2 using the same MATERIALs and LAYERS, but the MATERIALs and LAYERS available in the DOE-2 Library are not appropriate. He can create these data in the library, which can then be accessed in repeated runs of the LOADS program without having to be redefined for each run.

The user intends to make a number of parametric runs of DOE-2 using the same exterior walls. He can create a library of these walls that will include the response factors of the walls, and thereby avoid the time and cost of having BDL recalculate these response factors for every run.

The user has a space with large thermal mass, or a building using passive solar heating (direct gain); to simulate such conditions, he wishes to use Custom Weighting Factors calculated for the specific space or building. He can create a library of these weighting factors for use in a subsequent INPUT LOADS run.

TABLE III.2

"INPUT LOADS" ALTERNATIVES

Calculation Method		Required Input Steps	Options
Precalculated Weighting Factors	(a)	To run, specify INPUT LOADS ..	Libraries of MATERIALs and LAYERS (with response factors) may be created for repeated use
	(b)	Specify the FLOOR-WEIGHT keyword in the SPACE-CONDITIONS instruction at some value greater than 0.	
Custom Weighting Factors <u>without</u> a library	(a)	To run, use INPUT LOADS ..	
	(b)	Specify FLOOR-WEIGHT equal to 0 in the SPACE or SPACE-CONDITIONS instruction.	
	(c)	Specify values for SOLAR-FRACTION, in each wall instruction, and FURNITURE-TYPE, FURN-WEIGHT, and FURN-FRACTION, in the SPACE or SPACE-CONDITIONS instruction to create automatic Custom Weighting Factors (that is, without a library).	

Custom Weighting Factors with a library (BDLLIB)	(a) First create a Custom Weighting Factor library using LIBRARY-INPUT LOADS for the desired space(s).	Libraries of MATERIALs and LAYERS (with response factors) may be created for repeated use
	(b) Specify values for SOLAR-FRACTION, in each wall instruction, and FURNITURE-TYPE, FURN-WEIGHT, FURN-FRACTION, and WEIGHTING-FACTOR in the SPACE or SPACE-CONDITIONS instruction to create Custom Weighting Factors.	
	(c) To run, attach BDLLIB and specify INPUT LOADS ..	
	(d) Specify the correct U-name for the WEIGHTING-FACTOR keyword in a SPACE or SPACE-CONDITIONS instruction for those spaces with Custom Weighting Factors; for other spaces, specify FLOOR-WEIGHT at some value greater than 0.	

3. DOE-2 Library Files.

The BDL Processor of DOE-2 expects that any library file of MATERIALs, LAYERS, CONSTRUCTIONs, and/or Custom Weighting Factors available to it is named BDLLIB. A user-created library, if used, will have to be renamed BDLLIB and attached to the program. Described below are the requirements for the contents of BDLLIB, depending on whether the user is running

(1) Precalculated Weighting Factors with INPUT LOADS,

(2) a MATERIAL, LAYERS, or CONSTRUCTION library creation run using LIBRARY-INPUT LOADS,

(3) a Custom Weighting Factor creation run with LIBRARY-INPUT LOADS, or

(4) an INPUT LOADS run using a previously created Custom Weighting Factor library. The control card sequence needed to attach BDLLIB will, of course, vary from computer system to computer system, but the requirements for the contents of this file are set out below.

The output file of all library-creation runs will be named USRLIB.* It will always contain whatever was in the input file BDLLIB at the beginning of

*It is possible to submit library creation runs "back to back" in one submission, but this is not recommended. In this case, the output, USRLIB, of the first LIBRARY-INPUT LOADS deck is taken by the program to be the input file to the next LIBRARY-INPUT LOADS deck, and the output of the second deck is called BDLLIB. The input and output file names will alternate in this fashion, the final output file name depending on whether an odd or even number of input decks was involved.

the run plus the library created during the run. This file should be saved under some user-designated name, such as SAVLIB. Then, for the next successive run, SAVLIB must be renamed BDLLIB. The contents of BDLLIB will be read in and either combined with the output file from the new LIBRARY-INPUT LOADS run to produce a new USRLIB, or used as the library file for a standard INPUT LOADS run. If USRLIB is not saved, its contents will be lost for subsequent runs. (USRLIB should not be stored on BDLLIB.)

Whenever the BDL Processor finds a U-name in a "Keyword = U-name" statement, it will look in the rest of the current input for the declaration of that U-name. If it cannot find it there, it will search BDLLIB. In addition, if in an INPUT LOADS run the WEIGHTING-FACTOR keyword in a SPACE definition is given a U-name value, the BDL Processor will also go to the DOE-2 Library to find the Custom Weighting Factors associated with that U-name. The following example depicts this process. It is not necessary to create a library. MATERIALs and LAYERS may be defined in each input deck.

```
     Input to LOADS                        Some BDL Processor Actions

INPUT LOADS ..
     .
     .
ADOBE-12 = MATERIAL
     .
     .
SW-WALL = LAYERS
   MATERIAL = (ADOBE-12, IN03[a],      (Is ADOBE-12 declared as a MATERIAL
               GP01[a])                U-name;  Yes.
                                       Is IN03 declared as a MATERIAL U-name;
                                       No.  GO LOOK IN BDLLIB.
                                       Is GP01 declared as a MATERIAL U-name;
                                       No.  GO LOOK IN BDLLIB.)
CONST-1 = CONSTRUCTION
   LAYERS = SW-WALL                    (Is SW-WALL declared as a LAYERS
                                       U-name;  Yes.)
     .
     .
CONST-2 = CONSTRUCTION
   LAYERS = ASHW-2[a]                  (Is ASHW-2 declared as a LAYERS
U-name;
                                       No.  GO LOOK IN BDLLIB.)
     .
     .
SPACE-1 = SPACE
     .
     .
   WEIGHTING-FACTOR = WF-SP-1          (GO TO BDLLIB for Custom Weighting
                                       Factors called WF-SP-1)
     .
     .
END ..
```

[a] Code-words from Prespecified DOE-2 Library, BDLLIB.

NOTE: When specifying U-names in a library for MATERIALs, LAYERS, CONSTRUCTIONs, and WEIGHTING-FACTORs, the U-names may not exceed eight alphanumeric characters in length.

To list the contents of any library, enter the instruction DIAGNOSTIC = LIBRARY-CONTENTS (see DIAGNOSTIC instruction, Chap. II).

Associated with DOE-2 is a prespecified library file called BDLLIB that contains the DOE-2 MATERIALs Library, LAYERS Library (including the response factors associated with each set of LAYERS). The LAYERS information comprise the materials described in Chap. X of this manual, and the materials and layers described in the 1977 ASHRAE Handbook of Fundamentals (Ref. 5, Chap. 25).

The MATERIALs stored in the DOE-2 library may be entered into the LAYERS instruction with MATERIAL = code-word, where the code-words are those found in Chap. X, or by the code-words HF-x, where x is the code-number of the material listed in Table 8 on p. 25.10 of Ref. 5.*

The ASHRAE wall and roof LAYERS may be accessed and entered into the CONSTRUCTION instruction with LAYERS = code-word, where the code-words are ASHR-x for roofs, ASHW-x for exterior walls, and, for Custom Weighting Factor library creation runs, ASHI-x are for interior walls, interior floors, or ceilings. In these code-words, x is the number of the roof or wall in Table 26 (pp. 25.28 and 25.29), Table 27 (pp.25.30-25.32), or Table 29 (pp. 25.34 and 25.35) of Ref. 5, Chap. 25.

For each of its constructions, BDLLIB contains two sets of data, one calculated without an inside-film-resistance value, and one with such a value. These two sets appear under the same code-word for each construction, and the appropriate set will be chosen by BDL depending on whether the input instruction is INPUT LOADS or LIBRARY-INPUT LOADS. This is because the program must have constructions without inside-film-resistance values to create Custom Weighting Factors, but must have constructions with inside-film-resistance values for a regular INPUT LOADS run.

In addition to the prespecified DOE-2 library, BDLLIB, the user may create on BDLLIB his own library of MATERIALs, LAYERS, CONSTRUCTIONs, and Custom Weighting Factors, or may create a new library that is a combination of his own library and the DOE-2 prespecified library (see Fig. III.25).

Should a user wish to combine the prespecified library with his own MATERIALs, LAYERS, CONSTRUCTIONs and/or Custom Weighting Factor libraries, he should note two important restrictions. First, the space on BDLLIB is limited and there is no way to delete or modify information on BDLLIB once it has been added without restarting a new BDLLIB file. Therefore, in a complex building,

*The code-numbers A0 and E0 from Ref. 5 are not in BDLLIB. These are outside and inside film resistances, respectively, and are handled differently in DOE-2. The outside film resistance is calculated by DOE-2 from wind speed and the ROUGHNESS keyword in the CONSTRUCTION instruction. The inside film resistance is given in DOE-2 by the INSIDE-FILM-RES keyword in the LAYERS instruction and should not be included as a material.

the combination of DOE-2 and user-generated library information could fill the BDLLIB file. Should this occur, we recommend that the user choose from the DOE-2 libraries only those particular items that he requires, and that he redefine them as if they were his own, user-designed items. He would then create a wholly user-generated BDLLIB file as shown in Example b. The DOE-2 prespecified library contains 240 materials, 96 exterior walls, 36 roofs, and 47 interior walls, for a total of 419 entries. The second restriction is that, as mentioned before, all U-names entered into a library must not have more than eight alphanumeric characters.

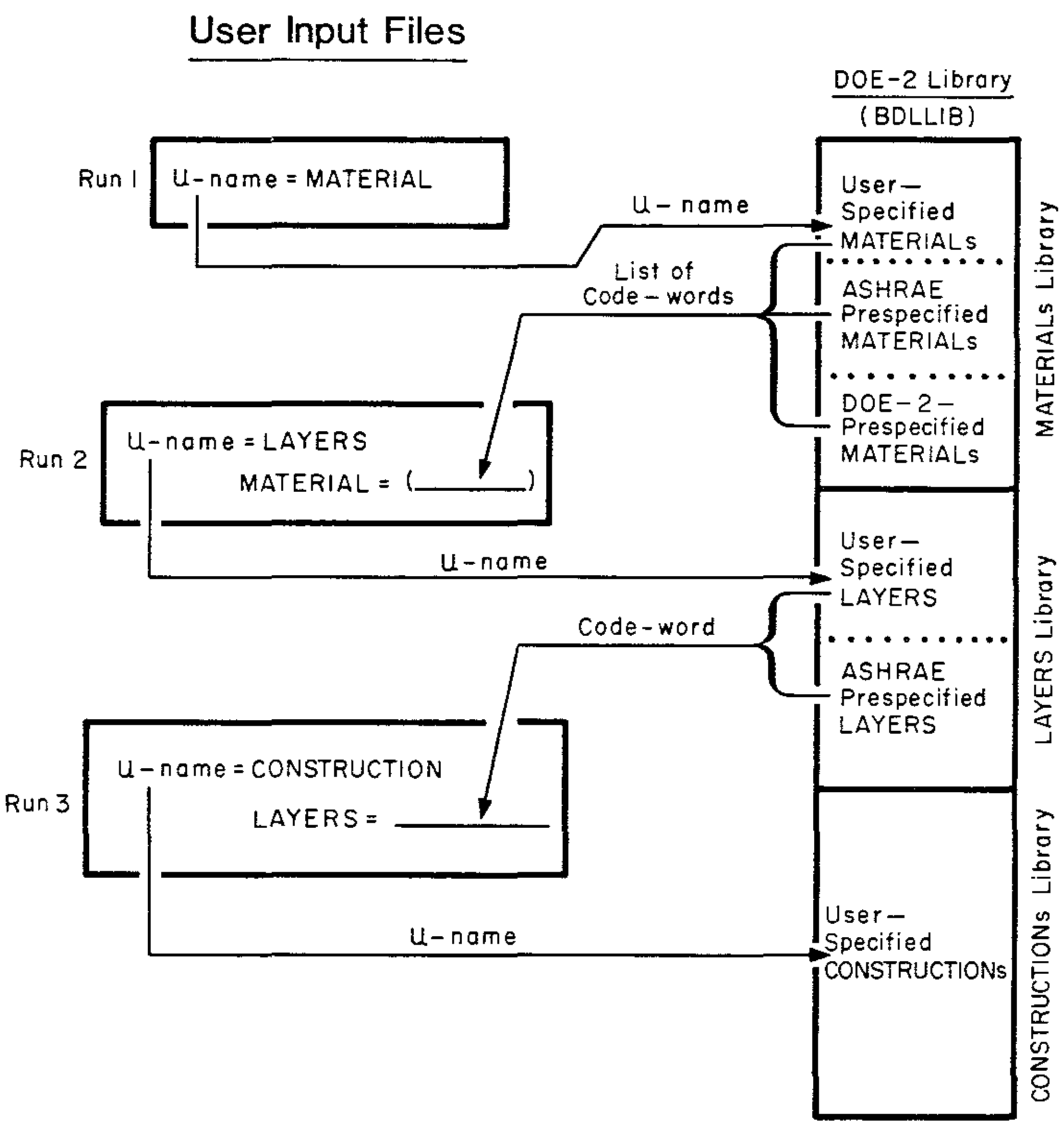


Fig. III.25. Creating or adding information to the DOE-2 library.

There is a hierarchy of libraries that extends from MATERIALs on the lowest level, LAYERS (response factors) on the second level, CONSTRUCTIONs on the third level, and up to Custom Weighting Factors. It is important that the user understand that a DOE-2 library cannot be created on more than one level at a time. For example, both a MATERIALs and a LAYERS library cannot be created in one run. Instead, the lowest level library must be created first and then attached as an input file named BDLLIB to the run in which the next higher level library will be created. The two libraries will be combined as output from the second run. Furthermore, only the "highest" level being run in a given library-creation run will be stored. For example, if both user-specified LAYERS and SPACE instructions that contain WEIGHTING-FACTOR keywords are found in a library-creation run, only the Custom Weighting Factors calculated from the SPACE instructions will be added to the output file of that run. Therefore, if MATERIALs, LAYERS, CONSTRUCTIONs, and Custom Weighting Factors are all desired in the library, they must be created in successive runs of LIBRARY-INPUT LOADS (see Fig. III.25).*

Four situations are described below to show the user what he needs to do when a. simply running INPUT LOADS with Precalculated Weighting Factors and the standard BDLLIB; b. creating his own library of MATERIALs, LAYERS, CONSTRUCTIONs, and Custom Weighting Factors; c. running LIBRARY-INPUT LOADS to create Custom Weighting Factors from the standard, prespecified DOE-2 library of MATERIALs and LAYERS; and d. using a combination of the prespecified DOE-2 library and his own library.

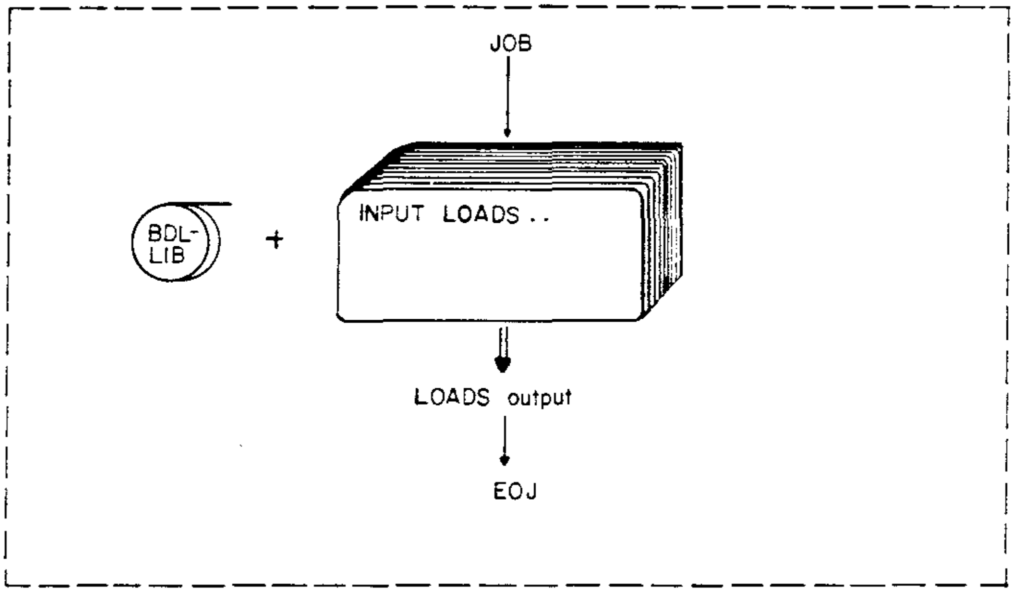
a. Standard INPUT LOADS with Precalculated Weighting Factors. In this situation, the user wishes to use Precalculated Weighting Factors, and does not wish to create his own libraries. In this case, the user builds his own LOADS input as usual and attaches BDLLIB to his run (unless it so defaults on his system). The user may, in any of these examples of LOADS input, define MATERIALs and LAYERS that are not in a library; he simply is not making a library of them for later access.

He must also give a value to the FLOOR-WEIGHT keyword (lb/ft^2) in the SPACE-CONDITIONS instruction for each SPACE in his building (or he may alternatively allow the keyword to default). This value will then be used by the program to choose a set of Precalculated Weighting Factors for that SPACE. If FLOOR-WEIGHT = 30., 70., or 130., standard, precalculated ASHRAE weighting factors for light, medium, or heavy construction will be used; for any other values, DOE-2 will interpolate between the ASHRAE weighting factors.

Example a. is a diagram of this operation.

---

* It is possible to submit library creation runs "back to back" in one submission, but this is not recommended. In this case, the output, USRLIB, of the first LIBRARY-INPUT LOADS deck is taken by the program to be the input file to the next LIBRARY-INPUT LOADS deck, and the output of the second deck is called BDLLIB. The input and output file names will alternate in this fashion, the final output file name depending on whether an odd or even number of input decks was involved.



Example a: Standard LOADS run.

b. Creating a User's Own Library of MATERIALs, LAYERS, and Custom Weighting Factors. Example b. shows how a user would build up a file of user-designed MATERIALs, LAYERS, and Custom Weighting Factors. For exterior surfaces, LAYERS are input with nonzero inside film resistances; the processor will automatically build two sets of response factors, with and without the inside film resistance. For interior surfaces, each may be defined as a "delayed" set of LAYERS for Custom Weighting Factor creation. He may then make his regular LOADS run with these same definitions of interior surfaces; LDL will automatically convert them to the appropriate U-value definitions. To create a file of only, say, MATERIALs and LAYERS, the user would not make the weighting-factor creation run.

To run this optional preprocessor, the user would do the following.

Build an input deck for the preprocessor beginning with the instruction

LIBRARY-INPUT LOADS ..

Follow this by either or both of the following commands (if both are entered, only the LAYERS library will be built):

MATERIAL
LAYERS

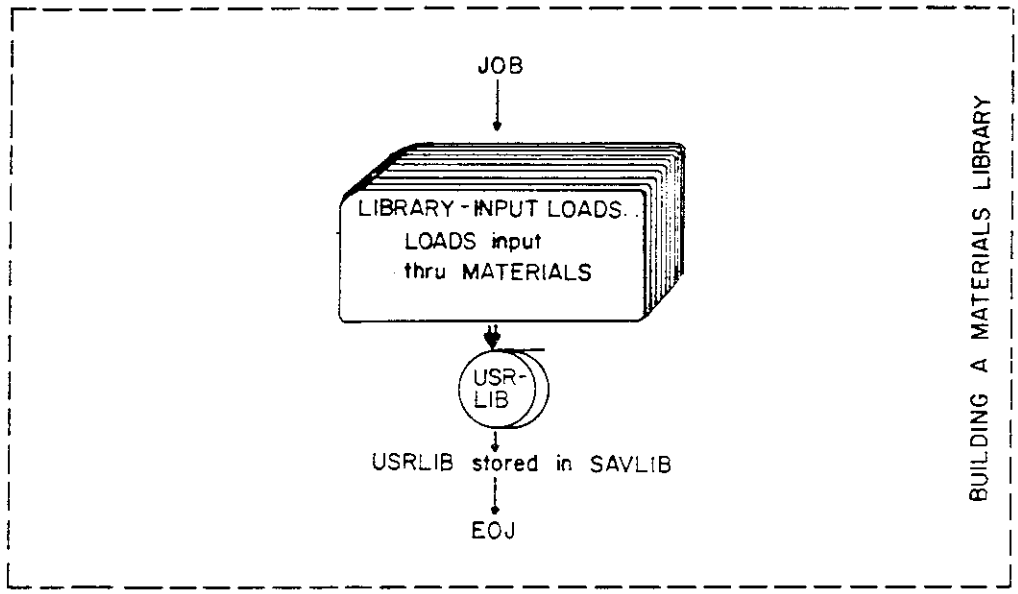
These commands will have their standard keywords in the input. If only the MATERIAL instructions are entered, a MATERIALs library will be created. If the LAYERS instructions are also entered, a response factor library for those walls defined in the LAYERS instructions will be created. These two libraries cannot be created in the same run, and if both are desired, the MATERIALs library must be created first using a subset input deck that contains no LAYERS instructions.

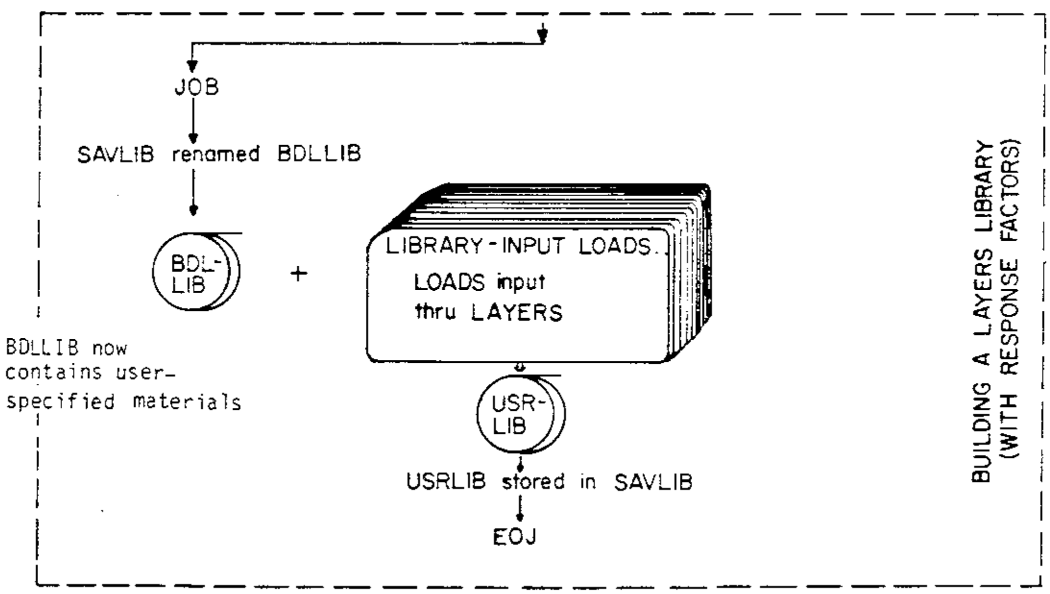
The user may then run the usual DOE-2 program using the INPUT LOADS instruction. The U-names of MATERIALs and/or LAYERS, created by his library run, may be called out in his LOADS input.

Example:

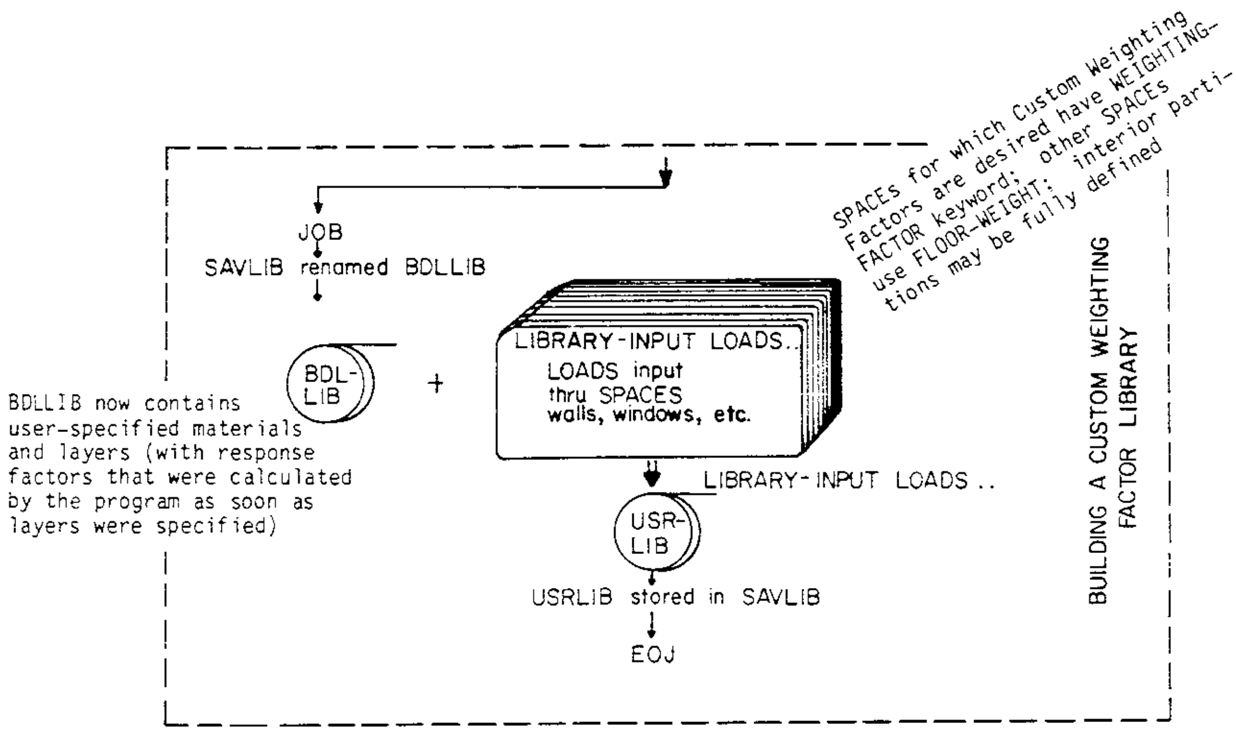
A user wishes to make DOE-2 runs on several buildings that all have the same wall characteristics. He therefore decides to build a library of the most frequently used MATERIALs and CONSTRUCTIONs. First, he builds the library-input deck.

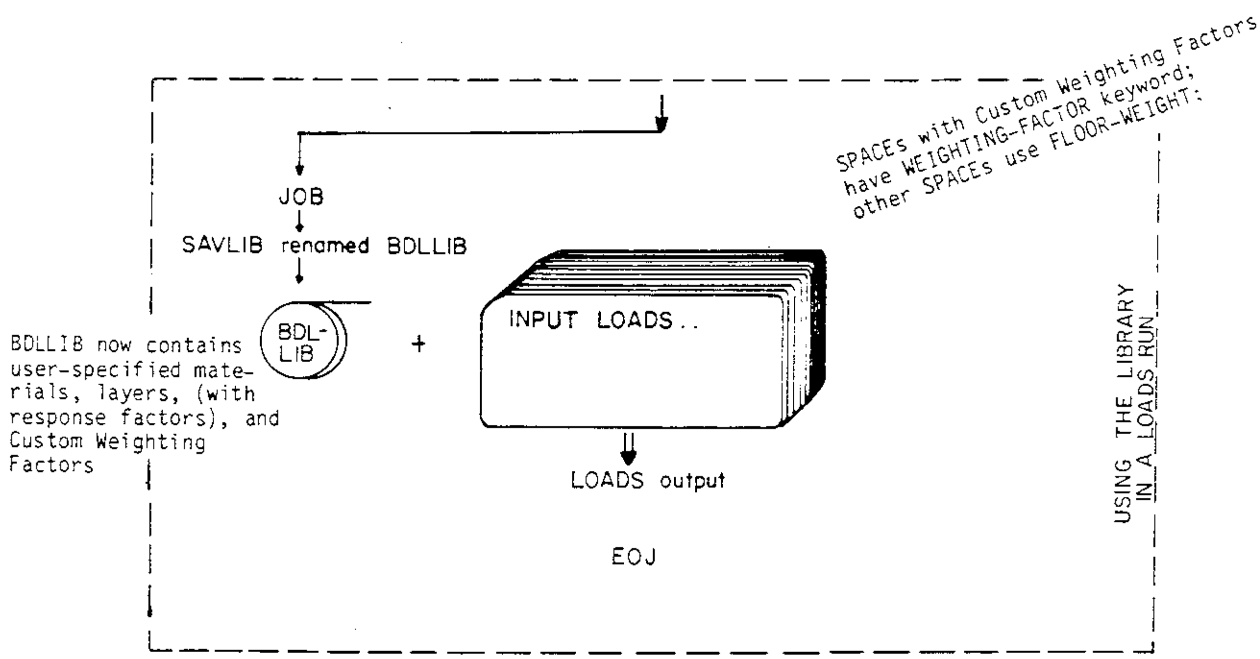
The control cards that are used to store the library, once created, are not shown. These control cards are specific to the user's site.





Example b: User-created libraries.





Example b (cont): User-created libraries.

```
LIBRARY-INPUT LOADS  ..
WOODSIDE = MATERIAL
           RESISTANCE = 1.4  ..
GYP-PLAS = MATERIAL
           THICKNESS = .042
           CONDUCTIVITY = 0.1330
           DENSITY = 45.
           SPECIFIC-HEAT = 0.2  ..
END ..
STOP ..
-------------
     Save the library file as shown in the diagram for Example b
-------------
LIBRARY-INPUT LOADS ..
   STD-WALL = LAYERS
              INSIDE-FILM-RES = 0.68
              MATERIAL = (WOODSIDE, BP01, PW03, IN03,
                          GYP-PLAS)  ..
END  ..
STOP  ..
-------------
     Save the library file as shown in the diagram for Example b
```

Note: BP01, PW03, and IN03 are code-words that identify MATERIALs in the DOE-2 Prespecified Library (see Chap. X).

This deck can then immediately be followed by the user's deck to run the DOE-2 program. He can access the MATERIALs and LAYERS defined in the library run by using the U-names (WOODSIDE, GYP-PLAS, and STD-WALL) assigned in that run in subsequent runs of DOE-2.

Suppose that the user has some features in his building that call for the use of Custom Weighting Factors. Such features could include a passive solar building, a building with heavy masonry construction, a building with a glass atrium, etc. This may be accomplished with or without a library.

To use this method, the user must run a LIBRARY-INPUT LOADS deck to build the library of Custom Weighting Factors for the SPACE or SPACEs that require this library (that is, only those SPACEs that will have Custom Weighting Factors). He will need to use some or all of the following sequence of commands (any other commands entered will be ignored):

DIAGNOSTIC
ABORT
SET-DEFAULT
MATERIAL
LAYERS
CONSTRUCTION, GLASS-TYPE
SPACE-CONDITIONS
SPACE
EXTERIOR-WALL, INTERIOR-WALL, UNDERGROUND-FLOOR and UNDERGROUND-WALL
WINDOW, DOOR

EXTERIOR-WALL, INTERIOR-WALL, UNDERGROUND-FLOOR, and UNDERGROUND-WALL, and DOOR will, in this situation, all have the following keywords:

AREA
-or-
HEIGHT
WIDTH
-or-
LOCATION

CONSTRUCTION
MULTIPLIER
TILT (if LOCATION is not used)
SOLAR-FRACTION
U-EFFECTIVE (for UNDERGROUND-FLOOR and UNDERGROUND-WALL only, assuming Custom Weighting Factors are used)

Note that if the user is not using the LOCATION keyword, all surfaces (INTERIOR-WALLs, UNDERGROUND-WALLs, UNDERGROUND-FLOORs, or EXTERIOR-WALLs) that are to be treated as floors or ceilings must be given a TILT keyword value. Any surface with a TILT of 170° or greater will be considered a floor by the program; a ceiling has a TILT of 10° or less.

In addition, for a library-creation run, four keywords are available in the SPACE-CONDITIONS instruction. These provide information needed for the preprocessor to develop the Custom Weighting Factors for the new library. These keywords are:

WEIGHTING-FACTOR
FURN-FRACTION
FURNITURE-TYPE
FURN-WEIGHT

When an actual run of DOE-2 is being made, after the creation of a library, for those SPACEs in which Custom Weighting Factors have been created, under SPACE-CONDITIONS, the user will input

WEIGHTING-FACTOR = the U-name that he assigned when creating the library.

A LIBRARY-INPUT LOADS run in which Custom Weighting Factors are created will produce, automatically, the Weighting Factor Summary Report. An example of such a report is shown on the following page. The titles specified in the TITLE command are printed at the top of the report. Then the U-names of the SPACEs (in this case, SPACE-1 and SPACE-2) are given across the top of the page with the corresponding Custom Weighting Factor U-names (WF-1 and WF-2), as these were specified in the WEIGHTING-FACTOR keyword in the SPACE-CONDITIONS subcommand. If more than seven SPACEs are analyzed in a run, the report will continue onto subsequent pages.

In each column below the U-names are listed the actual Custom Weighting Factors, broken down into six categories: solar, general lighting, task lighting, people/equipment, conduction, and air temperature. The first five categories will be used in a regular LOADS run to calculate the heating and cooling loads; the room air weighting factors are used in SYSTEMS to calculate the air temperature of each space.

Following the illustrations for "Example c." the user will find a list of WARNING and ERROR diagnostics for the program that generates Custom Weighting Factors.

Another example Custom Weighting Factor run may be seen in the DOE-2 Sample Run Book.

c. Creating Custom Weighting Factors from BDLLIB. In this situation, the user wishes to create Custom Weighting Factors for his SPACEs using the prespecified library of DOE-2 materials, walls, and roofs. BDLLIB is attached to the program, and the input file may contain references to the prespecified library MATERIALs and LAYERS along with the required input information to create Custom Weighting Factors. The output of this run, USRLIB, will then contain all the information that was in BDLLIB plus the newly created Custom Weighting Factors.

d. Combining the Prespecified and a User-Specified Library. Remember that, after a LIBRARY-INPUT LOADS run, the output file, USRLIB, will contain whatever was in BDLLIB at the beginning of the run plus any library created during the run. Therefore, to combine his own with the DOE-2 library, the user proceeds as in Example b. except that in the first run, the prespecified library BDLLIB is attached to the program so that the output library, USRLIB, will contain both the prespecified library and the user-specified items. Examples b. and c. depict the necessary steps in this process. Note again that the space on BDLLIB is limited. To avoid overfilling BDLLIB, see the discussion before Example a. on the limitations of BDLLIB.

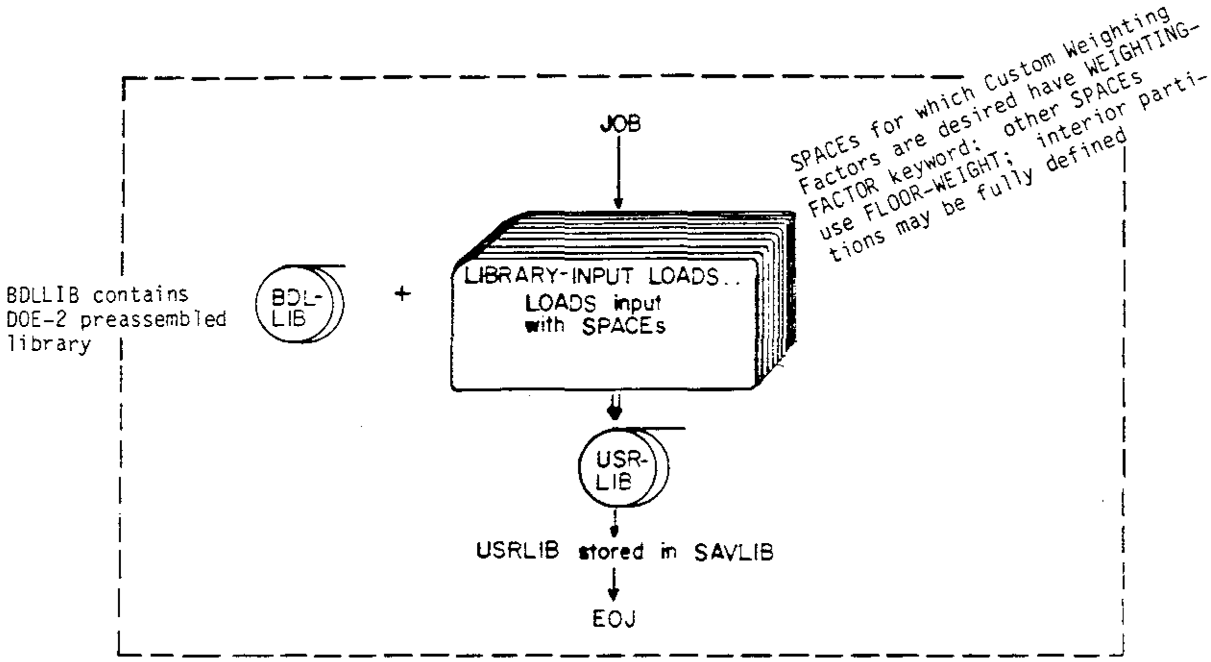
L D L   P R O C E S S O R   I N P U T   D A T A

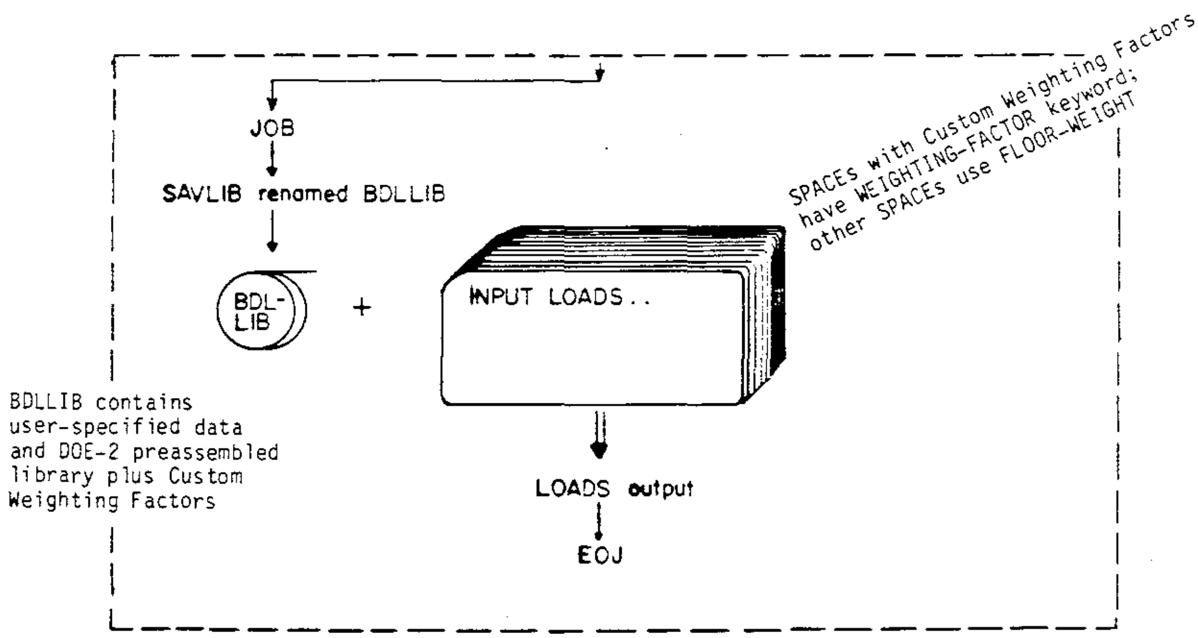
04 MAR 80   16.42.26   LDL RUN 0

```
TITLE       LINE-1 *DOE-2.1 USERS GUIDE EXAMPLE BUILDING 2*
            LINE-2 *WEIGHTING FACTOR CREATION RUN*
            LINE-3 *JANUARY, 1980*                                   ..
            ABORT ERRORS                                             ..
            DIAGNOSTIC CAUTIONS,NARROW                               ..
ROF-1       =CONSTRUCTION        LAYERS=ASHR-3 ABS=.5 RO=1           ..
EXTW-1      =CONSTRUCTION        LAYERS=ASHW-34 ABS=.88 RO=2         ..
FLOR-1      =CONSTRUCTION        LAYERS=ASHI-34                      ..
INWAL-1     =CONSTRUCTION        LAYERS=ASHI-2                       ..
WIND-1      =GLASS-TYPE          PANES=2 SHADING-COEF=.52
                                 GLASS-CONDUCTANCE=1.079             ..
            SET-DEFAULT          FOR SPACE
                                 SHAPE=BOX HEIGHT=8 WIDTH=50 DEPTH=15
                                 LIGHTING-TYPE=SUS-FLUOR             ..
            SET-DEFAULT          FOR EXTERIOR-WALL
                                 CONSTRUCTION=EXTW-1                 ..
            SET-DEFAULT          FOR WINDOW
                                 HEIGHT=5 WIDTH=20 GLASS-TYPE=WIND-1 ..
SPACE-1     =SPACE               WEIGHTING-FACTOR=WF-1
                                 FURNITURE-TYPE=LIGHT
                                 FURN-FRACTION=.25
                                 FURN-WEIGHT=5                       ..
WALL-1-1    =E-W                 LOCATION=FRONT SOLAR-FRACTION=.1    ..
WINDOW-1    =WINDOW                                                  ..
WALL-1-2    =E-W                 LOCATION=LEFT SOLAR-FRACTION=.1     ..
WALL-1-3    =E-W                 LOCATION=RIGHT SOLAR-FRACTION=.1    ..
INWALL-1-2=INTERIOR-WALL         LOCATION=BACK SOLAR-FRACTION=(.1,.15)
                                 CONSTRUCTION=INWAL-1 NEXT-TO SPACE-2 ..
FLOOR-1     =UNDERGROUND-FLOOR   LOCATION=BOTTOM SOLAR-FRACTION=.5
                                 CONSTRUCTION=FLOR-1                 ..
ROOF-1      =ROOF                LOCATION=TOP SOLAR-FRACTION=.1      ..
SPACE-2     =SPACE               Y=15  WEIGHTING-FACTOR=WF-2
                                 FURNITURE-TYPE=HEAVY
                                 FURN-FRACTION=.3
                                 FURN-WEIGHT=40                      ..
WALL-2-1    =E-W                 LOCATION=BACK SOLAR-FRACTION=.07    ..
WINDOW-2       =WINDOW                                               ..
WALL-2-2    =E-W                 LOCATION=LEFT SOLAR-FRACTION=.07    ..
WALL-2-3    =E-W                 LOCATION=RIGHT SOLAR-FRACTION=.1    ..
FLOOR-2     =U-F                 LOCATION=BOTTOM SOLAR-FRACTION=.5
                                 CONSTRUCTION=FLOR-1                 ..
ROOF-2      =ROOF                LOCATION=TOP SOLAR-FRACTION=.11     ..
END                                                                  ..
```

DOE-2.1 USERS GUIDE EXAMPLE BUILDING 2 WEIGHTING FACTOR CREATION RUN
JANUARY, 1980
CUSTOM WEIGHTING FACTOR SUMMARY

	SPACE-1 WF-1	SPACE-2 WF-2
SOLAR		
V0	.23182	.25689
V1	-.13225	-.19960
V2	.00175	.00438
W1	1.20195	1.37353
W2	-.32830	-.42150
GENERAL LIGHTING		
V0	.44412	.47712
V1	-.41892	-.52254
V2	.08546	.10754
W1	1.21931	1.38133
W2	-.34295	-.42792
TASK LIGHTING		
V0	.48069	.51152
V1	-.47158	-.57904
V2	.10240	.12862
W1	1.21931	1.38133
W2	-.34295	-.42792
PEOPLE-EQUIPMENT		
V0	.48800	.51840
V1	-.48211	-.59034
V2	.10578	.13283
W1	1.21931	1.38133
W2	-.34295	-.42792
CONDUCTION		
V0	.55025	.60282
V1	-.57173	-.72899
V2	.13461	.18456
W1	1.21931	1.38133
W2	-.34295	-.42792
AIR TEMP		
G0*	1.64333	4.55728
G1*	-2.46908	-6.92592
G2*	.82628	2.37337
G3*	-.00053	-.00473
P1	-1.24235	-1.38491
P2	.36186	.43014





Example c: Creating Custom Weighting Factors.

4. WARNING and ERROR Messages for the Custom Weighting Factors Generation Program

WARNING MESSAGES

Warning Message (1) — The INSIDE-FILM-RESISTANCE OF DELAYED SURFACE <U-name> IN SPACE <U-name> IS <value>. IT SHOULD BE BETWEEN 0.0 AND 1.0. CALCULATION OF WEIGHTING FACTORS FOR THIS SPACE WILL PROCEED USING A VALUE OF 0.68.

Meaning: The inside film resistance (INSIDE-FILM-RES) of a surface is the combined convective plus radiative inside air film resistance. The Custom Weighting Factor program obtains the convective resistance from the user-input value of INSIDE-FILM-RES and a fixed value for the radiative resistance. This convective resistance will be negative, i.e., unphysical, if INSIDE-FILM-RES exceeds 1.0 ft^2-hr-°F/Btu. In this case, the above warning message is printed, and the program resets INSIDE-FILM-RES to 0.68, which is typical of horizontal heat flows for vertical walls.

User Action: If 0.68 is acceptable, no action is necessary; otherwise, input a value between 0.0 and 1.0. Recommended values are listed in the ASHRAE Handbook of Fundamentals, 1977, p. 22.11.

Warning Message (2) — SPACE <U-name> HAS <number> WALL(S), <number> FLOOR(S), AND <number> CEILING(S). IT SHOULD HAVE AT LEAST ONE OF EACH. THE WEIGHTING FACTORS CALCULATED FOR THIS SPACE MAY BE INACCURATE. (QUICK INTERIOR WALLS WITH U-VALUE ABOVE 0.709 ARE NOT INCLUDED IN THIS SURFACE COUNT.)

Meaning: This message is a reminder that the user may have forgotten to specify some of the surfaces in a space, or may have intentionally left out some interior surfaces (such as a floor or ceiling between spaces) because the heat flow across these surfaces is expected to be small. However, an accurate calculation of the custom weighting factors requires that all the bounding surfaces of a space be input.

User Action: Be sure that all bounding surfaces (exterior walls, interior walls, and underground walls) are described if custom weighting factors are being calculated.

Note: This message will appear if all the surfaces have been specified, but the TILT of underground walls and interior walls has been allowed to default to 90°. The program, therefore, finds no floor or ceiling and prints the message. In this case, the message can be ignored.

Warning Message (3) SPACE <U-name> HAS <number> DELAYED WALL(S), <number> DELAYED FLOOR(S), AND <number> DELAYED CEILING(S). TWO OR ALL THREE OF THESE CATEGORIES SHOULD HAVE AT LEAST ONE DELAYED SURFACE. THE WEIGHTING FACTORS CALCULATED FOR THIS SPACE MAY BE INACCURATE.

Meaning: There are too few delayed walls in the space for the custom weighting factor program to properly account for the thermal mass of the space. This may lead to inaccuracy in the magnitude and time of occurrence of heating and cooling load peaks, and to inaccuracy in the calculation of space temperatures and extraction rates for spaces with thermostat setback or setup. Users are, therefore, advised to avoid specifying walls as quick because the custom weighting factor program must have the response factors to account for the thermal mass of walls.

User Action: Make all walls delayed, even INTERIOR-WALLs and UNDERGROUND-FLOORs.

Warning Message (4) SUM OF SOLAR-FRACTIONS FOR SPACE <U-name> IS <value>. THIS IS TOO FAR FROM 1.0. CHECK INPUT.

Meaning: If SOLAR-FRACTIONs are input for the surfaces of a space, their sum should be close to 1.0. To guard against input mistakes, this caution is printed if the sum is less than 0.9 or greater than 1.1. For example, if SOLAR-FRACTIONs of 0.2, 0.2, 0.02 and 0.4 were entered, their sum would be 0.82 and the caution would be printed. Note that whether or not the sum is in the 0.9 to 1.1 range, the program will adjust the SOLAR-FRACTIONs by dividing by the sum, so the new sum is exactly 1.0.

User Action: Check SOLAR-FRACTION input values.

ERROR MESSAGES

Error Message (1) WEIGHTING FACTORS CANNOT BE CALCULATED FOR SPACE <U-name> SINCE IT HAS FEWER THAN TWO WALLS, FLOORS, AND CEILINGS. ADD MORE SURFACES IN SPACE INPUT OR USE PRE-CALCULATED WEIGHTING FACTORS. (QUICK INTERIOR-WALLS WITH U-VALUE ABOVE 0.709 ARE NOT INCLUDED IN THIS SURFACE COUNT.)

Meaning: Radiation exchange cannot be calculated unless two opaque surfaces are present.

User Action: This error usually occurs for the perimeter zone of a non-residential building where the only surface described in the Custom Weighting Factor input is an exterior wall; because heat transfer across interior walls, floor, and ceiling was considered to be unimportant, these surfaces were not input. The result is a space with one opaque surface. The remedy is to include one or all of the originally neglected interior surfaces in the Custom Weighting Factor input. If surfaces must be omitted because the details of their geometry and construction are poorly known (such as in an energy analysis of a conceptual design), it is advisable to use precalculated weighting factors.

<u>Error Message (2)</u>

SPACE <U-name> HAS FURNITURE BUT NO VALID FLOOR. WEIGHTING FACTORS WILL NOT BE CALCULATED FOR THIS SPACE. IF FLOOR IS EXTERIOR-WALL, UNDERGROUND SURFACE, OR INTERIOR-WALL DEFINED IN THIS SPACE, BE SURE TILT = 180. IF FLOOR IS INTERIOR-WALL DEFINED IN AN ADJACENT SPACE, BE SURE TILT = 0.

Meaning:

Furniture has been specified for a space via the FURN-FRACTION, FURNITURE-TYPE, AND FURN-WEIGHT keywords. However, none of the surfaces in this space is a floor. Unless a floor is present, the Custom Weighting Factor calculation cannot take the effect of furniture into account in calculating the split of solar radiation between furniture and the part of the floor not covered by furniture.

User Action:

Be sure that at least one surface in the space is a floor. This means that

(a) for an EXTERIOR-WALL, TILT must be 180°;
(b) for an INTERIOR-WALL, which is defined in this space, TILT must be 180°;
(c) for an INTERIOR-WALL that is defined in another space, but is NEXT-TO this space, TILT must be 0° (i.e., this wall is a ceiling in the space in which it is defined, and therefore, is a floor in the adjacent space);
(d) for an UNDERGROUND-FLOOR or UNDERGROUND-WALL, TILT must be 180° (the default value is 90°).

If SHAPE = BOX is used, the surface with LOCATION = BOTTOM will be a floor; the surface with LOCATION = TOP will be a floor in the NEXT-TO space if this surface is an INTERIOR-WALL.

<u>Error Message (3)</u>

WEIGHTING FACTORS WILL NOT BE CALCULATED FOR SPACE <U-name> SINCE IT HAS NO DELAYED WALLS, FLOORS, OR CEILINGS. ADD DELAYED SURFACES IN SPACE INPUT OR USE PRE-CALCULATED WEIGHTING FACTORS.

Meaning: All the walls in a space are quick. Because the custom weighting factor calculation requires at least one delayed wall, weighting factors cannot be generated for this space.

User Action: Make at least one EXTERIOR-WALL, INTERIOR-WALL, or UNDERGROUND-WALL delayed. However, the most accurate weighting factors will be generated for spaces in which all of the bounding walls are delayed.

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IV. SYSTEMS PROGRAM

A. INTRODUCTION

1. Program Description

The SYSTEMS program simulates the operation of the equipment and systems that distribute cooling and/or heating directly to the spaces being conditioned. In the case of the "packaged systems," RESYS, PSZ, PMZS, PVAVS, and PTAC, or any system with a furnace, the SYSTEMS program simulates not only the heating and cooling distribution systems but also that equipment which would normally be part of the PLANT program, i.e., heating source, cooling source, pumps, etc. The reason for this approach is because in "packaged systems" it is difficult to clearly separate the primary systems from the secondary systems. Most such systems are treated by manufacturers in their performance data as a unit anyway. SYSTEMS also simulates the control of temperature and/or humidity in these spaces. These are sometimes called "secondary" or "terminal" energy distribution systems, to differentiate them from "primary energy distribution" or "energy conversion" systems. This latter category of equipment and the program that simulates its operation, called PLANT, are described in Chap. V.

The hourly space loads calculated by the LOADS program are not necessarily the loads that are imposed on the heating and cooling "plant." Because of outside ventilation air requirements, HVAC equipment operating schedules, and the temperature fluctuations required for control actuation, each building's hourly heating and/or cooling requirements will be different from the summation of the external and internal hourly space loads calculated in LOADS. The purpose of the SYSTEMS simulation program is, therefore, twofold:

a. To provide information for sizing of components in the "secondary" energy distribution system, based upon peak (or design day) heating and cooling requirements.

b. To simulate each distribution system as it responds to space thermal requirements, and to determine the demand it is imposing upon the central heating and cooling plant.

The SYSTEMS program mathematically simulates the heat and moisture exchange processes that occur in HVAC distribution systems. The user must select a system from a menu of "familiar" types of distribution systems. Additionally, optional component and control features, available for each type of system, can be selected. The systems are described in Sec. B of this chapter.

The SYSTEMS program receives, as input, a list of the hourly loads for each space from the LOADS programs, and requires a sequence of user-defined SDL input instructions. The output of the SYSTEMS program provides input to the PLANT program and information for the REPORT Generator Program.

2. Parametric Runs

The SYSTEMS program has been designed with the flexibility to permit parallel parametric runs. That is, more than one system or collection of systems can be simulated in a single run. Figure IV.1 is an example of this arrangement. In one computer run calculations can be made for two different plant assignments (PA-1 and PA-2), each plant assignment serving all ten (10) zones of the example building. Plant assignment PA-1 consists of systems S-1 (serving zones 1 through 5) and S-2 (serving zones 6 through 10). Plant assignment PA-2 consists of system S-3 (serving zones 1 through 3) and system S-4 (serving zones 4 through 10). A maximum of four plant assignments can be simulated in a single computer run. The purpose of this procedure is to reduce computer time and, hence, computation cost.

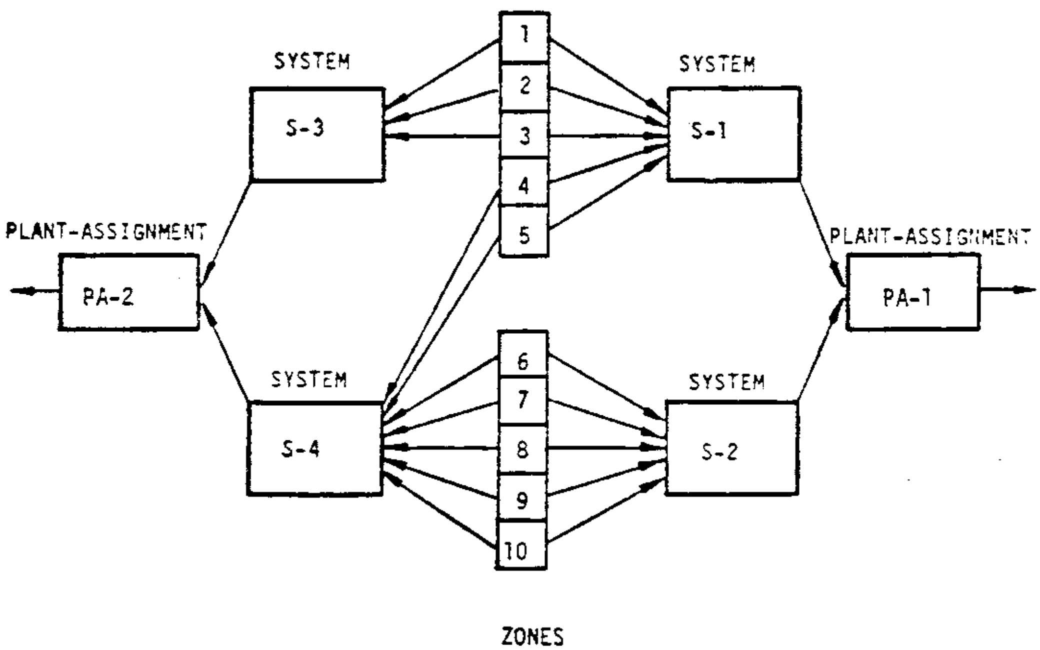


Fig. IV.1 Example of a "parallel" parametric run.

The user may assign to a system any set of zones, and also assign to a plant any set of systems, with the exception that a single system may appear in only one plant and a single zone may appear only once in a plant. The user may assign the same zone to more than one system if the SYSTEMs are in different PLANT-ASSIGNMENTs.

3. System Combinations

A considerable number of optional components and control strategies are available for many of the energy distribution systems that are modeled by this program. These options, described for each system in Sec. B, include optional return and exhaust fans; fixed outside-air flow rate, or one of two types of variable outside air flow rates; summer and/or winter humidity control; hourly, daily, and weekly operating schedules; four types of variable-volume fan controls; and constant, scheduled, or reset setpoints for supply air temperature. In addition, baseboard heating convectors can be used in combination with any of the central-fan air-side systems.

As an additional option, commercial and residential heat pumps can be assisted by a solar energy system. This support is described in the Introduction of Sec. C, Chap. V.

Other system combinations of component and control options can be simulated if the thermodynamic processes are the same as those specifically modeled by the program. For example, a dual-duct or multizone system with a cooling coil installed upstream of the supply fan, rather than in the cold duct, is thermodynamically the same as a reheat fan system, and can be modeled as such.

4. Calculation Procedures

a. System Sizing Calculations. The heat extraction/addition capability and air flow rates of the system may be assigned, if known (i.e., an existing system). If these quantities are not entered, the program will calculate them, based on design supply air temperatures and peak cooling/heating requirements. Alternatively, it may be desired to size the system for "design day" rather than peak conditions. To accomplish this, the user inputs design outdoor weather conditions (in LOADS) and the program generates 24-hour weather data for summer and/or winter design days. (See DESIGN-DAY in Chap. III for a discussion of the user input data required.) A SYSTEMS run using design-day LOADS output will yield the desired sizing information.

Design calculations are accomplished by the subroutine, DESIGN. The subroutine is described in detail in the DOE-2 Engineers Manual. The methodology used is discussed in Sec. D of this chapter.

b. Calculation of Heat Extraction/Addition Rate and Room Temperature. Instantaneous heat gains/losses and room cooling/heating loads are calculated by the LOADS program, using response factors and room weighting factors described in Ref. 1, Chap. XI. These loads are calculated on the basis of a constant air temperature in the space. The actual air temperature generally deviates from the reference value because of cooling/heating equipment characteristics and operating schedule and thermostat setback. Thus, heat extraction from the space will differ from cooling load, and heat addition to the space will differ from heating load. The final step in the calculation process, calculation of actual room temperature and heat extraction/addition rate, is accomplished by the SYSTEMS program with the algorithms, described in Ref. 2, Chap. XI. The previously calculated loads (from LOADS) are the input, along with the characteristics of the air-conditioning equipment and the thermal characteristics of the zone. Heat extraction or addition rate and air temperature are the output of SYSTEMS.

5. Systems Description Language (SDL)

A general discussion of Building Description Language (BDL) including rules, syntax, and notation can be found in Chap. II. The System Description Language (SDL) is that portion of BDL that is solely applicable to the SYSTEMS program. Section C of this chapter contains a description of each SDL instruction.

In addition, a number of the BDL instructions introduced in Chap. II are also applicable to the SYSTEMS program. These are the labeling instruction TITLE: the assignment instruction PARAMETER; the message instruction DIAGNOSTIC; the schedule instructions DAY-SCHEDULE, WEEK-SCHEDULE, and SCHEDULE; the program control instructions INPUT SYSTEMS, ABORT, and END; the hourly report instructions HOURLY-REPORT and REPORT-BLOCK; and the resimulation instruction PARAMETRIC-INPUT. See Chap. II for a description of these instructions, including definitions and instructions for the use of associated keywords. Note that the schedule instructions are used exactly as described in Chap. II for some SYSTEMS program applications, but are used differently for other applications described in Sec. C of this chapter (see DAY-RESET-SCH instruction). Note also that if the message instructions, such as DIAGNOSTIC, are omitted here, the message instructions used by the LOADS program will apply to the SYSTEMS program.

6. SDL Command Structure

The two basic instructions of the SYSTEMS program are ZONE and SYSTEM (see Fig. IV.2). Three other instructions, unique to the SYSTEMS program, are available: one for selecting output reports (SYSTEMS-REPORT), the second a special form of the DAY-SCHEDULE instruction (DAY-RESET-SCH), and the third for use in the parallel parametric run feature described in subsection B of this section (PLANT-ASSIGNMENT). In addition, the program control instructions (e.g., INPUT, END, COMPUTE SYSTEMS) must be used and one or more of the other applicable BDL instructions described in Chap. II (DIAGNOSTIC, DAY-SCHEDULE, WEEK-SCHEDULE, SCHEDULE, REPORT-BLOCK, and HOURLY-REPORT) may be needed to complete data entry. However, ZONE and SYSTEM instructions provide the bulk of the information required for a SYSTEMS program simulation. As the names imply, they define, respectively, thermal zones and secondary HVAC distribution systems.

A number of the keywords in the ZONE and SYSTEM instructions, which are related by subject or category of information, have been combined into subcommands that can, at the user's discretion, be entered as separate and independent instructions. This organization into subgroups is for user convenience only. Once a ZONE subcommand has been labeled and data entered for the applicable keywords, it can be referenced by a number of different zones, thus reducing data entry effort. For example, a building may have 64 zones but only two or three variations in the conditions specified by the ZONE subcommands (ZONE-AIR and ZONE-CONTROL). The discussion above applies equally to the six SYSTEM subcommands (SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, SYSTEM-TERMINAL, SYSTEM-FLUID, and SYSTEM-EQUIPMENT).

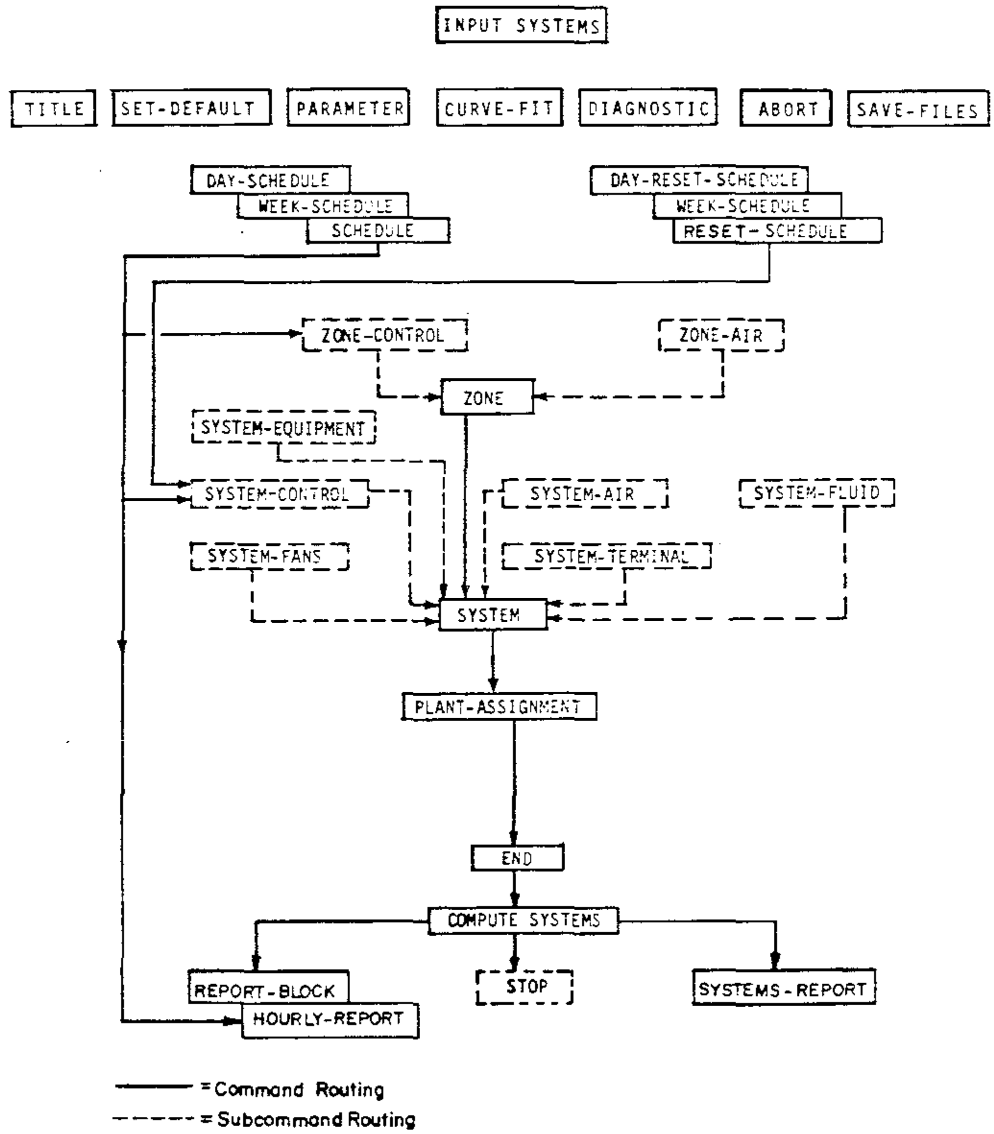


Fig. IV.2 Interrelationship of SDL instructions.

User worksheets, intended as an organizational aid for SYSTEMS program data entry, are provided for each instruction in this chapter.

7. Example SDL Instruction Sequence

The following is a suggested sequence of data preparation and entry.

a. Initiate data entry by entering program control instruction

INPUT SYSTEMS ..

b. Enter a DIAGNOSTIC instruction if it is desired to change what has been specified in LOADS.

c. If parametric study is planned, to evaluate the effect of varying specific system parameters, use the PARAMETER instruction to simplify preparation of input data for the multiple runs required (see discussion in Chap. II).

d. If, at this point, the user is able to identify the SYSTEM-TYPE (see SYSTEM command), he should refer to the proper Applicability Table in Sec. B. of this chapter. This table will identify, for the user's chosen system, which commands and keywords are applicable, required, and optional. This table is the user's guide and checklist because not all commands and keywords are appropriate to all systems. This chapter addresses 21 different types of systems. The user will notice that after identifying his SYSTEM-TYPE, the magnitude of this manual will appear to diminish. He can then turn his attention to "what is necessary", not "what all is available". The alternative, of course, to identifying SYSTEM-TYPE now is to review the entire chapter and then select a SYSTEM-TYPE. Entering data without having chosen a SYSTEM-TYPE is next to impossible (see the keyword SYSTEM-TYPE in the SYSTEM instruction for more information on this subject). If, of course, the user chooses the wrong SYSTEM-TYPE, he can always return to this point and choose a different one.

e. Prepare and enter as many schedule instructions (DAY-SCHEDULE, WEEK-SCHEDULE, SCHEDULE, and/or DAY-RESET-SCH, RESET-SCHEDULE) as are required for the system(s) being specified. (The following SDL keywords are schedule-dependent; HEATING-SCHEDULE, COOLING-SCHEDULE, FAN-SCHEDULE, HEAT-TEMP-SCH, COOL-TEMP-SCH, MIN-AIR-SCH, COOL-SET-SCH, HEAT-SET-SCH, HEAT-RESET-SCH, COOL-RESET-SCH, NATURAL-VENT-SCH, BASEBOARD-SCH, VENT-TEMP-SCH, INDUC-MODE-SCH, and REPORT-SCHEDULE). Note that the same SCHEDULE instruction (or RESET-SCHEDULE instruction) can be referenced by more than one keyword.

   In actual practice, the user will probably generate the schedules if and when needed. The input tends to be more orderly if schedules are grouped at this point, but that is not necessary.

f. One or both of the ZONE subcommands, ZONE-AIR and ZONE-CONTROL, may be used to enter zone data (in lieu of entering this data directly with the ZONE instruction). The user may prepare and enter as many of each type as there are zone-to-zone variations in the specified data, up to the limit specified for that command. Once a ZONE subcommand is labeled and data are entered for the applicable keywords, it can be referenced by any number of different ZONE instructions, thus reducing data input effort. A ZONE subcommand, when used, must always be entered before the ZONE instruction in which it is referenced.

   Note: All subcommands must be defined before being referenced. However, DAY-SCHEDULEs, WEEK-SCHEDULEs, SCHEDULEs, ZONEs, and SYSTEMs may be referenced and defined later (except for use in the REPORT-BLOCK instruction).

Prepare and enter a ZONE instruction for each thermal zone in the building. A thermal zone is defined as: 1) an area (or space) having a common temperature control, 2) an unconditioned space, or 3) a plenum. At least one "conditioned" thermal zone must be specified for each different system simulated. A ZONE instruction should be prepared and entered for each SPACE instruction entered for the LOADS program and, furthermore, the ZONE instruction must have the same U-name as the SPACE instruction and represent the same physical area of the building.)

g. One or more CURVE-FIT commands may be input if and when needed to represent equipment operation (see SYSTEM-EQUIPMENT) when default values are inappropriate for a user's simulation.

h. One or more of the SYSTEM subcommands SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, SYSTEMS-TERMINAL, SYSTEM-FLUID, and SYSTEM-EQUIPMENT, may be used to enter system data (in lieu of entering this data directly with the SYSTEM instruction). The user may prepare and enter as many of each type as there are system-to-system variations in the specified data. Once a SYSTEM subcommand is labeled and data are entered for the applicable keywords, it can be referenced by any number of different SYSTEM instructions, thus reducing data input effort. A SYSTEM subcommand, when used, must always be entered before the SYSTEM instruction in which it is referenced.

   Prepare and enter a SYSTEM instruction for each system being simulated. At least one system must be simulated per computer run.

i. Use the PLANT-ASSIGNMENT instruction if a comparison study is desired of different types, sizes, or arrangements of systems using the parallel parametric run feature of the SYSTEMS program (described in subsection 2 of this section). One PLANT-ASSIGNMENT instruction must be prepared and entered for each system (or group of systems) to be compared.

j. Prepare a SYSTEMS-REPORT instruction defining which verification and/or summary reports are to be printed. This instruction can be omitted if only the summary report, SS-A (default value), is desired.

   Hourly reports of selected variables are also available. To obtain these reports, instructions that define the variables to be printed and the desired time should be prepared. These instructions (HOURLY-REPORT and REPORT-BLOCK) and their associated keywords are described in detail in Chap. II. The REPORT-BLOCK instruction, because it references the U-name of a ZONE or SYSTEM instruction, must be entered subsequent to the referenced instruction.

k. When SYSTEMS data entry is complete, enter the program control instruction

   END ..

l. Enter program control instruction

    COMPUTE SYSTEMS ..

   to instruct the processor to perform calculations.

m. If the PLANT and ECONOMICS programs are not to be run, enter the program control instruction

    STOP ..

n. The User Worksheets with each command have been provided to help organize the data-input effort. They provide a space for the entry of a label or a value for each command word, keyword, and code-word.

   It is suggested that the applicable worksheets be reproduced by photocopy in the requisite numbers (i.e., one copy for each ZONE, each SYSTEM, etc.). The worksheets can be filled out in any convenient order, but it is recommended that they be arranged in the sequence described in paragraphs a thru m above, before starting data input.

WARNING

The proper specification of SCHEDULEs in the SYSTEMS simulator is as important, if not more important, than the proper specification of SCHEDULEs in the LOADS simulator. In SYSTEMS, these SCHEDULEs turn the HVAC equipment on and off, reset temperatures, establish flow rates, etc. These SCHEDULEs should be thought of as "system controls". They control the HVAC system as much as do economizer control strategies and fan control strategies. The program does not automatically control, nor optimize the operation of, the HVAC equipment. The user must control the equipment via the input for his SCHEDULEs or be aware of what the program is doing if a SCHEDULE is allowed to default. The improper specification of SCHEDULEs can easily double the energy consumption of the simulated building.

8. SDL Input Instruction Limitations

The maximum number of each type of SDL instruction that the program can accept in a single run is shown in Table IV.1. A building that cannot be specified, without exceeding these limits, should be divided in the most convenient manner and modeled as two separate buildings, or the user should inquire concerning the availability of larger limits at the user's computer facility.

TABLE IV.1

SDL Command	Maximum Number
DAY-RESET-SCH and/or DAY-SCHEDULE	60 combined
WEEK-SCHEDULE	40
RESET-SCHEDULE and/or SCHEDULE	40 combined
ZONE-AIR	20
ZONE-CONTROL	20
ZONE	64
CURVE-FIT	100
SYSTEM-CONTROL	20
SYSTEM-AIR	20
SYSTEM-FANS	20
SYSTEM-TERMINAL	20
SYSTEM-FLUID	20
SYSTEM-EQUIPMENT	20
SYSTEM	40
PLANT-ASSIGNMENT	4
SYSTEMS-REPORT	1 command (200 reports)
HOURLY-REPORT	16
REPORT-BLOCKS	64
PARAMETER	50
SET-DEFAULT	100
TITLE	5
U-names	180*

* The use of the advanced scheduling technique (described in Chapter II) 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 SDL. Also, specifying an output report by code-word (SV-A, SS-A, etc.) will result in the use of one U-name internally specified by SDL.

B. AVAILABLE HVAC DISTRIBUTION SYSTEMS

1. General Discussion of Systems

The SYSTEMS program mathematically 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. When the user specifies one of the packaged systems (PSZ, PMZS, PVAVS, or PTAC), the SYSTEMS program sometimes simulates both the secondary HVAC distribution systems and the primary HVAC systems (that equipment that, in a built-up system, would be simulated in the PLANT program). The user selects appropriate systems (plus options) from a list of twenty-one different "standard" or familiar types of systems. The SYSTEMS program cannot, however, simulate two different types of 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 Multizone Fan System (MZS). The available systems are listed in Table IV.2 and are described in the following pages of this section.

Input data required for simulation varies from system to system. A table of applicable and required commands and keywords is included with each system description. In general, however, the following information is required for basic system simulation:

- operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL subcommand and keyword FAN-SCHEDULE in the SYSTEM-FANS subcommand),
- space temperature control (see keywords HEAT-TEMP-SCH, COOL-TEMP-SCH, THERMOSTAT-TYPE, and THROTTLING-RANGE in the ZONE-CONTROL subcommand),
- system design temperatures (see keywords DESIGN-HEAT-T and DESIGN-COOL-T in the ZONE-CONTROL subcommand and keywords MAX-SUPPLY-T and MIN-SUPPLY-T in the SYSTEM-CONTROL subcommand),
- outside air quantities (see SYSTEM-AIR and ZONE-AIR subcommands),
- fan characteristics (see SYSTEM-FANS subcommand), and
- identification of the zones served by the system (see keywords PLENUM-NAMES and ZONE-NAMES in the SYSTEM instruction).

2. List of Available Systems and Options

A number of optional or alternative component and control features can be simulated by the program. The applicability of each option to the different SYSTEM-TYPEs is shown in Table IV.2.

The suggested approach to the beginning user is:

a) choose a system(s) from Table IV.2,
b) review the description of the chosen system(s) and its Applicability Table,
c) go to Sec. C of this Chapter, where the commands and keywords are defined, and then specify values for the applicable commands and keywords (User Worksheets are included in Sec. C to assist the user).

TABLE IV.2

LIST OF AVAILABLE SYSTEMS AND OPTIONS

SYSTEM-TYPE Code-word	Name of SYSTEM-TYPE	Applicable Options*
SUM	Sums Building Loads (no system simulation)	Thermostat, Night Cycle Control
SZRH	Single-Zone Fan System w/optional Subzone Reheat	Outside Air, Return Air, Exhaust Fan, Fan Control, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Subzones, Variable Flow in subZONEs, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control, Fan Sizing
MZS	Multizone Fan System	Outside Air, Return Air, Exhaust Fan, Fan Control, Hot Deck Temperature Control, Cold Deck Temperature Control, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Variable Flow, Equipment Sizing, Heat Source, Motor Placement, Night Cycle Control, Fan Sizing
DDS	Dual-Duct Fan System	Outside Air, Return Air, Exhaust Fan, Fan Control, Hot Deck Temperature Control, Cold Deck Temperature Control, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Variable Flow, Equipment Sizing, Heat Source, Motor Placement, Night Cycle Control, Fan Sizing
SZCI	Ceiling Induction System	Outside Air, Return Air, Exhaust Fan, Fan Control, Supply Air Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control, Fan Sizing

*Following this table the user can find more information on the applicable options.

Table IV.2 Cont.

SYSTEM-TYPE Code-word	Name of SYSTEM-TYPE	Applicable Options*
UHT	Unit Heater	Baseboard Heat, Thermostat, Equipment Sizing, Heat Source, Night Cycle Control
UVT	Unit Ventilator	Outside Air, Baseboard Heat, Thermostat, Equipment Sizing, Heat Source, Night Cycle Control
FPH	Floor Panel Heating System	Thermostat, Equipment Sizing, Heat Source
TPFC	Two-Pipe Fan Coil System	Outside Air, Exhaust Fan, Baseboard Heat, Minimum Humidity Control, Thermostat, Equipment Sizing, Heat Source, Night Cycle Control
FPFC	Four-Pipe Fan Coil System	Outside Air, Exhaust Fan, Baseboard Heat, Minimum Humidity Control, Thermostat, Equipment Sizing, Heat Source, Night Cycle Control
TPIU	Two-Pipe Induction Unit System	Outside Air, Return Air, Exhaust Fan, Supply Air Temperature Control, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control
FPIU	Four-Pipe Induction Unit System	Outside Air, Return Air, Exhaust Fan, Supply Air Temperature Control, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control

*Following this table the user can find more information on the applicable options.

Table IV.2 Cont.

SYSTEM-TYPE Code-word	Name of SYSTEM-TYPE	Applicable Options*
VAVS	Variable-Volume Fan System w/optional reheat	Outside Air, Return Air, Exhaust Fan, Fan Control, Supply Air Temperature Control, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Variable Flow, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control, Fan Sizing
RHFS	Constant-Volume Reheat Fan System	Outside Air, Return Air, Exhaust Fan, Fan Control, Supply Air Temperature Control, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control, Fan Sizing
HP	Unitary Hydronic Heat Pump System	Outside Air, Fan Control, Baseboard Heat, Thermostat, Equipment Sizing, Heat Source, Night Cycle Control
HVSYS	Heating and Ventilating System	Outside Air, Return Air, Exhaust Fan, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Thermostat, Heat Recovery, Equipment Sizing, Heat Source, Motor Placement, Night Cycle Control
CBVAV	Ceiling Bypass Variable Volume System	Outside Air, Return Air, Exhaust Fan, Fan Control, Supply Air Temperature Control, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Variable Flow, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control, Fan Sizing

*Following this table the user can find more information on the applicable options.

Table IV.2 Cont.

SYSTEM-TYPE Code-word	Name of SYSTEM-TYPE	Applicable Options*
RESYS	Residential System	Fan Control, Baseboard Heat, Thermostat, Equipment Sizing, Heat Source, Openable Windows
PSZ	Packaged Single Zone Air Conditioner w/optional Heating and Subzone Reheating	Outside Air, Return Air, Exhaust Fan, Fan Control, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Subzones, Variable Flow in subZONEs, Equipment Sizing, Heat Source, Fan Placement, Motor Placement, Night Cycle Control, Fan Sizing
PMZS	Packaged Multizone Fan System	Outside Air, Return Air, Exhaust Fan, Fan Control, Hot Deck Temperature Control, Cold Deck Temperature Control, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Variable Flow, Equipment Sizing, Heat Source, Motor Placement, Night Cycle Control, Fan Sizing
PVAVS	Packaged Variable Air Volume System	Outside Air, Return Air, Exhaust Fan, Fan Control, Supply Air Temperature Control, Heating Coil Temperature Control, Reheat Coil, Baseboard Heat, Minimum Humidity Control, Maximum Humidity Control, Thermostat, Heat Recovery, Subzones, Variable Flow, Equipment Sizing, Heat Source, Motor Placement, Night Cycle Control, Fan Sizing
PTAC	Packaged Terminal Air Conditioner	Outside Air, Exhaust Fan, Fan Control Baseboard Heat, Thermostat, Equipment Sizing, Heat Source, Night Cycle Control

*Following this table the user can find more information on the applicable options.

3. Explanation of System Options

1) Outside Air Option: A fixed quantity of outside air, or one of two different types of economizer cycles, can be specified (see keyword OA-CONTROL and MIN-OUTSIDE-AIR in SYSTEM-AIR subcommand).

2) Return Air Option: Return air may be pulled back to the air-handling unit by the supply fan, or a separate return air fan may be specified for this purpose (see keywords RETURN-CFM, RETURN-DELTA-T, RETURN-KW, RETURN-STATIC, and RETURN-EFF in SYSTEM-FANS subcommand). The air may be returned directly from the conditioned space or be drawn through a return air plenum (see keyword RETURN-AIR-PATH in the SYSTEM command).

3) Exhaust Fan Option: Direct exhaust, independent of the return air system, may be specified for one or more zones (see keywords EXHAUST-CFM, EXHAUST-KW, EXHAUST-STATIC, and EXHAUST-EFF in the ZONE-AIR subcommand).

4) Fan Control Option: One of seven different methods of reducing system fan capacity, in accordance with system flow requirements, can be specified: fan discharge damper, fan inlet vanes, variable fan speed, and cycling for variable volume systems; two-speed for PTAC system; and standard constant-volume. In addition, the user may input his own fan curve (see keyword FAN-CONTROL in the SYSTEM-FANS subcommand).

5) Supply Air Temperature Control Option: The temperature of supply air, discharging from the primary air supply unit of single-duct systems, can be maintained constant, can be reset in accordance with outside air temperature, can be scheduled in time, or can be based on the requirements of the warmest zone (see keyword COOL-CONTROL in the SYSTEM-CONTROL subcommand). Note: RESET outside air temperature control is most commonly used with the two-pipe induction system.

6) Heating Coil Temperature Control Option: The temperature of the air leaving the central (or main) heating coil of single-duct air systems is constant and is controlled by the value specified (or defaulted) for HEAT-SET-T (see SYSTEM-CONTROL subcommand).

7) Reheat Coil Option: Reheat (zone) coil operation for single-duct air systems is controlled by the user input for the keyword REHEAT-DELTA-T (see SYSTEM-TERMINAL subcommand) and the hourly values referenced by HEAT-TEMP-SCH (see ZONE-CONTROL subcommand).

8) Hot Deck Temperature Control Option: Hot deck temperature for dual-duct air systems can be maintained constant, can be reset in accordance with outside air temperature, can be scheduled in time, or can be based on the requirements of the coldest zone served by the system (see keywords HEAT-CONTROL, HEAT-SET-T, HEAT-SET-SCH, and HEAT-RESET-SCH in the SYSTEM-CONTROL subcommand).

9) Cold Deck Temperature Control Option: Cold deck temperature for dual-duct air systems can be maintained constant, can be reset in accordance with outside air temperature, can be scheduled in time, or can be based on the requirements of the warmest zone served by the system (see keywords COOL-CONTROL, COOL-SET-T, COOL-SET-SCH, and COOL-RESET-SCH in the SYSTEM-CONTROL subcommand).

10) Baseboard Heat Option: Baseboard heating may be specified for one or more zones (see keywords BASEBOARD-RATING in the ZONE instruction and BASEBOARD-SCH in the SYSTEM-CONTROL subcommand). The heating element output may be controlled thermostatically or may be automatically reset on the basis of outside air temperature (see keyword BASEBOARD-CTRL in the ZONE-CONTROL subcommand.

11) Minimum Humidity Control Option: Minimum humidity control, by control of relative humidity in the return air, can be specified (see keyword MIN-HUMIDITY in the SYSTEM-CONTROL subcommand). The program converts any increase in absolute humidity into a heat load (Btu/hr) and passes this load to the PLANT progam.

12) Maximum Humidity Control Option: Maximum humidity control, by control of relative humidity in the return air, can be specified (see keyword MAX-HUMIDITY in the SYSTEM-CONTROL subcommand).

13) Thermostat Option: Three different types of thermostat action can be specified, i.e., two-position, proportional band, and reverse action proportional (see keyword THERMOSTAT-TYPE in the ZONE-CONTROL subcommand).

14) Heat Recovery Option: Recovery of heat from exhausted air, for preheating outside air, can be simulated (see keyword RECOVERY-EFF in the SYSTEM-AIR subcommand). Heat recovery, from double-bundle chillers and other types of primary equipment, is simulated by the PLANT program.

15) Subzones Option: One or more subzones, with optional reheat coil temperature control and variable-air volume flow, can be specified for SYSTEM-TYPE = SZRH or PSZ (see keyword ZONE-NAMES in the SYSTEM instruction and keywords REHEAT-DELTA-T and MIN-CFM-RATIO in the SYSTEM-TERMINAL subcommand).

16) Variable Flow Option: The normally constant flow simulation for the Dual Duct Fan System (DDS) can be changed to a variable flow simulation by supplying an entry for keyword MIN-CFM-RATIO (see SYSTEM-TERMINAL subcommand). This entry specifies the flow reduction permitted before mixing of hot and cold air streams is initiated to prevent additional decrease in flow.

17) Equipment Sizing Ratio: It is possible to deliberately oversize or undersize the system equipment. The possible reasons for doing this include (1) trying to incorporate an equipment safety factor, (2)

trying to change the system's responsiveness, or (3) attempting to reduce initial costs of construction by assuming a measure of risk (see keyword SIZING-RATIO in SYSTEM command).

18) Heat Source Option: The user may choose between GAS-FURNACE, OIL-FURNACE, HOT-WATER, HOT-WATER/SOLAR, and ELECTRIC for HEAT-SOURCEs. The same code-words are available for the keywords ZONE-HEAT-SOURCE, PREHEAT-SOURCE, and BASEBOARD-SOURCE (except HOT-WATER/SOLAR should not be used with BASEBOARD-SOURCE). HEAT-PUMP is an appropriate option for the RESYS and PTAC systems only.

19) Fan Placement Option: A choice between BLOW-THROUGH and DRAW-THROUGH type fan is provided.

20) Motor Placement Option: The motors may be placed IN-AIRFLOW or OUTSIDE-AIRFLOW to correctly account for fan heat gain in the supply air stream.

21) Openable Windows: Windows may be opened for natural ventilation. This option is available for the RESYS system only. (See NATURAL-VENT-AC, NATURAL-VENT-SCH, and VENT-TEMP-SCH in SYSTEM-AIR subcommand).

22) Night Cycle Control: The user may specify the behavior of the fans during periods where the FAN-SCHEDULEs are not in operation. Although the fans may be turned off at night, to conserve energy, the night cycle control will turn the fans on to maintain the temperature within the THROTTLING-RANGE, thus preventing building freezeup.

23) Fan Sizing Option: It is possible to select the size of the SUPPLY-CFM (supply air fan) to meet either the block, or building, peak load (COINCIDENT for SIZING-OPTION in the SYSTEM command) or the sum of the individual zone peak loads (NON-COINCIDENT for SIZING-OPTION in the SYSTEM command).

4. System Descriptions

a. Summation of LOADS to PLANT (SUM)

This is actually not a secondary HVAC distribution system, but rather a diagnostic tool, which is used to 1) pass the hourly LOADS program output to the PLANT program without simulating a system, 2) adjust the constant zone temperatures specified in LOADS, 3) simulate the thermostat schedules (but not the equipment), and 4) tabulate energy consumption by ZONE (or group of ZONEs). SUM is not a miscellaneous SYSTEM-TYPE for UNCONDITIONED zones. UNCONDITIONED ZONEs should be assigned to another SYSTEM.

Table IV.3 shows the commands and keywords that must be entered for this simulation, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).

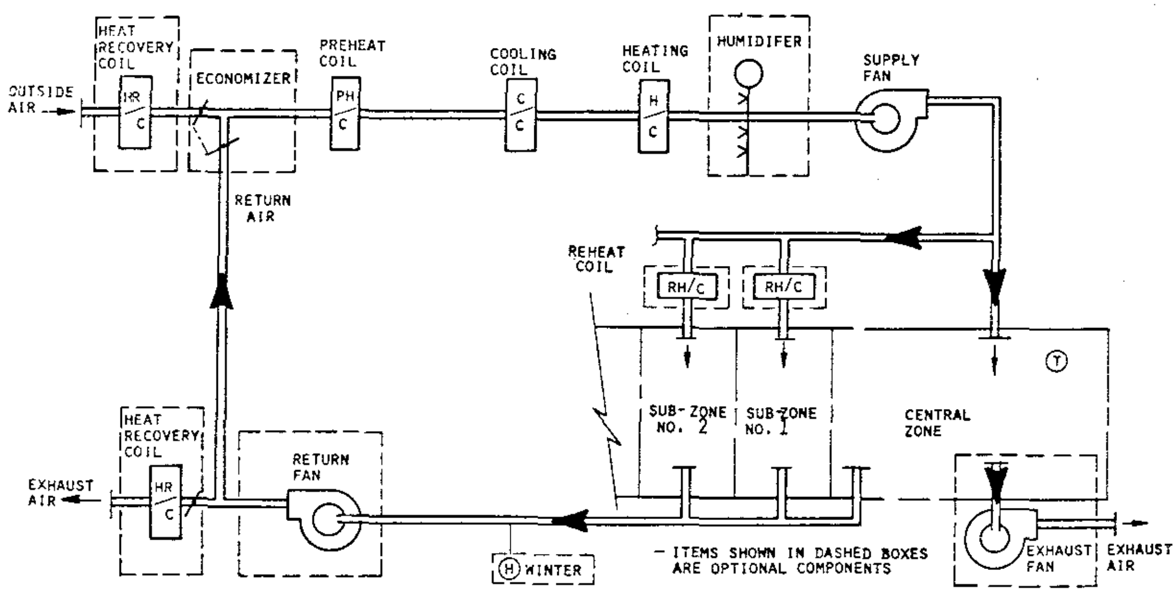
TABLE IV.3

APPLICABILITY OF COMMANDS AND KEYWORDS TO SUM

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	*
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	*
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
ZONE	ZONE-CONTROL	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load
	MAX-COOL-RATE	Peak load
SYSTEM-CONTROL	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
SYSTEM-FANS	FAN-SCHEDULE	Always on
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM	SYSTEM-TYPE=SUM	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-FANS	**
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

b. Single-Zone Fan System w/Optional Subzone Reheat (SZRH)



The single-zone type fan system (w/optional subzone reheat) is illustrated in the schematic above. In its most basic configuration, the system provides constant volume, forced air heating and cooling for a single zone (with subzones) from an air-handling unit containing a heating coil, a cooling coil, filters (not shown), and a supply fan. Exhaust fan(s) 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 (see SYSTEM COMMAND). 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. 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.4 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.4

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM SZRH

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	MAX-SUPPLY-T
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.4 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR (cont)	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.42°F
	SUPPLY-KW	.000783 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-EQUIPMENT	COOLING CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	0.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM-TERMINAL	REHEAT-DELTA-T	No reheat simulated in subzones
	MIN-CFM-RATIO	1.0 (Constant Volume System)

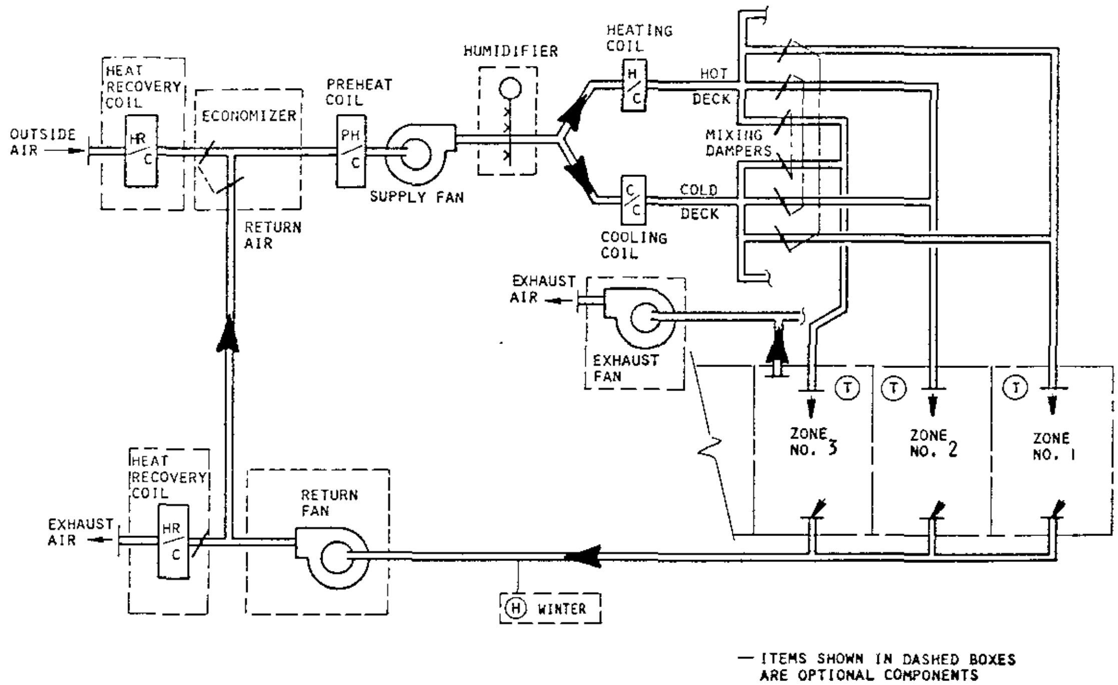
* Required command or keyword.

TABLE IV.4 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=SZRH	*
	ZONE-NAMES	* (First ZONE listed is the control ZONE)
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	SIZING-OPTION	NON-COINCIDENT
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

c. Multizone Fan System (MZS)



The multizone type fan system is illustrated in the schematic above. In its most basic configuration, the system provides constant flow, forced air heating and cooling to multiple, individually controlled zones from an air-handling unit containing a filter (not shown), a blow-through type supply fan, a heating coil, and a 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 fan(s) are optional for any or all zones. The program assumes the existence of 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. 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.5 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).

TABLE IV.5

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM MZS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STASTIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-CONTROL	CONSTANT
	HEAT-SET-T	MAX-SUPPLY-T if HEAT-CONTROL = CONSTANT
	HEAT-RESET-SCH	* (only if HEAT-CONTROL=RESET)
	HEAT-SET-SCH	* (only if HEAT-CONTROL=SCHEDULED)
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.5 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.723°F
	SUPPLY-KW	0.00088 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC)	(If neither pair, (RETURN-STATIC,
	RETURN-EFF)	(RETURN-EFF) or (RETURN-DELTA-T,
	RETURN-DELTA-T)	(RETURN-KW), is specified,
	RETURN-KW)	(no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	MIN-CFM-RATIO	1.0 (Constant volume system)
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.078
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102

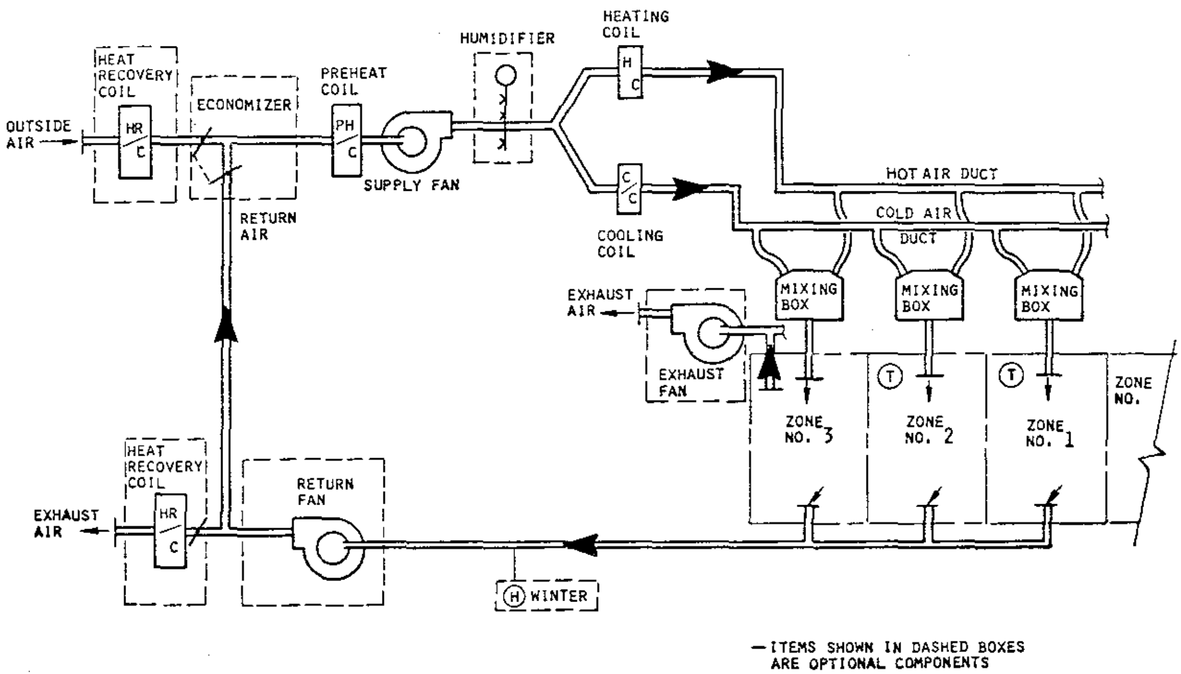
* Required command or keyword.
**Required only if this keyword is entered as a subcommand.

TABLE IV.5 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-EQUIPMENT (continued)	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=MZS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	SIZING-OPTION	NON-COINCIDENT
	HCOIL-WIPE-FCFM	No effect
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

d. Dual-Duct Fan System (DDS)



The dual-duct type fan system, illustrated in the schematic above, can be either the constant volume or variable volume type.

The constant-volume type is identical to the multizone type of system (see MZS for description), 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 type dual duct system is as described above, 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 fan(s) are optional for any or all zones. The program assumes the existence of a preheat coil and calculates the preheat load, if and when the mixed air temperature falls below the required PREHEAT-T. 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.6 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.6

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM DDS

Command	Keyword	Default Value or Consequences
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-CONTROL	CONSTANT
	HEAT-SET-T	MAX-SUPPLY-T if HEAT-CONTROL = CONSTANT
	HEAT-RESET-SCH	* (only if HEAT-CONTROL=RESET)
	HEAT-SET-SCH	* (only if HEAT-CONTROL=SCHEDULED)
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.6 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	3.37°F
	SUPPLY-KW	.00109 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified, no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	MIN-CFM-RATIO	1.0 (Constant volume system)
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

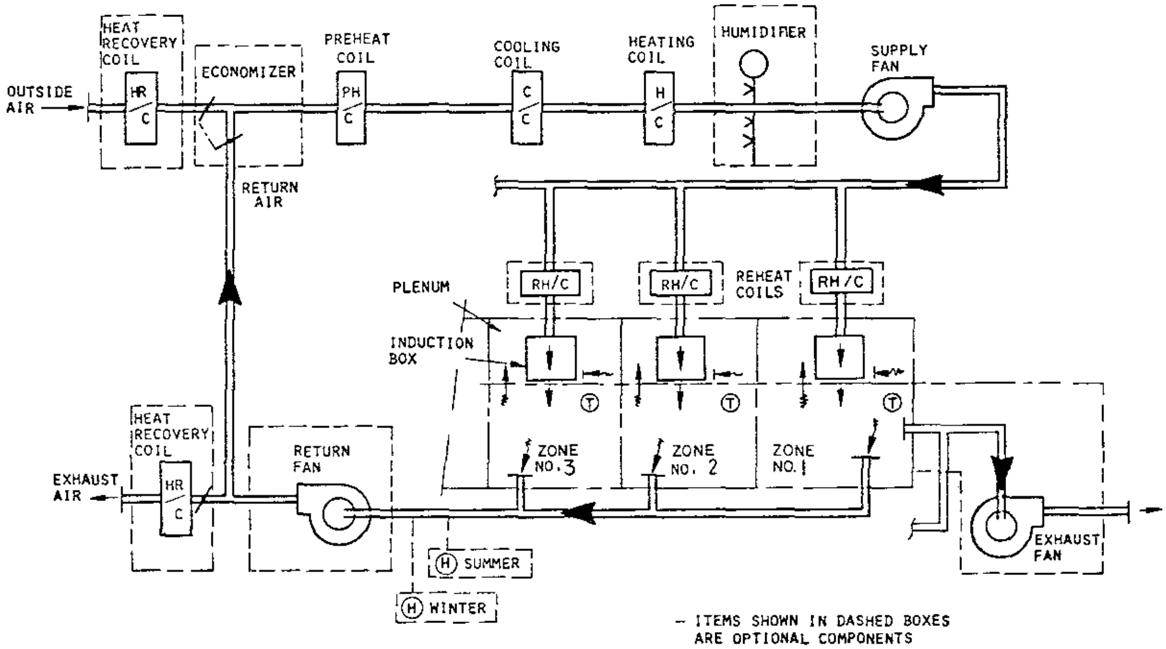
* Required command or keyword

TABLE IV.6 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=DDS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	HCOIL-WIPE-FCFM	No effect
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if the keyword is entered as a subcommand.

e. Ceiling Induction System (SZCI)



This system is identical to the Variable Volume Fan System (VAVS) in any of its optional configurations, with the addition of induction mixing boxes to provide individual temperature control for one or more zones. Total system air flow is affected by operation of the induction box units. These units reduce supply air flow during periods when supply air is colder than required by their respective subzones, while simultaneously introducing room (or ceiling plenum) air into the mixing box, so that the flow of air into the space remains relatively constant. Because induction flow is limited to a maximum of 50 per cent, reheat coils may be installed if further primary air heating is required.

Exhaust fan(s) are optional for any or all zones. The program assumes that a heating coil is installed (downstream of the cooling coil) if maximum humidity control is specified (keyword MAX-HUMIDITY). 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.7 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.7

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM SZCI

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER IN LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	MAX-SUPPLY-T (for design purposes)
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.7 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	3.11°F
	SUPPLY-KW	.00101 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified, no return fan is simulated
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	REHEAT-DELTA-T	No reheat simulated
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

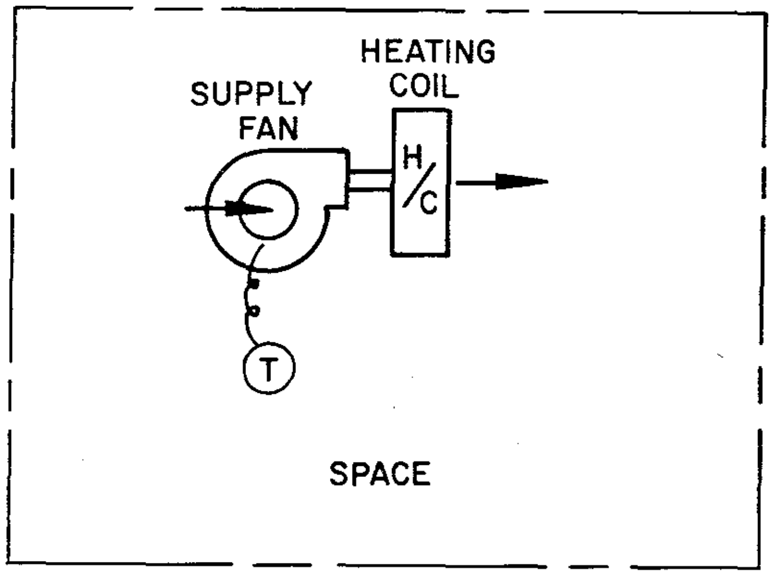
*Required command or keyword.

TABLE IV.7 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=SZCI	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenums

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

f. 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is <u>highly recommended</u> that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.8 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

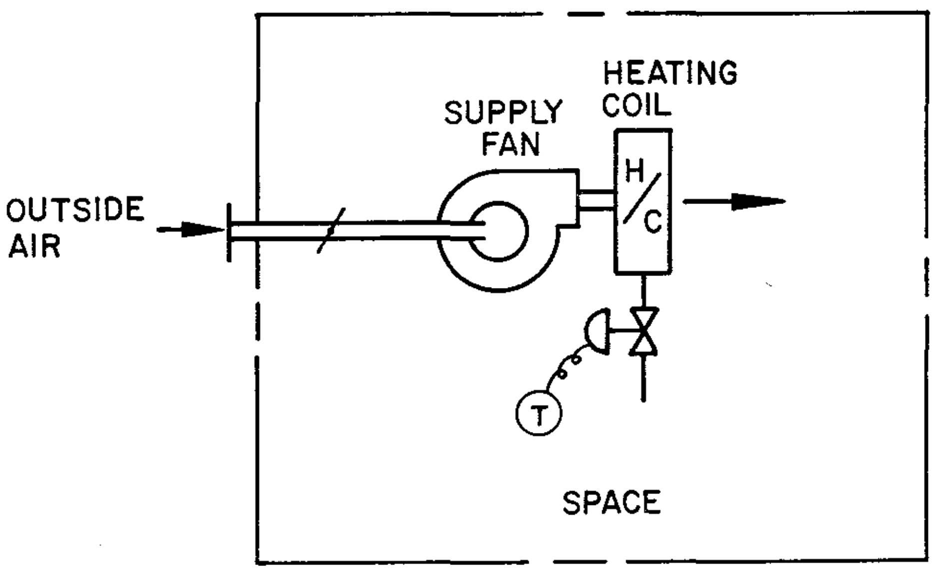
TABLE IV.8

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM UHT

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	$2^{o}F$
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	RATED-CFM	No performance adjustment
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	BASEBOARD-SCH	Always off
SYSTEM-AIR	RATED-CFM	No performance adjustment
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	0.218°F
	SUPPLY-KW	.00007 kW/cfm
	FAN-SCHEDULE	Always on
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-EQUIPMENT	HEATING-CAPACITY	Dependent on peak loads
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=UHT	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

g. 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 (see SYSTEM-AIR and ZONE-AIR instructions).

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.9 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.9

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM UVT

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No openable damper (fixed)
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	RATED-CFM	No performance adjustment
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	BASEBOARD-SCH	Always off
SYSTEM-AIR	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	MAX-OA-FRACTION	1.0
	RATED-CFM	No performance adjustment
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	0.182°F
	SUPPLY-KW	.000059 kW/cfm
	FAN-SCHEDULE	Always on
	NIGHT-CYCLE-CTRL	CYCLE-ON-ANY (but with no outside air)
SYSTEM-EQUIPMENT	HEATING-CAPACITY	Dependent on peak loads
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

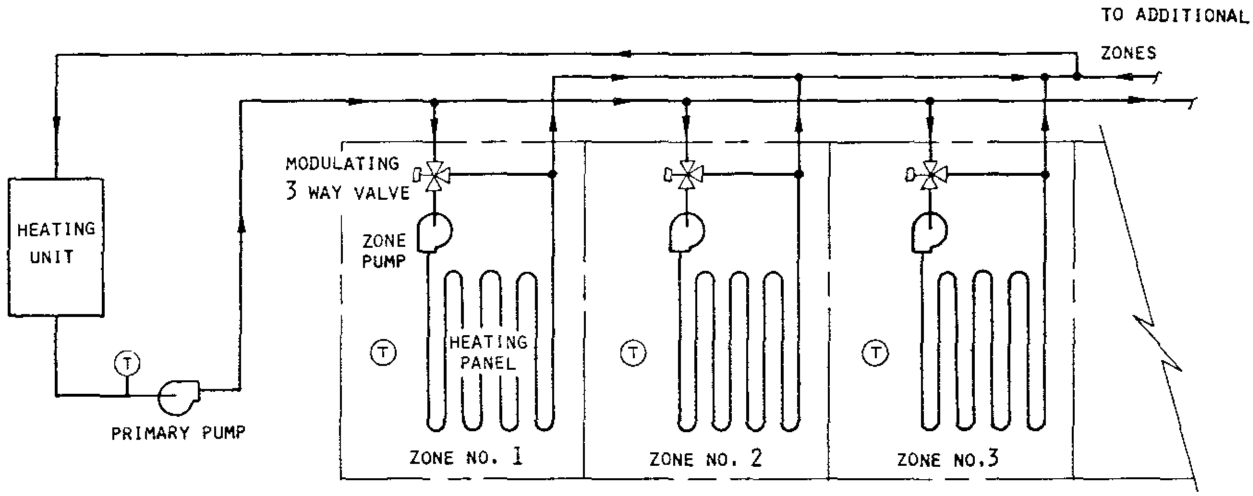
* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.9 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=UVT	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

h. Floor Panel Heating System (FPH)



The Floor Panel Heating system, illustrated in the schematic above, provides heating for one or more zones by circulation of heated fluid through a network of pipes embedded in the floor or ceiling. A single pump, rather than the primary-secondary pumping arrangement shown, is installed for single-zone systems. Space temperature in each zone is controlled by varying the temperature of the fluid circulating in that zone.

Hourly heat addition rate is determined for this system exactly as for other types of systems (see Sec. A, subsection 4 of this chapter). Note that pumping energy associated with this system is accounted for by the PLANT program, rather than the SYSTEMS program (see Chap. V).

The ratio of panel heat losses to panel heating output must be estimated by the user and entered (see keyword PANEL-HEAT-LOSS in the ZONE instruction). The program assumes that this ratio of heat loss to heat output remains constant over the full range of panel output.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is <u>highly recommended</u> that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.10 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

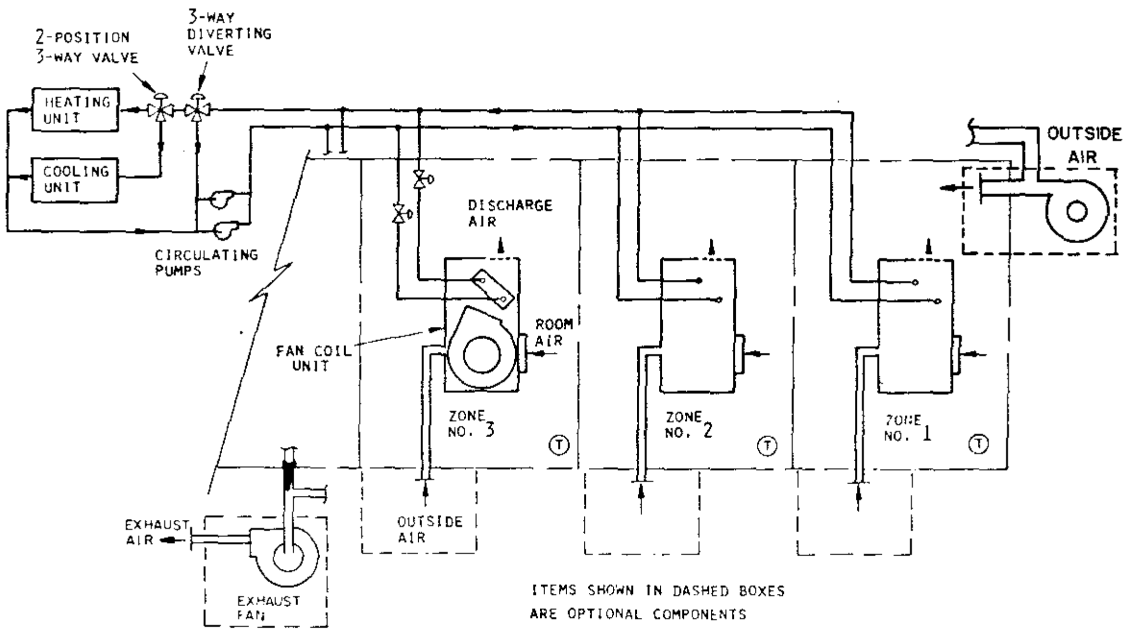
TABLE IV.10

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM FPH

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	* (Required but not used)
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2^oF
ZONE	ZONE-CONTROL	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	PANEL-LOSS-RATIO	0.0
SYSTEM-CONTROL	HEATING-SCHEDULE	Always on
SYSTEM	SYSTEM-TYPE=FPH	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

i. Two-Pipe Fan Coil System (TPFC)



The Two-Pipe Fan Coil system, illustrated in the schematic above, can provide both heating and cooling to a number of individually controlled zones. However, all zones served by the system must be operating in the same mode (i.e., either heating or cooling) at any given time.

The fan coil unit consists of a filter (not shown), a combination heating/cooling coil, and a fan. The coil is connected to a piping system that can provide either hot or cold water (according to the prevailing mode of operation as defined by the HEATING-SCHEDULE and COOLING-SCHEDULE). The unit can provide a fixed quantity of outside air ventilation or merely recirculate conditioned air. Exhaust fan(s) 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 set points.

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

Note that 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 of a specific, commercially available unit is recommended for improved simulation accuracy. An alternative to this is, if the user has to select a fan that is significantly different in capacity from the calculated value (that is, one that will be forced to operate above or below its rated capacity to meet the calculated value), he may elect to specify data for the keyword RATED-CFM (see ZONE-AIR command).

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.11 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.11

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM TPFC

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	RATED-CFM	From SYSTEM-AIR
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
	COOLING-CAPACITY	From SYSTEM-EQUIPMENT
	COOL-SH-CAP	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	MIN-HUMIDITY	No humidification
	BASEBOARD-SCH	Always off
SYSTEM-AIR	RATED-CFM	No performance adjustment
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None

* Required command or keyword.

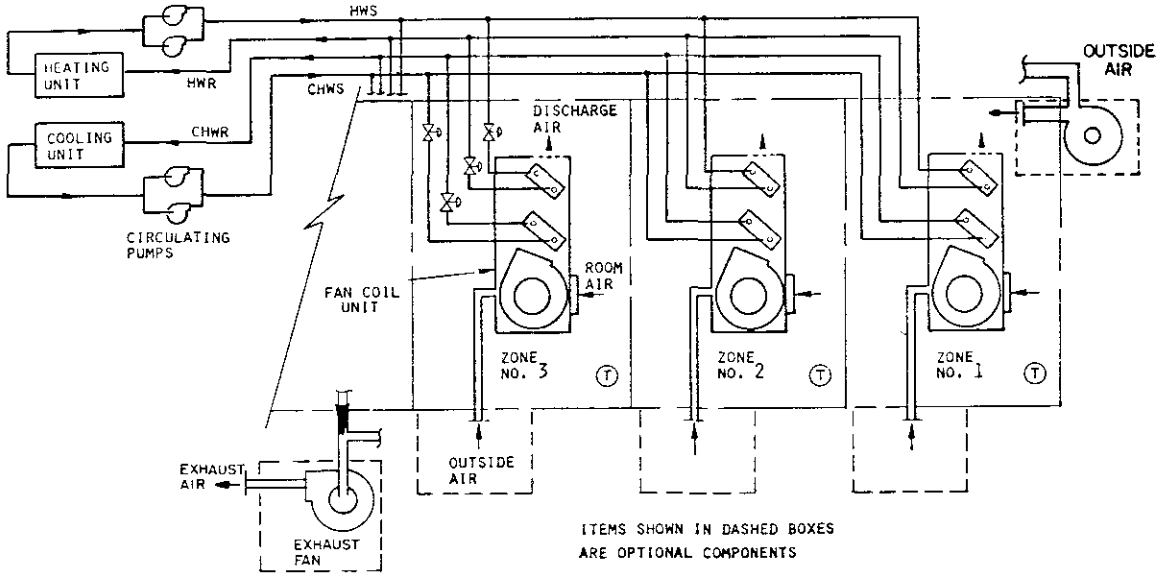
** Required only if this keyword is entered as a subcommand.

TABLE IV.11 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	0.218°F
	SUPPLY-KW	.00007 kW/cfm
	FAN-SCHEDULE	Always on
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C10
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-30
	COIL-BF	.14
	COIL-BF-FCFM	Standard curve SDL-C40
	COIL-BF-FT	Standard curve SDL-C50
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C81
	RATED-SH-FCFM	Standard curve SDL-C88
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C103
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=TPFC	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

j. Four-Pipe Fan Coil System (FPFC)



The Four-Pipe Fan Coil system, illustrated in the schematic above, is identical to the Two-Pipe Fan Coil system (TPFC), with the following exceptions: 1) the fan coil units have separate heating and cooling coils (rather than a combined heating/cooling coil), and 2) each coil is connected to a separate piping system, one circulating cooled fluid and one circulating heated fluid. Thus, the fan coil, or coils, in one zone can cool at the same time that those in another zone are heating, and changeover energy losses are minimal. Exhaust fan(s) are optional for any or all zones. Additionally, humidity control by subcooling and reheating of air in the same fan coil unit is possible. Except as noted above, the discussion of system design features, options, and SDL input language for TPFC applies as well to this system.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.12 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.12

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM FPFC

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	RATED-CFM	From SYSTEM-AIR
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
	COOLING-CAPACITY	From SYSTEM-EQUIPMENT
	COOL-SH-CAP	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	MIN-HUMIDITY	No humidification
	BASEBOARD-SCH	Always off
SYSTEM-AIR	RATED-CFM	No performance adjustment
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None

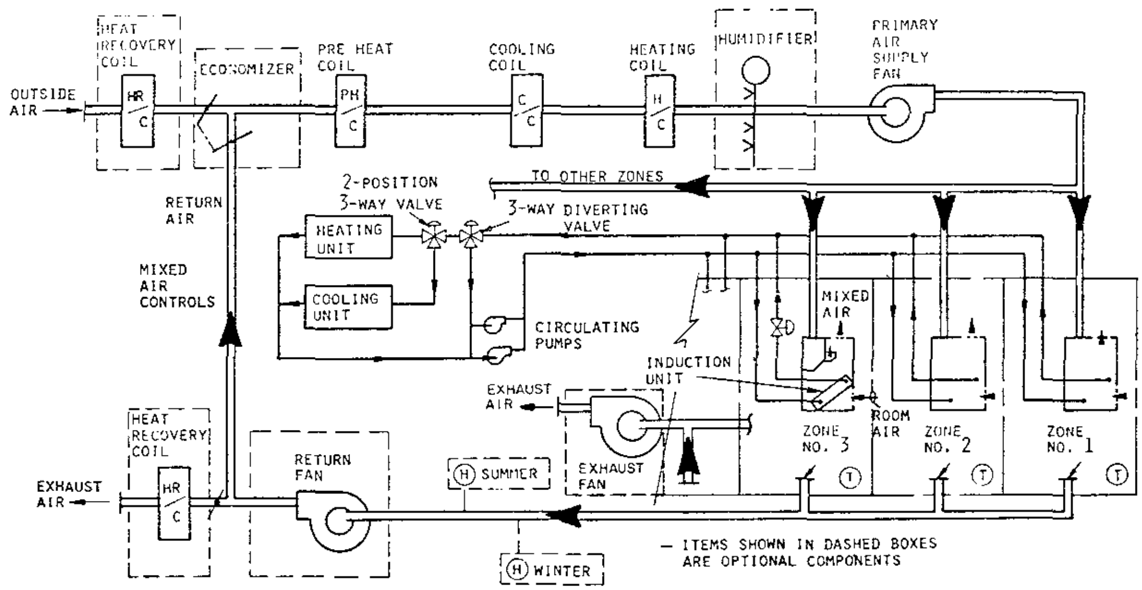
* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.12 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	.218°F
	SUPPLY-KW	.00007 kW/cfm
	FAN-SCHEDULE	Always on
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C10
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C30
	COIL-BF	.14
	COIL-BF-FCFM	Standard curve SDL-C40
	COIL-BF-FT	Standard curve SDL-C50
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C81
	RATED-SH-FCFM	Standard curve SDL-C88
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C103
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=FPFC	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

k. Two-Pipe Induction Unit System (TPIU)



The Two-Pipe Induction Unit system, illustrated above, is a mixed air-hydronic system that can provide both heating and cooling to a number of individually controlled zones. However, all zones served by the system must be operating in the same mode (i.e., either heating or cooling) at any given time. Exhaust fan(s) are optional for any or all zones.

A constant flow rate of primary air is supplied to induction-type terminal devices in each zone. The primary air is discharged through the nozzles in each terminal unit, thus providing the motive force for drawing room air over a combination heating/cooling coil. The coil is connected to a piping system that can provide either hot or cold water (according to the prevailing mode of operation). These systems are commonly designed so that only sensible cooling, and no dehumidification, can be done in the induction unit. 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.

In its most basic configuration, the primary air system consists of a filter (not shown), cooling/heating coil, a draw-through supply fan, and air distribution ducts. It is often designed to provide 100 per cent outside air; however, an economizer cycle or total recirculation can be specified (see discussion of options).

Temperature control is achieved by throttling the flow of water through the heating/cooling coil in the terminal unit. The control thermostat commonly used for this type of system has separate heating and cooling set points. Thermostat set point is alternated with each changeover from heating to cooling and from cooling to heating.

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

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.13 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.13

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM TPIU

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
	COOLING-CAPACITY	From SYSTEM-EQUIPMENT
	COOL-SH-CAP	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	MIN-SUPPLY-T
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.13 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	4.467°F
	SUPPLY-KW	.001445 kW/cfm
	FAN-SCHEDULE	Always on
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	RETURN-STATIC	If neither pair, (RETURN-STATIC,
	RETURN-EFF	RETURN-EFF) or (RETURN-DELTA-T,
	RETURN-DELTA-T	RETURN-KW), is specified
	RETURN-KW	no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-TERMINAL	INDUCTION-RATIO	*
SYSTEM-FLUID	INDUC-MODE-SCH	*
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

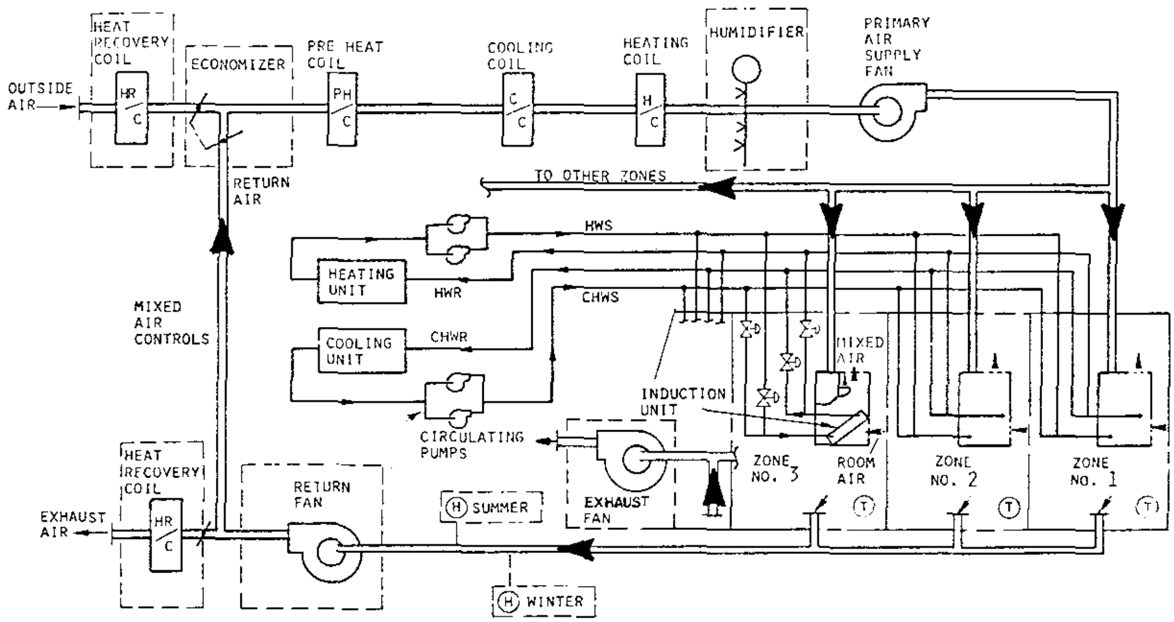
*Required command or keyword.

TABLE IV.13 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=TPIU	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-FLUID	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

1. Four-Pipe Induction Unit System (FPIU)



The Four-Pipe Induction Unit system, illustrated above, is identical to the Two-Pipe Induction Unit system (TPIU), except that the coil located in each terminal induction unit is connected to two different piping systems, one circulating cooled fluid and one circulating heated fluid. Thus, the induction unit in one zone can provide heating, by selecting flow from the heated fluid circulation piping, at the same time that a unit in another zone is providing cooling, by selecting flow from the cold fluid circulating system. Changeover energy losses are minimal, and are not taken into account by the program. The control system for each unit provides automatic switchover from cooling to heating (and vice versa) as required to maintain space temperature conditions. With the exception noted above, the discussion of system design features and options for System TPIU also applies to this system.

Exhaust fan(s) are optional for any or all zones. 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.14 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.14

APPLICABILITY OF COMMANDS KEYWORDS TO SYSTEM FPIU

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGE/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
	COOLING-CAPACITY	From SYSTEM-EQUIPMENT
	COOL-SH-CAP	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	MIN-SUPPLY-T
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.14 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	4.467°F
	SUPPLY-KW	.001445 kW/cfm
	FAN-SCHEDULE	Always on
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	RETURN-STATIC	If neither pair, (RETURN-STATIC,
	RETURN-EFF	RETURN-EFF) or (RETURN-DELTA-T
	RETURN-DELTA-T	RETURN-KW), is specified,
	RETURN-KW	no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-TERMINAL	INDUCTION-RATIO	*
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

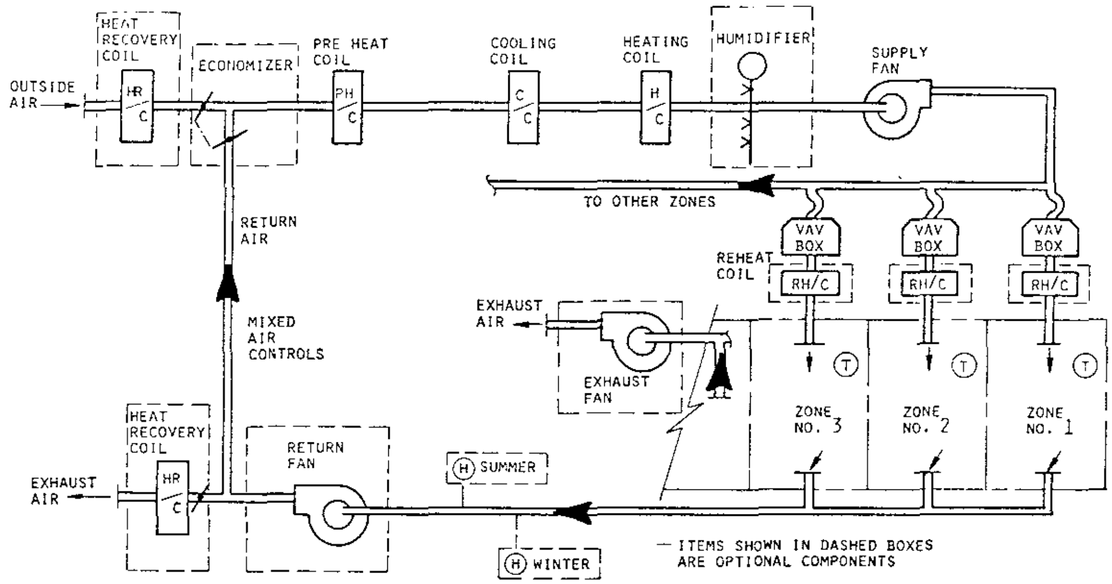
*Required command or keyword.

TABLE IV.14 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=FPIU	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

m. Variable-Volume Fan System w/Optional Reheat (VAVS)



The Variable-Volume Fan System is illustrated in the schematic above. In its most basic configuration, it 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 fan(s) 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 <u>if</u> 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is <u>highly recommended</u> that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.15 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.15

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM VAVS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
	CFM/SQFT	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
	ASSIGNED-CFM	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	(MIN-SUPPLY-T) + (REHEAT-DELTA-T)
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	No main heating coil capacity
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.

** Required only if this keyword is entered as a subcommand.

TABLE IV.15 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	3.37°F
	SUPPLY-KW	.00109 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	INLET
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified, no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	REHEAT-DELTA-T	No reheat simulated
	MIN-CFM-RATIO	From outside air or heating load
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

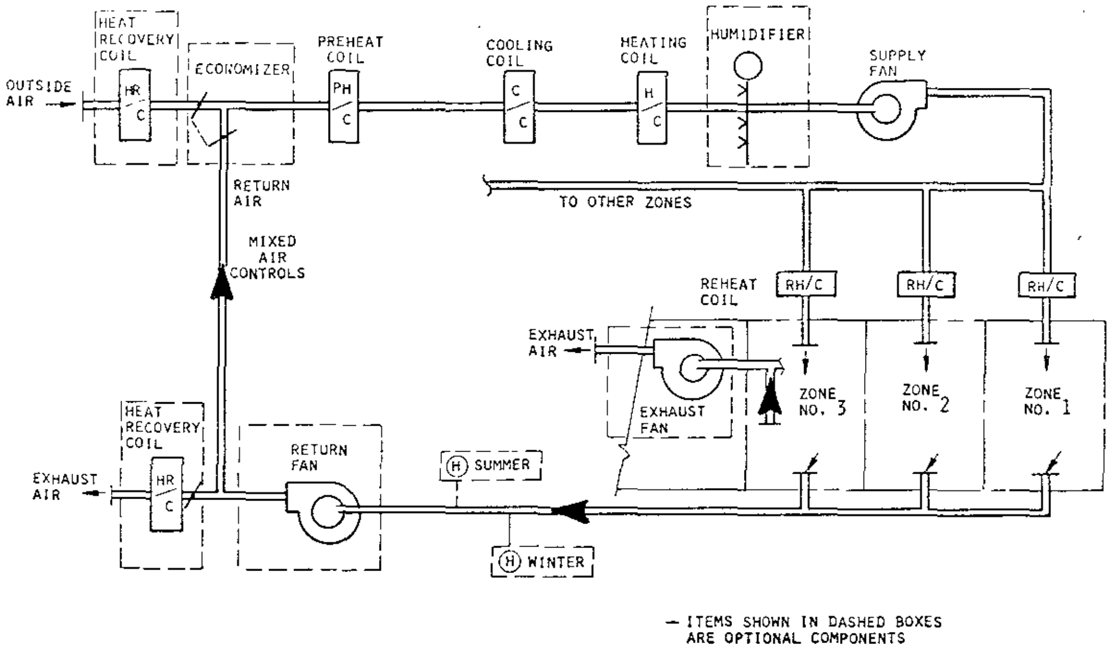
* Required command or keyword.

TABLE IV.15 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=VAVS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

n. Constant-Volume Reheat Fan System (RHFS)



The Constant-Volume Reheat Fan System is illustrated in the schematic above. In its most basic configuration, the system 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 fan(s) 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 the moisture that is added to the air stream, to maintain a minimum humidity, is passed to the PLANT program as a heating load.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.16 shows the command and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.16

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM RHFS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
SYSTEM-CONTROL	MAX-SUPPLY-T	(MIN-SUPPLY-T) + (REHEAT-DELTA-T)
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	MAX-SUPPLY-T
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

*Required command or keyword.
**Required only if this keyword is entered as a subcommand.

TABLE IV.16 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	3.11°F
	SUPPLY-KW	.00101 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified, no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	REHEAT-DELTA-T	*
	MIN-CFM-RATIO	1.0 (constant volume system)
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

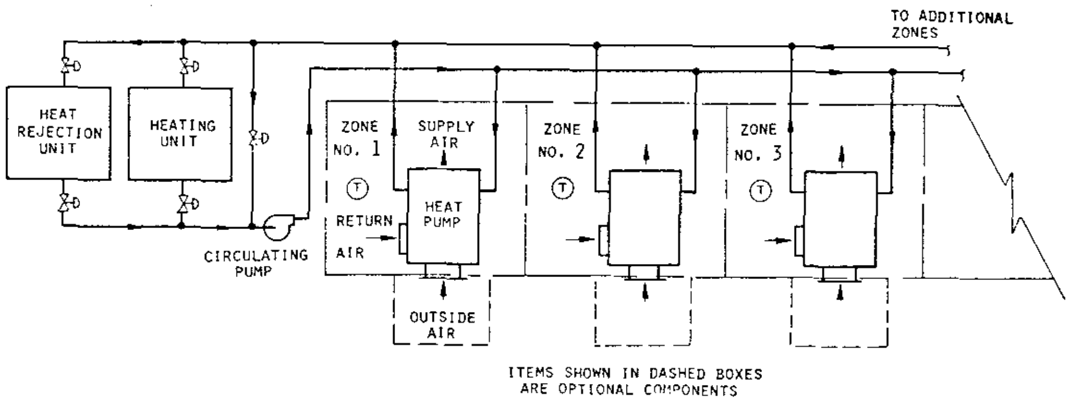
*Required command or keyword.

TABLE IV.16 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=RHFS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

o. Unitary Hydronic Heat Pump System (HP)



The Unitary Hydronic Heat Pump System, illustrated above, provides heating and cooling for a number of individually controlled zones by operation of 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, a room air-to-refrigerant heat exchanger, a 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, a supply air fan, and a two-set point 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 set points. The heat pump unit provides cooling when space temperature increases to the upper set point, and heating when the space temperature falls to the lower set point; it does not operate when space temperature is between set points. 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 those units that are operating in the cooling mode, and gives up heat to those units that are operating in the heating mode. Because some zone units may be cooling, while others are heating, the temperature of the fluid circulating 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 instruction), heat is dissipated to the atmosphere through an evaporative cooler (or a 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 70°F and 90°F. This allows the circulating piping loop to be uninsulated.

The heat rejection unit (evaporative condenser or cooling tower), heating unit, and circulating pump are simulated by the PLANT program.

The program assumes that the heat pump requires COOLING-EIR Btu of equivalent electrical energy for each Btu of heat extracted from the space, and HEATING-EIR Btu of equivalent electrical energy for each Btu of heat added to the space. Of course, COOLING-EIR is corrected by COOL-EIR-FT, COOL-EIR-FPLR, and RATED-CEIR-FCFM, using either the default curves or the user-supplied curves. The same is true for HEATING-EIR.

Note that the heat pump units, particularly in the smaller sizes equipped with direct-drive fans, may not be available with a fan capacity that matches the calculated value. Similarly, heat pump units that can match both calculated heating and calculated cooling requirements are probably not available. Therefore, assignment of the heating capacity, cooling capacity, and fan capacity of a specific, commercially available heat pump unit is recommended for improved simulation accuracy. An alternative to assigning fan capacity is to select an available fan with a rated capacity relatively close to the calculated fan capacity and then specify data for the keyword RATED-CFM (see ZONE-AIR subcommand).

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is <u>highly recommended</u> that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.17 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.17

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM HP

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
	CFM/SQFT	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
	ASSIGNED-CFM	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
	RATED-CFM	From SYSTEM-AIR
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
	COOLING-CAPACITY	From SYSTEM-EQUIPMENT
	COOL-SH-CAP	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	BASEBOARD-SCH	Always off
SYSTEM-AIR	RATED-CFM	No performance adjustment
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	.218°F
	SUPPLY-KW	.00007 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CYCLING
	NIGHT-CYCLE-CTRL	STAY-OFF

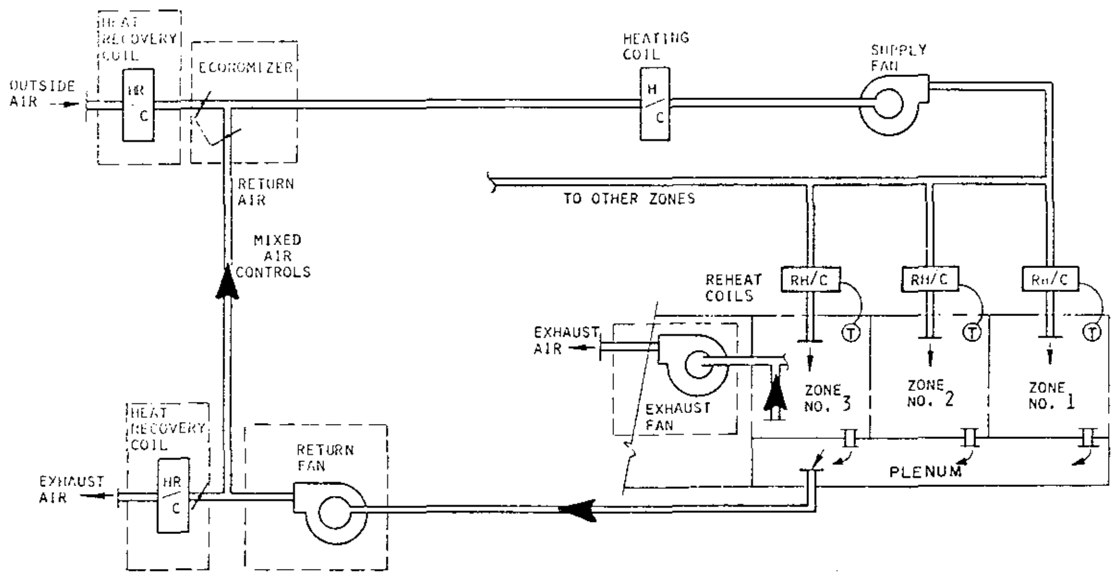
* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.17 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-FLUID	MIN-FLUID-T	*
	MAX-FLUID-T	*
	FLUID-HEAT-CAP	*
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C5
	COOLING-EIR	.382 Btu/Btu
	COOL-EIR-FT	Standard curve SDL-C15
	COOL-EIR-FPLR	Standard curve SDL-C20
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C25
	COIL-BF	0.241
	COIL-BF-FCFM	Standard curve SDL-C35
	COIL-BF-FT	Standard curve SDL-C45
	RATED-CCAP-FCFM	Standard curve SDL-C79
	RATED-CEIR-FCFM	Standard curve SDL-C94
	RATED-SH-FCFM	Standard curve SDL-C86
	RATED-HCAP-FCFM	Standard curve SDL-C101
	RATED-HEIR-FCFM	Standard curve SDL-C109
	HEATING-CAPACITY	Dependent on peak loads
	HEAT-CAP-FT	Standard curve SDL-C55
	HEATING-EIR	.357 Btu/Btu
	HEAT-EIR-FT	Standard curve SDL-C60
	HEAT-EIR-FPLR	Standard curve SDL-C65
	ELEC-HEAT-CAP	From heating load
SYSTEM	SYSTEM-TYPE=HP	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-FLUID	**
	SYSTEM-EQUIPMENT	**
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

p. Heating and Ventilating System (HVSYS)



The Heating and Ventilating System, illustrated above, is a constant volume system without cooling capability or humidity control. In its most basic configuration, the system provides forced air heating from an air-handling unit that contains a heating coil, filters (not shown), and a supply fan. The amount of heat added by the zone coil is controlled from a thermostat that senses zone temperature. The main air handler heating coil can be controlled by various strategies or held constant in temperature (see HEAT-CONTROL). The system may be specified to provide outside air ventilation, exhaust air, baseboard heating, and heat recovery.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.18 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).

TABLE IV.18

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM HVSYS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	HEAT-CONTROL	CONSTANT
	HEAT-SET-T	MAX-SUPPLY-T if HEAT-CONTROL ≠ CONSTANT; otherwise, the weighted average of DESIGN-HEAT-T for all ZONEs in the SYSTEM
	HEAT-RESET-SCH	*(only if HEAT-CONTROL=RESET)
	HEAT-SET-SCH	*(only if HEAT-CONTROL=SCHEDULED)
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none

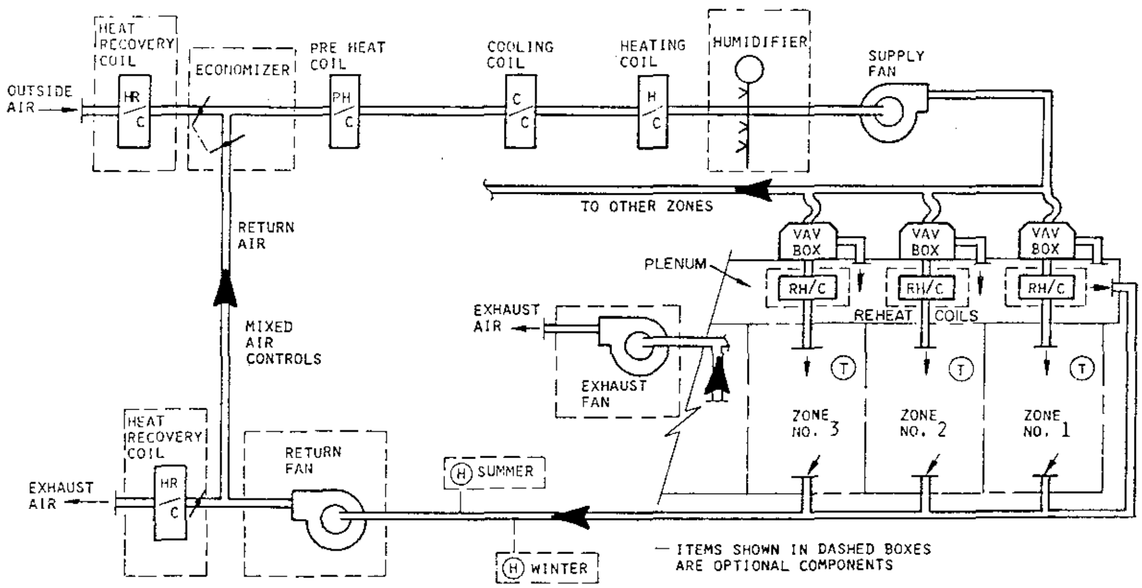
* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.18 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.42°F
	SUPPLY-KW	0.000783 kW/cfm
	FAN-SCHEDULE	Always on
	MOTOR-PLACEMENT	IN-AIRFLOW
	RETURN-STATIC)	(If neither pair, (RETURN-STATIC,
	RETURN-EFF)	(RETURN-EFF) or (RETURN-DELTA-T,
	RETURN-DELTA-T)	(RETURN-KW), is specified,
	RETURN-KW)	(no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-TERMINAL	REHEAT-DELTA-T	No reheat simulated
SYSTEM-EQUIPMENT***	HEATING-CAPACITY	Dependent on peak loads
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=HVSYS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	SIZING-RATIO	1.0
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.
*** If HEAT-SOURCE is not equal to OIL-FURNACE or GAS-FURNACE, this command, or any of its associated keywords, should not be specified (a furnace will not be simulated).

q. Ceiling Bypass Variable-Volume System (CBVAV)



The Ceiling Bypass Variable-Volume system, illustrated above, is exactly the same as the variable volume fan system (VAVS) with one exception: the method of reducing the air supply when the zone temperature falls below the thermostat setpoint. Instead of throttling to reduce flow, the zone VAV box opens a damper that diverts flow to the plenum space above the zone. Thus, total air supply in the duct remains constant, even at part-load. This arrangement is most commonly used for systems that are too small for the economical use of flow reduction devices, such as inlet vanes or variable-speed drives. Exhaust fan(s) are optional for any or all zones. The discussion of system design features for VAVS applies as well to this system. 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.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.19 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

TABLE IV.19

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM CBVAV

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	(MIN-SUPPLY-T) + (REHEAT-DELTA-T)
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	No main heating coil capacity
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	PREHEAT-T	45°F
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

*Required command or keyword.
**Required only if this keyword is entered as a subcommand.

TABLE IV.19 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.42°F
	SUPPLY-KW	.000783 kW/cfm
	FAN-SCHEDULE	Always on
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	RETURN-STATIC)	(If neither pair, (RETURN-STATIC,
	RETURN-EFF)	(RETURN-EFF) or (RETURN-DELTA-T,
	RETURN-DELTA-T)	(RETURN-KW), is specified,
	RETURN-KW)	(no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
SYSTEM-TERMINAL	REHEAT-DELTA-T	0. (No reheat simulated)
	MIN-CFM-RATIO	From outside air or heating load.
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C7
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C27
	COIL-BF	0.037
	COIL-BF-FCFM	Standard curve SDL-C38
	COIL-BF-FT	Standard curve SDL-C48
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C80
	RATED-SH-FCFM	Standard curve SDL-C87
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C102
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

* Required command or keyword.

TABLE IV.19 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=CBVAV	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	PREHEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	HOT-WATER
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	SIZING-RATIO	1.0
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenums

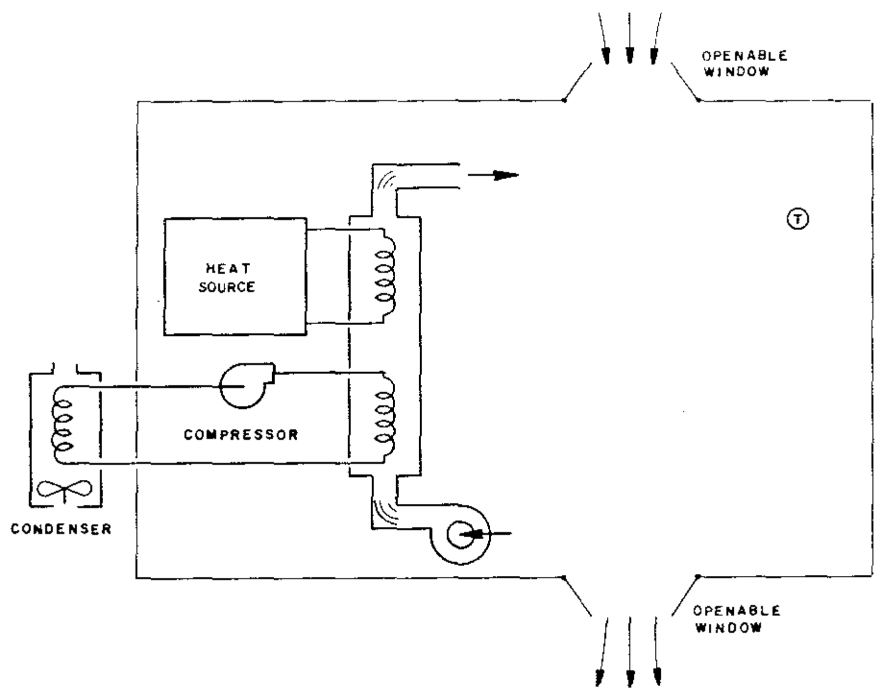
* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

r. Residential System (RESYS)

The Residential System models direct expansion air-cooled air conditioning and forced air heating for residences. Residences that do not include unconditioned zones, such as 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/heating by outdoor air. The ventilation is simulated through the keywords NATURAL-VENT-SCH, VENT-TEMP-SCH, and NATURAL-VENT-AC. (The simulation theory can be found in the SYSTEM-AIR section of this chapter.)

<u>DX Cooling with a Heating Coil:</u>



This version of the RESYS system provides heating through a hot water coil, an electric heater, a gas furnace, an oil furnace, or the heating load can be passed to PLANT (CBS) for solar heat. The system also includes a cooling coil with a compressor and an air-cooled condenser, a supply fan, and openable windows to provide natural ventilation and outside cooling/heating. Ordinarily, the electric load for the supply fan and compressor are included in the cooling EIR. The user may separate these out by specifying SUPPLY-KW, SUPPLY-STATIC, and SUPPLY-EFF for the supply fan and OUTSIDE-FAN-KW and COOLING-EIR for the condenser fan and compressor, respectively.*

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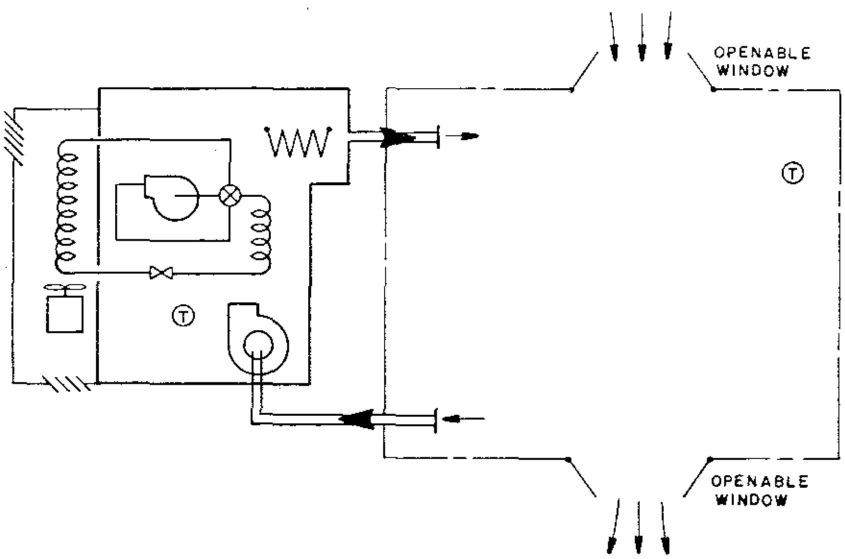
* In the BEPS report in PLANT the fan electric energy for this system will appear as the electric contribution to SPACE COOLING and not to HVAC AUXILIARY, if these keywords are not provided.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.20 shows the commands and keywords that must be entered for simulation of this version of the system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted.)

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 first two paragraphs of RESYS system description apply also to this version of the system. This unit provides forced-air heating and cooling. In its basic configuration the Residential Heat Pump con- sists of a compressor, a four-way valve for reversing the refrigerant flow direction, an air-cooled condenser with fan, an evaporator with fan, a filter (not shown), and a thermostat. The condenser also serves as an evaporator and the evaporator also serves as condenser, depending on whether the unit is in the heating or cooling mode of operation. 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 specify this type of RESYS, specify HEAT-SOURCE = HEAT-PUMP (plus the other keywords appropriate to a heat pump, if desired).

Optionally, solar heating may be specified for the RESYS system. Note: If solar heating is specified (HEAT-SOURCE = HOT-WATER/SOLAR), a different philosophy is involved. While the cooling system will be simulated here in SYSTEMS, the heating system simulation will be accomplished entirely in the subsequent PLANT run, because the solar heating demand must be passed from SYSTEMS to the Solar Simulator (CBS) in PLANT. In CBS the user may select any preassembled residential system or user-assembled residential system. Additionally, the user may assemble his own solar-assisted heat pump system. The heating demand not met by the solar system will then be satisfied by a conventional furnace that must be specified in PLANT. The unsatisfied load cannot be passed back to SYSTEMS. See Chap. V., Sec. C. for other equipment combinations that are available.

If solar heating is not chosen, the heating load will be met here in SYSTEMS and a utility load will be passed to PLANT.

Table IV.20 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).

A multizone residential system may be modeled with the RESYS system type. The first zone listed under ZONE-NAMES is assumed to have the thermostat and to control the system. The subzones receive air at the times and at the temperature as determined by the thermostat action in the control zone.

TABLE IV.20

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM RESYS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*(Required although not actually used)
	HEAT-TEMP-SCH	*
	DESIGN-COOL-T	*(Required although not actually used)
	COOL-TEMP-SCH	*
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR CFM/SQFT ASSIGNED-CFM	Based on heating/cooling loads, supply air, ΔT, and sizing ratio
ZONE	ZONE-CONTROL	**
	ZONE-TYPE	CONDITIONED (PLENUM not allowed)
	BASEBOARD-RATING	no baseboard heating
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	BASEBOARD-SCH	Always off
SYSTEM-AIR	SUPPLY-CFM	From loads or capacities
	RATED-CFM	No performance adjustment
	NATURAL-VENT-AC	No natural ventilation
	NATURAL-VENT-SCH	No natural ventilation
	VENT-TEMP-SCH	HEAT-TEMP-SCH - top of heating T-R
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	.396°F
	SUPPLY-KW	.000128 kW/cfm
	FAN-SCHEDULE	Always on
	LOW-SPEED-RATIOS	*(only if COMPRESSOR-TYPE = DUAL-SPEED). Otherwise, default is 1.,1.,1.,1.
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak load
	COOL-CAP-FT	Standard curve SDL-C1
	COOLING-EIR	0.460 Btu/Btu
	COOL-EIR-FT	Standard curve SDL-C11

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.20 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-EQUIPMENT (continued)		
	COOL-EIR-FPLR	Standard curve SDL-C16
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C21
	COIL-BF	0.241
	COIL-BF-FCFM	Standard curve SDL-C31
	COIL-BF-FT	Standard curve SDL-C41
	COOL-FT-MIN	70°F
	CRANKCASE-HEAT	0.05 kW
	CRANKCASE-MAX-T	65°F
	OUTSIDE-FAN-KW	No explicit condenser fan electric energy
	OUTSIDE-FAN-T	Fan always on
	OUTSIDE-FAN-MODE	INTERMITTENT
	COMPRESSOR-TYPE	SINGLE-SPEED
	RATED-CCAP-FCFM	Standard curve SDL-C76
	RATED-SH-FCFM	Standard curve SDL-C83
	RATED-CEIR-FCFM	Standard curve SDL-C91
	HEATING-CAPACITY	From loads ***
	RATED-HCAP-FCFM	Standard curve SDL-C98 ***
	RATED-HEIR-FCFM	Standard curve SDL-C105 ***
	HEAT-CAP-FT	Standard curve SDL-C51 ***
	HEATING-EIR	0.360 Btu/Btu ***
	HEAT-EIR-FT	Standard curve SDL-C56 ***
	HEAT-EIR-FPLR	Standard curve SDL-C61 ***
	ELEC-HEAT-CAP	From heating load ***
	MIN-HP-T	10.0°F ***
	MAX-ELEC-T	17.0°F ***
	DEFROST-T	No defrost cycle for heat pump ***
	DEFROST-DEGRADE	No effect ***
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=RESYS	*
	ZONE-NAMES	* (First ZONE listed is the control ZONE)
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	GAS-FURNACE
	BASEBOARD-SOURCE	ELECTRIC
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.
*** Appropriate only if HEAT-SOURCE = HEAT-PUMP

s. 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 normally 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 desires to have 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 the PSZ system consists of a compressor, an air-cooled condenser, an evaporator with a fan supplying cooled air to the indoors, a filter (not shown), and a thermostat. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The PSZ unit 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 fan, 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.

The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.21 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).

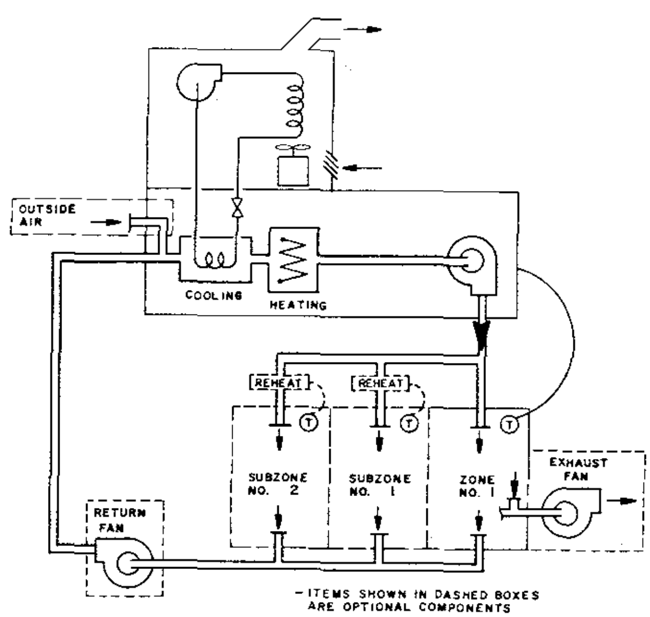


TABLE IV.21

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM PSZ

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal multiplier in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-SET-T	MAX-SUPPLY-T
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.21 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	1.815°F
	SUPPLY-KW	0.000587 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified, no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	REHEAT-DELTA-T	No reheat simulated
	MIN-CFM-RATIO	1.0 (Constant volume system)
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C3
	COOLING-EIR	0.365 Btu/Btu
	COOL-EIR-FT	Standard curve SDL-C13
	COOL-EIR-FPLR	Standard curve SDL-C18
	COOL-SH-CAP	Dependent on peak loads
	COOL-SH-FT	Standard curve SDL-C23
	COIL-BF	0.19
	COIL-BF-FCFM	Standard curve SDL-C33
	COIL-BF-FT	Standard curve SDL-C43

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.21 - Continued

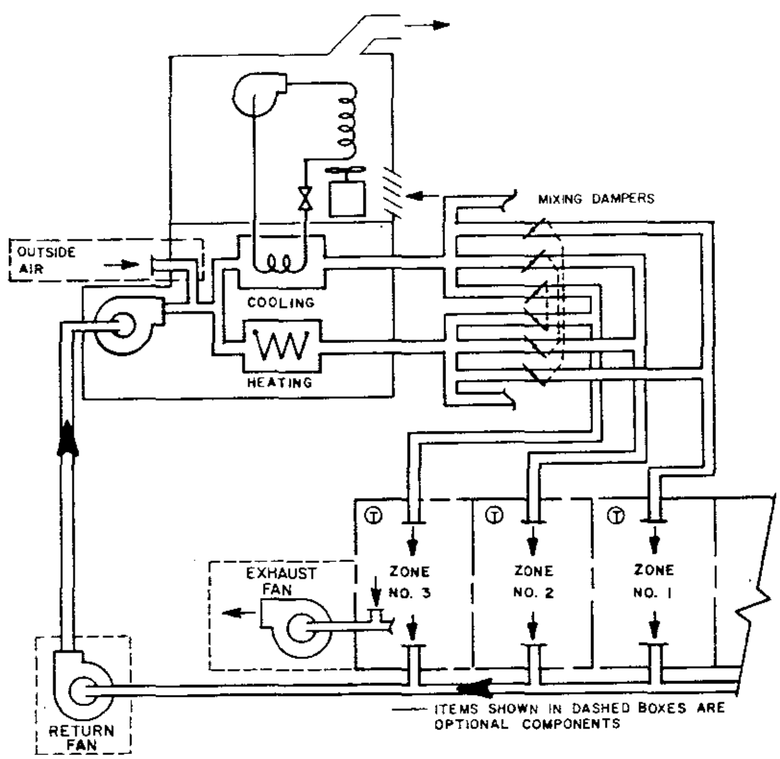
Command	Keyword	Default Value or Consequence
SYSTEM-EQUIPMENT (continued)		
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70°F
	MIN-UNLOAD-RATIO	0.25
	MIN-HGB-RATIO	0.25
	MAX-COND-RCVRY	No heat recovery from condenser
	CRANKCASE-HEAT	0.1 kW
	CRANKCASE-MAX-T	Heater runs when compressor is not on
	OUTSIDE-FAN-KW	No explicit condenser fan electric energy
	OUTSIDE-FAN-T	45.0°F
	OUTSIDE-FAN-MODE	INTERMITTENT
	RATED-CCAP-FCFM	Standard curve SDL-C78
	RATED-SH-FCFM	Standard curve SDL-C85
	RATED-CEIR-FCFM	Standard curve SDL-C93
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C100
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=PSZ	*
	ZONE-NAMES	* (First ZONE listed is the control ZONE)
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	GAS-FURNACE
	ZONE-HEAT-SOURCE	ELECTRIC
	BASEBOARD-SOURCE	ELECTRIC
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

t. Packaged Multizone Fan System (PMZS)

The 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. The unit may have heat recovery from condenser coils. The unit may optionally provide humidity control. The PMZS normally consists of a manufacturer-matched set of components within a single enclosure that is normally rooftop mounted but it may instead be a split unit (partially inside and partially outside.) In its most basic configuration the 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, a filter (not shown), and a thermostat in each zone. The 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 in the airstream 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 the PMZS there is individual control of temperature in the different zones. In the simulation there is no preconditioning of outside ventilation air.



A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.22 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).

TABLE IV.22

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM PMZS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	From EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	HEAT-CONTROL	CONSTANT
	HEAT-SET-T	MAX-SUPPLY-T if HEAT-CONTROL = CONSTANT
	HEAT-RESET-SCH	* (only if HEAT-CONTROL=RESET)
	HEAT-SET-SCH	* (only if HEAT-CONTROL=SCHEDULED)
	COOL-CONTROL	CONSTANT
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.22 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.117°F
	SUPPLY-KW	0.000685 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	CONSTANT-VOLUME
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC RETURN-EFF RETURN-DELTA-T RETURN-KW	If neither pair, (RETURN-STATIC, RETURN-EFF) or (RETURN-DELTA-T, RETURN-KW), is specified, no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	MIN-CFM-RATIO	1.0 (Constant volume system)
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C3
	COOLING-EIR	0.365 Btu/Btu
	COOL-EIR-FT	Standard curve SDL-C13
	COOL-EIR-FPLR	Standard curve SDL-C18
	COOL-SH-CAP	Dependent on peak loads
	COOL-SH-FT	Standard curve SDL-C23
	COIL-BF	0.19
	COIL-BF-FCFM	Standard curve SDL-C33
	COIL-BF-FT	Standard curve SDL-C43
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°F
	MIN-UNLOAD-RATIO	0.25
	MIN-HGB-RATIO	0.25
	MAX-COND-RCVRY	No heat recovery from condenser
	CRANKCASE-HEAT	0.1 kW
	CRANKCASE-MAX-T	Heater runs when compressor is not on

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.22 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-EQUIPMENT (continued)		
	OUTSIDE-FAN-KW	No explicit condenser fan electric energy
	OUTSIDE-FAN-T	45.0°
	OUTSIDE-FAN-MODE	INTERMITTENT
	RATED-CCAP-FCFM	Standard curve SDL-C78
	RATED-SH-FCFM	Standard curve SDL-C85
	RATED-CEIR-FCFM	Standard curve SDL-C93
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C100
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=PMZS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	GAS-FURNACE
	BASEBOARD-SOURCE	ELECTRIC
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	HCOIL-WIPE-FCFM	No effect
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

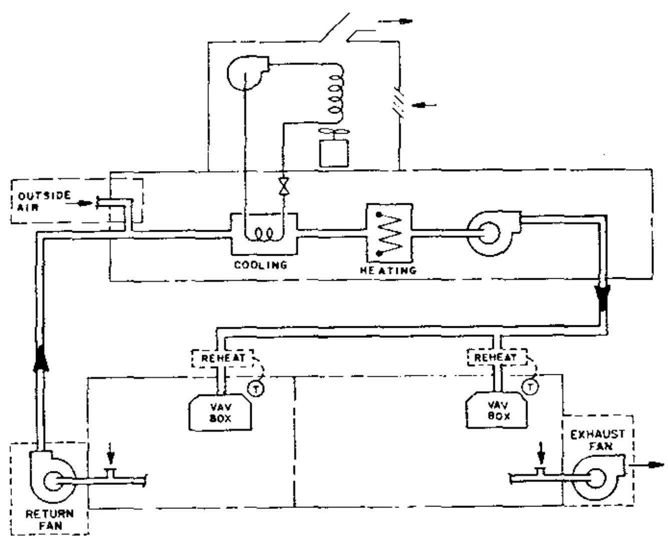
* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

u. Packaged Variable-Air-Volume System (PVAVS)

This 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 the PVAVS system consists of a compressor, an air-cooled condenser with a fan discharging heat to the outdoors, an evaporator with a fan supplying cooled air to the indoors, reheat coils at the ZONE level, a filter (not shown), variable-volume control boxes, and thermostats. The PVAVS unit can optionally be specified with outside ventilating air, an exhaust fan, a return air fan, and economizer control. The supply fan may be either a blowthrough or a draw-through fan, with the fan motor either in the airstream or outside the airstream. The thermostat may be specified with night setback and night cycle control.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.23 shows the commands and keywords that must be specified for the simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted).



- ITEMS SHOWN IN DASHED BOXES ARE OPTIONAL COMPONENTS

TABLE IV.23

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM PVAVS

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR)	(Based on heating/cooling
	CFM/SQFT)	(loads, supply air, ΔT, and
	ASSIGNED-CFM)	(sizing ratio
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	EXHAUST-CFM	0
	EXHAUST-EFF	0.75
	EXHAUST-STATIC	0.0
	EXHAUST-KW	EXHAUST-EFF and EXHAUST-STATIC
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	MIN-CFM-RATIO	From SYSTEM-TERMINAL
SYSTEM-CONTROL	MAX-SUPPLY-T	(MIN-SUPPLY-T) + (REHEAT-DELTA-T)
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	COOL-CONTROL	CONSTANT
	HEAT-SET-T	No main heating coil capacity
	COOL-SET-T	MIN-SUPPLY-T if COOL-CONTROL=CONSTANT
	COOL-RESET-SCH	* (only if COOL-CONTROL=RESET)
	COOL-SET-SCH	* (only if COOL-CONTROL=SCHEDULED)
	MAX-HUMIDITY	No dehumidification control (100. percent)
	MIN-HUMIDITY	No humidification
	ECONO-LIMIT-T	Weighted average DESIGN-COOL-T for all ZONEs in the SYSTEM
	BASEBOARD-SCH	Always off

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.23 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-AIR	SUPPLY-CFM	From ZONE-AIR or load/1.08 x ΔT
	RATED-CFM	No performance adjustment
	RETURN-CFM	SUPPLY-CFM minus EXHAUST-CFM or 0
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
	OA-CONTROL	TEMP
	MAX-OA-FRACTION	1.0
	RECOVERY-EFF	No heat recovery simulated
	DUCT-AIR-LOSS	None
	DUCT-DELTA-T	None
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.117°F
	SUPPLY-KW	0.000685 kW/cfm
	FAN-SCHEDULE	Always on
	FAN-CONTROL	INLET
	SUPPLY-MECH-EFF	From SUPPLY-EFF
	MOTOR-PLACEMENT	IN-AIRFLOW
	FAN-PLACEMENT	DRAW-THROUGH
	MAX-FAN-RATIO	1.1
	MIN-FAN-RATIO	0.3
	RETURN-STATIC	If neither pair, (RETURN-STATIC,
	RETURN-EFF	RETURN-EFF) or (RETURN-DELTA-T,
	RETURN-DELTA-T	RETURN-KW), is specified,
	RETURN-KW	no return fan is simulated.
	NIGHT-CYCLE-CTRL	STAY-OFF
	FAN-EIR-FPLR	*(only if FAN-CONTROL = FAN-EIR-FPLR)
SYSTEM-TERMINAL	REHEAT-DELTA-T	No reheat simulated
	MIN-CFM-RATIO	From outside air or heating load
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C3
	COOLING-EIR	0.365 Btu/Btu
	COOL-EIR-FT	Standard curve SDL-C13
	COOL-EIR-FPLR	Standard curve SDL-C18
	COOL-SH-CAP	Dependent on peak loads
	COOL-SH-FT	Standard curve SDL-C23
	COIL-BF	0.19
	COIL-BF-FCFM	Standard curve SDL-C33
	COIL-BF-FT	Standard curve SDL-C43
	COOL-CTRL-RANGE	4.0°F
	COOL-FT-MIN	70.0°

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.23 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-EQUIPMENT (continued)		
	MIN-UNLOAD-RATIO	0.25
	MIN-HGB-RATIO	0.25
	MAX-COND-RCVRY	No heat recovery from condenser
	CRANKCASE-MAX-T	Heater runs when compressor is not on
	CRANKCASE-HEAT	0.1 kW
	OUTSIDE-FAN-KW	No explicit condenser fan electric energy
	OUTSIDE-FAN-T	45.0°F
	OUTSIDE-FAN-MODE	INTERMITTENT
	RATED-CCAP-FCFM	Standard curve SDL-C78
	RATED-SH-FCFM	Standard curve SDL-C85
	RATED-CEIR-FCFM	Standard curve SDL-C93
	HEATING-CAPACITY	Dependent on peak loads
	RATED-HCAP-FCFM	Standard curve SDL-C100
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for
SYSTEM	SYSTEM-TYPE=PVAVS	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-TERMINAL	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	HOT-WATER/SOLAR
	ZONE-HEAT-SOURCE	HOT-WATER/SOLAR
	BASEBOARD-SOURCE	ELECTRIC
	SIZING-RATIO	1.0
	SIZING-OPTION	COINCIDENT
	RETURN-AIR-PATH	DIRECT
	PLENUM-NAMES	No return air plenum

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

v. Packaged Terminal Air Conditioner (PTAC)

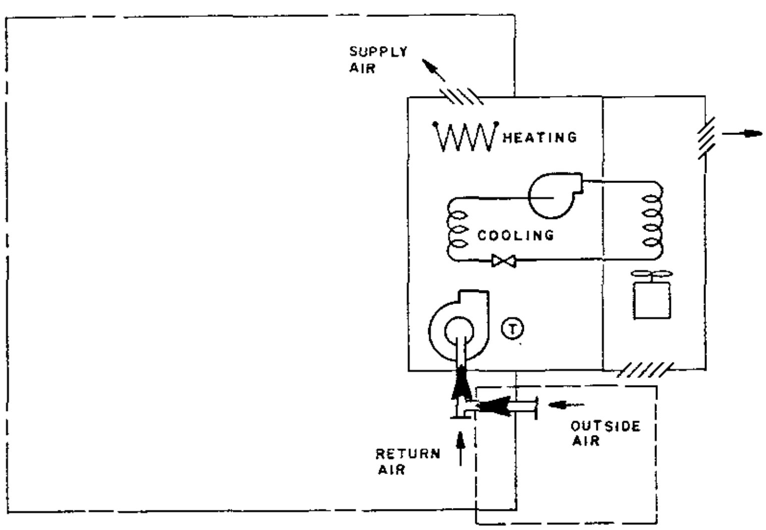
Packaged Terminal Air Conditioners (PTAC) are designed primarily for commercial installations to provide the total heating and cooling function for a room or zone, and are specifically designed for through-the-wall installation. The units (which are hybrid systems/plants) are mostly used in hotel and motel guest rooms, apartments, hospitals, nursing homes, and office buildings (Ref. 10). All PTAC units discharge air directly into the space without ductwork.

PTAC with DX Cooling and Electric Resistance Heating:

This particular PTAC unit provides cooling by the direct expansion of a refrigerant and heating by an electric resistance heater. In its most basic configuration this PTAC consists of a compressor, an air-cooled condenser with a fan discharging heat to the outdoors, an evaporator usually with a two-speed fan supplying cooled air to the indoors, an electric heater, a filter (not shown), and a 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 fan with the fan motor located inside the airstream. Optionally, the unit may be specified with a thermostat with night setback.

A number of optional features and control strategies can be specified for this system. The optional features are discussed in Table IV.2 and the section entitled, "Explanation of System Options" (immediately following Table IV.2). The possible control strategies for this system are discussed in Sec. B.5 of this chapter. It is highly recommended that the user read that portion of Sec. B.5 that is applicable to this system.

Table IV.24 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value if entry is omitted). To specify this type of PTAC, specify HEAT-SOURCE = ELECTRIC.



– ITEMS SHOWN IN DASHED BOXES ARE OPTIONAL COMPONENTS

PTAC with Air-to-Air Heat Pump:

This type of PTAC unit provides year-round forced-air heating and cooling. This system consists of a single air-to-air heat pump. In its basic configuration the heat pump unit consists of a compressor, a four-way valve for reversing the refrigerant flow direction, a condenser with a fan, an evaporator usually with a two-speed fan, a filter (not shown), and a thermostat. The condenser also serves as an evaporator and the evaporator also serves 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 and the supply fan is assumed to be a two-speed blowthrough fan with the fan motor located inside the airstream. Optionally, the unit may be specified with a thermostat with night setback.

Table IV.24 shows the commands and keywords that must be entered for simulation of this system, as well as those that are applicable but optional (i.e., program uses default value·if entry is omitted). To specify this type of PTAC, specify HEAT-SOURCE = HEAT-PUMP (plus the other keywords appropriate to a heat pump, if desired).

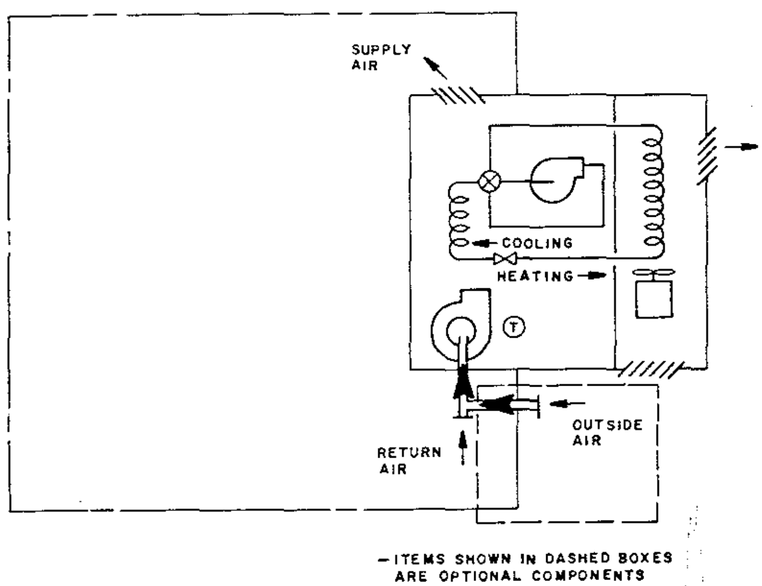


TABLE IV.24

APPLICABILITY OF COMMANDS AND KEYWORDS TO SYSTEM PTAC

Command	Keyword	Default Value or Consequence
ZONE-CONTROL	DESIGN-HEAT-T	*
	HEAT-TEMP-SCH	No active heating control
	DESIGN-COOL-T	*
	COOL-TEMP-SCH	No active cooling control
	THERMOSTAT-TYPE	PROPORTIONAL
	THROTTLING-RANGE	2°F
	BASEBOARD-CTRL	OUTDOOR-RESET
ZONE-AIR	AIR-CHANGES/HR	Based on heating/cooling loads, supply air, ΔT, and sizing ratio.
	CFM/SQFT	
	ASSIGNED-CFM	
	OA-CHANGES	Based on MIN-OUTSIDE-AIR
	OA-CFM/PER	Based on MIN-OUTSIDE-AIR
	OUTSIDE-AIR-CFM	Based on MIN-OUTSIDE-AIR
	RATED-CFM	From SYSTEM-AIR
ZONE	ZONE-CONTROL	**
	ZONE-AIR	**
	ZONE-TYPE	CONDITIONED
	MULTIPLIER	Must equal MULTIPLIER in LOADS
	MAX-HEAT-RATE	Peak load or 1.08 x ΔT x CFM
	MAX-COOL-RATE	Peak load or 1.08 x ΔT x CFM
	BASEBOARD-RATING	No baseboard heating
	HEATING-CAPACITY	From SYSTEM-EQUIPMENT
	COOLING-CAPACITY	From SYSTEM-EQUIPMENT
	COOL-SH-CAP	From SYSTEM-EQUIPMENT
SYSTEM-CONTROL	MAX-SUPPLY-T	*
	MIN-SUPPLY-T	*
	HEATING-SCHEDULE	Always on
	COOLING-SCHEDULE	Always on
	BASEBOARD-SCH	Always off
SYSTEM-AIR	SUPPLY-CFM	From loads or capacities
	RATED-CFM	No performance adjustment
	MIN-OUTSIDE-AIR	From ZONE-AIR or none
	MIN-AIR-SCH	No scheduling of outside air
SYSTEM-FANS	SUPPLY-STATIC	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-EFF	From SUPPLY-DELTA-T and SUPPLY-KW
	SUPPLY-DELTA-T	2.18°F
	SUPPLY-KW	0.00007 kW/cfm

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

TABLE IV.24 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM-FANS (continued)		
	FAN-SCHEDULE	Always on
	FAN-CONTROL	TWO-SPEED
	NIGHT-CYCLE-CTRL	STAY-OFF
	LOW-SPEED-RATIOS	Applies only if FAN-CONTROL=TWO-SPEED. Default is 1., 1., 1., 1.
SYSTEM-EQUIPMENT	COOLING-CAPACITY	Dependent on peak loads
	COOL-CAP-FT	Standard curve SDL-C2
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C22
	COOLING-EIR	0.568 Btu/Btu
	COOL-EIR-FT	Standard curve SDL-C12
	COOL-EIR-FPLR	Standard curve SDL-C17
	COOL-SH-CAP	From loads
	COOL-SH-FT	Standard curve SDL-C22
	COIL-BF	0.241
	COIL-BF-FCFM	Standard curve SDL-C32
	COIL-BF-FT	Standard curve SDL-C42
	COOL-FT-MIN	70.0°F
	RATED-CCAP-FCFM	Standard curve SDL-C77
	RATED-SH-FCFM	Standard curve SDL-C84
	RATED-CEIR-FCFM	Standard curve SDL-C92
	RATED-HCAP-FCFM	Standard curve SDL-C99 **
	RATED-HEIR-FCFM	Standard curve SDL-C106 **
	HEATING-CAPACITY	Dependent on peak loads **
	HEAT-CAP-FT	Standard curve SDL-C52 **
	HEATING-EIR	0.448 Btu/Btu **
	HEAT-EIR-FT	Standard curve SDL-C57 **
	HEAT-EIR-FPLR	Standard curve SDL-C62 **
	ELEC-HEAT-CAP	From heating load **
	MIN-HP-T	40.0°F **
	MAX-ELEC-T	40.0°F **
	DEFROST-T	No defrost cycle for heat pump **
	DEFROST-DEGRADE	No effect **
	FURNACE-AUX	800.0 Btu/hr
	FURNACE-HIR	1.35 Btu/Btu
	FURNACE-HIR-FPLR	Standard curve SDL-C111
	FURNACE-OFF-LOSS	No loss accounted for

* Required command or keyword.
** Appropriate only if HEAT-SOURCE = HEAT-PUMP.

TABLE IV.24 - Continued

Command	Keyword	Default Value or Consequence
SYSTEM	SYSTEM-TYPE=PTAC	*
	ZONE-NAMES	*
	SYSTEM-CONTROL	**
	SYSTEM-AIR	**
	SYSTEM-FANS	**
	SYSTEM-EQUIPMENT	**
	HEAT-SOURCE	ELECTRIC
	BASEBOARD-SOURCE	ELECTRIC
	SIZING-RATIO	1.0

* Required command or keyword.
** Required only if this keyword is entered as a subcommand.

5. SYSTEM Control Strategy

a. General Discussion for all SYSTEM-TYPEs

The following information describes how DOE-2 simulates the different control strategies for each SYSTEM-TYPE. The information in this subsection applies to all strategies and all SYSTEM-TYPEs (it is inserted here in an attempt to eliminate unnecessary repetition).

The importance of understanding how an HVAC system works cannot be over emphasized. Minor changes in the system control strategy can often have large effects in energy consumption and conservation. Often these energy conserving changes involve a minimum of expense to employ. Examples of such changes include using temperature setback, resetting the economizer limit temperature, reducing excessive outside ventilation air, resetting hot and cold deck temperatures, and employing better fan schedules. However, to employ the proper changes in the system, the user must first understand how his system is simulated by DOE-2. That is the purpose of the following discussions.

Occasionally, the user will note that there are slight differences between the simulation methodology and the "real world of hardware". That is to say, although the computer simulation will be thermodynamically close, it would be impossible to purchase equipment that would exactly duplicate the simulation action. This is true of most computer models and the user should not be unduly concerned.

Some control strategy keywords are appropriate only at the ZONE level, while others are appropriate only at the SYSTEM level. Still others are appropriate at both levels. If a keyword, which is appropriate at both levels, is specified only at the SYSTEM level it will apply to all ZONEs served by the SYSTEM. If a keyword, which is appropriate at both levels, is specified both at the SYSTEM level and at the ZONE level, the specification made at the ZONE level will take precedence over the SYSTEM level specification.

In the following discussions, the term constant volume flow refers to the volume of supply air entering the ZONE for all hours of the simulation. Likewise, variable volume flow, refers to the volume of supply air entering the ZONE; however, in this case, the quantity of air may vary from one simulation hour to the next (but during any one simulation hour the volume remains constant). Likewise, in the following discussions, constant temperature and variable temperature have analogous definitions.

Also, the user will note in the following discussions that "heating sources" are generally referred to as preheat coils, main heating coils, or zone coils. The same is true for "cooling sources". In DOE-2 heating and cooling can be accomplished with other energy sources other than fluids (gas, electricity, solar, heat pumps, etc.) "Heating coils" and "cooling coils" are used, in the following discussions, in the generic sense.

Throughout this section on SYSTEM Control Strategy, keywords are identified as belonging to certain subcommands. The user is reminded here that any keyword that belongs to a subcommand (i.e., ZONE-AIR and ZONE-CONTROL) can also be entered in the parent command (i.e., ZONE). The same is true for SYSTEM subcommands and the SYSTEM command.

COOLING-SCHEDULE, HEATING-SCHEDULE, and FAN-SCHEDULE

The keywords COOLING-SCHEDULE and HEATING-SCHEDULE are used to reference SCHEDULE instructions that activate and deactivate the cooling and heating capabilities of the PLANT. These SCHEDULEs do not turn the PLANT "ON" and "OFF"; rather, they specify the availability of heating and cooling for this SYSTEM (some SYSTEMs served by a PLANT may be "ON" and some may be "OFF"). A SYSTEM may be calling for heating, however, that heating will not be available unless the HEATING-SCHEDULE is referencing a SCHEDULE that is specified as "ON" during that hour (possessing a positive hourly value). The same is true with respect to the COOLING-SCHEDULE. Similarly, FAN-SCHEDULE references a SCHEDULE instruction that specifies the availability of the system's fans (supply, return, and exhaust). Note: There is one exception to the preceding discussion. If the user specifies any value for NIGHT-CYCLE-CTRL other than STAY-OFF, the FAN-SCHEDULE may be overidden to provide heating should the ZONE temperature fall below the heating THROTTLING-RANGE (see NIGHT-CYCLE-CTRL, Sec. C.8 of this chapter).

Zone Thermostats and THROTTLING-RANGEs:

In DOE-2 the ZONE thermostats have two control bands, or THROTTLING-RANGEs with associated set points, and one dead band. Some system control strategies involve only one ZONE thermostat set point, which is used to control either heating or cooling of the ZONE. Other strategies involve two ZONE thermostat set points, one for cooling and one for heating. The desired set points are specified, respectively, with the keywords COOL-TEMP-SCH and HEAT-TEMP-SCH (plus their associated SCHEDULEs). Each set point has its own THROTTLING-RANGE. Only one specification for THROTTLING-RANGE can be made for a ZONE and that range is used for both cooling and heating.

In general, the upper control band, or cooling THROTTLING-RANGE, governs the main cooling coil (for central systems), the zone cooling coil (for zonal systems), and the air volume for variable volume systems (MIN-CFM-RATIO < 1). At the top of the cooling THROTTLING-RANGE there is full cooling and full air volume. At the bottom of the cooling THROTTLING-RANGE there is minimum cooling and minimum air volume.

The lower control band, or heating THROTTLING-RANGE, governs the main heating coil (for central systems), the zone heating coil (for zonal systems), the reheat coil, the thermostatically controlled baseboards, and the air volume (for variable volume systems with THERMOSTAT-TYPE = REVERSE-ACTION). At the bottom of the heating THROTTLING-RANGE there is full heating and in the case of THERMOSTAT-TYPE = REVERSE-ACTION, full air flow. At the top of the heating THROTTLING-RANGE the heating is off and the air flow is at a minimum.

If the cooling and heating set points are separated by more than one THROTTLING-RANGE, a dead band will result between the two THROTTLING-RANGEs. The response of the system, when the calculated ZONE temperature is within the dead band, will be constant and will correspond to the system response at the bottom of the cooling THROTTLING-RANGE. If the user specifies overlapping THROTTLING-RANGEs, the program will assume that the user has made an error and it will move the set points apart until they are separated by one

THROTTLING-RANGE. The cooling set point (with its THROTTLING-RANGE) is moved upward and the heating set point (with its THROTTLING-RANGE) is moved downward, both by equal amounts (one-half of the overlap).

Example:

User-Specified Overlapping Ranges	DOE-2 Adjusted Ranges
THROTTLING-RANGE = 4	THROTTLING-RANGE = 4
Cooling Set Point - 70	Cooling Set Point - 71
Heating Set Point - 68	Heating Set Point - 67

If the system being modeled has no controls corresponding to one of the two control bands, the corresponding temperature schedule need not be entered. Thus, for example, if a system has no capability for cooling, such as a unit heater (SYSTEM-TYPE = UHT), it is not necessary to specify COOL-TEMP-SCH; specify only HEAT-TEMP-SCH.

As the calculated ZONE temperature rises and falls within the THROTTLING-RANGEs, different actions are simulated. No changes in simulation actions take place outside of the THROTTLING-RANGEs. The exact actions that take place depend on the SYSTEM-TYPE and keyword values that are specified. Subsections b. thru j. discuss these actions by SYSTEM-TYPE and control strategy. Selected example strategies are given, but it is not possible to discuss all the possible strategies for each SYSTEM-TYPE. Table IV.25 summarizes, by SYSTEM-TYPE, the possible actions that can be obtained using the specification of values for COOL-TEMP-SCH and HEAT-TEMP-SCH (the cooling and heating set points).

The user may argue that most SYSTEMs have only one thermostat set point and THROTTLING-RANGE, not two. At any one time that is true, because only one set point and THROTTLING-RANGE are active. Herein lies one of the slight differences between simulation methodology and the "real world of hardware". The heating set point and THROTTLING-RANGE control the heating equipment. The cooling set point and THROTTLING-RANGE control the cooling equipment. The heating equipment and cooling equipment are two separate sets of equipment, normally operating with different actions. The user should determine how many set points, one or two, are required for his SYSTEM-TYPE, by referring to the appropriate Applicability Table or to Table IV.25. To obtain a proper simulation, when the control strategy requires two set points, the user must specify two set points. Strategies that involve only one set point require that only that set point be specified. If the user specifies two set points, when only one is required, only the proper set point will be used by the program. If in doubt, specify both COOL-TEMP-SCH and HEAT-TEMP-SCH.

The user should be aware that if he specifies the cooling set point to be equal to the heating set point (on the insistence that there is really only one set point), several things may happen. First, the set points will be

TABLE IV.25

ACTIONS SIMULATED BY SPECIFYING
COOL-TEMP-SCH AND HEAT-TEMP-SCH FOR EACH SYSTEM-TYPE

	Heating (on a fall in ZONE temperature)		Cooling (on a rise in ZONE temperature)	
SYSTEM-TYPE	Action Simulated by HEAT-TEMP-SCH	Additional Required Keyword(s) and Value(s)	Action Simulated by COOL-TEMP-SCH	Additional Required Keyword(s) and Value(s)
MZS,DDS,PMZS	Increase heating air temperature Increase baseboard output Mix hot and cold air Increase supply air volume	HEAT-CONTROL = COLDEST BASEBOARD-CTRL = THERMOSTATIC - MIN-CFM-RATIO < 1 and THERMOSTAT-TYPE = REVERSE-ACTION	Reduce cooling air temperature Increase supply air volume	COOL-CONTROL = WARMEST MIN-CFM-RATIO < 1
VAVS,PVAVS CBVAV,RHFS	Increase baseboards output Increase reheat coil output Increase supply air volume	BASEBOARD-CTRL = THERMOSTATIC REHEAT-DELTA-T ≠ 0 MIN-CFM-RATIO < 1 and THERMOSTAT-TYPE = REVERSE-ACTION	Reduce supply air temperature Increase supply air volume (not on RHFS)	COOL-CONTROL = WARMEST MIN-CFM-RATIO < 1
SZRH, PSZ	Increase reheat (subzone only) Increase supply air temperature	- -	Reduce supply air temperature	-
TPFC,FPFC,HP, RESYS,PTAC	Increase zone heating coil output	-	Increase zone cooling coil output	-
UHT,UVT	Close OA damper (UVT only) Increase heating coil output	- -	Open OA damper (UVT only)	-
FPH	Increase heat addition	-	Unused	-
HVSYS	Increase supply air temperature Increase baseboards output Increase reheat coil output	HEAT-CONTROL = COLDEST BASEBOARD-CTRL = THERMOSTATIC REHEAT-DELTA-T ≠ 0	Unused	-

TABLE IV.25 Continued

	Heating (on a fall in ZONE temperature)		Cooling (on a rise in ZONE temperature)	
SYSTEM-TYPE	Action Simulated by HEAT-TEMP-SCH	Additional Required Keyword(s) and Value(s)	Action Simulated by COOL-TEMP-SCH	Additional Required Keyword(s) and Value(s)
TPIU,FPIU	Increase zone heating coil output	-	Reduce cooling air temperature	COOL-CONTROL = WARMEST
			Increase zone cooling coil output	-
SZCI	Increase baseboard output	BASEBOARD-CTRL = THERMOSTATIC	Reduce cooling air temperature	COOL-CONTROL = WARMEST
	Increase reheat coil output	REHEAT-DELTA-T ≠ 0	Increase supply air volume	-
SUM	Increase heat addition	-	Increase heat extraction	-

separated, as explained earlier. Second, if the user is using nighttime setback or setup of the ZONE temperature, he may experience "forced" setback or setup, especially if a small THROTTLING-RANGE has been specified. Forced setback is the process that occurs when the winter heating temperature is lowered at night and the cooling system turns on and drives the temperature down, rather than allowing the temperature to drift down to the setback temperature. If this occurs, it is the fault of the user's input, not the program. The occurrence of "forced" setback or setup can easily be detected in the HOURLY-REPORTs but may go unnoticed in the VERIFICATION and SUMMARY reports.

Cold and Hot Deck Temperatures:

For central systems, the temperature of the cold air stream (cooling coil or cold deck temperature) is set at the SYSTEM level in the SYSTEM-CONTROL subcommand. The value specified for the keyword COOL-CONTROL determines the method for setting the cooling coil (or cold deck) temperature. If the user specifies COOL-CONTROL = CONSTANT, he should specify a value for COOL-SET-T, or allow it to default to MIN-SUPPLY-T (bear in mind, MIN-SUPPLY-T is defined as the lowest allowable temperature for air entering the ZONE(s); it is the cooling coil, or cold deck, temperature only when COOL-SET-T is allowed to default, or when the program resets this temperature to MIN-SUPPLY-T). If the user specifies COOL-CONTROL = RESET, he must specify COOL-RESET-SCH (plus an associated RESET-SCHEDULE), and if the user specifies COOL-CONTROL = SCHEDULED, he must specify COOL-SET-SCH (plus an associated SCHEDULE). If the user specifies COOL-CONTROL = WARMEST, the program will automatically reset the cooling coil (or cold deck) temperature each hour in an attempt to adequately cool the ZONE with the "highest relative temperature in its cooling THROTTLING-RANGE". This value is expressed in per cent (if this value is equal to or greater than 100 per cent, for any one or more ZONEs, it means that the cooling coil will be operated at its maximum capacity). Fig IV.3 illustrates graphically how the WARMEST ZONE is determined by the program. If conflicting input is specified by the user, the value for COOL-CONTROL always takes precedence.

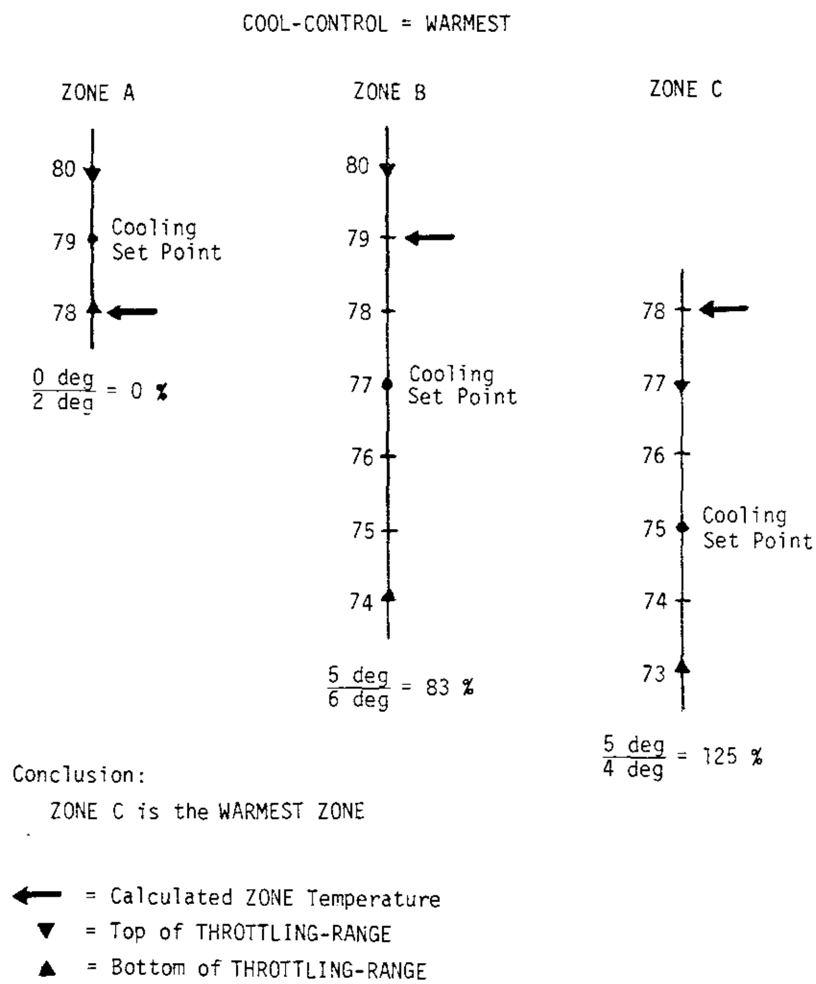


Fig. IV.3. Determining which zone is the WARMEST ZONE.

Similarly, for central systems, the value specified for the keyword HEAT-CONTROL determines the method for setting the heating coil (or hot deck) temperature. If the user specifies HEAT-CONTROL = CONSTANT, he should specify a value for HEAT-SET-T, or allow it to default. If the user specifies HEAT-CONTROL = RESET, he must specify HEAT-RESET-SCH (plus an associated RESET-SCHEDULE), and if the user specifies HEAT-CONTROL = SCHEDULED, he must specify HEAT-SET-SCH (plus an associated SCHEDULE). If the user specifies HEAT-CONTROL = COLDEST, the program will automatically reset the heating coil (or hot deck) temperature each hour in an attempt to adequately heat the ZONE with the "lowest relative temperature in its heating THROTTLING-RANGE". This value is also expressed in per cent (if this value is equal to or less than 0 per cent, for any one or more ZONEs, it means that the heating coil will be operated at its maximum capacity). Fig. IV.4 illustrates graphically how the COLDEST ZONE is determined by the program. If conflicting input is specified by the user, the value for HEAT-CONTROL will always take precedence.

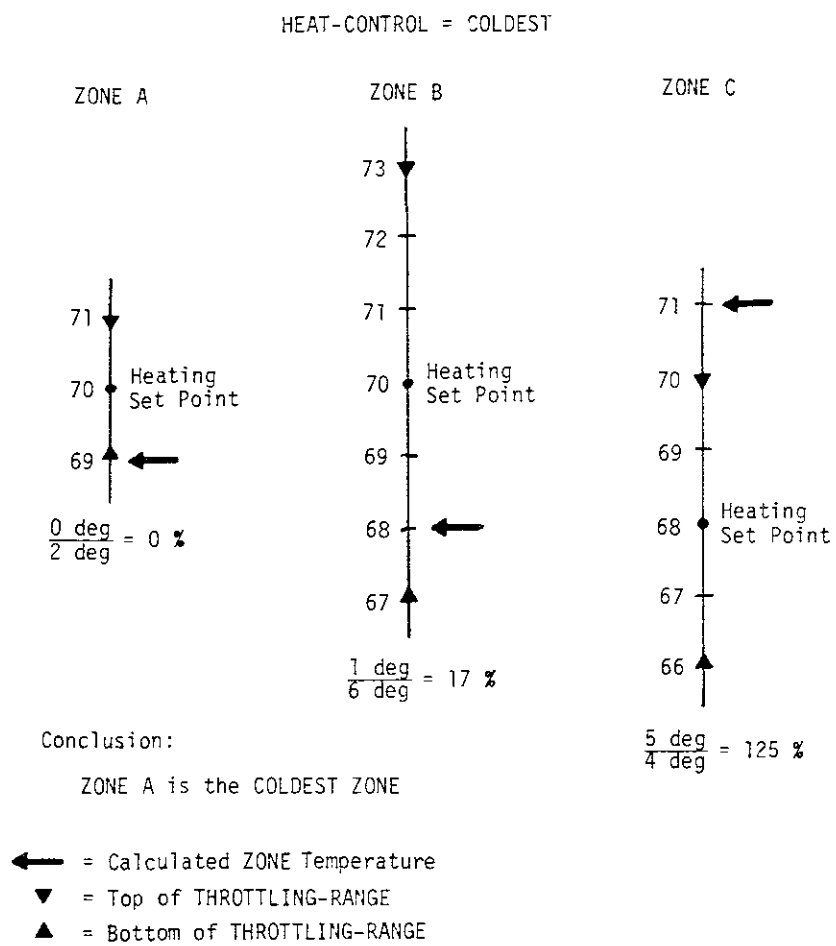


Fig. IV.4. Determining which zone is the COLDEST ZONE.

Economizer:

For SYSTEM-TYPE equals SZRH, MZS, DDS, SZCI, TPIU, FPIU, VAVS, RHFS, HVSYS, CBVAV, PSZ, PMZS, and PVAVS, an economizer will automatically be simulated, unless the user specifies a value for OA-CONTROL = FIXED in the SYSTEM-AIR subcommand. The code-word FIXED will set the outside air damper at the value expressed for MIN-OUTSIDE-AIR, which essentially means that no economizer exists. The economizer will attempt to maintain the mixed (return and outside) air temperature at the cooling coil (or cold deck) temperatures specified using COOL-CONTROL minus the fan heat gain, if any (the only exception to this statement is for SYSTEM-TYPE = HVSYS, where the economizer will attempt to maintain the mixed air temperature at the temperatures specified using HEAT-CONTROL, because the keyword COOL-CONTROL is not applicable to HVSYS).

Humidification:

In DOE-2 the process of humidification (if applicable to the SYSTEM-TYPE and if specified) is simulated by the injection of steam or hot water into the SYSTEM supply air stream. The relative humidity is calculated for the mixed (return and outside) air stream. The humidification process is described in the 1977 ASHRAE Handbook of Fundamentals (Ref. 5, p. 5.9, Example 5). The energy associated with humidification is the amount of energy required to evaporate the required amount of water. The minimum allowed relative humidity (per cent R. H.) in the SYSTEM return air stream (at the dry-bulb temperature for the hour) is specified with the keyword MIN-HUMIDITY in the SYSTEM-CONTROL subcommand.

Dehumidification:

The process of dehumidification, if and when required, is calculated as the energy required to cool the air to its dew point plus reheating, if necessary. If the cooling coil is operating at or below the dew point of the mixed (return and outside) air, dehumidification will occur. There will, however, be no control of the dehumidification process unless the user specifies a value for the keyword MAX-HUMIDITY in the SYSTEM-CONTROL subcommand. MAX-HUMIDITY is used to specify the maximum allowed relative humidity (per cent R.H.) in the SYSTEM return air stream. Not all SYSTEM-TYPEs have the capability for dehumidifying air. The SYSTEM-TYPEs SZRH, MZS, DDS, SZCI, FPFC, TPIU, FPIU, VAVS, RHFS, CBVAV, PSZ, PMZS, and PVAVS normally have the required equipment and controls. The user is reminded here that to have dehumidification and subsequent reheating, both the cooling and heating must be on; that is, the SCHEDULEs referenced by COOLING-SCHEDULE and HEATING-SCHEDULE must possess positive hourly values.

The value specified for MAX-HUMIDITY can override the cold deck temperatures, specified via COOL-CONTROL, in an attempt to maintain the return air relative humidity at the value specified for MAX-HUMIDITY. The program will reset the cooling coil temperature down toward MIN-SUPPLY-T, to increase dehumidification, and then the SYSTEM will either reheat the air (using the main heating coil), lower the volume of air to meet the temperature demands of the ZONEs, or overcool the ZONEs.

This is true for all the SYSTEM-TYPEs listed in the previous paragraph, even SZRH and PSZ, which normally cool and reheat the air sequentially. If reheating is not available during dehumidification, the supply air temperature is still reset toward MIN-SUPPLY-T and overcooling of the ZONE(s) could result.

For SYSTEM-TYPE equals MZS, DDS, or PMZS, the value specified for MAX-HUMIDITY does not override the hot deck temperatures (specified using HEAT-CONTROL) as a means of forcing more air through the cold deck to obtain increased dehumidification.

The program will not force the cooling coil (or cold deck) to perform beyond its dehumidification capability. The cooling coil temperature will be dropped to MIN-SUPPLY-T, but not below MIN-SUPPLY-T. If the value of MAX-HUMIDITY cannot be maintained when the coil is operating at MIN-SUPPLY-T, the program will calculate the MAX-HUMIDITY corresponding to the cooling coil's performance at MIN-SUPPLY-T. If it is not possible to dehumidify down to MAX-HUMIDITY, at design conditions, a diagnostic message will be printed for the user.

The user should exercise caution when specifying a value for MAX-HUMIDITY, because the program does not know the user's needs and, hence, cannot check the reasonableness of the specified value. As long as the value is between 30 per cent and 80 per cent R.H. (the program limits for MAX-HUMIDITY), the program will accept and use the value. An unnecessarily low value for MAX-HUMIDITY can be very wasteful. The user is urged to employ good engineering judgement by not specifying a MAX-HUMIDITY any lower than necessary.

Fan Heat:

The heat from the supply air fan may be added to the air stream either before or after the coils, depending upon the value specified for FAN-PLACEMENT. If FAN-PLACEMENT = DRAW-THROUGH, the supply fan heat is added after the coils. If FAN-PLACEMENT = BLOW-THROUGH, the supply fan heat is added before the coils. The heat of the optional return air fan is always added to the return air stream, after the plenum and before the system-level exhaust (relief). The heat from the optional exhaust air fan(s), either at the SYSTEM level or the ZONE level, is assumed to be lost from the building in the exhausted air.

Baseboard Heaters:

If the user chooses to use the optional thermostatically-controlled baseboard heaters (BASEBOARD-CTRL = THERMOSTATIC), he should be aware that the other heating device(s) in the SYSTEM and ZONE, regardless of SYSTEM-TYPE, do not start to add heat until the baseboard heaters are at maximum output. When baseboard heaters are reset by outdoor temperatures (BASEBOARD-CTRL = OUTDOOR-RESET), their heat contribution to the ZONE occurs irrespective of the ZONE temperature control. See Sec. B.6 of this chapter for more information on baseboard heaters.

Cautionary Warnings:

1. If the user substitutes keyword values for those keyword values recommended in the following discussions (including the default values), it is possible to simulate a control strategy other than the one originally intended by the user.

   Example: If the user wishes to specify an MZS system with a Variable Air Volume Cooling and Constant Air Volume Heating Strategy, but he specifies THERMOSTAT-TYPE = REVERSE-ACTION (instead of PROPORTIONAL, as it should be specified), he will instead get a Variable Air Volume Cooling and Heating Strategy. Because both strategies are available and permitted by the program, it cannot detect the user's error.

   Likewise, it is possible to change the generic SYSTEM-TYPE by specifying an incorrect keyword value for a system control parameter. This can be done without receiving a diagnostic message.

   Example: If the user specifies SYSTEM-TYPE = VAVS with MIN-CFM-RATIO = 1, the program will simulate a constant volume system and not a variable volume system.

2. The specified system control strategy and the actual system equipment must be compatible.

   Example: If the user should specify MIN-CFM-RATIO < 1 and COOL-CONTROL = WARMEST, the central system equipment that produces the cooling must have the capability of not only variable output volume but also variable output temperature. The same is true for MIN-CFM-RATIO < 1, THERMOSTAT-TYPE = REVERSE-ACTION, and HEAT-CONTROL = COLDEST.*

   Example: If the user specifies a multizone system, such as PMZS, with a furnace and HEAT-CONTROL = COLDEST, the simulation will probably be incorrect. Although the furnace can vary its heat output by cycling on and off during the hour, it probably cannot vary its output temperature to heat the COLDEST ZONE.

*In actual systems, one would probably never see two simultaneous corrections (air volume and deck temperature) made. This is because actual systems make their corrections continuously, not just at the end of the simulation hour. If the user specifies variable volume flow with the cold deck temperature being controlled by the WARMEST ZONE, the program divides the cooling THROTTLING-RANGE in half. The top half controls the system as if it were a variable volume system and the bottom half controls the system as if it were a variable cold deck temperature system. If at the end of the simulation hour, the calculated ZONE temperature has moved from the bottom half of the THROTTLING-RANGE to the top half (or vice versa), two corrections (air volume and deck temperature) will have occurred. If the program performed continuous simulation, rather than hourly simulation, these two corrections would have occurred sequentially. Thermally, there is very little difference.

Also, when the user specifies COOL-CONTROL = WARMEST or HEAT-CONTROL = COLDEST, this implies that the electrical or mechanical hardware is, or will be, available in the building to transmit a signal from each ZONE, or a sampling of ZONEs, to a central location for a comparison of ZONE signals to determine which ZONE is the COLDEST and which is the WARMEST. Although DOE-2 performs a comparison of all ZONEs in the SYSTEM, to find which is the COLDEST and which is the WARMEST, in actual buildings the comparison is often made on a sampling of representative ZONEs in the SYSTEM.

3. The user cannot assume that his system is efficient, if he gets no error diagnostics from his simulation. The program has no system optimizing routines.

Organization of System Control Strategies:

The available system control strategies in DOE-2 are dependent upon

(1) the user's SYSTEM-TYPE and

(2) the keyword values specified by the user for his SYSTEM-TYPE.

The following discussions are organized by "strategy within SYSTEM-TYPE". Having read this subsection, the user should next find his SYSTEM-TYPE in the discussions and read the general information subsection on his SYSTEM-TYPE. Then, the user should search the examples for the desired control strategy within his SYSTEM-TYPE. The user may not always find his desired control strategy but normally an example will be given, from which the user can develop his desired control strategy. Therefore, an example of one or more of the major control strategies are given for each SYSTEM-TYPE (or group of SYSTEM-TYPEs).

b. Examples

i. Example Control Strategies for SYSTEM-TYPE Equals MZS, DDS, or PMZS

If the user has not done so, he should read the General subsection (Sec. IV.B.5.a) before continuing here. That subsection contains information that is appropriate to these control strategies and SYSTEM-TYPEs.

In these three SYSTEM-TYPEs, the air flow rates in the individual cold and hot air ducts are automatically varied by the program, from one hour to the next hour, in an attempt to deliver the correct proportions of cold air and hot air (at the deck temperatures specified via COOL-CONTROL and HEAT-CONTROL) to meet the desired ZONE temperature, which is specified in COOL-TEMP-SCH and HEAT-TEMP-SCH. The program treats MZS and DDS thermally the same. The twelve major control strategies for each of these SYSTEM-TYPEs are listed in Table IV.26. Each strategy is defined by the selective specification of values for the keywords MIN-CFM-RATIO, COOL-CONTROL, HEAT-CONTROL, COOL-TEMP-SCH, HEAT-TEMP-SCH, and THERMOSTAT-TYPE.

In these strategies (dual duct strategies), the term constant volume flow refers to the hourly volume of air entering the ZONE, not the quantity of air flowing in the individual cold or hot air ducts. The air volume flowing in the cold air duct may vary from zero to a maximum of the design cooling flow rate (that is, the ASSIGNED-CFM, or in its absence, the amount of cold air required to meet the ZONE peak cooling load). The air volume flowing in the hot air duct is similarly simulated.

Likewise, the term variable volume flow for dual duct systems refers to the supply air entering the ZONE, not the quantity of air flowing in the individual cold and hot air ducts. The blended hot and cold quantity of air entering the ZONE may vary from a minimum of MIN-CFM-RATIO to a maximum of the design flow rate, assuming the supply air fan is on.

Use of the keyword DUCT-DELTA-T with these SYSTEM-TYPEs can cause an over-estimate of the heating supply air temperature, when the heating coil is not active.

The heat from the supply air fan is added, by the program, to the air stream ahead of the hot and cold decks. The effect of the humidifier, if specified, is added to the supply air stream.

Example:

Constant Volume Cooling and Heating with User-controlled Cold and Hot Deck Temperatures for MZS, DDS, and PMZS
(with COOL-CONTROL = CONSTANT, RESET, or SCHEDULED
and HEAT-CONTROL = CONSTANT, RESET, or SCHEDULED)

This example control strategy is an MZS or PMZS system with constant volume flow of mixed air entering the ZONE for both cooling and heating. In this SYSTEM-TYPE, with this strategy only, the cold air damper and the hot air damper are physically linked together (at 90 degrees to each other). Opening the hot air damper closes the cold air damper, and vice versa. Therefore,

TABLE IV.26

MAJOR CONTROL STRATEGIES FOR SYSTEM-TYPE = MZS, DDS, OR PMZS

	Strategy	MIN-CFM-RATIO	Cold Deck Temp. (COOL-CONTROL=)	Hot Deck Temp. (HEAT-CONTROL=)	Zone Cooling Set Point (COOL-TEMP-SCH)	Zone Heating Set Point (HEAT-TEMP-SCH)	Zone THERMOSTAT-TYPE
*1.	Constant Volume Cooling and Heating with User-controlled Cold and Hot Deck Temperatures	1.0	CONSTANT, RESET or SCHEDULED	CONSTANT, RESET or SCHEDULED	Not used	Required for zone heating control	PROPORTIONAL
2.	Constant Volume Cooling and Heating with Program-calculated Cold and Hot Deck Temperatures	1.0	WARMEST	COLDEST	Required for WARMEST control	Required for COLDEST and zone heating control	PROPORTIONAL
3.	Constant Volume Cooling and Heating with User-controlled Cold Deck Temperatures and Program-calculated Hot Deck Temperatures	1.0	CONSTANT, RESET or SCHEDULED	COLDEST	Not used	Required for COLDEST and zone heating control	PROPORTIONAL
4.	Constant Volume Cooling and Heating with Program-calculated Cold Deck Temperatures and User-controlled Hot Deck Temperatures	1.0	WARMEST	CONSTANT, RESET or SCHEDULED	Required for WARMEST control	Required for zone heating control	PROPORTIONAL
5.	Variable Volume Cooling and Heating with User-controlled Cold and Hot Deck Temperatures	< 1.0	CONSTANT, RESET or SCHEDULED	CONSTANT, RESET or SCHEDULED	Required for zone air flow control	Required for zone heating and air flow control	REVERSE-ACTION
6.	Variable Volume Cooling and Heating with Program-calculated Cold and Hot Deck Temperatures	< 1.0	WARMEST	COLDEST	Required for WARMEST and zone air flow control	Required for COLDEST, zone heating, and air flow control	REVERSE-ACTION
7.	Variable Volume Cooling and Heating with User-controlled Cold Deck Temperatures and Program-calculated Hot Deck Temperatures	< 1.0	CONSTANT, RESET or SCHEDULED	COLDEST	Required for zone air flow control	Required for COLDEST, zone heating, and air flow control	REVERSE-ACTION
8.	Variable Volume Cooling and Heating with Program-calculated Cold Deck Temperatures and User-controlled Hot Deck Temperatures	< 1.0	WARMEST	CONSTANT, RESET or SCHEDULED	Required for WARMEST and zone air flow control	Required for zone heating and air flow control	REVERSE-ACTION

TABLE IV.26 Continued

	Strategy	MIN-CFM-RATIO	Cold Deck Temp. (COOL-CONTROL=)	Hot Deck Temp. (HEAT-CONTROL=)	Zone Cooling Set Point (COOL-TEMP-SCH)	Zone Heating Set Point (HEAT-TEMP-SCH)	Zone THERMOSTAT-TYPE
9.	Variable Volume Cooling and Constant Volume Heating with User-controlled Cold and Hot Deck Temperatures	< 1.0	CONSTANT, RESET or SCHEDULED	CONSTANT, RESET or SCHEDULED	Required for zone air flow control	Required for zone heating control	PROPORTIONAL
*10.	Variable Volume Cooling and Constant Volume Heating with Program-calculated Cold and Hot Deck Temperatures	< 1.0	WARMEST	COLDEST	Required for WARMEST and zone air flow control	Required for COLDEST and zone heating control	PROPORTIONAL
11.	Variable Volume Cooling and Constant Volume Heating with User-controlled Cold Deck Temperatures and Program-calculated Hot Deck Temperatures	< 1.0	CONSTANT, RESET or SCHEDULED	COLDEST	Required for zone air flow control	Required for COLDEST and zone heating control	PROPORTIONAL
12.	Variable Volume Cooling and Constant Volume Heating with Program-calculated Cold Deck Temperatures and User-controlled Hot Deck Temperatures	< 1.0	WARMEST	CONSTANT, RESET or SCHEDULED	Required for WARMEST and zone air flow control	Required for zone heating control	PROPORTIONAL

*An example of this control strategy is included in the following discussion.

Notes:

1. Zone (reheat) coils are not applicable to these SYSTEM-TYPEs.

2. Baseboard heaters are optional with all these SYSTEM-TYPEs and strategies. If BASEBOARD-CTRL=THERMOSTATIC, control is exerted via HEAT-TEMP-SCH.

3. The above table is not entirely complete. Associated with most of the keywords and code-words listed in the table are other "related" keywords and code-words. Example: If COOL-CONTROL=CONSTANT, the user must <u>also</u> specify a value for its "related" keyword, COOL-SET-T.

this system can operate from one thermostat set point, which is specified via HEAT-TEMP-SCH. To obtain the same physical results for the DDS system, the user may alternatively employ a mixing box with a constant volume output.

Procedure:

(1) Specify SYSTEM-TYPE = MZS, DDS, or PMZS in the SYSTEM command.

(2) Specify MIN-CFM-RATIO (in either the ZONE command or in the SYSTEM-TERMINAL subcommand) as equal to 1.0, or allow it to default to that value. This assures a constant volume mixed air flow entering all ZONEs in this SYSTEM.

(3) Specify COOL-CONTROL in the SYSTEM-CONTROL subcommand equal to CONSTANT, RESET, or SCHEDULED. This establishes the method for setting the temperature of the cooling supply air that will be sent to all ZONEs in the SYSTEM. If the user does not specify a value for COOL-CONTROL, it will default to CONSTANT and COOL-SET-T will default to MIN-SUPPLY-T (a constant cold deck temperature the year around).

(4) Specify HEAT-CONTROL in the SYSTEM-CONTROL subcommand equal to CONSTANT, RESET, or SCHEDULED. This establishes the method for setting the temperature of the heating supply air that will be sent to all ZONEs in the SYSTEM. If the user does not specify a value for HEAT-CONTROL, it will default to CONSTANT and HEAT-SET-T will default to MAX-SUPPLY-T (a constant hot deck temperature the year around).

(5) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of ZONE thermostat set point temperature.

Specify a HEAT-TEMP-SCH for each conditioned ZONE in the SYSTEM. These set point temperatures will be used to modulate the air flow in the cold and hot air ducts to the ZONE. If the user does not specify a HEAT-TEMP-SCH for a ZONE, it will be cooled but not heated (except for baseboard heaters when BASEBOARD-CTRL = OUTDOOR-RESET).

If the user desires to have a temperature "setup" in the summer, this should be reflected in the SCHEDULE specified for HEAT-TEMP-SCH and the HEATING-SCHEDULE during the setup period should be set to off. This will prevent the heating system from wasting energy in the summer, in an attempt to hold the ZONE temperature up to the setup temperature.

(6) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand.

(7) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default. This example is the first strategy in Table IV.26.

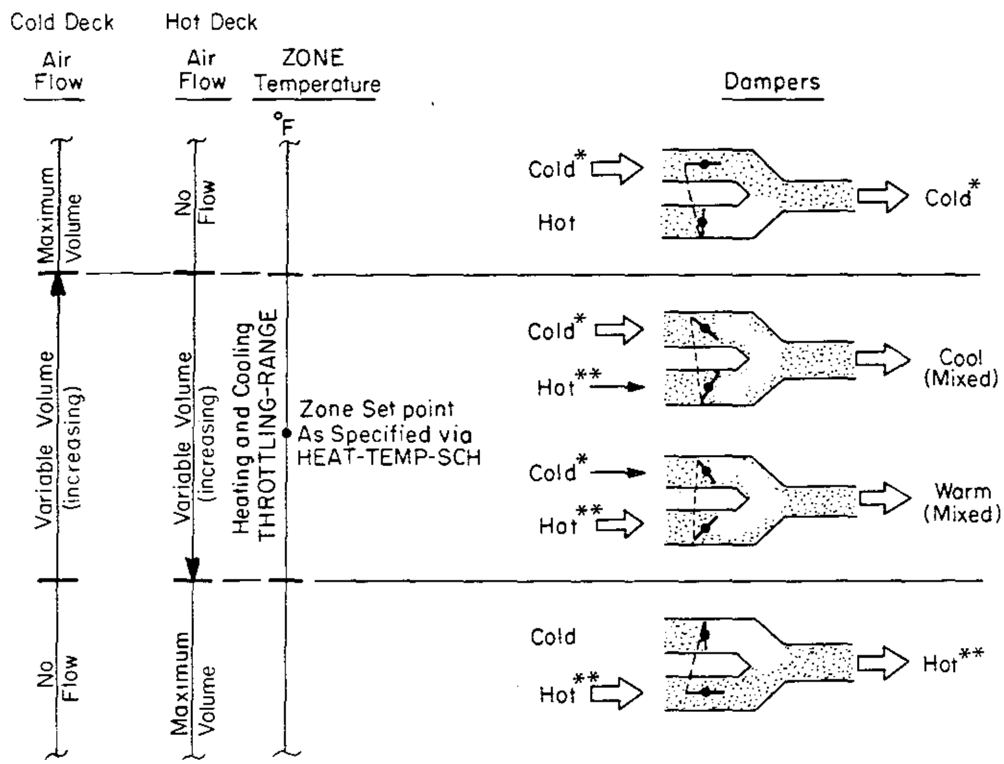
Graphically, this example strategy for MZS or PMZS looks like the following:

MZS, PMZS

Constant Air Volume

COOL-CONTROL = CONSTANT, RESET, or SCHEDULED
HEAT-CONTROL = CONSTANT, RESET, or SCHEDULED
MIN-CFM-RATIO = 1.0
THERMOSTAT-TYPE = any

specify HEAT-TEMP-SCH



* At the temperature specified by COOL-SET-T, COOL-SET-SCH, or COOL-RESET-SCH as appropriate plus DUCT-DELTA-T.

** At the temperature specified by HEAT-SET-T, HEAT-SET-SCH or HEAT-RESET-SCH as appropriate minus DUCT-DELTA-T.

If SYSTEM-TYPE = DDS, the above diagram would be identical, except that the dual dampers would be replaced with mixing boxes.

Example:

Variable Volume Cooling / Constant Volume Heating with Program Calculated Cold and Hot Deck Temperatures for MZS, DDS, and PMZS (with COOL-CONTROL = WARMEST and HEAT-CONTROL = COLDEST)

Note: This is not a commonly used strategy for actual HVAC systems. The example, however, serves to demonstrate the program's capability to simulate variable volume and variable temperature with dual duct systems.

This control strategy produces a variable volume flow of air entering the ZONE for cooling and a constant volume flow of air for heating. This strategy uses two thermostat set points, which are specified via COOL-TEMP-SCH and HEAT-TEMP-SCH. The hourly cold deck temperature and air flow rate vary for different calculated ZONE temperatures in the cooling THROTTLING-RANGE (COOL-CONTROL = WARMEST). The cold deck temperature is automatically set by the program to cool the ZONE with the highest relative temperature in its cooling THROTTLING-RANGE (COOL-CONTROL = WARMEST). The hourly hot deck temperature and air flow rates (through both the hot deck and cold deck) vary for different ZONE temperatures in the heating THROTTLING-RANGE (HEAT-CONTROL = COLDEST). The hot deck temperature is adequate to heat the ZONE with the lowest relative temperature in its heating THROTTLING-RANGE (HEAT-CONTROL = COLDEST). It is of importance to note that when specifying MZS, DDS, or PMZS with COOL-CONTROL = WARMEST and HEAT-CONTROL = COLDEST, both cold and hot deck temperatures are subject to change in the same hour. Fig. IV.5 illustrates graphically this concurrent resetting of the cold deck temperature and the hot deck temperature. The following description is based upon a system with dual dampers that are not physically linked to each other, that is, they each have their own controller. To obtain the same physical results, the user may alternatively employ a mixing box with a variable volume output.

Cold Deck Air Flow and Temperature for the WARMEST ZONE - At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the air flow rate in the cold duct is at the maximum. As the calculated ZONE temperature drops from the top to the midpoint of the cooling THROTTLING-RANGE, the air flow rate in the cold air duct drops from the maximum to the MIN-CFM-RATIO. As the calculated ZONE temperature continues to drop from approximately the midpoint to the bottom of the cooling THROTTLING-RANGE, the air flow rate remains at the MIN-CFM-RATIO. Simultaneously, the cold deck temperature is raised linearly such that at the bottom of the cooling THROTTLING-RANGE the cooling is completely turned off. As the calculated ZONE temperature drops across the deadband, the air flow rate remains at the MIN-CFM-RATIO and the air, a mixture of return and outside air, is uncooled. As the temperature continues to drop from the top to approximately the midpoint of the heating THROTTLING-RANGE, the air flow rate in the cold duct decreases linearly from MIN-CFM-RATIO to zero (this is accompanied by an opposite action in the hot air duct). The air, however, is not being cooled. For calculated temperatures below the midpoint of the heating THROTTLING-RANGE, the air flow rate in the cold duct remains at zero.

For those ZONEs other than the WARMEST ZONE, the damper actions (air flow rates) are identical to those of the WARMEST ZONE; however, their cooling supply air temperature is determined by the WARMEST ZONE.

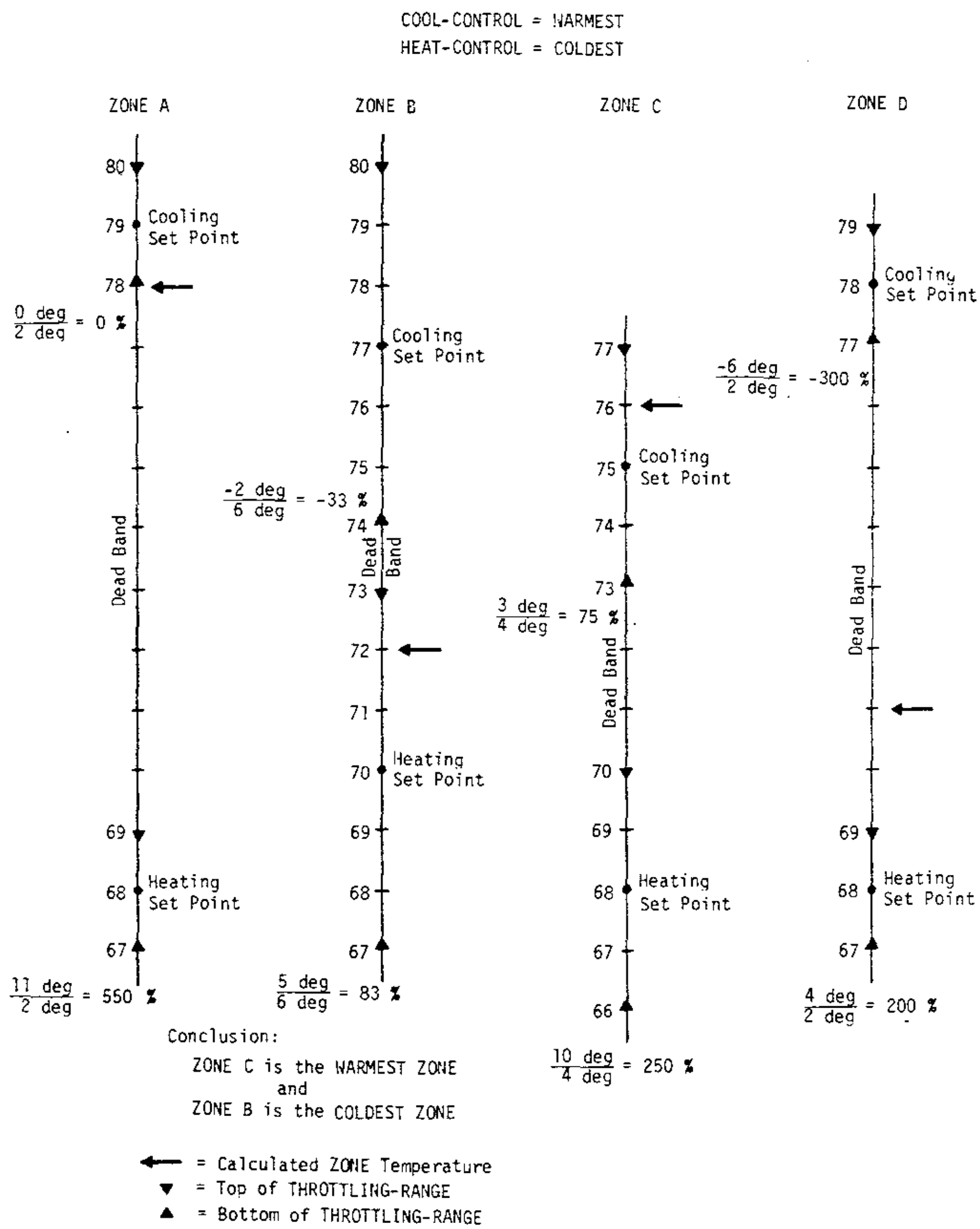


Fig. IV.5. Determining which ZONE is the WARMEST ZONE and which ZONE is the COLDEST ZONE for MZS, DDS, and PMZS.

Hot Deck Air Flow and Temperature for the COLDEST ZONE - At calculated ZONE temperatures above the heating THROTTLING-RANGE, the air flow rate in the hot duct is zero. As the calculated ZONE temperature drops from the top to approximately the midpoint of the heating THROTTLING-RANGE, the air flow rate in the hot duct increases linearly from zero to the MIN-CFM-RATIO (this is accompanied by an opposite action in the cold air duct). Also, as the calculated ZONE temperature drops, the hot deck temperature is raised linearly such that at the bottom of the heating THROTTLING-RANGE the hot deck is completely turned on. For calculated ZONE temperatures below the midpoint of the heating THROTTLING-RANGE, the air flow rate in the hot duct remains at the MIN-CFM-RATIO and the hot deck continues to rise toward its maximum temperature.

For those ZONEs other than the COLDEST ZONE, the damper actions (air flow rates) are identical to those of the COLDEST ZONE; however, their heating supply air temperature is determined by the COLDEST ZONE.

Procedure:

(1) Specify SYSTEM-TYPE = MZS, DDS, or PMZS in the SYSTEM command.

(2) Specify MIN-CFM-RATIO (in either the ZONE command or in the SYSTEM-TERMINAL subcommand) equal to some value less than 1.0 (setting MIN-CFM-RATIO equal to 1.0 will not simulate this control strategy). This, along with THERMOSTAT-TYPE = PROPORTIONAL, assures a variable volume mixed air flow entering this ZONE(s) for cooling and a constant volume mixed air flow entering the ZONE(s) for heating.

(3) Specify COOL-CONTROL in the SYSTEM-CONTROL subcommand equal to WARMEST. This determines the method for setting the hourly temperature of the cooling supply air that will be sent to all ZONEs in the SYSTEM. If the user does not specify a value for COOL-CONTROL, it will default to CONSTANT and the intended control strategy will not be simulated.

(4) Specify HEAT-CONTROL in the SYSTEM-CONTROL subcommand equal to COLDEST. This determines the method for setting the hourly temperature of the heating supply air that will be sent to all ZONEs in the SYSTEM. If the user does not specify a value for HEAT-CONTROL, it will default to CONSTANT and the intended control strategy will not be simulated.

(5) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of ZONE thermostat set point temperature for cooling. These temperatures will be used to modulate the cold deck temperature and the air flow in the cold air duct to the ZONE. If the user does not specify a COOL-TEMP-SCH for one ZONE in a multizone SYSTEM, it will be cooled, but without cooling (air volume) control.

(6) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of ZONE thermostat set point temperature for heating. These temperatures will be used to modulate the hot deck temperature and the air flow in both the cold and hot

air ducts to the ZONE. If the user does not specify a HEAT-TEMP-SCH for a ZONE, it will not be heated but it will be cooled (assuming at least one COOL-TEMP-SCH was specified and the baseboard heaters, if present, do not have BASEBOARD-CTRL = OUTDOOR-RESET).

(7) Specify THERMOSTAT-TYPE = PROPORTIONAL in the ZONE-CONTROL subcommand (or let it default).

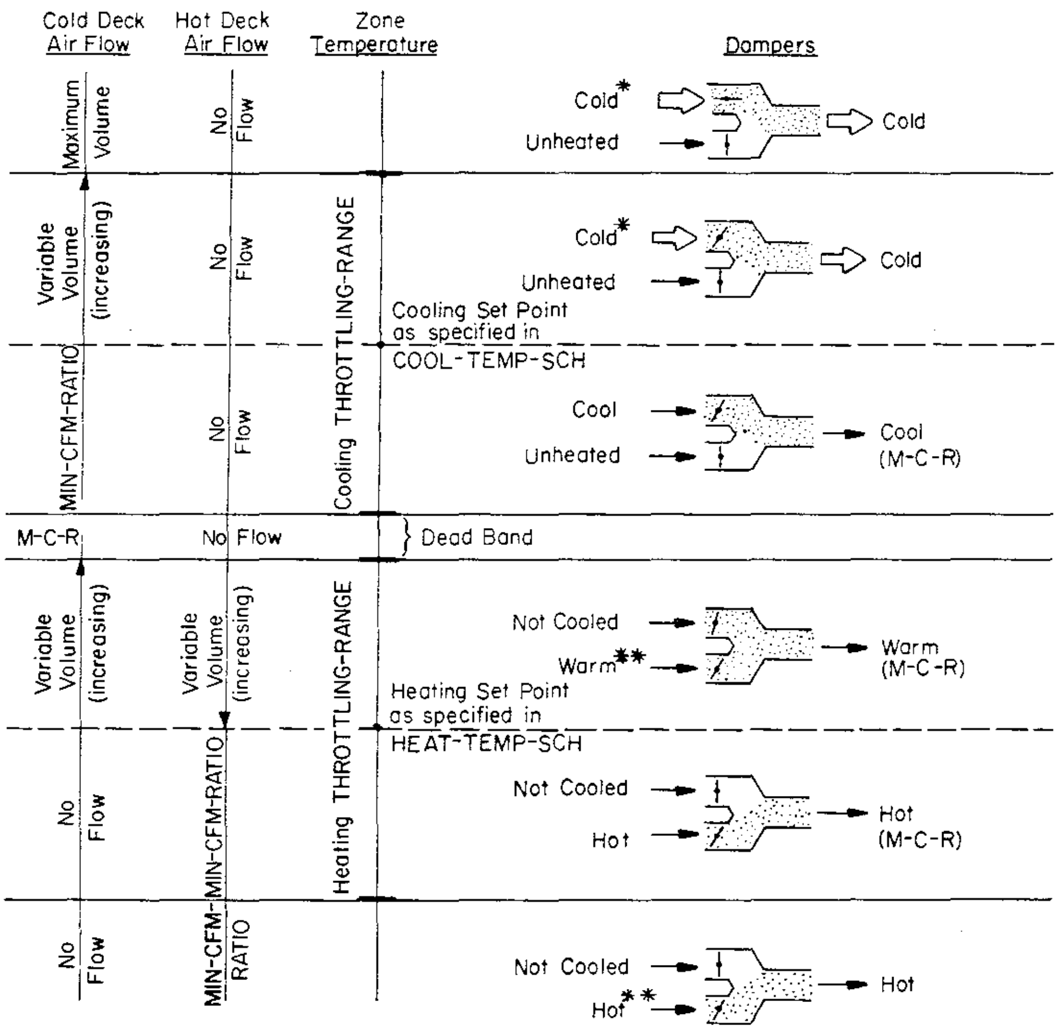
(8) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default. This example is the tenth strategy in Table IV.26.

Graphically, this example strategy for MZS or PMZS looks like the following:

MZS, PMZS

Variable Volume Cooling/Constant Volume Heating

COOL-CONTROL = WARMEST
HEAT-CONTROL = COLDEST
MIN-CFM-RATIO<1.0
specify COOL- & HEAT-TEMP-SCH
THERMOSTAT-TYPE=PROPORTIONAL



* The cold deck temperature between DESIGN-COOL-T and MIN-SUPPLY-T required by the WARMEST zone plus DUCT-DELTA-T.

** The hot deck temperature between DESIGN-HEAT-T and MAX-SUPPLY-T required by the COLDEST zone minus DUCT-DELTA-T.

Note: The preceding diagram is valid only for the WARMEST ZONE, when the calculated ZONE temperature is in the cooling THROTTLING-RANGE. For those ZONEs other than the WARMEST ZONE, the damper actions are identical; however, the cold duct air temperature is determined by the WARMEST ZONE. Likewise, the preceding diagram is valid only for the COLDEST ZONE, when the calculated ZONE temperature is in the heating THROTTLING-RANGE. For those ZONEs other than the COLDEST ZONE, the damper actions are identical; however, the hot duct air temperature is determined by the COLDEST ZONE.

If SYSTEM-TYPE = DDS, the preceding diagram would be identical, except that the dual dampers would be replaced with mixing boxes.

ii. Example Control Strategies for SYSTEM-TYPE Equals VAVS, PVAVS, CBVAV, or RHFS

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to these control strategies and SYSTEM-TYPEs.

In these SYSTEM-TYPEs a single supply air duct provides either hot or cold air to each ZONE. The four major control strategies that are defined by the selective specification of values for the keywords MIN-CFM-RATIO, COOL-CONTROL, COOL-TEMP-SCH, HEAT-TEMP-SCH, THERMOSTAT-TYPE, REHEAT-DELTA-T, and BASEBOARD-CTRL are listed in Table IV.27. These control strategies all involve two thermostat set points, one for cooling and one for heating.

All the control strategies for these SYSTEM-TYPEs have variable air volume flow for cooling. During the cooling mode of operating, the air flow rate in the air duct is automatically varied by the program, from one hour to the next hour, in an attempt to deliver the correct amount of cold air (at the cold deck temperature specified via COOL-CONTROL) to meet the desired ZONE temperature, which is specified in COOL-TEMP-SCH. The cooling supply air volume entering the ZONE may vary from a minimum of MIN-CFM-RATIO to a maximum of the design cooling flow rate (that is, the ASSIGNED-CFM, and in its absence, the amount of air required to meet the ZONE peak cooling load), assuming the supply air fan is on. Air flow in the duct during the heating mode is either constant or variable air volume flow, depending upon the value specified (or defaulted) for THERMOSTAT-TYPE. Space heating is accomplished at the ZONE level by zone (reheat) coils in the air duct, or by baseboard heaters within the ZONE, or both.

The physical method of varying the air flow for cooling is accomplished by several different methods, depending upon the SYSTEM-TYPE specified by the user. If the SYSTEM-TYPE equals either VAVS or PVAVS, the total SYSTEM cooling air is supplied by a variable volume fan (FAN-CONTROL = SPEED, INLET, or DISCHARGE) and the quantity of air to each ZONE is varied by a variable air volume box (VAV Box). If SYSTEM-TYPE = RHFS and the user has specified MIN-CFM-RATIO less than 1.0, the cooling air is supplied by a constant volume fan (FAN-CONTROL = CONSTANT-VOLUME) and the quantity of air delivered to each ZONE is varied by a VAV box. If the SYSTEM-TYPE = CBVAV, the cooling air is supplied by a constant volume fan (FAN-CONTROL = CONSTANT-VOLUME). However, a different type of VAV Box is used that injects the correct amount of cooling air into the ZONE to meet the cooling load and the excess cooling air is bypassed into a ceiling plenum that returns the excess cooling air to the air handling unit.

The heat from the supply air fan is added, by default, to the air downstream from the cooling coil, unless the user specifies FAN-PLACEMENT = BLOW-THROUGH. The effect of the humidifier, if specified, is added to the mixed outside and return air stream.

TABLE IV.27

MAJOR CONTROL STRATEGIES FOR SYSTEM-TYPE = VAVS, PVAVS, CBVAV, or RHFS

	Strategy	MIN-CFM-RATIO	Cooling Coil Temp. (COOL-CONTROL)	Zone Cooling Set Point (COOL-TEMP-SCH)	Zone Heating Set Point (HEAT-TEMP-SCH)	Zone THERMOSTAT-TYPE	Zone (Reheat) Coil, and/or Baseboard Heaters (REHEAT-DELTA-T ≠ 0)
*1.	Variable Volume Cooling and Constant Volume Heating with User-controlled Cooling Coil Temperatures	< 1.0	CONSTANT, RESET or SCHEDULED	Required for zone air flow control	Required for zone heating	PROPORTIONAL	One or both required for zone heating
2.	Variable Volume Cooling and Constant Volume Heating with Program-calculated Cooling Coil Temperatures	< 1.0	WARMEST	Required for WARMEST and zone air flow control	Required for zone heating	PROPORTIONAL	One of both required for zone heating
3.	Variable Volume Cooling and Heating with User-controlled Cooling Coil Temperatures	< 1.0	CONSTANT, RESET or SCHEDULED	Required for zone air flow control	Required for zone heating and air flow control	REVERSE-ACTION	One of both required for zone heating
4.	Variable Volume Cooling and Heating with Program-calculated Cooling Coil Temperatures	< 1.0	WARMEST	Required for WARMEST and zone air flow control	Required for zone heating and air flow control	REVERSE-ACTION	One or both required for zone heating

*An example of this control strategy is included in the following discussion.

Notes:

1. All heating is accomplished at the ZONE level either by optional zone (reheat) coils or by optional baseboard heaters, or both. Zone coils are controlled via HEAT-TEMP-SCH and baseboard heaters are controlled via HEAT-TEMP-SCH only if BASEBOARD-CTRL=THERMOSTATIC.

2. The above table is not entirely complete. Associated with most of the keywords and code-words listed in the table are other "related" keywords and code-words. Example: If COOL-CONTROL=CONSTANT, the user must also specify a value for its "related" keyword, COOL-SET-T.

Example:

Variable Volume Cooling / Constant Volume Heating with User-controlled Cold Deck Temperature for VAVS, PVAVS, CBVAV, and RHFS (with COOL-CONTROL = CONSTANT)

The cooling is accomplished by a variable air volume flow. In this example, the temperature of the cold air stream (air temperature leaving the cooling coil) is set by the user at a fixed value. The variable volume flow of cooling air is controlled at the ZONE level with the keyword COOL-TEMP-SCH.

The heating is accomplished at the ZONE level by a constant air volume flow over a variable temperature zone coil, located in the supply air duct. The temperature of the hot air stream (zone coil temperature) is controlled at the ZONE level with the keyword HEAT-TEMP-SCH.

Cold Deck Air Flow and Temperature - The cooling coil temperature is set by the user at a fixed value for all hours of the year. At calculated ZONE tempera- tures above the cooling THROTTLING-RANGE, the air flow rate in the air duct is at the maximum. As the calculated ZONE temperature drops from the top to the bottom of the cooling THROTTLING-RANGE, the air flow rate in the duct drops from the maximum to the MIN-CFM-RATIO. For all calculated ZONE temperatures below the cooling THROTTLING-RANGE the air flow rate remains at the MIN-CFM-RATIO.

Zone Coil Temperature - As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the zone coil output increases linearly from zero at the top of the heating THROTTLING-RANGE to maximum at the bottom of the heating THROTTLING-RANGE.

Procedure:

(1) Specify SYSTEM-TYPE = VAVS, PVAVS, CBVAV, or RHFS in the SYSTEM command.

(2) Specify MIN-CFM-RATIO (in either the ZONE command or in the SYSTEM-TERMINAL subcommand) equal to some value less than 1.0 (MIN-CFM-RATIO = 1.0 will simulate a constant volume system). If the user does not specify a value for MIN-CFM-RATIO, the program will calculate the value, based upon outside air flow rate or peak heating load. The value of MIN-CFM-RATIO along with THERMOSTAT-TYPE = PROPORTIONAL, assures a variable volume air flow entering this ZONE(s) for cooling and a constant volume air flow entering the ZONE(s) for heating.

(3) Specify COOL-CONTROL in the SYSTEM-CONTROL subcommand equal to CONSTANT, or allow it to default. Also specify COOL-SET-T equal to the desired fixed cooling coil temperature, normally equal to or greater than MIN-SUPPLY-T. This establishes the temperature of the cooling supply air that will be sent to all ZONEs in the SYSTEM. If the user does not specify a value for COOL-CONTROL, it will default to CONSTANT and COOL-SET-T will default to MIN-SUPPLY-T.

(4) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for cooling. These temperatures will be used to modulate the cooling air flow in the air duct. If the user does not specify a COOL-TEMP-SCH for a ZONE, it will be cooled, according to COOL-SET-T, (unless the COOLING-SCHEDULE is set to off) but there will be no control of the cooling process.

(5) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for heating. These temperatures will be used to modulate the output of the zone heating coil. If the user does not specify a HEAT-TEMP-SCH or a ZONE, it will be cooled, according to COOL-SET-T, but not heated (except for primary air and baseboard heaters when BASEBOARD-CTRL = OUTDOOR-RESET).

(6) Specify THERMOSTAT-TYPE = PROPORTIONAL (or let it default) in the ZONE-CONTROL subcommand.

(7) Specify a value for REHEAT-DELTA-T in the SYSTEM-TERMINAL subcommand. This indicates to the program that zone (reheat) coils are to be used in the ZONEs and it also indicates the maximum increase in temperature of the supply air passing over the zone coils. If the user does not specify a value for REHEAT-DELTA-T, there will be no reheating; if the value is specified too small, there will be inadequate reheating.

(8) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default. This example is the first strategy in Table IV.27.

Graphically, this example strategy for VAVS, PVAVS, CBVAV, and RHFS looks like the following:

VAVS, PVAVS, CBVAV, RHFS

Variable Volume Cooling/Constant Volume Heating

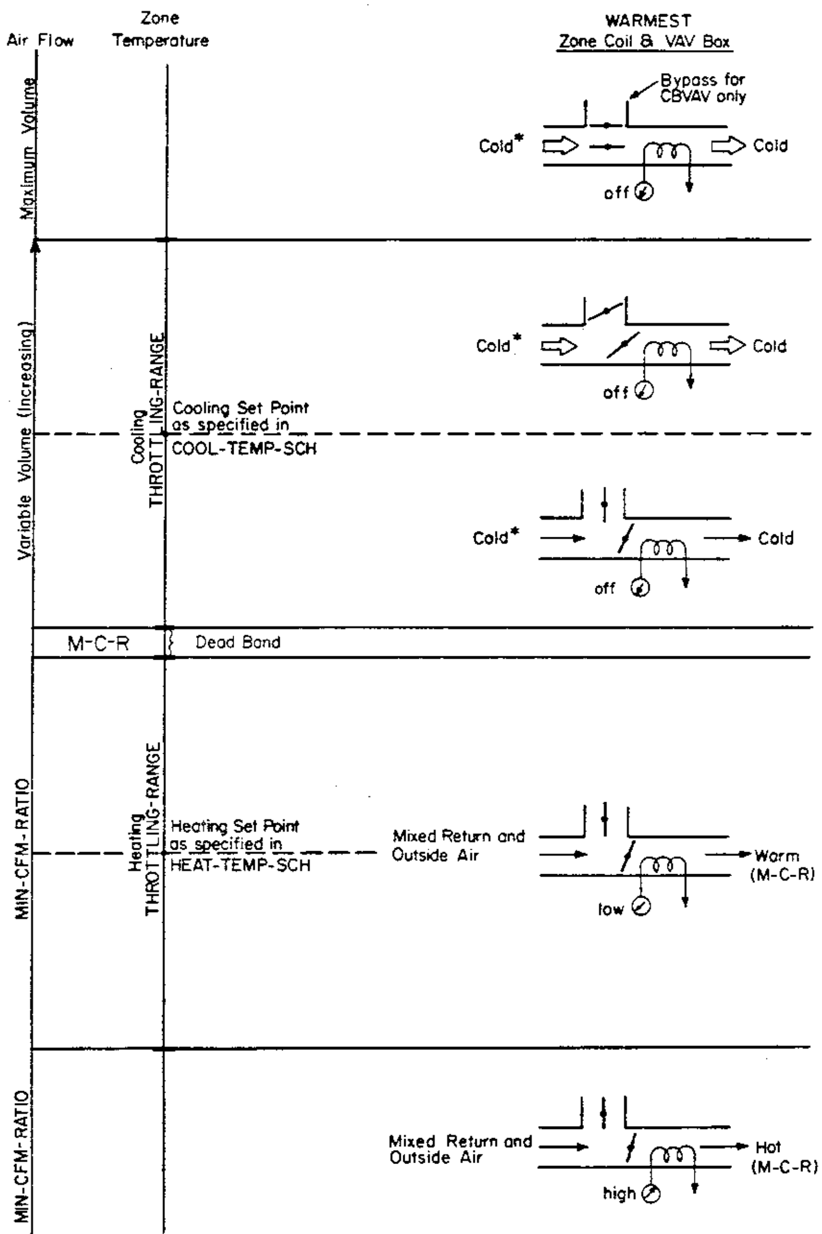
COOL-CONTROL= CONSTANT

REHEAT-DELTA-T≠ 0

HEAT-& COOL-TEMP-SCH

MIN-CFM-RATIO<1

THERMOSTAT-TYPE = PROPORTIONAL



*The cold deck temperature (COOL-SET-T) plus DUCT-DELTA-T

iii. Example Control Strategy for SYSTEM-TYPE Equals SZRH and PSZ

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to the control strategies for these SYSTEM-TYPEs. There is only one major control strategy that is defined by the selective specification of values for the keywords COOL-TEMP-SCH, HEAT-TEMP-SCH, and REHEAT-DELTA-T.

In these SYSTEM-TYPEs a single supply air duct provides either cold or hot air, at constant volume, to a control ZONE, and (optionally at variable flow) to one or more subZONEs. The control ZONE is the first ZONE specified by the user in the ZONE-NAMES keyword list (see SYSTEM command). The ZONE chosen as the control ZONE should be the one that is the easiest to heat in the winter and the hardest to cool in the summer. If this criterion is not met, it will be impossible for the subZONE reheat coils to maintain temperature control in the subZONEs.

The cooling supply air temperature is controlled at the SYSTEM level via COOL-TEMP-SCH for the control ZONE. The subZONEs control only the reheat coil unless the variable air volume option is used.

Space heating is controlled at both the SYSTEM level and the subZONE level. The SYSTEM level heating is controlled via HEAT-TEMP-SCH for the control ZONE and the ZONE level heating is controlled via HEAT-TEMP-SCH for the subZONE(s). The heating for the subZONEs is accomplished by zone (reheat) coils.

If the SYSTEM does not have one single ZONE that meets the criterion, stated above, for a control ZONE, the following can be done. The user can intervene in the automatic process of calculating the design flow rate by specifying values for ASSIGNED-CFM, AIR-CHANGE/HR, or CFM/SQFT (see ZONE-AIR subcommand) for those ZONEs that are improperly conditioned. Often, such a correction for heating in the winter will be detrimental to the cooling process in the summer. This is not surprising and is quite indicative of this SYSTEM-TYPE in real life.

The heat from the supply air fan is added, by default, downstream from the cooling coil, unless the user specifies FAN-PLACEMENT = BLOW-THROUGH. The effect of the humidifier, if specified, is added to the mixed air stream.

Example:

Constant Volume Cooling and Heating Strategy for SZRH and PSZ with ZONE Reheating

This strategy involves two thermostat set points in the control ZONE, one for cooling and one for heating. The control ZONE does not have a zone (reheat) coil. In the subZONEs, only the heating set point is used, to control the reheat coils (unless a variable air volume capability has been specified).

The temperature of the cold air stream (cooling coil temperature) is held constant throughout each hour for simulation purposes, but varies with each successive hour. This temperature is controlled via the input for COOL-TEMP-SCH and THROTTLING-RANGE in the control ZONE. At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the cooling supply air is delivered at MIN-SUPPLY-T. As the ZONE temperature drops from the top to the bottom of the cooling THROTTLING-RANGE, the cooling coil temperature rises linearly such that at the bottom of the range the coil is completely off (passing mixed air).

Similarly for the heating mode, the supply air temperature is controlled via the input for HEAT-TEMP-SCH in the control ZONE. Within the subZONEs, the hot air stream temperature may be modified upward by zone (reheat) coils located in the supply air ducts. If the user does not want a reheat coil in a particular subZONE, he should not specify a HEAT-TEMP-SCH for that subZONE. The output of the reheat coil is controlled by the user input for the keywords HEAT-TEMP-SCH and REHEAT-DELTA-T in the subZONE.

If the calculated control ZONE temperature is in the dead band, the air is neither heated nor cooled at the SYSTEM level. If the calculated subZONE temperature is above the heating THROTTLING-RANGE, no reheating is done.

Procedure:

(1) Specify SYSTEM-TYPE = SZRH or PSZ in the SYSTEM command.

(2) Determine which ZONE in the SYSTEM is the control ZONE, according to the criterion specified earlier. Specify that ZONE U-name as the first U-name in the ZONE-NAMES list.

(3) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for cooling in the control ZONE. These ZONE temperatures will be used to modulate the cold deck temperature, at the SYSTEM level, to satisfy the cooling load of the control ZONE. If the user does not specify a COOL-TEMP-SCH for the control ZONE, it will not be cooled. The temperature of the cooling air supplied to the subZONEs is always determined by the control ZONE.

(4) Specify a value for REHEAT-DELTA-T in the SYSTEM-TERMINAL subcommand. This indicates to the program that zone (reheat) coils are to be used in the subZONEs and it also indicates the maximum increase in temperature of the supply air passing over the zone coils.

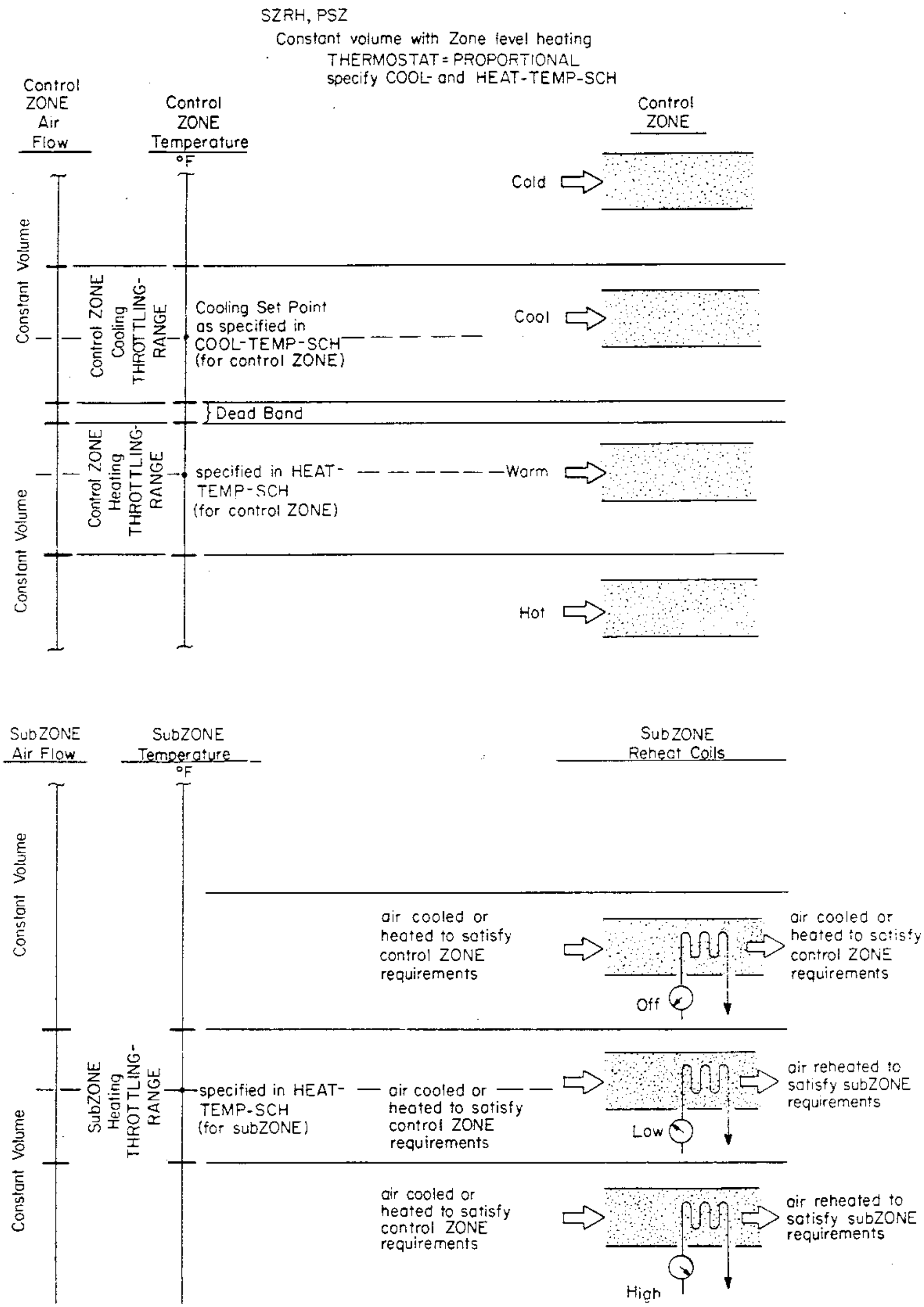
(5) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for heating in the control ZONE. Specify a HEAT-TEMP-SCH for each subZONE that is to have reheating. These latter ZONE temperatures will be used to modulate the output of the subZONE reheat coils.

(6) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand for the control ZONE and any subZONE that has reheating.

(7) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default.

Note: If the user should specify SZRH or PSZ with variable volume air flow rate (MIN-CFM-RATIO < 1), only the subZONEs will experience variable volume flow. In this case, to maintain cooling control in the subZONEs, the user should also specify COOL-TEMP-SCH for each subZONE.

Graphically, this example strategy for SZRH and PSZ looks like the following:



iv. Example Control Strategy for SYSTEM-TYPE Equals TPFC, FPFC, HP, RESYS, or PTAC

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to these control strategies and SYSTEM-TYPEs. There is only one major control strategy (for each of these SYSTEM-TYPEs) that is defined by the selective specification of values for the keywords COOL-TEMP-SCH, HEAT-TEMP-SCH, MAX-FLUID-T, MIN-FLUID-T, FLUID-HEAT-CAP, NATURAL-VENT-SCH, VENT-TEMP-SCH, and NATURAL-VENT-AC.

SYSTEM-TYPE Equals TPFC or FPFC

The Two Pipe Fan Coil (TPFC) SYSTEM-TYPE is a "zonal" type that has a central cooling source, a central heating source, and a pipe loop with a working fluid, which flows to all the ZONEs. The loop provides either cooling fluid or heating fluid to all the fan coil units, which are located in the ZONEs. This means that all ZONEs in the SYSTEM must either be in the cooling mode or the heating mode. The decision of when to switch the TPFC SYSTEM from cooling to heating, and vice versa, is made by the user and is expressed via the keywords COOLING-SCHEDULE and HEATING-SCHEDULE (see SYSTEM-CONTROL subcommand). The SCHEDULEs referenced by COOLING-SCHEDULE and HEATING-SCHEDULE must not overlap. Each TPFC fan coil unit has a constant volume supply air fan, one heat exchanger coil, a modulating control valve, and a two set point thermostat. The desired set points are specified, respectively, with the keywords COOL-TEMP-SCH and HEAT-TEMP-SCH (plus their associated SCHEDULEs).

The Four Pipe Fan Coil (FPFC) SYSTEM-TYPE, also a "zonal" type, has a central cooling source, a central heating source, and two pipe loops, one for cooling and one for heating. The FPFC fan coil units are identical to the TPFC fan coil units except the FPFC units have two heat exchanger coils. Depending upon the hourly values referenced by COOLING-SCHEDULE and the HEATING-SCHEDULE, either cooling or heating, or both, can be made available at any time to the ZONEs. That is, SYSTEM-TYPE = FPFC permits some ZONEs to be cooled while other ZONEs are being heated.

Cooling Mode for TPFC and FPFC - This explanation assumes THERMOSTAT-TYPE = PROPORTIONAL. At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the cooling output of the ZONE fan coil unit is at the maximum as calculated or specified. As the calculated ZONE temperature drops from the top to the bottom of the cooling THROTTLING-RANGE, the cooling output decreases linearly from maximum to zero. For calculated ZONE temperatures below the cooling THROTTLING-RANGE, the cooling output of the ZONE fan coil unit remains at zero. The air flow rate is always constant, assuming the FAN-SCHEDULE is on.

Heating Mode for TPFC and FPFC - At calculated ZONE temperatures above the heating THROTTLING-RANGE, the heating output of the ZONE fan coil unit is zero. As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the heating output of the ZONE fan coil unit increases linearly from zero to its maximum, as calculated or specified. At ZONE temperatures below the heating THROTTLING-RANGE, the heating output remains at the maximum. The air flow rate is always constant, assuming the FAN-SCHEDULE is on.

The heat from the supply air fan is added entirely to the supply air. The effect of the humidifier, if specified, is also added entirely to the ZONE.

Procedure:

(1) Specify SYSTEM-TYPE = TPFC or FPFC in the SYSTEM command.

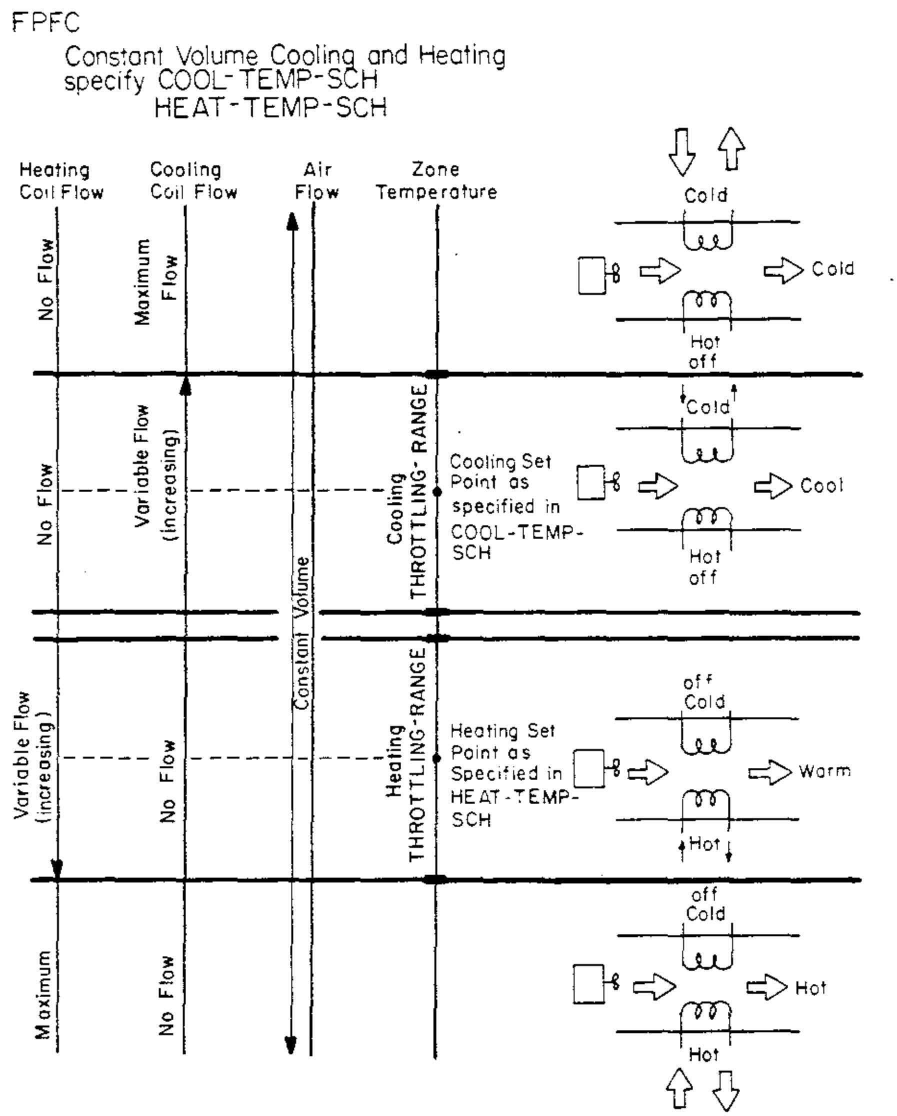
(2) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for cooling. These temperatures will be used to modulate the fluid flow rate in (1) the one coil of the TPFC unit or (2) the cooling coil of the FPFC unit. If the user does not specify a COOL-TEMP-SCH for a ZONE, this zone cooling coil is never activated.

(3) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. These temperatures will be used to modulate the fluid flow rate in (1) the one coil of the TPFC unit or (2) the heating coil of the FPFC unit. If the user does not specify a HEAT-TEMP-SCH for a ZONE, this zone heating coil is never activated.

(4) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand.

(5) The control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default.

Graphically, the example strategy for FPFC looks like the following:



If SYSTEM-TYPE = TPFC, the previous diagram would be the same except there would be only one heat exchanger coil instead of two.

SYSTEM-TYPE Equals HP

The Unitary Hydronic Heat Pump (SYSTEM-TYPE = HP), also known as a California Heat Pump, is a "zonal" type system. The HP system has one central liquid cooling source, one central liquid heating source, and a single pipe loop, which distributes a working fluid to and from the individual heat pumps. Each conditioned ZONE has a heat pump, which takes heat from the working fluid or gives up heat to the working fluid. Some ZONEs can be cooled while other ZONEs are being heated.

This SYSTEM-TYPE utilizes a two set point thermostat. The desired cooling and heating set points are specified, respectively, with the keywords COOL-TEMP-SCH and HEAT-TEMP-SCH (plus their associated SCHEDULEs). If outside ventilation air is specified, the supply air fan operates continuously, assuming the FAN-SCHEDULE is turned on. If outside ventilation air is not specified, the fan cycles on and off with the refrigeration compressor, again, assuming the FAN-SCHEDULE is turned on.

The working fluid in the pipe loop absorbs heat from those heat pumps that are operating in the cooling mode and gives up heat to those heat pumps that are operating in the heating mode. When the total cooling demand exceeds the total heating demand, the fluid temperature increases. If the fluid temperature exceeds MAX-FLUID-T (SYSTEM-FLUID subcommand), the excess heat is dissipated to the atmosphere through a cooling tower or through other cooling equipment specified in PLANT. When the total heating demand exceeds the total cooling demand, the fluid temperature decreases. If the fluid temperature drops below MIN-FLUID-T (SYSTEM-FLUID subcommand), heat is added to the fluid by a boiler, or other heat source, to maintain the fluid temperature at MIN-FLUID-T. No heat is added to or rejected from the fluid when its temperature is between MAX-FLUID-T and MIN-FLUID-T. When this occurs, the system is merely transporting energy between the ZONEs. The cooling tower, the boiler, the pump, and the water circulation loop are simulated in the PLANT program.

Example:

Assuming outside air has been specified, the heat pump and supply air fan work as follows. The supply air fan runs continuously (even though FAN-CONTROL = CYCLING). At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the heat pump runs continuously, in the cooling mode. At all calculated ZONE temperatures within the cooling THROTTLING-RANGE, the heat pump cycles on and off, still in the cooling mode. The heat pump runs just long enough, during the simulation hour, to extract the correct number of Btus to cool the ZONE. As the calculated ZONE temperature drops across the dead band, the heat pump is turned off; the fan continues to operate, however, bringing outside air to the ZONE. As the calculated ZONE temperature drops into the top of the heating THROTTLING-RANGE, the heat pump cycles on, but this time in the heating mode. At ZONE temperatures below the heating THROTTLING-RANGE, the heat pump runs continuously, in the heating mode.

The heat from the supply air fan is added to the air flowing into the ZONE. The air flow rate of each supply air fan is calculated, or specified, to match the needs of its ZONE. The power consumption rate per CFM of all the fans is assumed to be the same. That total fan consumption rate for all the heat pumps is specified in the SYSTEM-FANS subcommand. The energy input to the compressor acts to increase or decrease the amount of heat rejected to or withdrawn from the fluid loop.

Procedure:

(1) Specify SYSTEM-TYPE = HP in the SYSTEM command.

(2) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for cooling. Specify one COOL-TEMP-SCH for each ZONE in the SYSTEM, assuming cooling is desired in that ZONE. If the user does not specify a COOL-TEMP-SCH for a ZONE, the cooling mode is never entered.

(3) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. Specify one HEAT-TEMP-SCH for each ZONE in the SYSTEM, assuming heating is desired in that ZONE. If the user does not specify a HEAT-TEMP-SCH for a ZONE, the heating mode is never entered.

(4) Specify values for MAX-FLUID-T, MIN-FLUID-T, and FLUID-HEAT-CAP in the SYSTEM-FLUID subcommand. This describes the working fluid in the pipe loop and its range of permissible temperatures.

(5) Specify THERMOSTAT-TYPE = TWO-POSITION or PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand. Repeat this specification for every conditioned ZONE.

(6) The control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to this SYSTEM-TYPE, or allow these keywords to default.

SYSTEM-TYPE Equals RESYS

The central cooling and heating sources for RESYS, the Residential System, may be either (1) a DX refrigeration unit for cooling plus a heating source fueled by hot water, electricity, gas, oil, or solar or (2) an air-to-air heat pump. The Residential System (SYSTEM-TYPE = RESYS) has a single supply air duct that provides either cold or hot air to one or more ZONEs in a residence. The cold or the hot air stream always flows at a constant flow rate, assuming the supply fan is on. The RESYS does not have a return air fan or exhaust fans.

Residences that do not include unconditioned ZONEs, such as crawl spaces and attics, can be simulated as a single ZONE residence, served by one SYSTEM. If the user elects to simulate a SYSTEM that serves more than one ZONE, the program will treat the residence as consisting of a control ZONE, and one or more subZONES. The control ZONE is the first ZONE specified by the user in the ZONE-NAMES keyword list (see SYSTEM command).

When SYSTEM-TYPE = RESYS is specified, the program sets the THROTTLING-RANGE to .5°F, which is approximately the "swing about the set point" that is required during cycling operations (a two position thermostat).

The central cooling source for RESYS is controlled by the user input for COOL-TEMP-SCH for the control ZONE (plus its associated SCHEDULE). The subZONEs, if they exist, do not have control of their own cooling; therefore, the subZONEs may be overcooled or undercooled, which is not uncommon with this SYSTEM-TYPE.

The central heating source for RESYS is controlled by the user input for HEAT-TEMP-SCH for the control ZONE (plus its associated SCHEDULE). The subZONEs, if they exist, do not have any control of their own heating, unless they have the optional baseboard heaters with BASEBOARD-CTRL = THERMOSTATIC. With this option, it is possible to prevent underheating of the subZONEs, but not overheating.

At calculated control ZONE temperatures above the cooling THROTTLING-RANGE, the cooling unit and supply air fan run continuously. At all calculated control ZONE temperatures within the small cooling THROTTLING-RANGE, the cooling unit and fan cycle on and off. The cooling unit runs just long enough, during the simulation hour, to extract the correct number of Btus to cool the ZONE. As the control ZONE temperature drops into the dead band, the cooling source and fan are turned off. As the calculated control ZONE temperature drops into the top of the heating THROTTLING-RANGE, the heating source and fan cycle on. At control ZONE temperatures below the heating THROTTLING-RANGE, the heating source and fan run continuously.

The calculated temperatures in the subZONEs of a multizone residence may not be acceptable if the wrong ZONE is chosen as the control ZONE. This is not surprising and is quite indicative of this SYSTEM-TYPE in real life. There are several solutions to this problem; however, a less obvious solution is the following. The user can intervene in the automatic process of calculating the design flow rate by specifying values for ASSIGNED-CFM, AIR-CHANGES/HR, or CFM/SQFT (see ZONE-AIR subcommand) for those subZONEs that are improperly conditioned. Often, however, such a correction for heating in the winter will be detrimental to the cooling process in the summer.

RESYS is the only SYSTEM-TYPE in DOE-2 that is capable of simulating cooling by natural ventilation through openable windows. The natural ventilation cooling is simulated based on the user input for NATURAL-VENT-SCH, VENT-TEMP-SCH, and NATURAL-VENT-AC (see SYSTEM-AIR subcommand). The user should note that natural ventilation cooling is specified at the SYSTEM level, which means that the input will apply to every ZONE in the SYSTEM. The lower limit (on ZONE air temperatures) for cooling by natural ventilation is specified via the keyword, VENT-TEMP-SCH. At calculated control ZONE temperatures within the cooling THROTTLING-RANGE (T-R = .5) and down to the temperatures specified (or defaulted) via VENT-TEMP-SCH, the residence may be put into the natural ventilation mode for cooling. If NATURAL-VENT-SCH is specified such that the occupant is at home and wishes to ventilate the residence (that is, if the hourly values in the referenced DAY-SCHEDULE are either 1 or -1), the following will occur. The windows will be opened and closed by the occupant, if the act of doing so will help keep the control ZONE temperature between the top of its cooling THROTTLING-RANGE and the temperatures specified (or defaulted) via VENT-TEMP-SCH. If the occupant does not wish to ventilate the residence, or cannot ventilate the residence because he is not at home at the time, that should be reflected in the NATURAL-VENT-SCH (that is, the hourly values in the referenced DAY-SCHEDULE should be specified as 0). If natural ventilation for purposes of cooling is not done, one of two actions will occur, (1) if the calculated control ZONE temperature is within its cooling THROTTLING-RANGE, the cooling source cycles on, or (2) if the calculated control ZONE temperature is within the dead band, the SYSTEM is turned off. If the user does not specify VENT-TEMP-SCH and an associated SCHEDULE, it will default to the temperature at the top of the heating THROTTLING-RANGE in the control ZONE. The simulation theory and an example input can be found in the SYSTEM-AIR section of this chapter. Increasing the spread between the set points would further increase the possibility for cooling by natural ventilation.

Example:

Cycling Forced Air Cooling and Heating Strategy for RESYS (with an Air-to-Air Heat Pump, subZONE Baseboard Heaters, and Natural Ventilation)

The user has chosen to supply additional heating in the subZONEs with baseboard heaters. These heaters are controlled by the user input for HEAT-TEMP-SCH (in the subZONEs). For the best control set BASEBOARD-CTRL = THERMOSTATIC.

Procedure:

(1) Specify SYSTEM-TYPE = RESYS in the SYSTEM command.

(2) Specify HEAT-SOURCE = HEAT-PUMP in the SYSTEM command.

(3) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for cooling in the control ZONE. The ZONE chosen as the control ZONE should be the one that is the easiest to heat in the winter and the hardest to cool in the summer. If this criterion is not met, it will be impossible for the subZONE baseboard heaters to maintain temperature control in the subZONEs. If the user does not specify a COOL-TEMP-SCH for the control ZONE, no ZONE will be cooled.

(4) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for heating for the control ZONE. Specify a HEAT-TEMP-SCH for each subZONE with baseboard heaters. The specified control ZONE temperatures will control the heat pump cycling. The specified subZONE temperatures will be used to modulate the output of the baseboard heaters. If the user does not specify a HEAT-TEMP-SCH for the control ZONE, the HEAT-PUMP will not be activated. If the user does not specify a HEAT-TEMP-SCH for a subZONE, its baseboard heaters will not be activated.

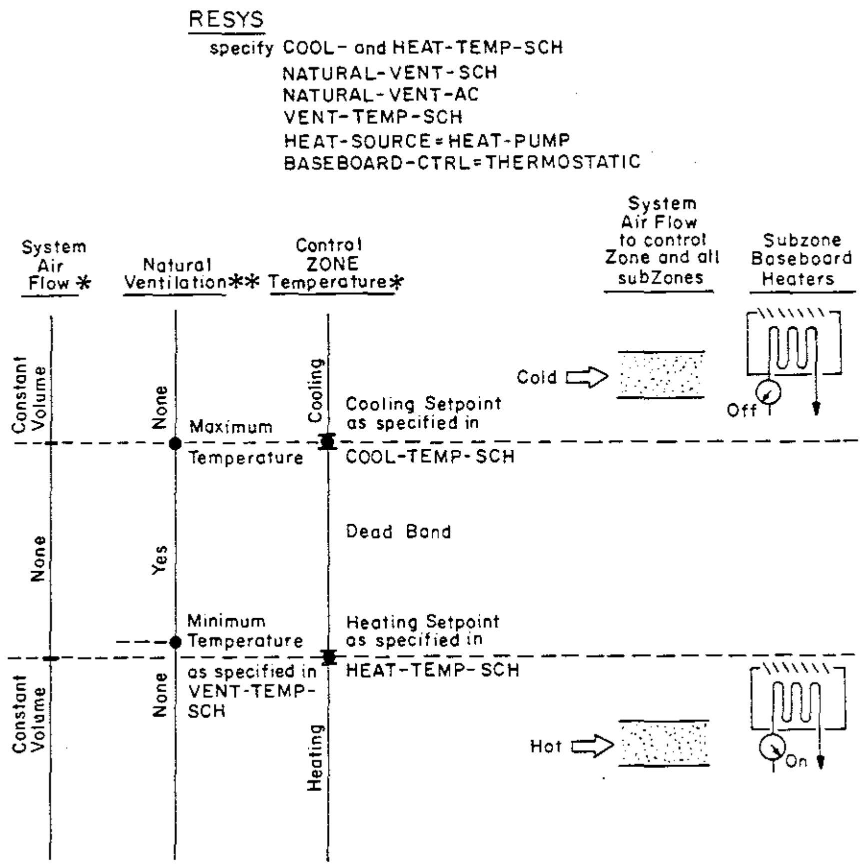
(5) Specify BASEBOARD-SOURCE in the SYSTEM command. Also, specify (for each ZONE that is to have baseboard heaters) a value for BASEBOARD-RATING in the ZONE command and specify BASEBOARD-CTRL = THERMOSTATIC in the ZONE-CONTROL subcommand. This indicates the heat source for the baseboard heaters, their maximum heating rates, and that they are to be controlled by thermostats within the ZONEs.

(6) Specify a value for THERMOSTAT-TYPE (or allow it to default to PROPORTIONAL).

(7) Specify input for NATURAL-VENT-SCH and NATURAL-VENT-AC in the SYSTEM-AIR subcommand. If the user wishes to specify a lower limit (on ZONE air temperatures) for cooling by natural ventilation, he should specify input for VENT-TEMP-SCH, including a SCHEDULE of hourly values, or allow it to default to the temperature at the top of the heating THROTTLING-RANGE for all hours.

(8) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to this SYSTEM-TYPE, or allow these keywords to default.

Graphically, the Cycling Forced Air Cooling and Heating Strategy for RESYS (with an Air-to-Air Heat Pump, subZONE Baseboard Heaters, and Natural Ventilation) looks like the following:



* Assuming THERMOSTAT-TYPE = TWO-POSITION

** Provided the SCHEDULE referenced by NATURAL-VENT-SCH has an hourly value of +1 or -1.

SYSTEM-TYPE Equals PTAC

The Package Terminal Air Conditioner (SYSTEM-TYPE = PTAC) is a "zonal" type system. The PTAC system provides either cold or hot air to one room, or ZONE, normally in a commercial building such as a hotel or motel room, a hospital room, or an office. The cold or the hot air stream may flow at one of two constant volume flow rates, high or low, assuming the supply fan is on. The PTAC does not have a return air fan.

The cooling and heating sources for PTAC may be either (1) a DX refrigeration unit for cooling plus a heating source fueled by hot water, electricity, gas, oil, or solar or (2) an air-to-air heat pump.

This SYSTEM-TYPE utilizes a thermostat with two set points, only one of which is effective at any one time, depending upon the occupants needs.

The cooling source for PTAC is controlled by the user input for COOL-TEMP-SCH for the ZONE plus its associated SCHEDULE. The heating source is similarly controlled by HEAT-TEMP-SCH.

The supply air fan speed is determined by the program based upon the zone load. At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the cooling source runs continuously. At all calculated ZONE temperatures within the cooling THROTTLING-RANGE, the cooling source cycles on and off. The cooling source runs just long enough, during the simulation hour, to extract the correct number of Btus to cool the ZONE. As the ZONE temperature drops into the dead band, the cooling source is turned off. The fan runs continuously if outside air was specified; otherwise, the fan cycles on and off with the heating or cooling source. As the calculated ZONE temperature drops into the top of the heating THROTTLING-RANGE, the heating source cycles on. At ZONE temperatures below the heating THROTTLING-RANGE, the heating source runs continuously.

Procedure:

(1) Specify SYSTEM-TYPE = PTAC in the SYSTEM command.

(2) If the user wishes to use the heat pump option, he should specify HEAT-SOURCE = HEAT-PUMP in the SYSTEM command. An electrical utility demand will be passed on to PLANT.

(3) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for cooling. If the user does not specify a COOL-TEMP-SCH for the ZONE, the cooling source is never activated.

(4) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. If the user does not specify a HEAT-TEMP-SCH for the ZONE, the heating source is never activated.

(5) Specify FAN-CONTROL = TWO-SPEED (or allow it to default to that value) in the SYSTEM-FANS subcommand. Also, specify values for LOW-SPEED-RATIOS in the same subcommand.

(6) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to this SYSTEM-TYPE, or allow these keywords to default.

v. Control Strategy for SYSTEM-TYPE Equals UHT or UVT

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to these control strategies and SYSTEM-TYPEs. There is only one major control strategy (for each of these SYSTEM-TYPEs) that is defined by the specification of the keyword HEAT-TEMP-SCH.

UHT

The Unit Heater (UHT) SYSTEM-TYPE is a "zonal" type with a heating source, a supply air fan, and a one set point thermostat, all located within the ZONE. The desired heating set point is specified with the keyword HEAT-TEMP-SCH plus its associated SCHEDULE.

At calculated ZONE temperatures above the heating THROTTLING-RANGE, the ZONE heat source and the supply air fan are turned off. As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the heating coil output increases linearly from zero to maximum, in an attempt to maintain the heating set point. At ZONE temperatures below the heating THROTTLING-RANGE, the output of the heating coil remains at the maximum and the supply fan remains on, in an attempt to raise the ZONE temperature back up to within the heating THROTTLING-RANGE.

UVT

The Unit Ventilator (UVT) SYSTEM-TYPE is also a "zonal" type. It is physically identical to the Unit Heater except that it has, in addition, a moveable outside air damper. The outside air damper permits the passage of a fixed (minimum) amount of ventilation air during the heating mode. The UVT system does not have exhaust fan capability.

The supply air fan runs continously to ensure ventilation except when the fan is scheduled to be off or NIGHT-CYCLE-CTRL is in effect. At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the outside air damper is wide open. As the calculated ZONE temperature drops from the top to the bottom of the cooling THROTTLING-RANGE, the outside air damper moves linearly from fully open to the minimum position, in an attempt to provide cooling by ventilation. Within the dead band of the thermostat, the outside air damper remains at the minimum position and the air is not heated. As the temperature continues to drop from the top to the bottom of the heating THROTTLING-RANGE, the heating coil output increases from zero to its maximum, in an attempt to maintain the heating set point. The ventilation air flow remains at the minimum specified by MIN-OUTSIDE-AIR. Below the heating THROTTLING-RANGE the heating coil remains fully on with the fan on in an attempt to raise the ZONE temperature back up to within the heating THROTTLING-RANGE.

The heat from the supply air fan is added entirely, by the program, to the supply air.

Procedure:

(1) Specify SYSTEM-TYPE = UHT or UVT in the SYSTEM command.

(2) If SYSTEM-TYPE = UVT, specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for cooling by ventilation. These temperatures will be used to modulate the ventilation air flow rate.

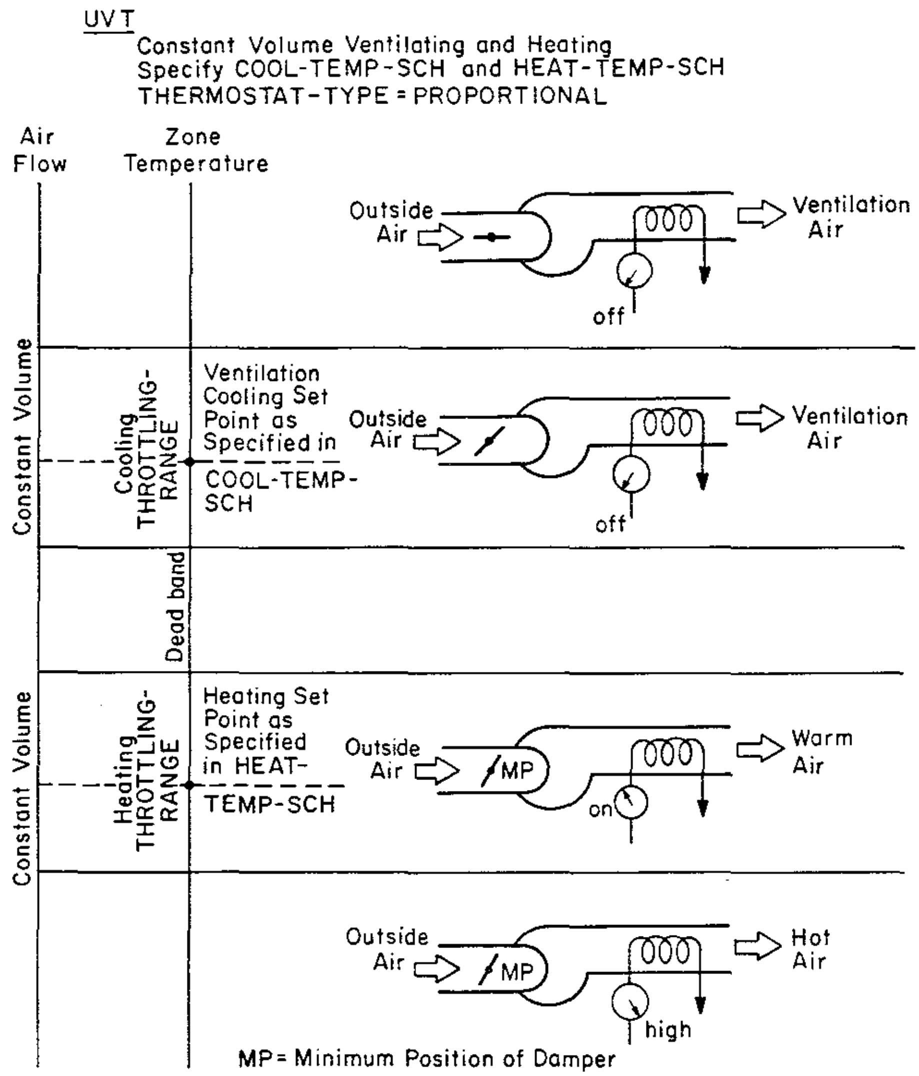
(3) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. These temperatures will be used to modulate the heating coil output in the ZONE. If the user does not specify a HEAT-TEMP-SCH for a ZONE, it will not be heated.

(4) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default to that value) in the ZONE-CONTROL subcommand.

(5) Specify MIN-OUTSIDE-AIR in the SYSTEM-AIR subcommand (UVT only).

(6) The control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default.

Graphically, the strategy for UVT looks like the following:



If SYSTEM-TYPE = UHT, the previous diagram would be the same except there would be no dead band and no cooling THROTTLING-RANGE (that is, no outside air). Also, above the heating THROTTLING-RANGE, the fan would cycle to off.

vi. Control Strategy for SYSTEM-TYPE Equals FPH

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to the control strategy for the Floor Panel Heating (FPH) system.

The FPH SYSTEM-TYPE has a central heating source, a primary pump, and a pipe loop with a heating fluid, which flows to all the heated ZONEs in the SYSTEM. Each ZONE contains a secondary pump, a heating panel (normally located in the floor), a modulating control valve, and a one set point thermostat. The desired heating set point is specified with the keyword HEAT-TEMP-SCH (plus its associated SCHEDULE). The primary pump operates on demand from any one or all of the ZONEs. The secondary pump and control valve in each heated ZONE operate on demand from the thermostat within that ZONE.

At calculated ZONE temperatures above the heating THROTTLING-RANGE, the output rate in the heating panel is zero. As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the heating output rate increases linearly from zero to maximum. Below the bottom of the heating THROTTLING-RANGE, the heating output rate remains at the maximum, in an attempt to raise the ZONE temperature back to within the heating THROTTLING-RANGE.

Procedure:

(1) Specify SYSTEM-TYPE = FPH in the SYSTEM command.

(2) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. If the user does not specify a HEAT-TEMP-SCH for a ZONE, it will not be heated.

(3) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand.

(4) The control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to this SYSTEM-TYPE, or allow these keywords to default.

vii. Example Control Strategies for SYSTEM-TYPE Equals HVSYS

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to these control strategies.

In this SYSTEM-TYPE a single supply air duct provides hot air and outside ventilation air to each ZONE. This SYSTEM-TYPE has no mechanical cooling capability or humidity control. Under the correct conditions, the SYSTEM will attempt to cool the ZONE(s) with outside air. This SYSTEM-TYPE is most commonly referred to as the school heating and ventilating system. Air is supplied at a constant flow rate when the supply air fan is on. The SYSTEM will have an economizer, unless the user specifies OA-CONTROL = FIXED in the SYSTEM-AIR subcommand. The economizer will attempt to maintain the mixed (return and outside) air temperature at the value specified via HEAT-CONTROL. There are three major control strategies that are defined by the selective specification of values for the keywords HEAT-CONTROL, HEAT-TEMP-SCH, THERMOSTAT-TYPE, REHEAT-DELTA-T, and BASEBOARD-CTRL.

These control strategies all involve one thermostat set point. The desired set point is specified with the keyword HEAT-TEMP-SCH (plus its associated SCHEDULE).

The temperature of the air stream leaving the central heating coil is determined by the value specified (or defaulted) for the keyword HEAT-CONTROL in the SYSTEM-CONTROL subcommand:

(a) If HEAT-CONTROL = CONSTANT, the user should specify a value for HEAT-SET-T (SYSTEM-CONTROL subcommand) that will not overheat any one ZONE in the SYSTEM. Some ZONEs, however, may be underheated. This can be remedied by specifying either zone coils or baseboard heaters. Unfortunately, with this strategy a correct value for HEAT-SET-T for heating may be too high for cooling with outside ventilation air.

(b) If HEAT-CONTROL = RESET or SCHEDULED, the temperature of the air leaving the central heating coil will be based upon a user-specified RESET-SCHEDULE or SCHEDULE. The hourly values specified in the SCHEDULE should be such that no ZONE becomes overheated. This approach may lead to the underheating of some ZONEs, in which case, zone coils or baseboard heaters may be used. When HEAT-CONTROL = SCHEDULED, it affords the opportunity to have seasonal reset of the central heating coil temperature, as opposed to the approach (a). These strategies, especially HEAT-CONTROL = RESET, allow the SYSTEM to take better advantage of the outdoor air temperature for cooling by ventilation.

(c) If HEAT-CONTROL = COLDEST, the temperature of the air leaving the central heating coil will be automatically set by the program to heat (or cool) the ZONE with the lowest relative temperature in its heating THROTTLING-RANGE.

At the ZONE level, the air stream temperature may be modified upward by zone (reheat) coils located in the supply air ducts. To accomplish this, the user should specify a value for REHEAT-DELTA-T (not equal zero). Because REHEAT-DELTA-T is a SYSTEM level keyword, when it is specified, all ZONEs will have zone coils. The heating output of the zone coils is controlled by the user input for the keyword HEAT-TEMP-SCH. Alternatively, the user may supply the additional heating in one or more ZONEs with baseboard heaters.

To obtain the most accurate heating control from this SYSTEM-TYPE, the air must be properly heated in two increments, before it is introduced to the space. First, at the SYSTEM level, the temperature of the air is raised to the value specified via the input for HEAT-CONTROL. At this temperature, the air should not overheat any one of the ZONEs. The second heating of the air, if necessary, is done within each ZONE (by the zone coil or baseboard heaters), according to the needs of that ZONE, which are specified in HEAT-TEMP-SCH.

If ZONE level heating is specified, the following occurs. At calculated ZONE temperatures above the heating THROTTLING-RANGE, the heat output of the zone coil (or alternatively the baseboard heater) is turned off. As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the heat output rate increases linearly from zero to maximum. This assumes that THERMOSTAT-TYPE = PROPORTIONAL. At calculated ZONE temperatures below the heating THROTTLING-RANGE the heating fluid flow rate remains at maximum, in an attempt to raise the ZONE temperature to within the heating THROTTLING-RANGE.

The heat from the supply air fan is added, by the program, to the supply air stream.

Example:

(1) Specify SYSTEM-TYPE = HVSYS in the SYSTEM command.

(2) Specify input for HEAT-CONTROL in the SYSTEM-CONTROL subcommand, according to the rules (a), (b), or (c) at the beginning of this discussion. This establishes the method for setting the hourly temperature of the air leaving the central heating coil of the SYSTEM. This is the temperature of the supply air that will be sent to all ZONEs in the SYSTEM. If the user does not specify a value for HEAT-CONTROL, it will default to CONSTANT and HEAT-SET-T will default to the weighted average DESIGN-HEAT-T of all the ZONEs in the SYSTEM.

(3) Specify a non zero value for REHEAT-DELTA-T in the SYSTEM command. This indicates to the program that zone (reheat) coils are to be used in all the ZONEs and it also indicates the maximum increase in temperature of the supply air passing over the zone coils.

(4) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. Specify a HEAT-TEMP-SCH for each ZONE in the SYSTEM, assuming supplemental heating is desired in that ZONE. These

temperatures will be used to modulate the output of the zone reheat coil. If the user does not specify a HEAT-TEMP-SCH for a ZONE, it will be heated as determined by HEAT-CONTROL at the SYSTEM level, but the ZONE will probably lack heating control.

(5) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand.

(6) The control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to this SYSTEM-TYPE, or allow these keywords to default.

Had the user chosen to provide the additional heat at the ZONE level by using baseboard heaters, instead of zone coils, Step 3 in the preceding example should be replaced by Step 3 below.

(3) Specify BASEBOARD-SOURCE in the SYSTEM command. Also, specify (for each ZONE that is to have baseboard heaters) a value for BASEBOARD-RATING in the ZONE command and specify BASEBOARD-CTRL = THERMOSTATIC in the ZONE-CONTROL subcommand. This indicates the heat source for the baseboard heaters, their maximum heating rates, and that they are to be controlled by thermostats within the ZONEs.

It is possible for the user to specify both zone coils and baseboard heaters in each ZONE. If so, the baseboards will be sequenced on before the zone coils.

TABLE IV.28

MAJOR CONTROL STRATEGIES FOR SYSTEM-TYPE = HVSYS

	Strategy	Heating Coil Temp. (HEAT-CONTROL)	Zone Heating Set Point (HEAT-TEMP-SCH)	Zone THERMOSTAT-TYPE	Zone (Reheat) Coil, and/or Baseboard Heaters (REHEAT-DELTA-T $\neq$ 0)
1.	Constant Volume Heating with User-fixed Heating Coil Temperature	CONSTANT	Required for control of zone heating	PROPORTIONAL	One or both required for proper heating of all zones
2.	Constant Volume Heating with User-controlled Heating Coil Temperatures	RESET or SCHEDULED	Required for control of zone heating	PROPORTIONAL	One of both required for proper heating of all zones
3.	Constant Volume Heating with Program-calculated Heating Coil Temperatures	COLDEST	Required for control of zone heating	PROPORTIONAL	One or both required for proper heating of all zones

Notes:

1. Zone coils are controlled via HEAT-TEMP-SCH and optional baseboard heaters are controlled via HEAT-TEMP-SCH only if BASEBOARD-CTRL = THERMOSTATIC.

2. The above table is not entirely complete. Associated with most of the keywords and code-words listed in the table are other "related" keywords and code-words. Example: If the user specifies a HEAT-TEMP-SCH, he must also specify a SCHEDULE, the "related" keyword.

viii. Example Control Strategies for SYSTEM-TYPE Equals TPIU or FPIU

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to these SYSTEM-TYPEs. There is only one major control strategy (for each of these SYSTEM-TYPEs) that is defined by the selective specification of values for the keywords INDUCTION-RATIO, COOL-CONTROL, COOL-TEMP-SCH, HEAT-TEMP-SCH, and INDUC-MODE-SCH (TPIU only).

SYSTEM-TYPE Equals TPIU

The Two Pipe Induction Unit (TPIU) SYSTEM-TYPE is a "zonal" type system, although a portion of the cooling and heating is supplied by a primary system. TPIU has one central air cooling source and one central air heating source, which either cool or heat the primary supply air. The tempered primary supply air is then distributed, at constant volume flow rate, through a single duct distribution system, to the induction units, which are located in the individual ZONEs. In each induction unit, the primary air is mixed with "tempered room air" before the mixture is introduced into the room. To temper the room air in the induction unit, the room air passes over the zone coil. To supply a working fluid to the zone coil, the TPIU system has one central liquid cooling source, one central liquid heating source, and a single pipe loop, which distributes the working liquid to and from all the ZONEs. The loop provides either cooling fluid or heating fluid to all the induction units, but not both at any one time.

Only sensible cooling is simulated in the induction units and all dehumidification is simulated at the SYSTEM level. Each TPIU induction unit has one heat exchanger coil and a modulating control valve, which is operated by a two set point thermostat in the ZONE. The desired set points are specified, respectively, with the keywords COOL-TEMP-SCH and HEAT-TEMP-SCH plus their associated SCHEDULEs.

The basic concept of the TPIU SYSTEM-TYPE is one of providing a method by which some ZONEs in a SYSTEM can be cooled, while other ZONEs are being heated. Although this feature is available on a year-round basis, in the summer it is normal to provide cooling at the zone level and heating of the zones, if necessary, by resetting the central supply air temperature. The opposite is true for winter; cooling is provided at the system level and heating is provided at the zone level. The changeover (date and hour) from winter operation to summer operation, and vice versa, is specified, in the simulation, by the user via the keyword INDUC-MODE-SCH. The changeover is not automatic, based upon outdoor dry-bulb temperature, due to the difficulty of heating and cooling of the potentially large mass of fluid in the zone coil pipe loop during the changeover. In a real system, the changeover is accomplished manually, on a seasonal basis, by the operator of the system. The selection of a changeover date and hour can drastically affect the consumption of energy and building comfort.

When the hourly values specified in the SCHEDULE that is referenced by INDUC-MODE-SCH are positive (see right side of Fig. IV.6), the zone coils are in the cooling mode and the central coil may be either heating or cooling, depending upon how the user specifies COOL-CONTROL and HEAT-SET-T. The most common strategy is to specify COOL-CONTROL = RESET with a COOL-RESET-SCH, a RESET-SCHEDULE, and a DAY-RESET-SCH.

When the hourly values specified in the SCHEDULE that is referenced by INDUC-MODE-SCH are negative (see left side of Fig. IV.6), the zone coils are in the heating mode and the central coil is in the cooling mode. In this mode of operation, the program resets the central cooling coil to MIN-SUPPLY-T (unless COOL-CONTROL = CONSTANT, in which case the central cooling coil is reset to the temperature specified in COOL-SET-T).

During winter operation (that is, when the hourly values in the SCHEDULE referenced by INDUC-MODE-SCH are negative), the cold outside air is used for cooling any zone that requires cooling and the zone coils provide added heating. During the summer, the central coil provides cool dry air and the zone coils provide any extra cooling that may be necessary.

SYSTEM-TYPE Equals FPIU

The Four Pipe Induction Unit (FPIU) SYSTEM-TYPE is physically identical to the TPIU except that the FPIU has two pipe loops, one for cooling and one for heating. Depending upon the COOLING-SCHEDULE and the HEATING-SCHEDULE, either cooling or heating, or both, are available at all times to the ZONEs. That is, the FPIU SYSTEM-TYPE permits some ZONEs to be cooled while other ZONEs are being heated. The changeover from cooling to heating, and vice versa, is automatic. The INDUC-MODE-SCH capability is not available, nor necessary, for FPIU.

SYSTEM Cooling Mode for TPIU and FPIU:

The method for setting the temperature of the cold air stream leaving the main cooling coil is determined by the value specified (or defaulted) for the keyword COOL-CONTROL in the SYSTEM-CONTROL subcommand.

For SYSTEM-TYPE = TPIU, the most commonly used strategy is to specify COOL-CONTROL = RESET (with an associated COOL-RESET-SCH, RESET-SCHEDULE, and DAY-RESET-SCH). This strategy resets the primary air temperature each hour based upon the outdoor dry-bulb temperature and the user's input for the keywords SUPPLY-HI, SUPPLY-LO, OUTSIDE-HI, and OUTSIDE-LO in the DAY-RESET-SCH command. Figure IV.6 shows example air temperatures for winter and summer operation.

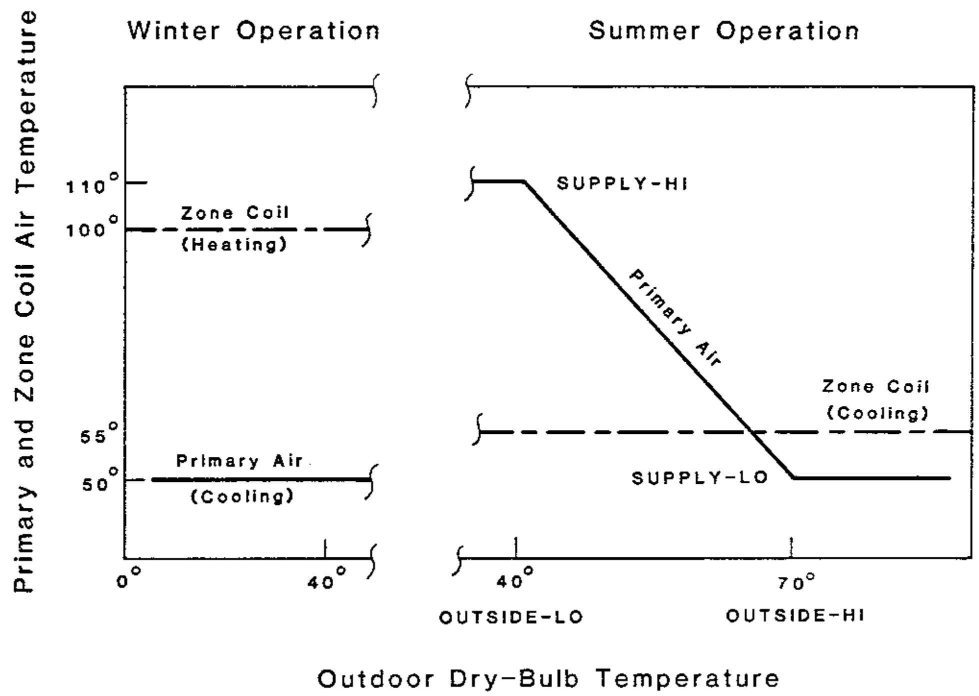


Fig. IV.6. Specifying COOL-CONTROL = RESET for TPIU with an INDUC-MODE-SCH.

For SYSTEM-TYPE = FPIU, COOL-CONTROL should be optimized for the type of zones attached to this system. Normally, a RESET schedule similar to Fig. IV.7 is used for the primary air.

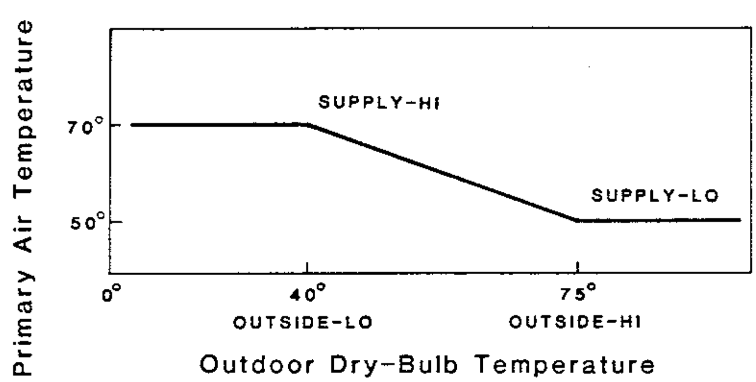


Fig. IV.7. Specifying COOL-CONTROL = RESET for FPIU.

ZONE Cooling Mode for TPIU and FPIU:

The output of the zone coil, when in the cooling mode, is controlled by the user input for the keyword COOL-TEMP-SCH.

At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the output of the cooling coil in the ZONE induction unit is at its maximum. As the calculated ZONE temperature drops from the top to the bottom of the cooling THROTTLING-RANGE, the cooling output decreases linearly from its maximum to zero. At calculated ZONE temperatures below the top of the deadband, the output of this coil is zero and the only heating or cooling is done by the primary air. The air flow rate is always constant, assuming the FAN-SCHEDULE is on.

SYSTEM Heating Mode for TPIU and FPIU:

When the TPIU is operating in the winter mode (that is, when the hourly values in the SCHEDULE referenced by INDUC-MODE-SCH are negative), the terminal unit coils are in the heating mode. At this time, the primary air controller is reset to COOL-SET-T if COOL-CONTROL = CONSTANT, or MIN-SUPPLY-T if COOL-CONTROL ≠ CONSTANT. Thus, outside air is used for cooling (or there is active cooling if COOLING-SCHEDULE ≠ 0).

For the FPIU, the primary air temperature is controlled by the user input for COOL-CONTROL (normally RESET).

If the user does not specify a value for HEAT-SET-T, it will default to MIN-SUPPLY-T, thus sizing the heating coil to zero.

ZONE Heating Mode for TPIU and FPIU:

Zone heating is controlled by the user input for HEAT-TEMP-SCH. This controls the zone coil heating output. Alternatively, the user may supply the additional heating at the ZONE level with baseboard heaters.

At calculated ZONE temperatures above the heating THROTTLING-RANGE, the heating output of the ZONE coil is zero. As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the output of the ZONE coil increases linearly from zero to its maximum. At ZONE temperatures below the heating THROTTLING-RANGE, the output remains at maximum. The air flow rate is always constant, assuming the FAN-SCHEDULE is on.

The heat from the supply air fan is added to the primary air downstream from the cooling coil, unless the user specifies FAN-PLACEMENT = BLOW-THROUGH. The effect of the humidifier is added to the mixed air stream.

Procedure:

(1) Specify SYSTEM-TYPE = TPIU or FPIU in the SYSTEM command.

(2) Specify input for COOL-CONTROL in the SYSTEM-CONTROL subcommand, according to the preceeding suggestions.

This establishes the hourly temperature of the primary air of the SYSTEM. If the user does not specify a value for COOL-CONTROL, it will default to CONSTANT and COOL-SET-T will default to MIN-SUPPLY-T. (However, if SYSTEM-TYPE = TPIU and the hourly SCHEDULE value referenced by INDUC-MODE-SCH is < 0, COOL-CONTROL will default to CONSTANT and the value specified for COOL-SET-T, if specified, will be used.)

If SYSTEM-TYPE = TPIU, specify an INDUC-MODE-SCH and its associated SCHEDULE with the value 1 for those hours when the SYSTEM is operating in the summer mode and the value -1 for those hours when the SYSTEM is operating in the winter mode.

(3) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for cooling. These temperatures will be used to modulate the output of the coil in the TPIU or FPIU unit. If the user does not specify a COOL-TEMP-SCH for a ZONE, it will be cooled (unless the COOLING-SCHEDULE is set to off) only by the primary air stream.

(4) Specify input for HEAT-SET-T in the SYSTEM-CONTROL subcommand. This value is used to size the heating coil in the main air-handler.

(5) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand (and an associated SCHEDULE) with hourly values of desired ZONE temperature for heating. These temperatures will be used to modulate the heating output of the zone coil of the TPIU or FPIU unit. If the user does not specify a HEAT-TEMP-SCH for a ZONE, it will be heated (per HEAT-SET-T) but only by the primary air.

(6) Specify THERMOSTAT-TYPE = PROPORTIONAL (or allow it to default) in the ZONE-CONTROL subcommand.

(7) The control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to the SYSTEM-TYPE being simulated, or allow these keywords to default.

ix. Example Control Strategies for SYSTEM-TYPE Equals SZCI

If the user has not done so, he should read the General subsection (Sec. B.5.a of this chapter) before continuing here. That subsection contains information that is appropriate to this SYSTEM-TYPE, the Ceiling Induction System.

In this SYSTEM-TYPE a single supply air duct provides treated air to each ZONE. There are two major control strategies that are defined by the selective specification of values for the keywords COOL-CONTROL, COOL-TEMP-SCH, HEAT-TEMP-SCH, THERMOSTAT-TYPE, and REHEAT-DELTA-T. These control strategies are listed in Table IV.29.

These control strategies all involve two ZONE thermostat set points, one for cooling and one for heating. The desired set points are specified, respectively, with the keywords COOL-TEMP-SCH and HEAT-TEMP-SCH (plus their associated SCHEDULEs).

The user may specify zone (reheat) coils in the air duct (see REHEAT-DELTA-T in the SYSTEM-TERMINAL subcommand).

Both the major control strategies for this SYSTEM-TYPE have variable air volume flow, at the SYSTEM level, for cooling. The flow rate of air entering each ZONE, however, is constant due to the action of the ZONE induction box. The hourly temperature of the cooling supply air (specified via COOL-CONTROL in the SYSTEM-CONTROL subcommand) entering each induction box is often colder than required to meet the cooling needs of the ZONE. During these times, this flow of cooling air is reduced. The volume of cooling supply air entering the induction box may vary hourly from 100 per cent down to 50 per cent of the ZONE design cooling flow rate (that is, the amount of air required to meet the ZONE peak cooling load). The balance of the air is induced from the plenum above the room ceiling. This induced air is intended to reduce the cooling ability of the primary air. The induced air flow rate is limited to a maximum of 50 per cent of the ZONE design cooling flow rate. In summation, variable volume cooling air is mixed with the variable volume induced warm air to produce a constant volume supply air flow to the ZONE.

Air flow in the supply duct during the heating mode is constant at 50 per cent of the maximum. The final temperature of the air stream is controlled at the ZONE level with the keyword HEAT-TEMP-SCH. As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the air flow into the ZONE is 50 per cent primary air and 50 per cent induced warm air. The zone coil heating output rate increases linearly from zero at the top of the heating THROTTLING-RANGE to maximum at the bottom of the heating THROTTLING-RANGE.

This system type is normally used for interior zones only. Often there are no reheat coils, although baseboards are sometimes used.

TABLE IV.29

MAJOR CONTROL STRATEGIES FOR SYSTEM-TYPE = SZCI

	Strategy	Cooling Coil Temp. (COOL-CONTROL=)	Zone Cooling Set Point (COOL-TEMP-SCH)	Zone Heating Set Point (HEAT-TEMP-SCH)	Zone THERMOSTAT-TYPE	Zone (Reheat) Coils (REHEAT-DELTA-T ≠ 0)
*1.	Variable Volume Cooling and Constant Volume Heating with User-controlled Cooling Coil Temperatures	CONSTANT, RESET or SCHEDULED	Required for control of zone cooling	Required for control of zone heating	PROPORTIONAL	Required for zone heating
2.	Variable Volume Cooling and Constant Volume Heating with Program-calculated Cooling Coil Temperatures	WARMEST	Required for control of zone cooling	Required for control of zone heating	PROPORTIONAL	Required for zone heating

*An example of this strategy is included in the following discussion.

Notes:

1. If THERMOSTAT-TYPE=PROPORTIONAL, COOL-TEMP-SCH controls the induction mixing box during cooling and HEAT-TEMP-SCH controls the zone coil during heating.

2. The above table is not entirely complete. Associated with most of the keywords and code-words listed in the table are other "related" keywords and code-words. Example: If COOL-CONTROL=SCHEDULED, the user must <u>also</u> specify its "related" keyword, SCHEDULE.

The heat from the supply air fan is added, by default, to the primary air downstream of the cooling coil, unless the user specifies FAN-PLACEMENT = BLOW-THROUGH. The effect of the humidifier, if specified, is added to the mixed air stream.

This system type is normally used for interior zones only. Often, there are no reheat coils, although baseboards are sometimes used.

Example:

Variable Volume Cooling Into the Induction Box / Constant Volume Heating with User-controlled Cold Deck Temperatures for SZCI (with COOL-CONTROL = SCHEDULED)

The cooling is accomplished by a variable air volume flow, in the supply air duct up to the ZONE induction box. The temperature of the cold air stream (cooling coil temperature) is set each hour by the user in a SCHEDULE. The process of blending the cooling air with induced air, in the induction box, is controlled at the ZONE level with the keyword COOL-TEMP-SCH.

At calculated ZONE temperatures above the cooling THROTTLING-RANGE, the cooling air flow rate into the induction box is at the maximum, the ZONE design cooling flow rate (100 per cent cooling air and no induced air). As the calculated ZONE temperature drops from the top to the bottom of the cooling THROTTLING-RANGE, the cooling air flow rate into the induction box decreases linearly from the maximum of 100 per cent to 50 per cent of the ZONE design cooling flow rate, while simultaneously the induced air flow rate into the induction box increases linearly from zero to 50 per cent. This produces a constant volume flow, of variable temperature, out of the induction box into the ZONE. As the calculated ZONE temperature drops across the deadband, the air flow into the ZONE is 50 per cent induced air and 50 per cent cooling air (or mixed outside and return air, if the cooling has been turned off).

At all calculated ZONE temperatures from the top to the bottom of the heating THROTTLING-RANGE, the air flow into the ZONE is 50 per cent induced air and 50 per cent cooling air (or mixed outside and return air, if the cooling has been turned off). As the calculated ZONE temperature drops from the top to the bottom of the heating THROTTLING-RANGE, the heating output of the zone coils increases linearly for zero to maximum.

Procedure:

(1) Specify SYSTEM-TYPE = SZCI in the SYSTEM command.

(2) Specify COOL-CONTROL in the SYSTEM-CONTROL subcommand equal to SCHEDULED. This establishes the method for setting the temperature of the supply air that will be sent to all ZONE induction boxes in the SYSTEM. If the user does not specify a value for COOL-CONTROL, it will default to CONSTANT and COOL-SET-T will default to MIN-SUPPLY-T.

(3) Specify COOL-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for cooling. These temperatures will be used to operate the induction box in the cooling mode. If the user does not specify a COOL-TEMP-SCH for a ZONE, it will be cooled (unless the COOLING-SCHEDULE is set to off) but there will be no control of the cooling process.

(4) Specify HEAT-TEMP-SCH in the ZONE-CONTROL subcommand and an associated SCHEDULE with hourly values of desired ZONE temperature for heating. These temperatures will be used to modulate the output of the zone coil. If the user does not specify a HEAT-TEMP-SCH for a ZONE, the only heating available will be from the supply air and light heat.

(5) Specify THERMOSTAT-TYPE = PROPORTIONAL (the default) in the ZONE-CONTROL subcommand. This assures a variable volume air flow entering the induction box for cooling and a constant volume air flow entering the induction box for heating.

(6) Specify a value for REHEAT-DELTA-T in the SYSTEM-TERMINAL subcommand. This indicates to the program that zone (reheat) coils are to be used in the ZONEs and it also indicates the maximum increase in temperature of the supply air passing over the zone coils.

(7) The desired control strategy for the system has now been specified. To complete the input, specify values for the other keywords that are appropriate to this SYSTEM-TYPE, or allow these keywords to default. This example is the first strategy in Table IV.29.

6. Thermostat Simulation

The discussion in this subsection is related to the simulation of various zone temperature control strategies and the SDL input data required to specify each of them.

The simulations for PROPORTIONAL and TWO-POSITION types of thermostats (see keyword THERMOSTAT-TYPE in ZONE-CONTROL subcommand) are essentially the same, except that the program automatically selects a very narrow throttling range for the two-position type of thermostat to simulate on-off operation, thus negating the necessity to enter data for the keyword THROTTLING-RANGE (see ZONE-CONTROL subcommand). The REVERSE-ACTION type of thermostat (see THERMOSTAT-TYPE) is applicable only for variable air volume systems, and then, only when appropriate. This thermostat allows the supply air flow rate (for heating as well as cooling) to rise above the design minimum flow rate, as defined in MIN-CFM-RATIO.

The keywords HEAT-TEMP-SCH and COOL-TEMP-SCH are used to reference SCHEDULE instructions that specify the heating and cooling temperature control set points of the zone. Note that all schedules may change hourly and seasonally, thus allowing summer/winter, and day/night, or even finer adjustments of set points.

Almost any imaginable thermostatic control scheme can be simulated. The user should take care that the scheme specified is physically possible with the HVAC system being modeled. The program does not make such a check.

The user should avoid throttling range overlap when simulating sequential control of heating and cooling. If the user inadvertently specifies overlapping throttling ranges, the program will move the cooling and heating set points until they are one throttling range apart.

A number of different thermostatic control options and the SDL input data required for the simulation of each are shown in the examples that follow. There is no priority or preference intended; Case 1 through Case 9 are presented in order of increasing difficulty.

Case 1 - TWO-POSITION Heating/Cooling Thermostat Operation (with deadband)

Figure IV.8 depicts the operation of a TWO-POSITION dual-set point thermostat (or two single-set point thermostats) that provides on-off operation of the system heating component, whenever zone temperature falls below 68°F, and on-off operation of the system cooling component, whenever zone temperature increases above 78°F.

No heat is either added to or extracted from the zone when zone temperature is between these set points. If a single thermostat is being simulated, it is the type that has two independently adjustable set points (dual-set point). The program simulates a thermostat with narrow nonadjustable differential. This thermostat should not be used for multizone and dual duct systems.

The following is an example of data entry needed to simulate the thermostat operation shown in Fig. IV.8.

```
H-SCH1 = SCHEDULE                THRU DEC 31 (ALL)   (1,24)(68)   ..

C-SCH1  = SCHEDULE               THRU DEC 31 (ALL)   (1,24)(78)   ..

SP-1    = ZONE                   DESIGN-HEAT-T    = 68
                                 DESIGN-COOL-T    = 78
                                 HEAT-TEMP-SCH    = H-SCH1
                                 COOL-TEMP-SCH    = C-SCH1
                                 THERMOSTAT-TYPE = TWO-POSITION   ..
```

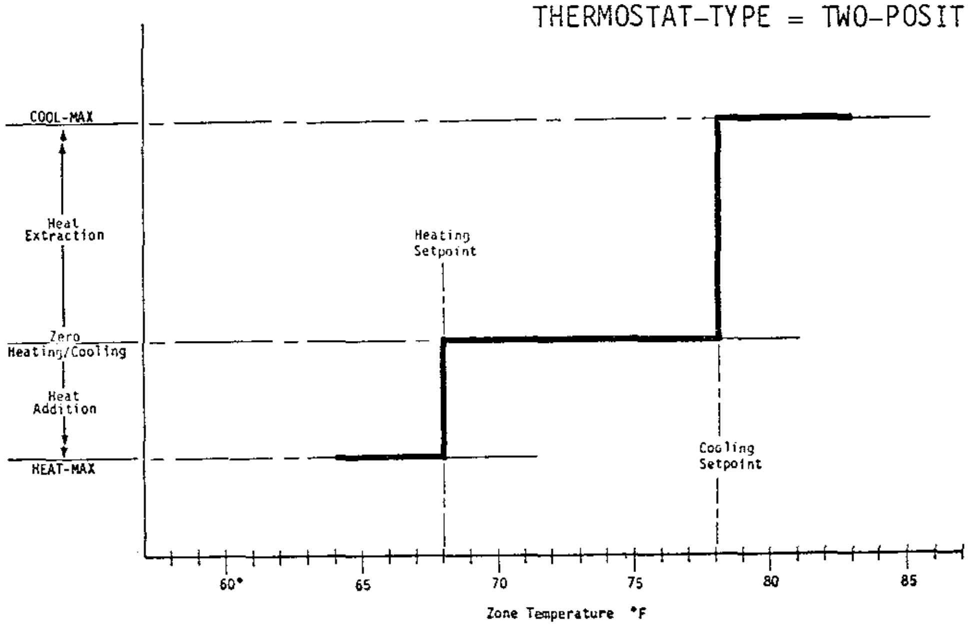


Fig. IV.8. TWO-POSITION heating/cooling thermostat operation (with deadband).

Entry for the keyword THROTTLING-RANGE is not required when a TWO-POSITION thermostat is specified. IF the system (or zone) does not have heating capability, entry for keyword HEAT-TEMP-SCH should be omitted. If the system (or zone) does not have cooling capability, entry for keyword COOL-TEMP-SCH should be omitted.

Note that entry of both DESIGN-HEAT-T and DESIGN-COOL-T is required in any case (program will abort if entry for either is omitted). These two keywords are shown in the above example, and in those that follow, merely to illustrate this requirement although they do not provide information related to thermostat simulation. They do provide information for the calculation of zone supply air flow rate (see Sec. D.1 of this chapter).

<u>Case 2</u> - TWO-POSITION Heating or Cooling Thermostat Operation with Seasonal Reset

This simulation is exactly as shown for Case 1, except that only one temperature set point can be active at any given time. To simulate this condition, the heating capability of the system serving the zone must be turned off during the cooling season and the cooling capability turned off during the heating season.

Data entry is as shown for Case 1, except that cooling and heating must be scheduled by data entry for the appropriate SYSTEM instruction keywords. An example of the additional schedules and the additional SYSTEM instruction data entry is shown below. Note that an entry of 1.0 indicates the availability of heating (or cooling) and a value of zero indicates shut-off.

```
H-SCH 3 = SCHEDULE          THRU MAY 15 (ALL)  (1,24)  (1.0)
                            THRU NOV 15 (ALL)  (1,24)  (0.0)
                            THRU DEC 31 (ALL)  (1,24)  (1.0)  ..
C-SCH3  = SCHEDULE          THRU MAY 15 (ALL)  (1,24)  (0.0)
                            THRU NOV 15 (ALL)  (1,24)  (1.0)
                            THRU DEC 31 (ALL)  (1,24)  (0.0)  ..

S-2     = SYSTEM                    Keyword = Value
                                    Keyword = Value

                            HEATING-SCHEDULE = H-SCH3
                            COOLING-SCHEDULE = C-SCH3

                                    Keyword = Value   ..
```

An alternative approach to shutting-off heating and cooling during the off seasons is to prevent simulation of heat addition/extraction by scheduling a very high cooling temperature during the heating season and a very low heating temperature during the cooling season. To do so, the schedules shown for Case 1 would be revised and entered as shown below.

```
H-SCH1 = SCHEDULE           THRU MAY 15 (ALL)  (1,24)  (68)
                            THRU NOV 15 (ALL)  (1,24)  (40)
                            THRU DEC 31 (ALL)  (1,24)  (68)  ..

C-SCH1 = SCHEDULE           THRU MAY 15 (ALL)  (1,24)  (99)
                            THRU NOV 15 (ALL)  (1,24)  (78)
                            THRU DEC 31 (ALL)  (1,24)  (99)  ..
```

<u>Case 3</u> - TWO-POSITION Heating/Cooling Thermostat Operation (with deadband) and Off-Hour Offset

Figure IV.9 depicts the operation of TWO-POSITION thermostats similar to Case 1, but with off-hour temperature offset added. The following example shows the data entry required for this simulation.

```
H-SCH2 = SCHEDULE                 THRU DEC 31
         (WD)(1,8)(60)(9,18)(68)(19,24)(60)
         (WEH)(1,24)(60)  ..

C-SCH2 = SCHEDULE                 THRU DEC 31
         (WD)(1,8)(85)(9,18)(78)(19,24)(85)
         (WEH)(1,24)(85)  ..
```

```
SP-2 = ZONE          DESIGN-HEAT-T = 68
                     DESIGN-COOL-T = 78
                     HEAT-TEMP-SCH = H-SCH2
                     COOL-TEMP-SCH = C-SCH2
                     THERMOSTAT-TYPE = TWO-POSITION  ..
```

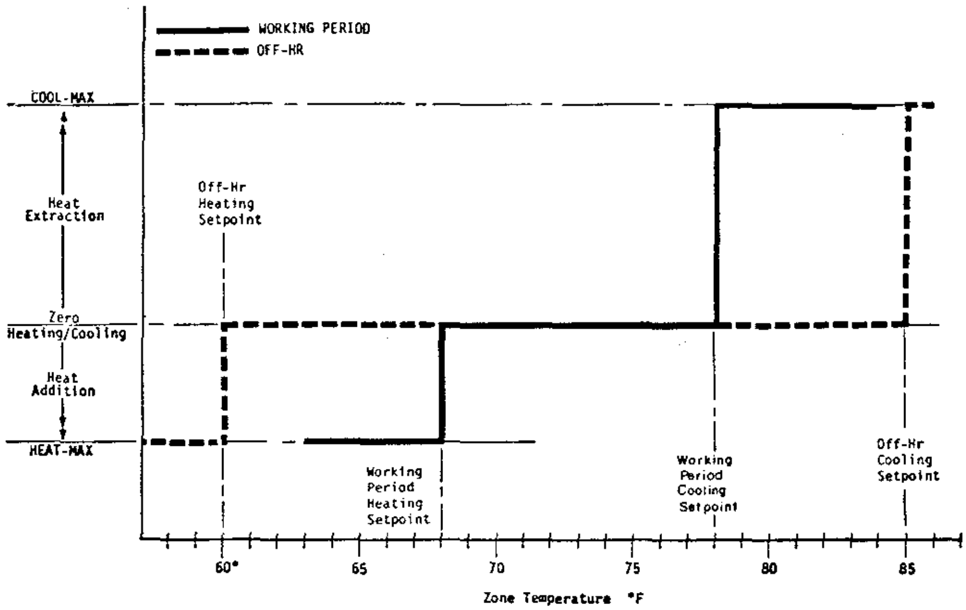


Fig. IV.9. TWO-POSITION heating/cooling thermostat operation (with deadband) and off-hour offset.

Case 4 - TWO-POSITION, Heating or Cooling, Thermostat Operation with Seasonal Reset and Off-Hour Offset

This simulation is as shown for Case 3, except that system heating and cooling capability is scheduled on a seasonal basis (as for Case 2), so that only one temperature control set point is active at any given time.

Case 5 PROPORTIONAL Heating/Cooling Thermostat Operation (with deadband)

Figure IV.10 depicts the operation of a PROPORTIONAL dual-set point type thermostat (or two PROPORTIONAL single-set point thermostats). A single thermostat can also provide this mode of operation, if the control components are split-ranged as shown on Fig. IV.11. The thermostat sends a signal to the heating control component (valve, damper, or electric heat controller) to start adding heat when the zone temperature falls to 70°F. Heat addition is proportionally increased as zone temperature falls, reaching maximum capacity when zone temperature is 66°F. The zone cooling control component is likewise controlled to start heat extraction when zone temperature rises to 76°F and to increase the heat extraction rate proportionally to maximum as zone temperature increases to 80°F. No heat is added or extracted when zone temperature is between 70°F and 76°F.

Input data required for the simulation of this mode of operation is:

```
H-SCH1 = SCHEDULE    THRU DEC 31 (ALL)     (1,24)(68)  ..

C-SCH1 = SCHEDULE    THRU DEC 31 (ALL)     (1,24)(78)  ..

SP-1 = ZONE          DESIGN-HEAT-T = 68
                     DESIGN-COOL-T = 78
                     HEAT-TEMP-SCH = H-SCH1
                     COOL-TEMP-SCH = C-SCH1
                     THERMOSTAT-TYPE = PROPORTIONAL
                     THROTTLING-RANGE = 4                  ..
```

<u>Case 6</u> PROPORTIONAL Heating/Cooling Thermostat Operation (with deadband) and Off-Hour Offset

This simulation, shown in Fig. IV.12, is as described for Case 5, except that off-hour temperature setback is provided for both heating and cooling.

Input data necessary for simulation of this mode of operation is:

```
H-SCH2 = SCHEDULE    THRU DEC 31
         (WD)(1,8)(60)(9,18)(68)(19,24)(60)
         (WEH)(1,24)(60)  ..

C-SCH2 = SCHEDULE   THRU DEC 31
         (WD)(1,8)(85)(9,18)(78)(19,24)(85)
         (WEH)(1,24)(85)  ..

SP-2 = ZONE          DESIGN-HEAT-T = 68
                     DESIGN-COOL-T = 78
                     HEAT-TEMP-SCH = H-SCH2
                     COOL-TEMP-SCH = C-SCH2
                     THERMOSTAT-TYPE = PROPORTIONAL
                     THROTTLING-RANGE = 4  ..
```

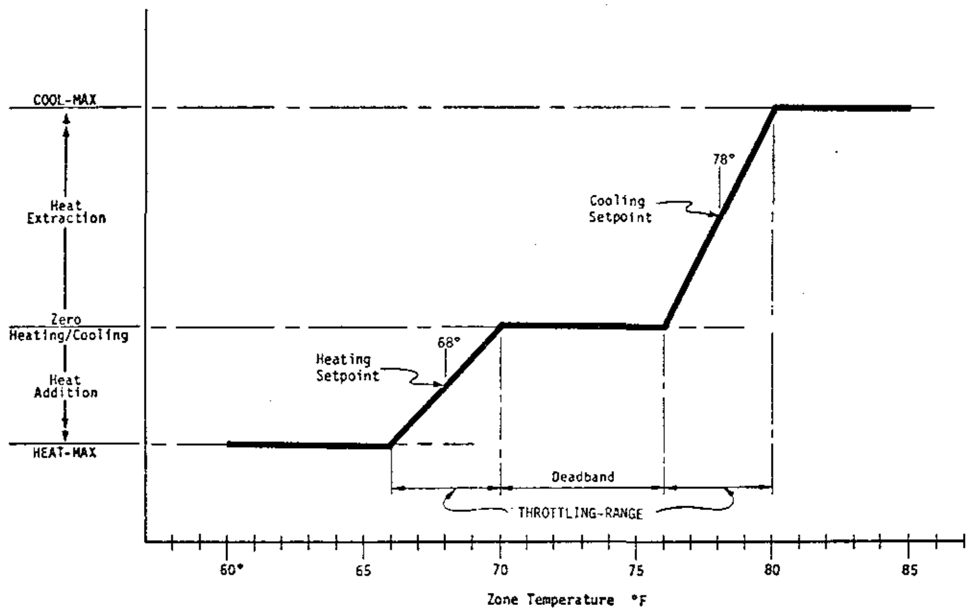


Fig. IV.10. PROPORTIONAL heating/cooling thermostat operation (with deadband).

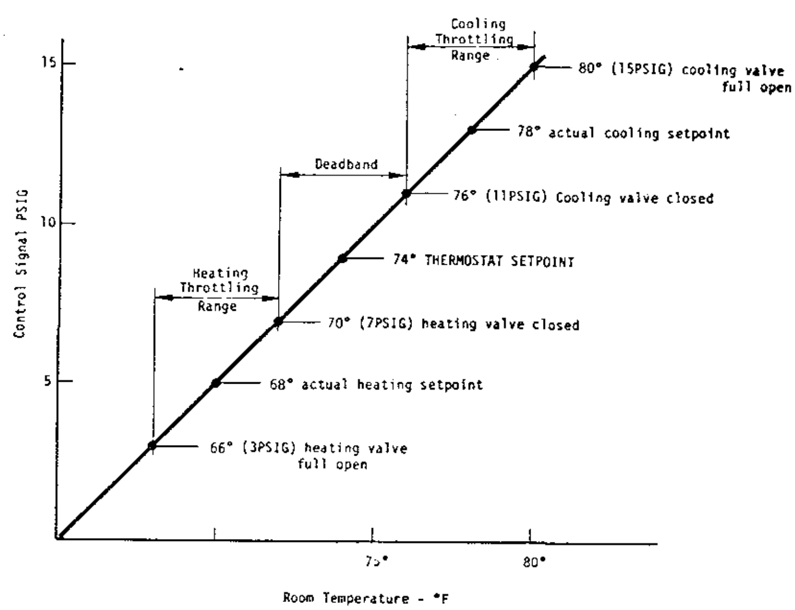


Fig. IV.11. PROPORTIONAL heating/cooling control (with deadband) from single setpoint thermostat.

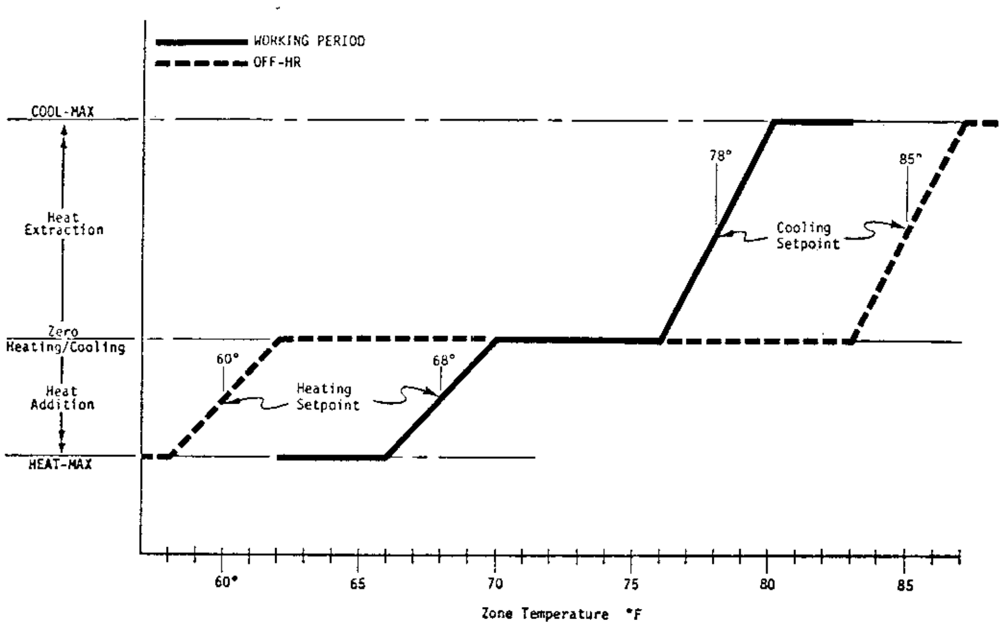


Fig. IV.12. PROPORTIONAL heating/cooling thermostat operation (with deadband) and off-hour offset.

Case 7 PROPORTIONAL Heating/Cooling Controlled in Sequence (no deadband) from Single Setpoint with Seasonal Temperature Reset

Figure IV.13 depicts this mode of operation, which differs from that shown in Case 5 primarily in that there is no deadband. Note that DOE-2 requires the specification of separate heating and cooling set points, despite the fact that the thermostat installed in this case, has only one set point. These set points must be separated by exactly one THROTTLING-RANGE, to avoid erroneous simulation of a deadband. (The actual thermostat has a proportional band that is twice the simulated THROTTLING-RANGE.) The actual thermostat set point is at the point where the heating and cooling throttling ranges meet.

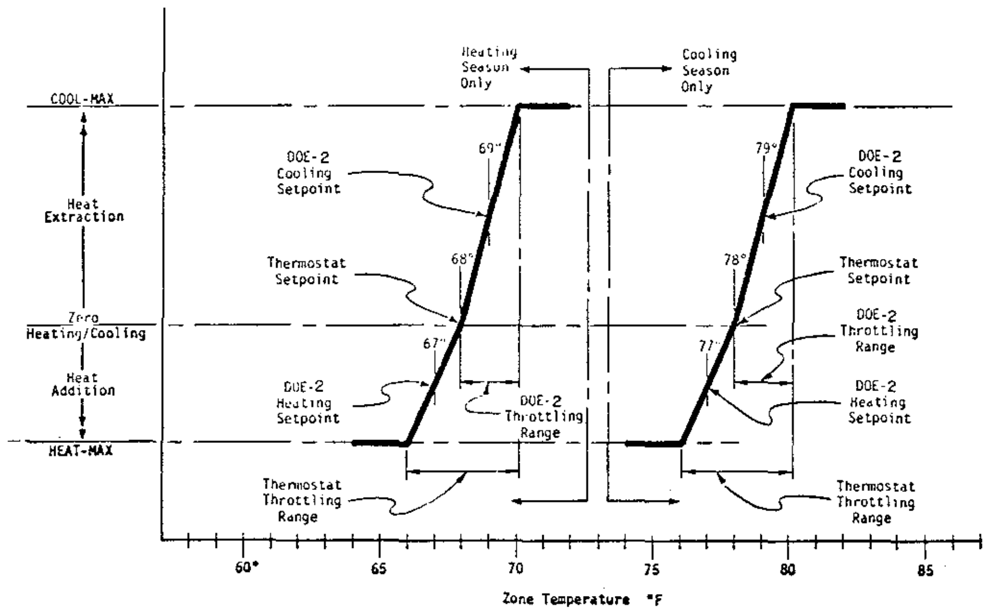


Fig. IV.13. PROPORTIONAL heating/cooling controlled in sequence (no deadband) from single setpoint with seasonal temperature reset.

System heating and/or cooling capability may be deactivated seasonally, although both heating and cooling are often available, at least during the intermediate seasons. The following is an example of data input to simulate the thermostat operation shown in Fig. IV.13 for a system that has cooling equipment shut off in winter and heating equipment shut-off in summer. The values entered for COOL-TEMP-SCH during the month that cooling is shut off, and for HEAT-TEMP-SCH during the months that heating is shut off, have no significance. Note that when simulating a constant-volume reheat type system, heating is required for temperature control, even in summer, and should not be shut-off.

```
H-SCH6 = SCHEDULE          THRU MAY 15 (ALL)  (1,24)  (67)
                           THRU NOV 15 (ALL)  (1,24)  (77)
                           THRU DEC 31 (ALL)  (1,24)  (67)    ..

C-SCH6 = SCHEDULE          THRU MAY 15 (ALL)  (1,24)  (69)
                           THRU NOV 15 (ALL)  (1,24)  (79)
                           THRU DEC 31 (ALL)  (1,24)  (69)    ..
```

```
H-SCH7 = SCHEDULE          THRU JUN 15 (ALL)  (1,24)  (1.0)
                           THRU SEP 15 (ALL)  (1,24)  (0.0)
                           THRU DEC 31 (ALL)  (1,24)  (1.0)    ..

C-SCH7 = SCHEDULE          THRU MAY 15 (ALL)  (1,24)  (0.0)
                           THRU NOV 15 (ALL)  (1,24)  (1.0)
                           THRU DEC 31 (ALL)  (1,24)  (0.0)    ..

SP-3   = ZONE              DESIGN-HEAT-T  = 68
                           DESIGN-COOL-T  = 78
                           HEAT-TEMP-SCH  = H-SCH6
                           COOL-TEMP-SCH  = C-SCH6
                        THERMOSTAT-TYPE  = PROPORTIONAL
                        THROTTLING-RANGE = 2               ..

SP-4   = SYSTEM                Keyword = Value
                               Keyword = Value

                        HEATING-SCHEDULE = H-SCH7
                        COOLING-SCHEDULE = C-SCH7

                               Keyword = Value
                               Keyword = Value ..
```

From an examination of Fig. IV.13 and the example input above, it can be seen that operation in this control mode will require more energy than required for the previously described cases. Not only have the energy conserving deadband operating periods (when neither heating nor cooling is provided) been eliminated, but the system must provide excess heating during cold intermediate season periods that occur after the zone temperature has been reset upward to reduce cooling load, but before the heating system can be deactivated. This mode of operation is especially energy intensive when used for a constant-volume reheat system, or when summer humidity control is required because, in those cases, heating capability must be maintained throughout the cooling season.

For these reasons, retrofit of systems that incorporate this type of control arrangement generally offers favorable investment potential and such retrofit is being implemented, or actively investigated, by many organizations and engineers.

One, relatively easy to incorporate, method of reducing energy use is to install controls that sense the cooling requirement in each zone and reset the cooling air supply temperature upward until the warmest zone can be satisfied without the addition of heat. To simulate this control strategy, the keyword data entry COOL-CONTROL = WARMEST is added to the SYSTEM instruction data entry shown in the preceding example. Note however, that summer humidity control, when specified (see keyword MAX-HUMIDITY in SYSTEM-CONTROL subcommand), may override supply air temperature setback and reduce energy saving benefits.

For multizone and dual-duct systems, additional energy saving can be accomplished by resetting hot deck temperature downward until the coldest zone can be satisfied without addition of cooling. To simulate this, the keyword data entry HEAT-CONTROL = COLDEST is added to the SYSTEM instructions input.

Case 8 PROPORTIONAL Heating/Cooling, Controlled in Sequence (no deadband) from Single Set Point with Seasonal Temperature Reset and Off-Hour Temperature Offset

Figure IV.14 depicts this mode of operation, which is the same as that for Case 7, except that off-hour temperature offset has been added (generally by a time clock-actuated day/night thermostat arrangement). The input data is the same except that the schedule instructions referenced by HEAT-TEMP-SCH and COOL-TEMP-SCH must be expanded to show off-hour temperature offset. As for Case 7, cooling and heating set points must be separated by exactly one throttling range (2°F) during all time periods, to avoid simulating either a deadband that does not exist or reduced proportional band.

The following is an example of temperature set point data input for this case.

```
H-SCH8 = SCHEDULE        THRU MAY 15
                         (MON,FRI)(1,8)(59)(9,18)(67)(19,24)(59)
                         (WEH)(1,24)(59)
                         THRU NOV 15
                         (MON,FRI)(1,8)(84)(9,18)(77)(19,24)(84)
                         (WEH)(1,24)(84)
                         THRU DEC 31
                         (MON,FRI)(1,8)(59)(9,18)(67)(19,24)(59)
                         (WEH)(1,24)(59) ..
```

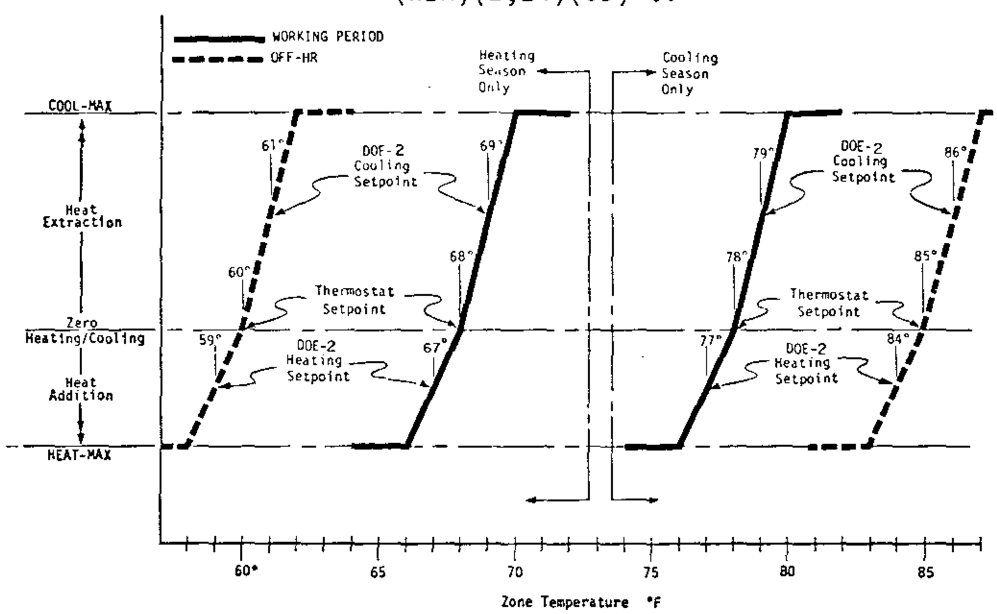


Fig. IV.14. PROPORTIONAL heating/cooling, controlled in sequence (no deadband) from single setpoint with seasonal temperature reset and off-hour temperature offset.

```
C-SCH8 = SCHEDULE         THRU MAY 15
                          (MON, FRI)(1,8)(61)(9,18)(69)(19,24)(61)
                          (WEH)(1,24)(61)
                          THRU NOV 15
                          (MON, FRI)(1,8)(86)(9,18)(79)(19,24)(86)
                          (WEH)(1,24)(86)
                          THRU DEC 31
                          (MON, FRI)(1,8)(61)(9,18)(69)(19,24)(61)
                          (WEH)(1,24)(61) ..

SP-3   = ZONE                   Keyword  =  Value
                                Keyword  =  Value
                          HEAT-TEMP-SCH  =  H-SCH8
                          COOL-TEMP-SCH  =  C-SCH8
                                Keyword  =  Value
                                Keyword  =  Value  ..
```

This control mode, being essentially the same as for Case 7, incorporates the same energy-wasteful features discussed for that case. Cooling season temperature offset may actually increase energy use, and is particularly not recommended for constant-volume reheat systems.

<u>Case 9</u> Deactivation of Cooling and/or Heating During Off-Hour Period

Shut-off of heating and/or cooling equipment during off-hours may be specified in lieu of the temperature offset of Cases 3, 4, 6 and 8. The normal method of doing this is to schedule fan operation. For example, the following data entry will shut-off all cooling and all heating (except baseboard) during all hours of the year except typical office working periods.

```
F-SCH1 = SCHEDULE     THRU DEC 31
                      (MON,FRI)(1,8)(0.0)(9,18)(1.0)(19,24)(0.0)
                      (WEH)(1,24)(0.0) ..

S-2    = SYSTEM           Keyword  =  Value

                      FAN-SCHEDULE  =  F-SCH1

                          Keyword  =  Value  ..
```

The following data entry will simulate off-hour fan shutdown during the cooling season, but continuous operation during the heating season.

```
F-SCH2 = SCHEDULE     THRU MAY 15
                      (ALL)(1,24)(1.0)
                      THRU NOV 15
                      (MON,FRI)(1,8)(0.0)(9,18)(1.0)(19,24)(0.0)
                      (WEH)(1,24)(0.0)
                      THRU DEC 31
                      (ALL)(1,24)(1.0) ..
```

```
S-3      = SYSTEM           Keyword  =  Value
                            Keyword  =  Value

                        FAN-SCHEDULE  =  F-SCH2

                            Keyword  =  Value
                            Keyword  =  Value ..
```

If the system fans must operate continuously because of ventilation requirements, or some other reason, but system heating and/or cooling is deactivated during off-hours, the keywords HEATING-SCHEDULE and/or COOLING-SCHEDULE can be used to simulate this condition. Note, however, that baseboard heating is also turned off when heating is deactivated in this manner.

Case 10 Addition of Baseboard Heat

Thermostatically controlled or outdoor-reset baseboard heating may be added to any of the control schemes described in the previous cases.

When thermostatically controlled baseboard heating is specified, by entry of a value for keyword BASEBOARD-RATING and entry of the code-word THERMOSTATIC for the keyword BASEBOARD-CTRL (both in the ZONE instruction), the program simulates control of the baseboard element in sequence with the system heating component, starting with the baseboard and turning on the system component only after maximum baseboard capacity has been reached. Baseboard heating is assumed to be available whenever heating is available (see keyword HEATING-SCHEDULE in SYSTEM-CONTROL subcommand).

When outdoor-reset baseboard heating is specified, by entry of a value for BASEBOARD-RATING as above, the baseboard output is independent of the zone temperature. A reset schedule that defines the relationship between the hourly baseboard output and the outside temperature must be entered. A data entry for the keyword BASEBOARD-SCH is required to reference the reset schedule (see SYSTEM-CONTROL subcommand).

C. SDL INPUT INSTRUCTIONS

> Caution:
> Although the Reset Schedule Instructions are the first SDL instructions to be discussed, they are not necessarily appropriate to your system. Chances are, they are not. If you are ready to start entering data, you should have by now chosen a SYSTEM-TYPE. Refer to the Applicability Table for your SYSTEM-TYPE (Sec. B. of this Chap.). It will tell you if this instruction, and subsequent instructions are appropriate. Remember: Your Applicability Table is your guide and it will simplify data entry.

1. Reset Schedule Instructions

a. DAY-RESET-SCH
b. 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 parameters (such as hot deck temperature, cold deck temperature, and baseboard heating) only when the reset control strategy has been specified.

The RESET-SCHEDULE instruction is identical to the SCHEDULE instruction described in Chap. II. The user worksheet for the SCHEDULE instruction may be used for RESET-SCHEDULE with, of course, the proper substitution of command words. The LIKE keyword is not applicable to RESET-SCHEDULE, but it is applicable to DAY-RESET-SCH. The DAY-SCHEDULE instruction, however, is different than 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 for the DAY-RESET-SCH.

DAY-RESET-SCH — informs the SDL Processor that the data to follow will define how a system control parameter is to vary in response to changes in outside air temperature. An unique user-defined name must be entered in the U-name field of each DAY-RESET-SCH instruction. Omission of this entry will cause an error.

SUPPLY-HI — is the upper supply air set-point temperature (or output ratio) 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. (See keywords HEAT-RESET-SCH and COOL-RESET-SCH in the SYSTEM-CONTROL subcommand.) Fig. IV.15 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. IV.16 illustrates this application.

SUPPLY-LO — is the lower supply air set-point temperature (or output ratio) corresponding to the input value for the OUTSIDE-HI. See also the discussion for SUPPLY-HI.

OUTSIDE-HI — is the outside dry-bulb air temperature which corresponds to the input value for SUPPLY-LO (lower supply air set-point temperature).

OUTSIDE-LO — is the outside dry-bulb air temperature which corresponds to the input value for SUPPLY-HI (upper supply air set-point temperature).

Note that the value for OUTSIDE-LO must not be the same as or higher than the value for OUTSIDE-HI (the program will abort and give an error message if this occurs).

Notes:

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

2. 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  ..
```

   It should be specified as:

```
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  ..
```

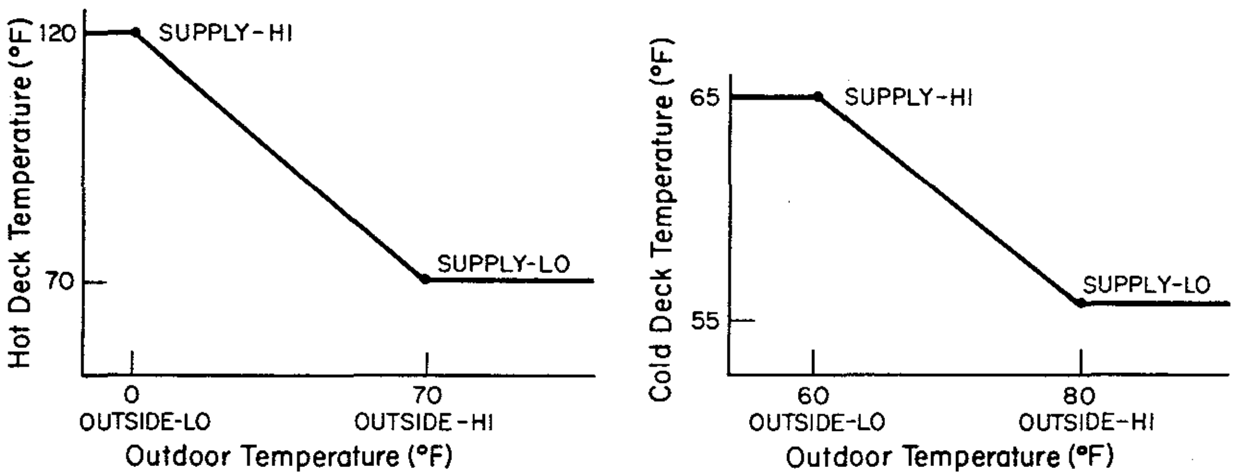


Fig. IV.15. Typical DAY-RESET-SCH when used for simulation of hot deck or cold deck temperature control.

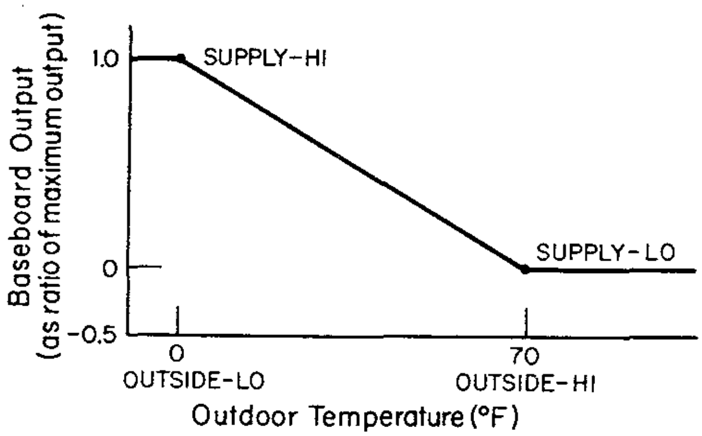


Fig. IV.16. Typical DAY-RESET-SCH when used for simulation of baseboard heating output.

______________________ = DAY-RESET-SCH or D-R-SCH (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	________	U-name	–	–	–
SUPPLY-HI	S-H	=	________	°F or ratio	–	Note 1	Note 1
SUPPLY-LO	S-L	=	________	°F or ratio	–	Note 1	Note 1
OUTSIDE-HI	O-H	=	________	°F or ratio	–	-20.	120.
OUTSIDE-LO	O-L	=	________	°F or ratio	–	-20.	120.

..

1) This entry may represent two different kinds of physical or numerical quantities (i.e., a temperature or a heating ratio), depending on where the instruction is referenced. If the entry is in °F, the range is 0. to 120.; if the entry is a ratio, the range is 0. to 1.

2. CURVE-FIT

The CURVE-FIT instruction exists both in SDL and PDL. It is described here because the first opportunity to use the CURVE-FIT instruction occurs here in the SYSTEMS program.

Often it is necessary to specify input data to the program in the form of a curve, or equation. The term "curve" in this connotation can be a line, a plane, a curve, or a curved surface. The program has built into it certain equipment performance curves, which are stored in the form of equations. These are the default performance curves (or equations). Often however, a user will select, for simulation, a piece of equipment with a performance curve that varies from, or does not fit, the default performance curve. It therefore is necessary to input data to override the default curve and establish a new curve to suit the user's chosen equipment. This is one of the purposes of the CURVE-FIT command. Another is to provide a method to input data where default curves do not already exist. If the user is satisfied with the default values in the program (or is uncertain about the default values at this time) he may skip over this section and go on to ZONE-AIR. The user should know that this capability does exist in the program and that he may return to this section at any future time should it become necessary.

The object is to establish new equations in the program. Since most vendor-supplied equipment information is provided in the form of curves or tabulated data, not equations, the user must assist the program in determining the new equation from the available curves and tabulated data. Even if the equation is known (and it is different than the default equation, should one exist) the user must specify the new equation using the CURVE-FIT instruction.

CURVE-FIT is used to specify data points or coefficients so that the program can determine and use the equation so defined. The particular equation will then be associated by keyword to a particular packaged unit, piece of equipment, etc., by the user. Again, this instruction will be used only when a user finds that curve equation coefficient default values in the program are inappropriate for his use.

There are two methods of input reflecting the two ways of defining a curve, given the form of the curve (linear, bi-linear, quadratic, bi-quadratic, or cubic). These are (1) by giving a list of up to 20 sets of coordinates of points on the curve, or (2) by giving the coefficients of the equation. For example, the following simple linear curve may be defined

(1) as linear, with coordinate points of the form (x,z): (0,3) and (10,8); or

(2) as linear, with coefficients of the form $z = a + bx$: $a = 3$ and $b = 0.5$, where $z = f(x)$.

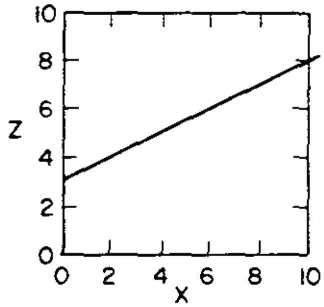


Fig. IV.17. Defining a linear curve.

The user must specify the form of the new curve. A bi-linear curve may be pictured as a plane in three dimensions; it has the form $z = a + bx + dy$,* where the dependent variable, z, depends on two independent variables, x and y. A quadratic equation has the form $z = a + bx + cx^2$, and will be graphed as a parabola. A bi-quadratic equation has the form $z = a + bx + cx^2 + dy + cy^2 + fxy$, and it may be pictured as a curved surface. A cubic is of the form $z = a + bx + cx^2 + dx^3$ and may be graphed as a curve with one inflection point, a maximum, and a minimum.

U-name is a mandatory entry for this command.

CURVE-FIT informs the SDL or PDL processor that the data to follow define a particular curve. A maximum of 100 CURVE-FIT instructions may be entered in DOE-2. If CURVE-FIT is run with DIAGNOSTIC = COMMENTS, an output listing of the curve coefficients, input or calculated, will be printed.

TYPE specifies the form of the curve, and takes one of the following code-words as an input value.

LINEAR means that if the data are given with the DATA keyword they are to be fit to a linear equation in which there is one dependent variable, z, and one independent variable, x. If the data are given with the COEFFICIENTS keyword, they will be treated as coefficients of the equation. The curve, actually a line, will have the form $z = a + bx$, where the coefficients are a and b (see Fig. IV.17).

BI-LINEAR means that if the data that follow are given with the DATA keyword, they are to be fit to a bi-linear equation, one in which there is one dependent variable, z, and there are two independent variables, x and y. If the data are given with the COEFFICIENTS keyword, they will be treated as coefficients of the equation. The curve will have the form $z = a + bx + dy$,* and graphically it is represented by a plane. The coefficients are a, b, and d.

---

*A bi-linear curve is treated by the program as a bi-quadratic with zero coefficients on the x^2, y^2, and xy terms, that is $z = a + bx + 0x^2 + dy + 0y^2 + 0xy$. If TYPE is defined as bi-linear, therefore, and four coefficients are input, the first, second, and fourth coefficients will be used. However, only three coefficients need be input. To indicate this we are using the coefficient "d" on the y term.

QUADRATIC means that if the data are given with the DATA keyword, they are to be fit to a quadratic equation with one dependent variable, z, and one independent variable, x, of the form $z = a + bx + cx^2$. If the data are given with the COEFFICIENTS keyword, they will be treated as coefficients of the equation. The curve is represented graphically by a parabola (or half-parabola). The coefficients are a, b, and c.

BI-QUADRATIC means that if the data that follow are given with the DATA keyword, they will be fit to a bi-quadratic equation in which there is one dependent variable, z, and there are two independent variables, x and y. If the data are given with the COEFFICIENTS keyword, they will be treated as coefficients of the equation. The curve has the form $z = a + bx + cx^2 + dy + ey^2 + fxy$. It is represented graphically by a curved surface. The coefficients are a through f.

CUBIC means that if the data that follow are given with the DATA keyword, they will be fit to a cubic equation in which there is one dependent variable, z, and one independent variable x. If the data are given with the COEFFICIENTS keyword, they will be treated as coefficients of the equation. The curve has the form $z = a + bx + cx^2 + dx^3$ and may be represented graphically by a curve with one inflection point, a maximum, and a minimum. The coefficients are a through d.

DATA

will be followed by up to 20 sets of values. If TYPE = LINEAR, QUADRATIC, or CUBIC, each set will contain two values in the order (independent variable, dependent variable), or (x,z). If TYPE = BI-LINEAR or BI-QUADRATIC, each set will contain three values in the order (independent-variable-1, independent-variable-2, dependent-variable), or (x,y,z). If TYPE = LINEAR, at least two points (two lists of coordinate values) must be input. If TYPE = BI-LINEAR or QUADRATIC, at least three points (three lists of values) must be provided. Note that to input a plane, the three points must not all be on the same line. For example, (1,1), (3,3), and (6,6) define a line but not a plane; (1,1), (3,3), and (6,4) define a plane. When only three coordinate sets are input to define a quadratic, the best accuracy will be achieved if two of the points (pairs of coordinates) lie at either end of the user's range of interest, and the third lies between them, at the approximate maximum or minimum if the curve increases and decreases (see Fig. IV.18).

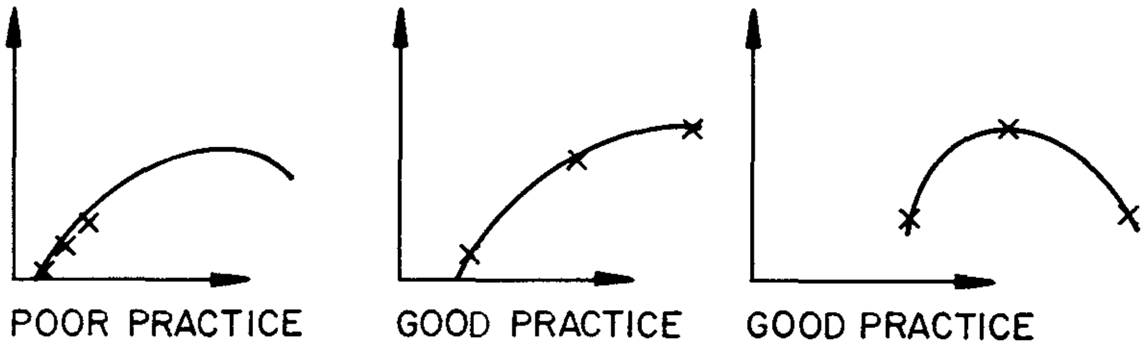


Fig. IV.18. Defining a quadratic curve.

If TYPE = CUBIC, at least four points (four lists of values) must be input. If TYPE = BI-QUADRATIC, at least six points (six lists of values) must be input. To define a bi-quadratic, the six points (six sets of three coordinates) must not all be in the same plane. If data points are input that, when graphed, form two orthogonal (perpendicular) lines, the program will incorrectly calculate the curve coefficients. This is because orthogonal lines determine a plane, and the user's curve may not be planar. Also, as interpolation will be more accurate than extrapolation, the user should, if possible, input points that "bound" his area of interest (see figure below).

Note that the first point entered is considered the design data point and should be the most accurately known (e.g., either the ARI point or that point in which the user has the highest confidence). The program will force the curve to go through the first data point.

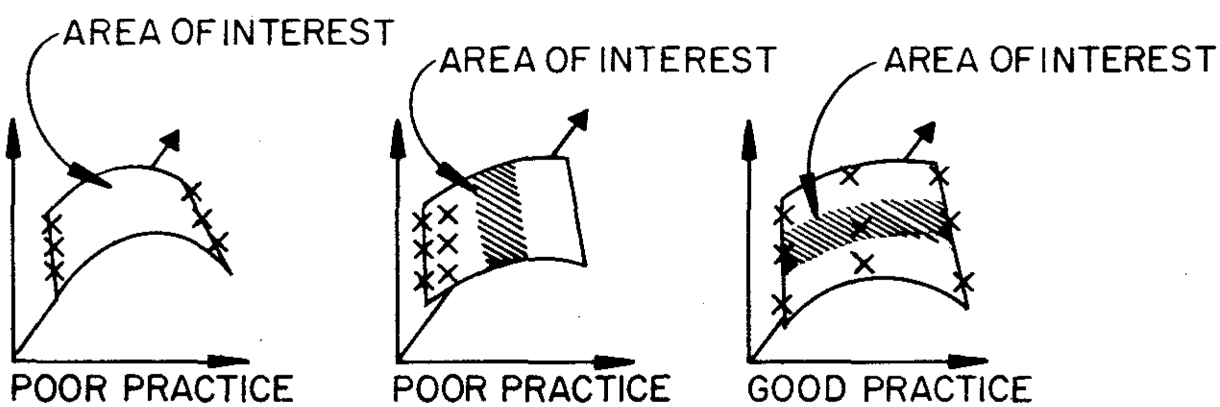


Fig. IV.19. Defining a bi-quadratic curve.

All curves will be fit by a least-squares approximation. If not enough points are input for the curve TYPE, it is an ERROR.

COEFFICIENTS takes, for its values, a list of the coefficients described under TYPE. If more coefficients are specified in the list than are required for a given type of curve, the program accepts the correct number of coefficients, starting from the left side of the list, and ignores the rest. If fewer are specified than required, the coefficients are taken from left to right and the missing ones default to zero.

The following examples show how data might be taken from manufacturer's specifications for each of these methods of input.

Example 1

A user's packaged heating-cooling system (PZS) shows cooling capacity data significantly different from that used in the DOE-2 model. The manufacturer lists the following data for cooling capacity of his unit at 2000 cfm, the design air flow rate.

Outside Dry-Bulb Temperature	Entering Wet-Bulb Temperature 72	67*	62
	Cooling Capacity (kBtuh)		
85	69	65	60
95*	68	63*	57
105	65	60	53
115	62	55	49

*ARI point (Air-Conditioning and Refrigeration Institute).

Because the user has two independent variables (entering wet-bulb and outside dry-bulb) and the dependent variable, cooling capacity, he will input a bi-quadratic curve using the given data points. His input will be as follows. Note that the third variable, cooling capacity, is not actually a cooling capacity but rather it is a ratio of two cooling capacities, the cooling capacity at operating conditions divided by the cooling capacity at ARI conditions. The ratio should equal 1.0 at the ARI point. Thus, in this case, all cooling capacity values have been divided through by the ARI value, 63. Throughout this manual this is the process referred to as "normalizing".

```
INPUT SYSTEMS  ..
     .
     .
COOL-CAP-CURVE = CURVE-FIT
                 TYPE = BI-QUADRATIC
                 DATA = (67, 95, 1.0)  $ARI POINT$
                        (72, 95, 1.079)
                        (62, 95, 0.905)
                        (72, 105, 1.032)
                        (67, 105, 0.952)
                        (62, 105, 0.841)
                        (72, 115, 0.984)
                        (67, 115, 0.873)
                        (62, 115, 0.778)
                        (72, 85, 1.095)
                        (67, 85, 1.032)
                        (62, 85, 0.952)  ..
          .
          .
          .
PACKAGED-SYS = SYSTEM-EQUIPMENT
               COOLING-CAPACITY = 150000
               COOL-CAP-FT = COOL-CAP-CURVE  ..
                  .
                  .
END ..
```

Figure IV.20 is a sample output of the program when DIAGNOSTIC = COMMENTS.

Example 2: Specification of Coefficients

In Table V.6 of the PLANT Chapter, the user finds that the default coefficients for the curve that expresses the exhaust heat of a gas turbine, as a function of ambient air temperature, (GTURB-EXH-FT), are 0.018226, 0.000029, and 0.0. The user's manufacturer's data indicate that for the turbine he is modeling, it would be more accurate to change the first coefficient to 0.022105. As the third coefficient is zero, the curve may be represented in the form z = a + bx. The input might look like:

```
     INPUT PLANT  ..
          .
          .
G-EXH-H = CURVE-FIT
          TYPE = LINEAR
          COEFFICIENTS = (0.022105, 0.000029)  ..
                .
                .
                .
          EQUIPMENT-QUAD
              GTURB-EXH-FT = G-EXH-H  ..
          .
          .
       END ..
```

```
*    2 *   COOL-CAP-CURVE = CURVE-FIT
*    3 *                    TYPE = BI-QUADRATIC
*    4 *                    DATA = (67, 95, 1.0)  $ARI POINT
*    5 *                           (72, 95, 1.079)
*    6 *                           (62, 95, 0.905)
*    7 *                           (72, 105, 1.032)
*    8 *                           (67, 105, 0.952)
*    9 *                           (62, 105, 0.841)
*   10 *                           (72, 115, 0.984)
*   11 *                           (67, 115, 0.873)
*   12 *                           (62, 115, 0.778)
*   13 *                           (72, 85, 1.095)
*   14 *                           (67, 85, 1.032)
*   15 *                           (62, 85, 0.952)  ..

           COEFFICIENT( 1) =     -.66252739
           COEFFICIENT( 2) =      .04085961
           COEFFICIENT( 3) =     -.00032544
           COEFFICIENT( 4) =     -.00154320
           COEFFICIENT( 5) =     -.00008629
           COEFFICIENT( 6) =      .00020600
```

INDEPENDENT	INDEPENDENT	INPUT DEPENDENT	CALC DEPENDENT	DIFFERENCE	PRCNT DIFF
67.000	95.000	1.000			
72.000	95.000	1.079	1.076	.003	.286
62.000	95.000	.905	.908	-.003	.301
72.000	105.000	1.032	1.036	-.004	.410
67.000	105.000	.952	.950	.002	.213
62.000	105.000	.841	.847	-.006	.765
72.000	115.000	.984	.979	.005	.479
67.000	115.000	.873	.883	-.010	1.114
62.000	115.000	.778	.770	.008	1.042
72.000	85.000	1.095	1.098	-.003	.305
67.000	85.000	1.032	1.033	-.001	.066
62.000	85.000	.952	.951	.001	.131

```
ROOT MEAN SQUARE DIFFERENCE =       .005
*   16 *
*   17 *   END ..
```

Fig. IV.20. Example output of CURVE-FIT with input data points.

________________ = CURVE-FIT or C-F (User Worksheet)
U-name*

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
TYPE	TYPE	= ____________	code-word	*	-	-
DATA	DATA	=(____________) (____________) (____________) (____________) (____________) (____________)	lists of coordinate values (x,y, etc.)	**	-	-
COEFFICIENTS	COEF	=(____________) ..	list of coefficients (a,b, etc.)	**	-	-

* Mandatory entry, if CURVE-FIT is specified.
**Alternative entries; the one used depends on form of input.

3. ZONE-AIR

The function of the ZONE-AIR instruction is to provide information on the flow of air into and out of each zone (supply air, exhaust air, and outside air). A number of ZONE-AIR instructions may be required to account for variations in zone size and/or usage or for parametric runs.

ZONE-AIR is a "subcommand" of ZONE and, as such, can be used to input a subset of data to ZONE.

An alternative mode for data entry is to complete and enter ZONE-AIR keywords and their values directly into the ZONE command (if this approach is chosen, omit the ZONE-AIR keyword in ZONE).

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.

There are four different methods of determining supply air flow rate to each zone. Three of the four methods are by specifying input data (ASSIGNED-CFM, AIR-CHANGES/HR, or CFM/SQFT) and the fourth method is by default (specifying no data), which allows the program to calculate the zone supply air flow rate based on peak heating/cooling load and temperature differential.

This large amount of program flexibility often leads to rather confusing situations. As an example, there are certain circumstances under which the user will specify data for AIR-CHANGES/HR or CFM/SQFT only to find that the program reports back a different value. This can be explained as follows. Normally, the program will calculate HEATING-CAPACITY and COOLING-CAPACITY, but it is possible for the user to specify these values. If the user chooses to specify HEATING-CAPACITY and/or COOLING-CAPACITY, the program more than likely will be faced with conflicting data.

For information on how the program adjusts user-specified values to maintain balanced equations, see Sec. D of the chapter.

ZONE-AIR — informs the SDL Processor that the data to follow are related to zone air flow (supply air, exhaust air, and outside air). A unique user-defined name must be entered in the U-name field of each ZONE-AIR instruction. Omission of this entry in the "subcommand" will cause an error.

ASSIGNED-CFM — specifies (in standard cfm) the design supply air flow rate for the zone. Two other keywords AIR-CHANGES/HR and CFM/SQFT have been provided as alternative methods of assigning this design parameter; however, any entry for ASSIGNED-CFM will take precedence and be used by the program. If data entry is made for both AIR-CHANGES/HR and CFM/SQFT, the program will calculate a flow rate based on each and use the larger value. If data entry is omitted for all these keywords, the program will calculate design flow rate based on peak heating/cooling loads calculated by the LOADS program and the temperature differential between design supply and zone conditions. The flow rates so calculated do not account for interzone heat transfer unless explicitly requested. For a more detailed discussion see Sec. D of this chapter.

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 is the 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. For a discussion of alternative ways to specify zone air flow rates, see ASSIGNED-CFM.

CFM/SQFT is the 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. For a discussion of alternative ways to specify zone air flow rates, see ASSIGNED-CFM.

RATED-CFM is the nominal capacity of the supply air fan in this zone, <u>as specified by the fan manufacturer.</u> This keyword and its associated value are input by the user <u>if</u> he has chosen a supply fan, from the manufacturers' literature, that will be forced to operate above or below its rated capacity to meet the flow rate of ASSIGNED-CFM (or the flow rate calculated by the program). The rating is in cfm at standard (sea level) conditions.

This over- or under-sized fan may affect other equipment in the system; therefore, the user should see also RATED-HCAP-FCFM, RATED-HEIR-FCFM, RATED-CCAP-FCFM, RATED-CEIR-FCFM, and RATED-SH-FCFM in SYSTEM-EQUIPMENT.

Note: Only "zonal" systems (UHT, UVT, TPFC, FPFC, TPIU, FPIU, HP, and PTAC) have a supply air fan <u>in the zone.</u> For all the central systems the data entry for RATED-CFM, if necessary, is input under the SYSTEM-AIR subcommand. If no value is specified here for "zonal" systems and a value is specified in SYSTEM-AIR, that value will be used by <u>all</u> zones.

Note: The following three 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.

The outside ventilation air quantity is not determined by the design space heating or cooling demands (except when an economizer is specified).

OUTSIDE-AIR-CFM specifies the minimum flow rate of outside air (in standard, or sea level, cfm) for the zone. Alternatively, or additionally, outside air flow rate may be specified by data entry for the keywords OA-CFM/PER and OA-CHANGES in this subcommand, or for the keyword MIN-OUTSIDE-AIR in the SYSTEM-AIR subcommand. The program will calculate outside air flow rate based on each entry and use the larger value, except that any data entry made for the keyword OUTSIDE-AIR-CFM will override the other entries and will be used by the program. Also, the specification of outside ventilation air at the zone level takes precedence over the specification of outside ventilation air at the system level. For additional discussion see Sec. D of this chapter.

OA-CHANGES — is the minimum flow rate of outside air for 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. For a discussion of alternative ways to specify outside air flow rate, see keyword OUTSIDE-AIR-CFM.

OA-CFM/PER — is the minimum flow rate of outside air (in standard, or sea level, cfm) per zone occupant at peak occupancy. For a discussion of alternative ways to specify outside air flow rate, see the keyword OUTSIDE-AIR-CFM.

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. Note that the SYSTEMS program does not simulate heat recovery from zone exhaust, but only from central exhaust. Therefore, if heat is to be recovered, zone exhaust should not be entered but rather allowed to default to the central system. Return fan static should be adjusted, on a weighted average basis, to reflect zone exhaust fan conditions.

(Note: 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 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 produced by the exhaust fan serving the zone (for additional discussion see keyword SUPPLY-EFF in the SYSTEM-FANS subcommand). 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 (for additional discussion see keyword SUPPLY-EFF in the SYSTEM-FANS subcommand). 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-AIR or Z-A (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
ASSIGNED-CFM	A-CFM	=	________	cfm	Note 1	0.	$1.x10^8$
AIR-CHANGES/HR	A-C/HR	=	________	number/hr	Note 1	0.	10.
CFM/SQFT	-	=	________	cfm/ft^2	Note 1	0.	5.
RATED-CFM	R-CFM	=	________	cfm	-	0.	$1.x10^8$
OUTSIDE-AIR-CFM	O-A-CFM	=	________	cfm	Note 2	0.	$1.x10^8$
OA-CHANGES	O-C	=	________	number/hr	Note 2	0.	10.
OA-CFM/PER	O-CFM/P	=	________	cfm/person	Note 2	0.	60.
EXHAUST-CFM	E-CFM	=	________	cfm	Note 3	0.	$1.x10^8$
EXHAUST-STATIC	E-S	=	________	inches W.G.	Note 3	0.	10.
EXHAUST-EFF	E-E	=	________	fraction (Note 3)	0.75	0.1	1.
EXHAUST-KW	E-KW	=	________	kW/cfm	-	0.	.01

..

1) If no data entry is made for this keyword (or alternative keywords), the program will calculate zone supply air flow rate on the basis of heating/cooling loads, supply air to space temperature differential, and a sizing-factor. For additional discussion see Sec. D.1 of this chapter.

2) If no data entry is made for this keyword (or alternative keywords), the program will determine minimum outside air flow rate from the data entry made for keyword MIN-OUTSIDE-AIR (see SYSTEM-AIR subcommand). If no data entry is made in either ZONE-AIR or SYSTEM-AIR, outside air flow is assumed to be zero. For additional discussion see Sec. D.1 of this chapter.

3) Use either EXHAUST-STATIC and EXHAUST-EFF or EXHAUST-KW. There are no default for EXHAUST-CFM, EXHAUST-STATIC, AND EXHAUST-KW.

4. ZONE-CONTROL

The function of the ZONE-CONTROL instruction is to provide information on zone temperature control characteristics such as set point, 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.

An alternative mode for data entry is to complete and enter ZONE-CONTROL keywords and their values directly into the ZONE command (if this approach is chosen, omit the ZONE-CONTROL keyword in ZONE).

ZONE-CONTROL — informs the SDL Processor that the data to follow are related to control of zone temperature. A unique user-defined name must be entered in the U-name field of each ZONE-CONTROL instruction. Omission of this entry in the "subcommand" will cause an error.

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.

See Sec. D of this chapter for discussion related to this and other system design calculations.

Note that a DESIGN-HEAT-T must be specified for all ZONE-TYPE = CONDITIONED.

DESIGN-HEAT-T may also be specified for ZONE-TYPE = UNCONDITIONED or PLENUM (in this case, a value should be specified that is the user's predicted temperature in this zone at the time of peak heating in adjacent zones, that is, those surrounding zones that share a common interior wall). If ZONE-TYPE = UNCONDITIONED or PLENUM and no value is specified for DESIGN-HEAT-T, it will default to the value for TEMPERATURE (see SPACE-CONDITIONS in LOADS).

HEAT-TEMP-SCH — is the U-name of the SCHEDULE instruction that specifies the set point of the zone heating thermostat. If no data entry is made, the program will assume that the zone has no zone-activated heating control.

See Chap. II for information on the SCHEDULE instruction. However, note that, in this case, the input for the DAY-SCHEDULE instruction should be hourly room temperature.

For additional discussion pertinent to the use of this keyword for simulation of zone thermostatic control see Sec. B.6 of this chapter.

The following is an example of data entry for the keyword HEAT-TEMP-SCH and the associated SCHEDULE instructions.

```
HEAT-SCHED = SCHEDULE THRU DEC 31
             (MON, FRI)(1,8)(55)(9,18)(69)(19,24)(55)
             (WEH)(1,24)(55) ..

   SP-1 = ZONE
      Keyword = Value
      HEAT-TEMP-SCH  = HEAT-SCHED
      Keyword = Value
      Keyword = Value ..
```

The hypothetical schedule above depicts the heating set point of a single thermostat that is reset for off-hours or multiple thermostats with fixed set points that are switched-in at the indicated times. For a more detailed description of thermostat simulation see the following discussion for thermostat type and Sec. B.6 of this chapter.

DESIGN-COOL-T — specifies the space temperature that the program uses to calculate the supply air flow rate required to meet peak (or design day) cooling loads for the zone.

Note that a value for DESIGN-COOL-T must be specified for all ZONE-TYPE = CONDITIONED.

DESIGN-COOL-T may also be specified for ZONE-TYPE = UNCONDITIONED or PLENUM (in this case, a value should be specified that is the user's predicted temperature in this zone at the time of peak cooling in adjacent zones, that is, those surrounding zones that share a common interior wall). If ZONE-TYPE = UNCONDITIONED or PLENUM and no value is specified for DESIGN-COOL-T, it will default to the value for TEMPERATURE (see SPACE-CONDITIONS in LOADS).

COOL-TEMP-SCH — is the U-name of the SCHEDULE instruction that specifies the set point of the zone cooling thermostat. If no data entry is made, the program will assume that the zone has no zone-activated cooling control.

The example given for the keyword HEAT-TEMP-SCH also applies to this keyword, if the temperatures indicated are increased to be more representative of summer conditions.

For additional discussion pertinent to the use of this keyword for simulation of zone thermostatic control see Sec. B.6 of this chapter.

BASEBOARD-CTRL — Input for this keyword is the code-word that specifies the method used for controlling the output of the baseboard heating element in the zone. See Table IV.30 for the applicable code-words.

TABLE IV.30

Code Word	BASEBOARD-CTRL
THERMOSTATIC	Temperature control of the baseboard element is by a thermostat located within the zone.
OUTDOOR-RESET	Temperature control of the baseboard element is by a thermostat located outside the building.

If code-word THERMOSTATIC is entered, the program will assume that the baseboard element adds heat as required, up to the maximum capacity of the element, to maintain zone temperature within the heating throttling range. The baseboards are sequenced on first in response to a drop in space temperature.

If no entry is made for this keyword (default), or if the code-word OUTDOOR-RESET is entered, the program assumes that baseboard heating output varies linearly with the temperature of the outdoor air (i.e., circulating fluid temperature is referenced to outside air temperature). The linear function and the operating period are specified by keyword BASEBOARD-SCH (see SYSTEM-CONTROL subcommand).

THERMOSTAT-TYPE — Input for this keyword is the code-word that identifies the type of thermostat action to be simulated. See Table IV.31 for the code-words and a brief description of the type of thermostat each represents. Note that the program will assume the same type of thermostat action for both cooling and heating.

TABLE IV.31

Code-Word	THERMOSTAT-TYPE
PROPORTIONAL	Thermostat throttles heat addition rate (or heat extraction rate) in linear proportion to the difference between zone set point temperature and actual zone temperature. The proportional band is input by the user (see keyword THROTTLING-RANGE). PROPORTIONAL is the default.
TWO-POSITION	On-off type thermostat simulated as a very narrow fixed throttling range around each set point. This code-word is normally not used for hot and chilled water system controls.

REVERSE-ACTION — In variable air volume systems it 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 PROPORTIONAL.

<u>For additional discussion pertinent to the use of this keyword for simulation of zone thermostatic control see Sec. B.6 of this chapter.</u>

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 set point is assumed to be at the midpoint of the throttling range. This keyword is appropriate to PROPORTIONAL and REVERSE-ACTION thermostats only.

THROTTLING-RANGE is also used by the program in determining the number of hours that each zone is either undercooled or underheated (see Systems Report SS-F). If the zone temperature is more than one THROTTLING-RANGE above the cooling set point, the zone for that hour is considered to be undercooled. Likewise, if the zone temperature is more than one THROTTLING-RANGE below the heating set point, the zone for that hour is considered to be underheated.

<u>For additional discussion pertinent to the use of this keyword for simulation of zone thermostatic control see Sec. B.6 of this chapter.</u>

_________________ = ZONE-CONTROL or Z-C (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
DESIGN-HEAT-T	D-H-T	=	________	°F	Note 1	0.	80.
HEAT-TEMP-SCH	H-T-SCH	=	________	U-name	Note 2	-	-
DESIGN-COOL-T	D-C-T	=	________	°F	Note 1	0.	90.
COOL-TEMP-SCH	C-T-SCH	=	________	U-name	Note 3	-	-
BASEBOARD-CTRL	B-C	=	________	code-word	OUTDOOR-RESET	-	-
THERMOSTAT-TYPE	T-TYPE	=	________	code-word	Note 4	-	-
THROTTLING-RANGE	T-R	=	________	°F	Note 5	0.1	10.

1) This is a required data entry for ZONE-TYPE = CONDITIONED (see ZONE command). This is an optional entry for ZONE-TYPE = UNCONDITIONED or PLENUM (in this case, the default will be the value for TEMPERATURE in SPACE-CONDITIONS in the LOADS program).

2) A data entry for this keyword (and for the referenced SCHEDULE instruction) is required if the zone is to be heated. WARNING: If this data entry is omitted the program will run, but NO HEATING WILL BE PROVIDED FOR THE ZONE.

3) A data entry for this keyword (and for the referenced SCHEDULE instruction) is required if the zone is to be cooled. WARNING: If this data entry is omitted the program will run, but NO COOLING WILL BE PROVIDED FOR THE ZONE.

4) If no data entry is made for this keyword, the program will assume a proportional thermostat (code-word PROPORTIONAL), except code-word TWO-POSITION is required for correct simulation of the PTAC and HP systems.

5) 2°F for PROPORTIONAL and REVERSE-ACTION thermostats and .5°F for TWO-POSITION thermostats.

5. 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 set point, thermostat characteristics, and maximum heating and/or cooling capacity. All zones that are to be simulated must also be specified in a SYSTEM command. This includes unconditioned and plenum type zones.

The ZONE subcommands (ZONE-AIR and ZONE-CONTROL) are each groups of data that are related by subject or category or information. The information is needed to supplement that provided in the ZONE instruction, but the organization into subgroups is for user convenience only. Once an instruction is labeled and data are entered for the applicable keywords, it can be referenced to any number of different zones, thus reducing data input effort. At his discretion, the user can input one or more of the ZONE subcommands or alternatively select the applicable keywords from these instructions and make a data entry for each with the ZONE instruction.

A separate ZONE instruction is required for each zone (including unconditioned and plenum zones). Note that there must be a one-to-one match-up between the zones specified here and the spaces specified in the LOADS program. That is, for each SPACE instruction in LOADS there will be a ZONE instruction here to represent a physically identical portion of the building.

ZONE — informs the SDL Processor that the data to follow are related to specific thermal zone characteristics. A unique user-defined name must be entered in the U-name field of the ZONE instruction. Omission of this entry will cause an error. Once again note that a zone, as specified here, must be physically identical to the area of the building specified by one of the SPACE instructions in the LOADS program (see Chap. III). The U-name for this data entry must, therefore, match the U-name entered for the corresponding SPACE instruction.

ZONE-TYPE — Input for this keyword is the code-word, from Table IV.32, that identifies the zone as a conditioned space (default value), an unconditioned space, or a plenum.

Note: Since PLENUM is an acceptable code-word for ZONE-TYPE, a plenum is a zone and may have any characteristic of a zone, including windows, people, infiltration, etc. (but not electrical equipment). This opens the possibility of using the code-word PLENUM to describe an atrium, a greenhouse, or sun porch. Return air may pass through this zone where it picks up solar preheating before being linked to the inlet of the air handling unit. Hallways, attics, and crawl spaces may also be specified as PLENUMs.

TABLE IV.32

Code-Word	ZONE-TYPE
CONDITIONED	The zone is heated and/or cooled, depending on the type of system selected.
UNCONDITIONED	This zone is neither heated nor cooled, but is located adjacent to one or more of the conditioned zones assigned to this system (false ceiling spaces not used as return air plenums are in this category).
PLENUM	The zone is a space used as a plenum for return air. All electrical loads are ignored. Heat to the plenum from other spaces is added into this zone during the simulation. An above-ceiling space with return air passing through internal air ducts does not qualify as a PLENUM. Zonal systems (UHT, UVT, TPIU, FPIU, TPFC, FPFC, HP, and PTAC) do not allow plenums.

ZONE-AIR is a U-name previously assigned under the subcommand ZONE-AIR. The specified U-name matches the correct "ZONE-AIR" to each "ZONE". No data entry here will result in default to the values specified under the subcommand ZONE-AIR.

An alternative mode for data entry is to complete and enter ZONE-AIR keywords directly into ZONE (if this approach is chosen, omit the ZONE-AIR instruction here in ZONE.)

ZONE-CONTROL The preceding discussion of the keyword ZONE-AIR applies equally to this keyword when the keyword names are interchanged.

MULTIPLIER is the number of zones in the facility that are identical to some specified zone, and are to be assigned to the same system (i.e., rather than describing 10 similar thermal zones, a multiplier of 10 can be used on a single zone). This data entry is used only when the facility has a number of identical rooms or spaces and, to simplify LOADS Program input, all of them have been specified with a single SPACE instruction, by use of the analogous keyword MULTIPLIER (see SPACE instruction Chap. III). The value entered here should match the value entered for MULTIPLIER in the SPACE instruction.

Warning: MULTIPLIER must be used with care for ZONEs that have INTERIOR-WALLs in common (see SPACE instruction, Chap. III).

MAX-HEAT-RATE is the maximum net heat addition rate from the air system for the zone. MAX-HEAT-RATE does not include the baseboard heat addition rate. If and when MAX-HEAT-RATE is used, it will override capacity calculations based on peak (or design day) loads (calculated by the LOADS program). Note that the input value for MAX-HEAT-RATE is a negative number. If the minus sign is omitted an ERROR will occur. See Sec. D of this chapter for additional discussion.

Note that the keyword MAX-HEAT-RATE can be used to suppress the heating capability of any given zone, should this be desired. To do so, the user enters a finite, but very low value for the keyword (e.g., -1). Zone air flow will then be calculated on the basis of cooling only, rather than on the larger of the cooling and heating requirements.

MAX-COOL-RATE — is the maximum net heat extraction rate of the air system for the zone. If and when this data entry is used, it will override capacity calculations based on peak (or design day) loads (calculated by the LOADS program). See Sec. D of this chapter for additional discussion.

Note that the keyword MAX-COOL-RATE can be used to suppress the cooling capability of any given zone, in the manner described above for MAX-HEAT-RATE.

BASEBOARD-RATING — is the baseboard heating element capacity for the zone. See Sec. D of this chapter for discussion related to zone heating capacity. The input for this keyword should be a negative number.

PANEL-LOSS-RATIO — is the heat loss from the floor heating panel in the zone, expressed as a decimal fraction of the energy added to the zone by the panel. Panel losses are the heat transferred from the underside of floor panels, the upper side of ceiling panels, and the edges of any panel. The user is required to calculate or estimate this ratio, which the program assumes to remain constant over the full range of panel heating output. This keyword applies only to zones equipped with panel heating elements.

MIN-CFM-RATIO — is the minimum allowable zone air supply flow rate, expressed as a decimal fraction of design flow rate. The keyword MIN-CFM-RATIO is applicable to variable-volume type systems only. (This keyword appears also under the SYSTEM-TERMINAL command. There it is a "system level" keyword and it applies to all zones in the system; here it is a "zone level" keyword and applies only to this zone. This capability allows different MIN-CFM-RATIOs for each zone). If the sum of all zones' MIN-CFM-RATIOs times the design flow rate equals a value less than the specified outside air flow rate, there is implied 100 per cent outside air operation at, and possibly above, the zone MIN-CFM-RATIO. If THERMOSTAT-TYPE = REVERSE-ACTION is not specified, zone MIN-CFM-RATIO is also the flow rate fraction in the heating mode.

Warning: When simulating a variable air volume system, the value of the THROTTLING-RANGE should be at least 4 degrees to insure stability of operation. This is especially true when a COLDEST or WARMEST control option in HEAT-CONTROL or COOL-CONTROL is also used.

The following three keywords are appropriate to the "zonal systems" (UHT, UVT, TPFC, FPFC, TPIU, FPIU, HP, and PTAC) only. Normally these keywords appear at the system level but for zonal systems they appear also at the zone level. If no data are input for these three keywords, the program will calculate their values, at ARI* conditions. At non-ARI conditions the program will automatically use the default performance curves to adjust their calculated values, unless the user specifies his own performance curves (see SYSTEM-EQUIPMENT).

HEATING-CAPACITY — is the total capacity of the zonal heating system (for HP and PTAC this HEATING-CAPACITY is at ARI rated conditions). Note that the input value is a negative value. If the minus sign is omitted, an ERROR will occur. The program-designed HEATING-CAPACITY does not include fan power and heat if specified separately (see COOLING-CAPACITY).

COOLING-CAPACITY — is the total cooling capacity (at ARI rated conditions) of either the zonal cooling coil or the zonal cooling system, depending upon which the user is attempting to specify. Note: When specifying COOLING-CAPACITY for packaged DX cooling units with draw-through fans, SUPPLY-EFF and SUPPLY-STATIC (see SYSTEM-FANS subcommand) should be omitted and SUPPLY-DELTA-T should be set equal to zero if the COOLING-CAPACITY being defined includes cooling of the fan motor. Otherwise, double accounting for supply fan motor heat will be experienced. For better latent simulation, the SUPPLY-DELTA-T should be specified and the COOLING-CAPACITY adjusted to describe the unit without the fan. The program-designed COOLING-CAPACITY (for DX systems) is at ARI rated conditions and fan power and heat are not included.

COOL-SH-CAP — is the sensible heat removal capacity of the zonal air cooling device at ARI rated conditions. At non-ARI rated conditions, the value will be corrected for entering wet-bulb temperature and outdoor dry-bulb temperature (or entering water temperature for HP). Note: The sensible capacity is always less than or equal to the total capacity.

* Air-Conditioning and Refrigeration Institute.

Warning: The following keyword is not to be confused with a keyword by the same name in the SYSTEM command. The two are related, but not the same.

SIZING-OPTION

Input for this keyword is a code-word that indicates if the user wishes the program to adjust the system equipment size to account for certain temperature differences in LOADS and SYSTEMS:

(1) If the constant space temperature specified in LOADS (see keyword TEMPERATURE in the SPACE-CONDITIONS subcommand) is between the zone DESIGN-HEAT-T and DESIGN-COOL-T (in the ZONE-CONTROL subcommand in SYSTEMS), the peak loads will be overestimated for cooling and heating. Consequently, the calculated air flow rate for the zone will not exactly correspond to the actual air flow rate necessary to meet the heat addition rate or heat extraction rate at the peaks.

(2) In the LOADS program, unconditioned spaces and plenums are assumed to be at constant temperature. In fact, the temperature is not constant because the temperature of an unconditioned zone is allowed to float and the temperature in a plenum is determined by the blend of return air temperatures and flow rates. As a result, there is no contribution to the peak loads of conditioned zones from interzone heat transfer with adjacent unconditioned zones.

To account for these two effects or not, the user may specify a code-word from Table IV.32.1. This assumes that the user does not specify the equipment size but rather allows automatic equipment sizing by the program.

TABLE IV.32.1

Code-Word	SIZING-OPTION
FROM-LOADS	The automatic sizing of equipment to heat or cool this zone will not consider the two previously listed effects. This is the default value.
ADJUST-LOADS	The automatic sizing of equipment to heat and cool this zone will consider the two previously listed effects. An adjustment will be made to the peak heating and cooling loads to account for a difference between the value specified for TEMPERATURE (in LOADS) and DESIGN-HEAT-T and DESIGN-COOL-T (in SYSTEMS). Also, a steady-state adjustment will be made to account for thermal conduction through interior and exterior walls. Note that DESIGN-HEAT-T and DESIGN-COOL-T should also be specified for unconditioned and plenum zones. Infiltration loads will also be adjusted.

(Revised 5/81)

Note: This keyword should normally be specified for each zone (explicitly or through a LIKE keyword) to get a more accurate air flow rate for the zone. Optionally, SIZING-OPTION could be specified only for ZONE-TYPE = CONDITIONED (where the user wishes a more accurate air flow rate) and be allowed to default for ZONE-TYPE = UNCONDITIONED or PLENUM. In this case, the user should still specify the DESIGN-HEAT-T and DESIGN-COOL-T for ZONE-TYPE = UNCONDITIONED or PLENUM, so that the peak heating and cooling loads of surrounding zones are appropriately modified.

_______________ = ZONE or Z (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	____________	U-name	-	-	-
ZONE-TYPE	Z-TYPE	=	____________	code-word	Note 1	-	-
ZONE-AIR	Z-A	=	____________	U-name	Note 2	-	-
ZONE-CONTROL	Z-C	=	____________	U-name	Note 2	-	-
MULTIPLIER	M	=	____________	number	1.	1.	50.
MAX-HEAT-RATE	MAX-H-R	=	____________	(-)Btu/hr	Note 3	$-1.\text{x}10^8$	0.
MAX-COOL-RATE	MAX-C-R	=	____________	Btu/hr	Note 3	0.	$1.\text{x}10^9$
BASEBOARD-RATING	B-R	=	____________	(-)Btu/hr	0.	$-1.\text{x}10^8$	0.
PANEL-LOSS-RATIO	P-L-R	=	____________	number	0.	0.	2.
MIN-CFM-RATIO	M-C-R	=	____________	fraction	Note 4	0.	1.
HEATING-CAPACITY	H-CAP	=	____________	(-)Btu/hr	Note 5	$-1.\text{x}10^8$	0.
COOLING-CAPACITY	C-CAP	=	____________	Btu/hr	Note 5	0.	$1.\text{x}10^8$
COOL-SH-CAP	C-S-C	=	____________	Btu/hr	Note 5	0.	$1.\text{x}10^8$
SIZING-OPTION	S-O	=	____________	code-word	FROM-LOADS	-	-

Plus any keywords under the ZONE-AIR and ZONE-CONTROL commands.

1) If no data entry is made for this keyword, the program will assume that the zone being specified is CONDITIONED, that is heated and/or cooled.
2) A data entry for this keyword is required to reference a subcommand.
3) If no data entry is made for this keyword, the program will determine this value using the methodology discussed in Sec. D.1 of this chapter. If a value is input for MAX-HEAT-RATE it should be input as a negative number.
4) If allowed to default, the value for MIN-CFM-RATIO in SYSTEM-TERMINAL will be used.
5) Appropriate at the zone level for "zonal" systems only (UHT, UVT, TPFC, FPFC, TPIU, FPIU, HP, and PTAC). An entry may be made here in ZONE for each zone or it may be allowed to default to the value for the same keyword in SYSTEM-EQUIPMENT. If a value is specified both here in ZONE and also in SYSTEM-EQUIPMENT, the value specified here takes precedence. Note that the input value for HEATING-CAPACITY is negative.

6. SYSTEM-CONTROL

The function of the SYSTEM-CONTROL instruction is to provide information on supply air temperature (set point, control strategy, and limits), humidity limits, and to identify the appropriate equipment operating schedules. Several SYSTEM-CONTROL instructions may be specified if the facility is served by more than one system and/or it is desired to conduct parametric runs.

SYSTEM-CONTROL is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

An alternative mode for data entry is to complete and enter SYSTEM-CONTROL keywords and their values directly into the SYSTEM command (if this approach is chosen, omit the SYSTEM-CONTROL keyword in SYSTEM).

SYSTEM-CONTROL — informs the SDL Processor that the data to follow are related to system temperature control, humidity control, and operating schedule. A unique user-defined name must be entered in the U-name field of each SYSTEM-CONTROL instruction. Omission of this entry in the "subcommand" will cause an error.

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 (see Sec. D of this chapter for additional discussion). This value is also used as an upper limit for supply air temperature control. MAX-SUPPLY-T should be greater than DESIGN-HEAT-T.

Note that this entry is mandatory for certain types of systems (RESYS, MZS, DDS, SZCI, UVT, UHT, HP, HVSYS, TPFC, FPFC, TPIU, FPIU, PSZ, PMZS, PTAC) and omission will cause the program to abort. The entry is optional for other types of systems (SZRH, VAVS, RHFS, CBVAV, PVAVS). If no entry is made, the program will use the sum of MIN-SUPPLY-T and REHEAT-DELTA-T (see SYSTEM-TERMINAL subcommand).

HEATING-SCHEDULE — is 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. It is possible for this system (or one or more of its zones) to be calling for heating but that heating is not available, because of the manner in which this schedule has been specified.

See Chap. II for information on the schedule instructions (DAY-SCHEDULE, WEEK-SCHEDULE, and SCHEDULE). Note that, in this case, the program checks only for on/off and, therefore, the hourly values entered for the DAY-SCHEDULE instruction should be either one (heating is on) or zero (heating is off).

Thermostat set point for space heating is specified by the keyword HEAT-TEMP-SCH in the ZONE or ZONE-CONTROL instruction.

For additional discussion pertinent to the use of this keyword for simulation of zone thermostatic control see Sec. B.6 of this chapter.

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 Table IV.33 for the code-words and a brief description of the control strategy each represents.

TABLE IV.33

Code-Word	HEAT-CONTROL and COOL-CONTROL
CONSTANT	Sets heating supply and/or cooling supply air temperature at 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 relative temperature in its heating THROTTLING-RANGE". 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 relative temperature in its cooling THROTTLING-RANGE". 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.

Warning: If using the COLDEST or WARMEST options in conjunction with a variable air volume system, there are two actions within the throttling range. To reflect reality and to prevent instability in the simulation, THROTTLING-RANGE should be increased to 4 to 6°F.

If the user has not done so already, he should review the information on his SYSTEM-TYPE in Sec. B.5 of this chapter. The user should thoroughly understand the meanings of the code-words in Table IV.33 before specifying HEAT-CONTROL and COOL-CONTROL.

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, PMZS, and HVSYS), this is the value used as the supply air temperature set point when HEAT-CONTROL is equal to CONSTANT. For DDS, MZS, and PMZS, this value defaults to MAX-SUPPLY-T. For HYSYS, this value defaults to the average zone DESIGN-HEAT-T when HEAT-CONTROL is equal to CONSTANT (and MAX-SUPPLY-T otherwise).

b. For single duct systems (air-handler systems that do not use the keyword HEAT-CONTROL) as well as dual duct and HVSYS systems, HEAT-SET-T is also used as the design main air-handler heating coil exit temperature. This value is used to size this coil. If this coil does not exist, enter a low value (equal to MIN-SUPPLY-T) for HEAT-SET-T. For RESYS, SZRH, RHFS, SZCI, and PSZ, the default is MAX-SUPPLY-T. For other single duct systems (VAVS, CBVAV, PVAVS, TPIU, and FPIU), 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.

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

SYS-1 = SYSTEM
        Keyword = Value
        HEAT-CONTROL = SCHEDULED
        HEAT-SET-SCH = HOT-COIL-SCH
        Keyword = Value
        Keyword = Value  ..
```

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 data entry is used only when the RESET control strategy is selected (i.e., entry for the keyword HEAT-CONTROL is the code-word RESET; see Table IV.33).

Information on the RESET-SCHEDULE instruction is provided in this section of the manual.

The following is an example of data entry for the keyword HEAT-RESET-SCH, and the associated reset schedule instructions DAY-RESET-SCH and RESET-SCHEDULE.

```
HOT-DECK-1  = DAY-RESET-SCH
              SUPPLY-HI  = 120
              SUPPLY-LO  = 70
              OUTSIDE-HI =  70
              OUTSIDE-LO =  0.0  ..

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

SYS-1 = SYSTEM
        Keyword  =  Value
        HEAT-CONTROL = RESET
        HEAT-RESET-SCH = HOT-RESET-1
        Keyword  =  Value
        Keyword  =  Value  ..
```

MIN-SUPPLY-T is the lowest allowable temperature for air entering the ZONE(s), that is, the lowest allowed diffuser temperature. The program will use this temperature to determine design supply air flow rate. See Sec. D of this chapter for discussion. MIN-SUPPLY-T must be less than DESIGN-COOL-T.

This entry is mandatory for all systems that have cooling capability (i.e., all systems except the Unit Heater (UHT), Unit Ventilator (UVT), Floor Panel Heating System (FPH) and Heating and Ventilating System (HVSYS)).

Note, that for those systems that are to maintain a constant cooling air discharge temperature (see keyword COOL-CONTROL), the control set point is determined by the value entered for keyword COOL-SET-T, rather than by this entry. In that case, the program uses the MIN-SUPPLY-T to limit subcooling for dehumidification purposes (and to calculate the design air flow rate for cooling - see discussion of relationship between MIN-SUPPLY-T and COOL-SET-T in Sec. D of this chapter).

COOLING-SCHEDULE is the 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 (for systems with cooling capability). It is possible for this system (or one or more of its zones) to be calling for cooling but that cooling is not available, because of the manner in which this schedule has been specified.

See Chap. II for information on the schedule instruction (DAY-SCHEDULE, WEEK-SCHEDULE, and SCHEDULE). Note that, in this case, the program checks only for on/off and, therefore, the hourly values entered for the DAY-SCHEDULE instruction should be either one (cooling is on) or zero (cooling is off).

Thermostat set point for space cooling is specified by the keyword COOL-TEMP-SCH in the ZONE or ZONE-CONTROL instruction.

For additional discussion pertinent to the use of this keyword for simulation of zone thermostatic control, see Sec. B.6 of this chapter.

COOL-CONTROL — Input for this keyword is the code-word that identifies the strategy to be used for control of the cooling air temperature leaving the system (central) cooling coil. See Table IV.33 for the code-words and a brief description of the control strategy each represents. For VAVS, SZCI, CBVAV, DDS, MZS, PMZS, or PVAVS (with MIN-CFM-RATIO less than 1), if COOL-CONTROL is WARMEST the system may cause a temperature reset sequentially with a volume reduction.

COOL-SET-T — is the value for cooling air supply temperature when the entry for COOL-CONTROL is the code-word CONSTANT (see Table IV.33). This entry should be omitted if one of the alternate control strategies (i.e., WARMEST or RESET) is selected.

Note that even though COOL-SET-T determines the cooling air supply temperature, the program uses MIN-SUPPLY-T to calculate the design supply air flow rate. See Sec. D of this chapter for additional discussion.

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 (i.e., entry for keyword COOL-CONTROL is the code-word RESET; see Table IV.33).

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

```
COOL-COIL-SCH = SCHEDULE THRU APR 30 (ALL)(1,24)(60)
                         THRU SEP 30 (ALL)(1,24)(55)
                         THRU DEC 31 (ALL)(1,24)(60)  ..

SYS-1 = SYSTEM
        Keyword = Value
        COOL-CONTROL = SCHEDULED
        COOL-SET-SCH = COOL-COIL-SCH
        Keyword = Value
        Keyword = Value  ..
```

MAX-HUMIDITY is the highest allowable relative humidity (R.H.) in the zone, or zones, served by the system. Because the program calculates the relative humidity in the return air, dehumidification is based on the average humidity condition for all the zones served by the system, as weighted by the relative return air flow rate from each zone. This data entry should be used only for those systems that have the components required for control of excess humidity (i.e., a humidistat and a heating coil downstream of the cooling coil). If no data entry is made, the program will assume that humidity control capability does not exist. The default value of 100 per cent is intended to specify no upper limit on humidity, that is, no humidity control.

The program will not force the cooling coil to perform beyond its dehumidification capability. The program will not be able to hold a specified MAX-HUMIDITY if MIN-SUPPLY-T is not low enough. Fig. IV.21 shows one type of dehumidification cycle.

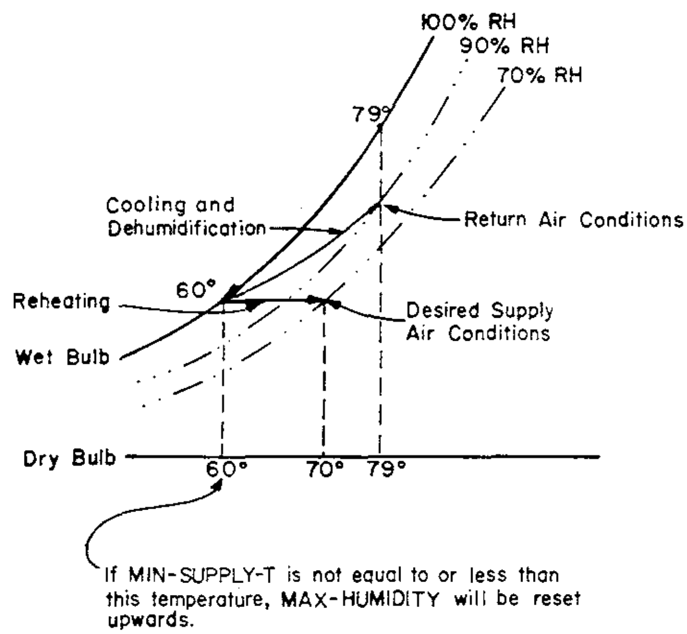


Fig. IV.21 Relationship of MAX-HUMIDITY to MIN-SUPPLY-T.

If a lower MAX-HUMIDITY is required to meet desired space conditions, a lower MIN-SUPPLY-T should be entered.

MIN-HUMIDITY is the lowest allowable relative humidity (R.H.) in the zone, or 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). The user should not set MIN-HUMIDITY so high that the ductwork condenses the humidity out of the supply air. If no data entry is made, the program will assume that minimum humidity control capability does not exist. The program simulates the use of a humidifier and the required heat for humidification is passed to PLANT as a steam or hot water load.

BASEBOARD-SCH — 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 BASEBOARD-CRTL = OUTDOOR-RESET. If BASEBOARD-CRTL = THERMOSTATIC, the program will use the HEAT-TEMP-SCH to control the baseboards. Note that the keywords SUPPLY-HI and SUPPLY-LO (in the DAY-RESET-SCH instruction) that usually specify temperatures are used here to specify baseboard output as a decimal fraction of the BASEBOARD-RATING. See RESET-SCHEDULE instruction for additional information. (See Chap. II for information on SCHEDULE instruction).

The user should be careful to avoid shutdown of system heating capability (see keyword HEATING-SCHEDULE) during periods when baseboard heating is desired.

The following is an example of data entry for the keyword BASEBOARD-SCH and the associated reset schedule instructions DAY-RESET-SCH, WEEK-SCHEDULE, and RESET-SCHEDULE.

```
BASE-DAY-1 = DAY-RESET-SCH
   SUPPLY-HI = 1.0
   SUPPLY-LO = 0.0
   OUTSIDE-HI = 70
   OUTSIDE-LO = 0  ..

BASE-DAY-2 = DAY-RESET-SCH
   LIKE  BASE-DAY-1
   SUPPLY-HI  = 0.0  ..

BASE-SCHED-1  = RESET-SCHEDULE   THRU DEC 31
                (MON, FRI)  BASE-DAY-1
                (WEH)       BASE-DAY-2  ..

SYS-1 = SYSTEM
   Keyword  =  Value
   BASEBOARD-SCH =  BASE-SCHED-1
   Keyword  =  Value   ..
```

The hypothetical schedule above depicts a baseboard heating system that provides design baseboard heat input to the zone, Monday through Friday, whenever outdoor temperature is 0°F (or below) and a heat input rate that is reduced linearly as outdoor air temperature increases, falling to zero at 70°F outside air temperature. Baseboard heat input is always zero on weekends and holidays. Design baseboard heat input is defined as BASEBOARD-RATING.

ECONO-LIMIT-T is the outside air temperature above which the economizer returns to minimum outside air operation. (See Fig. IV.22). ECONO-LIMIT-T will default to the weighted average, based on design CFM, of DESIGN-COOL-T for all ZONEs in the SYSTEM.

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.

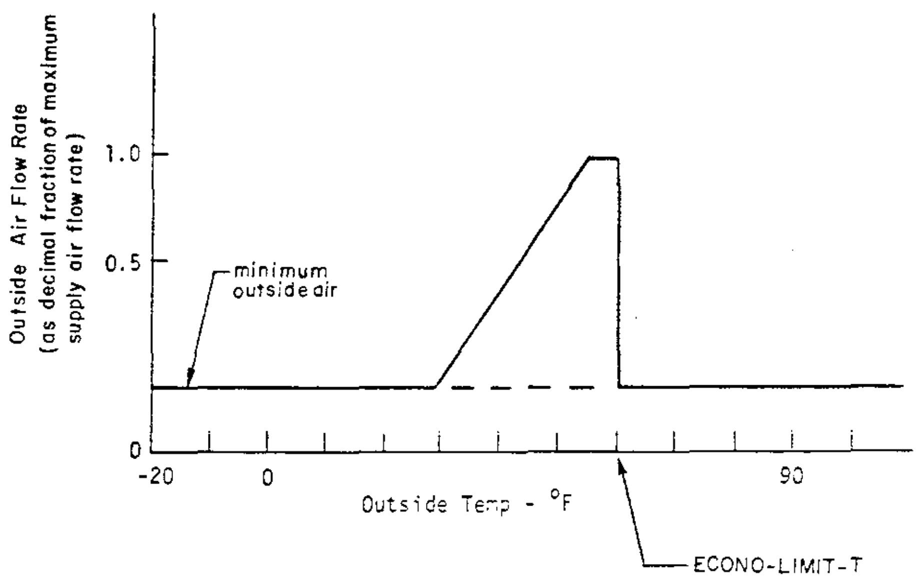


Fig. IV.22. Typical curve of air flow vs outside air temperature for systems with temperature type economizer (illustrating use of keyword ECONO-LIMIT-T).

______________________ = SYSTEM-CONTROL or S-C (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	______	U-name	-	-	-
MAX-SUPPLY-T	MAX-S-T	=	______	°F	Note 1	50.	200.
HEATING-SCHEDULE	H-SCH	=	______	U-name	Note 2	-	-
HEAT-CONTROL	H-C	=	______	code-word	Note 1	-	-
HEAT-SET-T	H-S-T	=	______	°F	Note 1	50.	200.
HEAT-SET-SCH	H-S-SCH	=	______	U-name	-	-	-
HEAT-RESET-SCH	H-R-SCH	=	______	U-name	Note 3	-	-
MIN-SUPPLY-T	MIN-S-T	=	______	°F	Note 1	45.	70.
COOLING-SCHEDULE	C-SCH	=	______	U-name	Note 2	-	-
COOL-CONTROL	C-C	=	______	code-word	Note 1	-	-
COOL-SET-T	C-S-T	=	______	°F	Note 1	45.	70.
COOL-SET-SCH	C-S-SCH	=	______	U-name	-	-	-
COOL-RESET-SCH	C-R-SCH	=	______	U-name	Note 4	-	-
MAX-HUMIDITY	MAX-H	=	______	per cent R.H.	Note 1	30.	80.
MIN-HUMIDITY	MIN-H	=	______	per cent R.H.	Note 1	0.	70.
BASEBOARD-SCH	B-SCH	=	______	U-name	Note 5	-	-
ECONO-LIMIT-T	E-L-T	=	______	°F	Note 6	45.	80.
PREHEAT-T	P-T	=	______	°F	Note 1	-50.	70.

1) See the proper Applicability Table (Sec. B.4 of this chapter) for applicability or the default value. If the keyword is not listed in the table, it is not applicable to the system being specified.

2) If no data entry is made for this keyword, the program assumes that the subject schedule has not been specified, and that the subject component or quantity is "always on" or "always available when needed", i.e., THRU DEC 31 (ALL) (1,24) (1).

3) A data entry for this keyword is required if the data entry for the keyword HEAT-CONTROL is the code-word RESET. If otherwise, this keyword is not applicable.

4) A data entry for this keyword is required if the data entry for the keyword COOL-CONTROL is the code-word RESET. If otherwise, this keyword is not applicable.

5) This data entry is required to simulate an OUTDOOR-RESET baseboard heating system (see keywords BASEBOARD-RATING in the ZONE command and BASEBOARD-CTRL in the ZONE-CONTROL subcommand) and requires in that case a RESET-SCHEDULE U-name.

6) The default for ECONO-LIMIT-T is the weighted average, based on design CFM, of DESIGN-COOL-T for all the ZONEs in the SYSTEM.

7. SYSTEM-AIR

The function of the SYSTEM-AIR instruction is to provide information on system air flow rate, both supply air and outside air. Several SYSTEM-AIR instructions may be required if the facility is served by more than one system and/or it is desired to conduct parametric runs.

SYSTEM-AIR is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

An alternative mode for data entry is to complete and enter SYSTEM-AIR keywords and their values directly into the SYSTEM command (if this approach is chosen, omit the SYSTEM-AIR keyword in 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.

SYSTEM-AIR informs the SDL Processor that the data to follow are related to system air flow (supply air and outside air). A unique user-defined name must be entered in the U-name field of each SYSTEM-AIR instruction. Omission of this entry in the "subcommand" will cause an error.

SUPPLY-CFM is the design capacity (in standard, or sea level, cfm) of the system air supply fan. <u>This entry is normally omitted, unless fan capacity is different than the maximum air flow rate assigned (using the ZONE-AIR instruction), or calculated by the program.</u> The program uses this value as the basis for determining part-load fan operation. Fan horsepower is calculated on the basis of typical part-load characteristics of the selected mode of capacity control (see the keyword FAN-CONTROL in the SYSTEM-FANS instruction) and of fan static pressure and efficiency (see keywords SUPPLY-STATIC and SUPPLY-EFF in the SYSTEM-FANS instruction). Note that the static pressure entry should also be at fan design conditions. If the SUPPLY-CFM is specified and if the ZONE-CFMs have not been specified, the total supply air capacity of the system is distributed among the zones in proportion to their peak loads. See Sec. D of this chapter for additional discussion.

As noted above, the program will calculate the design flow rate when data entry for this keyword is omitted. For those systems that can simulate a variable rate flow (SZRH, MZS, DDS, SZCI, VAVS, RHFS, PSZ, PMZS, and PVAVS) the program will use the default value for SIZING-OPTION to calculate the design flow rate, assuming certain conditions are met. That is if:

(1) MIN-CFM-RATIO is less than 1.0,
(2) SIZING-OPTION = COINCIDENT,
(3) SUPPLY-CFM is not specified, <u>and</u>
(4) only one SYSTEM is specified in the PLANT-ASSIGNMENT,

then the program will use COINCIDENT to calculate SUPPLY-CFM. Otherwise, if any of these conditions are not met, the program will use NON-COINCIDENT to calculate SUPPLY-CFM. (CBVAV is not included in the preceding list of variable volume systems because its supply air flow rate is actually constant in the supply duct. Only during the ceiling bypass operation in the zone does the supply air volume vary and that does not affect SUPPLY-CFM.

RATED-CFM is the nominal capacity of the supply air fan in this system, as specified by the fan manufacturer. This keyword and its associated value are input by the user if he has chosen a supply fan, from the manufacturers' literature, that will be forced to operate above or below its rated capacity to meet the flow rate of SUPPLY-CFM (or the flow rate calculated by the program). The rating is in cfm at standard (sea level) conditions.

This over- or under-sized fan may affect other equipment in the system; therefore, the user should see also RATED-HCAP-FCFM, RATED-HEIR-FCFM, RATED-CCAP-FCFM, RATED-CEIR-FCFM, and RATED-SH-FCFM in SYSTEM-EQUIPMENT.

RETURN-CFM is the design capacity (in standard, or sea level, cfm) of the system return air fan. The preceding discussion of keyword SUPPLY-CFM applies here, except that, if there is no data entry, the program always assumes that return air flow equals supply air flow minus zone exhaust (keyword EXHAUST-CFM in ZONE-AIR instruction).

Note: Although the outside ventilation air may vary in quantity (from the minimum allowed upward), as a function of time due to schedules or OA-CONTROL strategy, the flow of outside ventilation air is an uninterrupted flow of air as long as the FAN-SCHEDULE is on for that hour (or if NIGHT-CYCLE-CTRL intervenes to turn the fans on when the FAN-SCHEDULE is off). The outside ventilation air quantity is not determined by the space heating and cooling demands.

MIN-OUTSIDE-AIR is the minimum acceptable contant flow rate of fresh air, expressed as a decimal fraction of the maximum air supply flow rate. Note that the design flow rate for multiple zone, variable volume-type systems may be the concurrent peak flow rate, rather than the sum of individual zone peaks. (See the preceding discussion of SUPPLY-CFM.)

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.

If no outside air has been specified, no moveable dampers are simulated, even if OA-CONTROL equals TEMP or ENTHALPY.

(Note: 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 is the U-name used to identify the schedule for the ratio of minimum outside air flow to supply air flow. Values in the MIN-AIR-SCH vary as a function of time from 0 which indicates no outside air flow (and 100 per cent return air) to 1 which indicates 100 per cent outside air flow (with no return air flow). A value of 0.5 indicates a minimum of 50 per cent outside air flow. If EXHAUST-CFM in any zone (within this system) is not equal to zero in a given hour, the schedule referenced by MIN-AIR-SCH should not be zero in that same hour. The program does not use MIN-AIR-SCH in designing the system; therefore, if the user wants the program to size the SYSTEM, he should also specify a value for MIN-OUTSIDE-AIR that is representative of the outside air flow rate. A value of zero for an hour overrides any economizer operation and forces a no outside air system. Any value greater than zero allows economizer action as specified in OA-CONTROL.

OA-CONTROL Input for this keyword is the code-word for the type of outside air control strategy selected. See Table IV.34 for the code-words and a brief description of the control strategy each represents. Input for this keyword must be FIXED if the user does not want an economizer. It will default to TEMP, which will simulate a temperature-controlled economizer.

If no outside air has been specified, no moveable dampers are simulated, even if OA-CONTROL equals TEMP or ENTHALPY.

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 (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 exhaust air temperatures and exhaust 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 set point of the mixed air, no energy is exchanged. If the difference between exhaust and outside air temperatures is less than 10 degrees, no recovery is simulated.

A simpler, but less precise way of expressing the above is:
RECOVERY-EFF = the fraction of recoverable energy actually recovered.

(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).

The exhaust air flow used for the calculation of heat recovery is always the central exhaust, and is assumed to be equal, at any given time, to the fresh air supplied at that time, minus specified direct exhaust from zones. Any imbalance between fresh air and exhaust air flow rates, resulting from direct zone exhaust, should be considered when selecting the value for RECOVERY-EFF (i.e., a higher percentage of the heat avail- able in the exhaust air can be recovered when this heat is to be rejected to a larger mass of fresh air). At the present time, only sensible heat recovery is simulated.

TABLE IV.34

Code-Word	OA-CONTROL
FIXED	No moveable 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 set point (equal to the supply air set point 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.

DUCT-AIR-LOSS is the fraction of the supply air that is lost from the ductwork, thereby diminishing the design supply air at the zones. This keyword should not be used unless the air is lost from the building.

DUCT-DELTA-T is the temperature decrease in the hot ducts and the temperature increase in the cold ducts caused by imperfect insulation of the ducts. The program assumes that this same constant temperature change occurs in both hot and cold ducts. A positive value should be specified for both hot and cold ducts. This keyword should not be used unless heat is lost, or gained, from contact with conditions outside the building. A value of less than 1°F is suggested because this value is used for all hours of the year.

MAX-OA-FRACTION is the upper limit on the outside air quantity allowed when the temperature- or enthalpy-controlled economizer is operating, expressed as a fraction of the supply air quantity. This keyword should be used only if the outside dampers do not allow 100 percent outside air.

VENT-TEMP-SCH accepts as input the U-name of a schedule that provides the hourly minimum temperature set point for the natural venting algorithm. This keyword is appropriate to 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 set point. 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/hour due to natural ventilation through open windows. This value is constant and is not a function of wind speed. This keyword is appropriate to RESYS only.

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 to RESYS only.

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 COOL-TEMP-SCH THROTTLING-RANGE. The zone may be cooled down to the hourly minimun 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. Note that this assumes the occupant will open the windows if both the conditions are met.

To further illustrate, let it be assumed 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 the schedule

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

describes the cooling set point of the mechanical system; while the schedule

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

describes the minimum below which the windows will be closed. Then under ZONE-CONTROL, the user should specify COOL-TEMP-SCH = MECH-COOL-TEMP, while under SYSTEM-AIR, VENT-TEMP-SCH should be set equal to MIN-VENT-TEMP. The preceding example states 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 mechanical 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 meaningless. Note also that VENT-TEMP-SCH does not necessarily say that cooling by natural ventilation will be done (that is accomplished by NATURAL-VENT-SCH). VENT-TEMP-SCH only sets the minimum indoor temperature limits for natural ventilation. The conditions specified in NATURAL-VENT-SCH, determine when, and if, cooling by natural ventilation is done.

______________________ = SYSTEM-AIR or S-A (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	______	U-name	-	-	-
SUPPLY-CFM	S-CFM	=	______	cfm	Note 1	10.	$1.x10^7$
RATED-CFM	R-C	=	______	cfm	-	10.	$1.x10^7$
RETURN-CFM	R-CFM	=	______	cfm	Note 2	10.	$1.x10^7$
MIN-OUTSIDE-AIR	M-O-A	=	______	fraction	Note 3	0.	1.
MIN-AIR-SCH	M-A-SCH	=	______	U-name	-	-	-
OA-CONTROL	O-CTRL	=	______	code-word	Note 4	-	-
RECOVERY-EFF	REC-E	=	______	Btu/Btu	Note 5	0.2	0.8
DUCT-AIR-LOSS	D-A-L	=	______	fraction	Note 5	0.	1.
DUCT-DELTA-T	D-D-T	=	______	°F	Note 5	0.	10.
MAX-OA-FRACTION	M-O-F	=	______	fraction	Note 5	0.	1.
VENT-TEMP-SCH	V-T-SCH	=	______	U-name	*	-	-
NATURAL-VENT-AC	N-V-A	=	______	number	*	0.	100.
NATURAL-VENT-SCH	N-V-SCH	=	______	U-name	*	-	-
			..				

*This keyword is optional and applies only to RESYS system.

1) If no data entry is made for this keyword, the program will assume that fan capacity is the same as system design flow (see discussion in Sec. D.1 of this chapter and in the SYSTEM-AIR instruction).

2) If no data entry is made for this keyword, the program will use for this quantity the system design supply air flow rate minus the sum of the zone exhaust flow rates (for systems equipped with a return air fan).

3) See Sec. D.1 of this chapter for a discussion of how the program uses this keyword and/or alternative keywords to determine outside air flow rate.

4) TEMP, when applicable to the system being specified. This will simulate a temperature-controlled economizer.

5) See the proper Applicability Table (Sec. B.4 of this chapter) for applicability or the default value. If the keyword is not listed in the table, it is not applicable to the system being specified.

8. 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). Several SYSTEM-FANS instructions may be entered if the facility is served by more than one system and/or it is desired to conduct parametric runs.

SYSTEM-FANS is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

An alternative mode for data entry is to complete and enter SYSTEM-FANS keywords and their values directly into the SYSTEM command (if this approach is chosen, omit the SYSTEM-FANS keyword in SYSTEM).

SYSTEM-FANS — informs the SDL Processor that the data to follow are related to the operation of system supply and return fans. A unique user-defined name must be entered in the U-name field of each SYSTEM-FANS instruction. Omission of this entry in the "subcommand" will cause an error.

FAN-SCHEDULE — is the U-name of the SCHEDULE instruction that specifies the time periods (hours and days) during which this system's fans (supply, return, and exhaust) are operating and not operating (see Chap. II for information on SCHEDULE instruction). 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 U-name for this keyword and an associated SCHEDULE, the program will assume the fans run continuously.

If the fans (for all SYSTEM-TYPEs except FPH) are scheduled to be "off" (hourly SCHEDULE values equal 0), only baseboard units (if specified) can be operational. Thus for strictly forced air systems, <u>heating is available only during the time periods when the fans are scheduled to be "on", unless there are baseboard heating elements.</u> One exception to this rule is to specify CYCLE-ON-ANY or CYCLE-ON-FIRST for NIGHT-CYCLE-CTRL.

FAN-CONTROL — Input for this keyword is the code-word that identifies the kind of flow reduction or control methods to be simulated. See Table IV.35 for 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. IV.23). The program assumes that both supply and return fans have the same kind of flow control. The FAN-EIR-FPLR code-word is input for FAN-CONTROL when the user wishes to specify his own fan control method. The user must then enter, under the CURVE-FIT command, a replacement curve and then enter its U-name as a value for the FAN-EIR-FPLR keyword in the SYSTEM-FANS command (later in this section).

TABLE IV.35

Code-Word	FAN-CONTROL
SPEED	Variable speed motor (1)*
INLET	Fan inlet vanes (2)*
DISCHARGE	Damper in fan discharge (3)*
CYCLING	Cycles on and off (4)
TWO-SPEED	High or low speed (for PTAC only - represented as 100 per cent and another point lower on curve 1)
CONSTANT-VOLUME	Volume kept constant
FAN-EIR-FPLR	User specified fan control*

*For systems that have variable flow central air-handlers only.

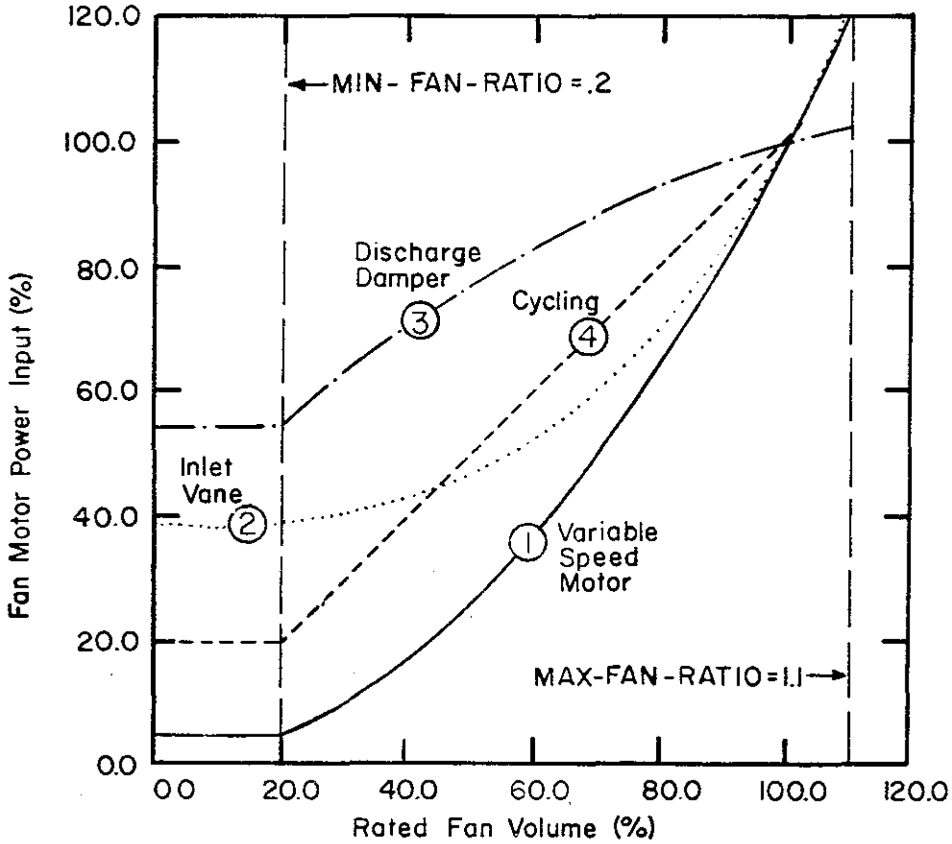


Fig. IV.23. Typical power requirements at part-load operation for four different methods of capacity control (Note that with the CYCLING code-word, the MIN-FAN-RATIO is meaningless for those hours when the fan is off.

When there is a difference between supply fan design capacity (specified via keyword SUPPLY-CFM in the SYSTEM-AIR instruction) and actual hourly flow, the program uses either the curves from Fig. IV.23 or a user-specified curve to recalculate power input to the fan.

SUPPLY-DELTA-T is used in conjunction with SUPPLY-KW and is defined as 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 IV.36, based on SYSTEM-TYPE. This default value, along with a default value for SUPPLY-KW, will be used in the absence of data entries for SUPPLY-STATIC, SUPPLY-MECH-EFF, and SUPPLY-EFF. If the user desires to eliminate the air temperature rise due to the fan, it is necessary to explicitly set SUPPLY-DELTA-T = 0 and omit values for SUPPLY-STATIC, SUPPLY-MECH-EFF, and SUPPLY-EFF (this approach may be necessary if the user inputs an electric-input-ratio for the system that already includes the fan effects). If the user specifies a value for SUPPLY-DELTA-T, any input for the keyword MOTOR-PLACEMENT will have no effect.

SUPPLY-KW is used in conjunction with SUPPLY-DELTA-T and is defined as 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 IV.36, based on SYSTEM-TYPE. This default value, along with a default value for SUPPLY-DELTA-T, will be used in the absence of data entries for SUPPLY-STATIC, SUPPLY-MECH-EFF, and SUPPLY-EFF. If the user desires to eliminate the fan energy consumption, it is necessary to explicitly set SUPPLY-KW = 0 and omit entries for SUPPLY-STATIC, SUPPLY-MECH-EFF, and SUPPLY-EFF. Also, if a user-specified COOLING-EIR includes indoor fan energy, set SUPPLY-KW = 0. The default curves related to COOLING-EIR (for commercial systems) already include compressor and outdoor fan energy but not indoor fan energy.

SUPPLY-STATIC is an alternative to specifying values for SUPPLY-DELTA-T and SUPPLY-KW. It is used in conjunction with SUPPLY-MECH-EFF and SUPPLY-EFF. It is defined as the total pressure increase produced across the system supply fan at design flow rate (see keyword SUPPLY-EFF below for additional discussion). It is expressed in inches W.G. and its default value can be found in Table IV.36, based on SYSTEM-TYPE. Design flow rate is the user input value for the keyword SUPPLY-CFM (see SYSTEM-AIR instruction) or if no data entry is made for that keyword, the tabulation of calculated (or assigned) flow rates for each zone.

SUPPLY-MECH-EFF is an alternative to specifying values for SUPPLY-DELTA-T and SUPPLY-KW. It is used in conjunction with SUPPLY-STATIC and SUPPLY-EFF. It is used to specify the mechanical efficiency of the fan <u>when the motor is located outside the airstream.</u> The SYSTEMS program separates the total fan efficiency into its mechanical and electrical components. The mechanical energy loss of the fan is always added to the airstream. The electrical energy loss of the fan is added to the airstream only if the fan motor is located inside the airstream.

Table IV.36

SYSTEM-TYPE	Default Value for SUPPLY-DELTA-T	Default Value for SUPPLY-KW	Effective Default Value for Total SUPPLY-STATIC*	Effective Default Value for SUPPLY-EFF*
	(°F)	(kW/std. cfm)	(inches, W.G.)	(fraction)
SUM	unused	unused	unused	unused
SZRH	2.42	.000783	4	.6
MZS	2.723	.00088	4.5	.6
DDS	3.37	.00109	6.5	.7
SZCI	3.11	.00101	6	.7
UHT	.218	.00007	.3	.5
UVT	.182	.000059	.3	.6
FPH	unused	unused	unused	unused
TPFC	.218	.00007	.3	.5
FPFC	.218	.00007	.3	.5
TPIU	4.467	.001445	8	.65
FPIU	4.467	.001445	8	.65
VAVS	3.37	.00109	6.5	.7
RHFS	3.11	.00101	6	.7
HP	.218	.00007	.3	.5
HVSYS	2.42	.000783	4	.6
CBVAV	2.42	.000783	4	.6
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

*If all four keywords in this table (SUPPLY-DELTA-T, SUPPLY-KW, SUPPLY-STATIC, and SUPPLY-EFF) are allowed to default, SUPPLY-DELTA-T and SUPPLY-KW will default to the values in column 2 and column 3 respectively. The default values for SUPPLY-STATIC and SUPPLY-EFF will then be calculated based upon the defaulted values in columns 2 and 3.

SUPPLY-EFF — is an alternative to specifying values for SUPPLY-DELTA-T and SUPPLY-KW. It is used in conjunction with SUPPLY-STATIC and SUPPLY-MECH-EFF. It is defined as the overall efficiency of the supply fan at design conditions (expressed as a decimal fraction). Overall efficiency is the combined efficiency of the fan and motor. The default value can be found in Table IV.36 based on SYSTEM-TYPE.

MOTOR-PLACEMENT — Input for this keyword is the code-word that specifies whether the supply and return fan motors are located inside the airstream or outside of the air stream. The SYSTEMS program uses this information to determine if the heat loss of the motors is to be added to the supply and return airstreams. See Table IV.37 for the applicable code-words.

FAN-PLACEMENT specifies whether the supply fan is a draw-through type fan or a blow-through type fan (that is, is the fan placed downstream or upstream from the central cooling/heating coils). See Table IV.38.

TABLE IV.37

Code-Word	MOTOR-PLACEMENT
IN-AIRFLOW	The fan motor is located inside the duct or airstream.
OUTSIDE-AIRFLOW	The fan motor is located outside the duct or airstream.

TABLE IV.38

Code-Word	FAN-PLACEMENT
BLOW-THROUGH	The supply fan is located upstream of the central heating/cooling coils and blows the air through the coils. Use of this code-word causes the program to add the supply fan heat to the air upstream of the central cooling/heating coils. Always used for DDS, UHT, UVT, PTAC, PMZS, TPFC, FPFC, HP, RESYS, and MZS systems.
DRAW-THROUGH	The supply fan is located downstream of the central heating/cooling coils and draws (sucks) the air through the coils. Use of this code-word causes the program to add the supply fan heat to the air downstream of the central cooling/heating coils. This is the default for SZRH, SZCI, TPIU, FPIU, VAVS, RHFS, CBVAV, PSZ, and PVAVS.

RETURN-DELTA-T is used in conjunction with RETURN-KW and is defined as the temperature rise in the air stream across the return air fan. It is expressed in °F and its default value is zero. This default value, and a similar value for RETURN-KW, will be used in the absence of data entries for RETURN-STATIC and RETURN-EFF. If the user specifies a value for RETURN-DELTA-T, any input for the keyword MOTOR-PLACEMENT will have no effect.

RETURN-KW is used in conjunction with RETURN-DELTA-T and is defined as 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. This default value, and a similar value for

RETURN-DELTA-T, will be used in the absence of data entries for RETURN-STATIC and RETURN-EFF.

RETURN-STATIC is an alternative to specifying values for RETURN-DELTA-T and RETURN-KW. It is used in conjunction with RETURN-EFF. It is defined as the total or static pressure produced by the system return air fan at design flow rate (see keyword RETURN-EFF for additional discussion). Design flow rate is the user input value for the keyword RETURN-CFM (see SYSTEM-AIR instruction) or, if no data entry is made for that keyword, the calculated return air flow rate.

RETURN-EFF is an alternative to specifying values for RETURN-DELTA-T and RETURN-KW. It is used in conjunction with RETURN-STATIC. It is defined as the overall efficiency of the return air fan at design conditions (expressed as a decimal fraction). Overall efficiency is the combined efficiency of the fan and motor - see keyword SUPPLY-EFF for additional discussion.

Note: If data entries are omitted for RETURN-DELTA-T, RETURN-KW, RETURN-STATIC and RETURN-EFF, the program assumes there is no return fan for this system.

MAX-FAN-RATIO is the maximum air flow through the fan, expressed as a fraction of the design flow rate.

MIN-FAN-RATIO is the minimum air flow through the fan (not through the system), expressed as a fraction of the design flow rate. When a variable air volume system requires less air flow, a fan bypass is utilized.

LOW-SPEED-RATIOS is used for TWO-SPEED fans or DUAL-SPEED compressors. Thus, the unit being described has the capability of controlling capacity in two steps, or being off. The values entered for this keyword are the ratio of air-flow, energy input, as well as heating and cooling at low speed to those at high (design) speed. These values are under the following conditions:

i) in PTAC for FAN-CONTROL = TWO-SPEED,
ii) in RESYS for COMPRESSOR-TYPE = DUAL-SPEED.

The list of four values to be entered are:

1) $\frac{\text{low speed cfm}}{\text{high speed cfm}}$ for TWO-SPEED fans, or 1.0 for DUAL-SPEED compressors,

2) $\frac{\text{EIR at low speed}}{\text{EIR at high speed}}$,

3) $\frac{\text{HEATING-CAPACITY at low speed}}{\text{HEATING-CAPACITY at high speed}}$, and

4) $\frac{\text{COOLING-CAPACITY at low speed}}{\text{COOLING-CAPACITY at high speed}}$.

If values are not specified, the default values will be 1., 1., 1., 1., which means either COMPRESSOR-TYPE = SINGLE-SPEED or FAN-CONTROL = CONSTANT-VOLUME (or in other words, one-speed).

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 already "on" and if the hourly SCHEDULE values are negative, the fans are not permitted to be "on"). If the user specifies hourly SCHEDULE values of 0 and -1, it is possible to impart on-off scheduling to the NIGHT-CYCLE-CTRL option. NIGHT-CYCLE-CTRL is appropriate to all systems except the Floor Panel Heating System (FPH) and the Residential System (RESYS).

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 acceptable code-words are:

STAY-OFF which 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.

For UVT, the outside air dampers are closed during the cycle-on period.

FAN-EIR-FPLR accepts the U-name of a linear, quadratic, or cubic equation that defines the ratio of electric energy input to the fan to the full load electric input to the fan, as a function of part-load ratio. The equation is input in a CURVE-FIT instruction and given a U-name. That U-name is specified as a value for this keyword to call the equation. However, note that FAN-EIR-FPLR is also a code-word under FAN-CONTROL. To obtain this control strategy 1) a U-named equation must be input in a CURVE-FIT instruction. 2) that U-name must be specified for this keyword, and 3) FAN-CONTROL must be specified as <u>code-word</u> FAN-EIR-FPLR.

_______________ = SYSTEM-FANS or S-FANS (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
FAN-SCHEDULE	F-SCH	=	________	U-name	Note 1	-	-
FAN-CONTROL	F-C	=	________	code-word	Note 2	-	-
SUPPLY-DELTA-T	SUP-D-T	=	________	°F	Note 3	0.	30.
SUPPLY-KW	S-KW	=	________	kW/std cfm	Note 3	0.	.01
SUPPLY-STATIC	S-S	=	________	inches W.G.	Note 3	0.	15.
SUPPLY-MECH-EFF	S-M-E	=	________	fraction	-	0.1	1.
SUPPLY-EFF	S-E	=	________	fraction	Note 3	0.1	1.
MOTOR-PLACEMENT	M-P	=	________	code-word	Note 4	-	-
FAN-PLACEMENT	F-P	=	________	code-word	Note 5	-	-
RETURN-DELTA-T	RET-D-T	=	________	°F	Note 6	0.	30.
RETURN-KW	R-KW	=	________	kW/cfm	Note 6	0.	.01
RETURN-STATIC	R-S	=	________	inches W.G.	Note 6	0.	10.
RETURN-EFF	R-E	=	________	fraction	Note 6	0.1	1.
MAX-FAN-RATIO	MAX-F-R	=	________	number	Note 2	1.	1.5
MIN-FAN-RATIO	MIN-F-R	=	________	fraction	Note 2	0.1	1.
LOW-SPEED-RATIOS	L-S-R	=	(________)	list of four values	Note 7	0.	1.
NIGHT-CYCLE-CTRL	N-C-C	=	________	code-word	Note 2	-	-
FAN-EIR-FPLR	F-E-FPLR	=	________	U-name of a linear, quadratic, or cubic CURVE-FIT	-	-	-

..

1) If no data entry is made for this keyword, the program assumes that the fan(s) are always available when needed, i.e., THRU DEC 31 (ALL) (1,24) (1).

2) See the proper Applicability Table (Sec. B.4 of this chapter) for applicability or the default value. If the keyword is not listed in the table, it is not applicable to the system being specified.

3) Use either SUPPLY-DELTA-T and SUPPLY-KW or SUPPLY-STATIC, SUPPLY-MECH-EFF, and SUPPLY-EFF. See Table IV.36 for default values for SUPPLY-DELTA-T and SUPPLY-KW. These default values will be used, based on SYSTEM-TYPE, if values are not input for SUPPLY-STATIC, SUPPLY-MECH-EFF, and SUPPLY-EFF.

4) The default for this keyword is IN-AIRFLOW for SZRH, MZS, DDS, SZCI, TPIU, FPIU, VAVS, RHFS, HVSYS, CBVAV, PSZ, PMZS, and PVAVS. The keyword is not applicable to other systems.

5) The default for this keyword is DRAW-THROUGH for SZRH, SZCI, TPIU, FPIU, VAVS, RHFS, CBVAV, PSZ, and PVAVS. The keyword is not applicable to other systems.

6) Use either RETURN-DELTA-T and RETURN-KW or RETURN-STATIC and RETURN-EFF. The default values for RETURN-DELTA-T and RETURN-KW are zero. The omission of an entry for all four keywords is interpreted by the program to mean that there is no return fan.

7) Applicable only when FAN-CONTROL = TWO-SPEED or COMPRESSOR-TYPE = DUAL-SPEED. Defaults are (1., 1., 1., 1.).

9. SYSTEM-TERMINAL

The function of the SYSTEM-TERMINAL instruction is to provide information on the characteristics of heat transfer, flow throttling, or air induction components that control individual zone temperatures. Several SYSTEM-TERMINAL instructions may be required if the facility is served by more than one type of system and/or it is desired to conduct parametric runs. These parameters are the same for all zones served by the system.

SYSTEM-TERMINAL is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

An alternative mode for data entry is to complete and enter SYSTEM-TERMINAL keywords and their values directly into the SYSTEM command (if this approach is chosen, omit the SYSTEM-TERMINAL keyword in SYSTEM).

The user is cautioned that at the present time, the values of REHEAT-DELTA-T and INDUCTION-RATIO must be identical for all zones served by the system. MIN-CFM-RATIO can be supplied separately at the zone level also.

SYSTEM-TERMINAL — informs the SDL Processor that the data to follow are related to zone temperature control components, such as reheat coils, induction units and VAV boxes. A unique user-defined name must be entered in the U-name field of each SYSTEM-TERMINAL instruction. Omission of this entry in the "subcommand" will cause an error.

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.

INDUCTION-RATIO — is the ratio of induced air flow to primary air flow. This entry is applicable to the fixed-ratio induction units (system types TPIU and FPIU), but not to the variable-ratio ceiling induction units used for subzone temperature control (System type SZCI), which has a preprogrammed value of 1.0. The value input 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. The keyword MIN-CFM-RATIO is applicable only to variable-volume type systems. (This keyword appears also under the ZONE command. The value specified here in the SYSTEM-TERMINAL command applies to all zones in the system that do not have an overriding specification at the zone level in the ZONE command.)

If MIN-CFM-RATIO is less than MIN-OUTSIDE-AIR, 100 per cent outside ventilation air flow will be simulated below MIN-OUTSIDE-AIR flow.

Warning: When simulating a variable-air volume system, the value of the THROTTLING-RANGE should be at least 4° to insure stability of operation. This is especially true when a COLDEST or WARMEST control option in HEAT-CONTROL or COOL-CONTROL is also used.

______________________ = SYSTEM-TERMINAL or S-T (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
REHEAT-DELTA-T	R-D-T	=	________	°F	Note 1	0.	100.
INDUCTION-RATIO	I-R	=	________	number	Note 2	1.	10.
MIN-CFM-RATIO	M-C-R	=	________	fraction	Note 3	0.	1.

1) This is a required entry for the Constant-Volume Reheat Fan System (RHFS). Default value for systems with optional zone heat coils (i.e., SZRH, SZCI, CBVAV, VAVS, PSZ, HVSYS, and PVAVS) is zero. The keyword is not applicable to other types of systems.

2) This is a required entry for TPIU and FPIU systems.

3) This keyword is applicable to SZRH, MZS, DDS, RHFS, PSZ, and PMZS where its default value is 1.0. It is also applicable to VAVS, CBVAV, and PVAVS where its value is calculated (from outside air requirement or peak heating load) if not input.

10. 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 and heat pump systems. This subcommand is appropriate only to the TPIU and HP systems. Several SYSTEM-FLUID instructions may be entered if the facility is served by more than one mixed air-water system and/or it is desired to conduct parametric runs.

SYSTEM-FLUID is a "subcommand" of SYSTEM and, as such, can be used to input a subset of data to SYSTEM.

An alternative mode for data entry is to complete and enter SYSTEM-FLUID keywords and their values directly into the SYSTEM command (if this approach is chosen, omit the SYSTEM-FLUID keyword in SYSTEM).

Note that pumping horsepower is accounted for by the PLANT Program, rather than the SYSTEMS Program. The calculations of pumping energy are based on the default value for plant constants HCIRC-IMPELLER-E, HCIRC-MOTOR-EFF, HCIRC-HEAD, and HCIRC-DESIGN-T-D (heating), CCIRC-IMPELLER-E, CCIRC-MOTOR-EFF, CCIRC-HEAD, and CCIRC-DESIGN-T-D (cooling), and, if SYSTEM-TYPE = HP or TPIU, TWR-MOTOR-EFF, TWR-IMPELLER-EFF, and TWR-PUMP-HEAD (cooling tower). These default values can be changed for any run using the PLANT-PARAMETERS instruction (see Chap. V).

SYSTEM-FLUID — informs the SDL Processor that the data to follow are related to the hydronic part of air-water type systems. A unique user-defined name must be entered in the U-name field of each SYSTEM-FLUID instruction. Omission of this entry in the "subcommand" will cause an error.

INDUC-MODE-SCH — specifies the U-name of a SCHEDULE that defines the mode of the coils in the terminal induction unit for a two-pipe induction system (TPIU). If the hour's SCHEDULE value is positive, all zone coils can provide cooling only. If the hour's SCHEDULE value is negative, all zone coils can provide heating only. Additionally, if the value is negative (zone heating) and COOL-CONTROL is not equal to CONSTANT, the primary air controller set point temperature is reset to MIN-SUPPLY-T (thus ensuring a cooling source in addition to a heating source).

MIN-FLUID-T — When the unitary heat pump system (HP) is being simulated, the input for this keyword is the minimum allowable temperature (entering the heat pumps) for the circulating heat addition/heat extraction fluid. The program simulates addition of heat, as required, to prevent fluid temperature from falling below this value. The heat addition component is specified in a PDL instruction for the PLANT Program and is simulated by the PLANT Program (see Chap. V).

MAX-FLUID-T — When the unitary heat pump system (HP) is being simulated, the input for this keyword is the maximum allowable temperature (entering the heat pumps) for the circulating heat addition/heat extraction fluid. The program simulates heat extraction, as required, to prevent fluid temperature from exceeding this value. The heat extraction component is specified in a PDL instruction from the PLANT Program and is simulated by the PLANT Program (see Chap. V).

FLUID-HEAT-CAP — This keyword is applicable to the unitary hydronic heat pump system (SYSTEM-TYPE = HP) only. The input 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; that is, the total mass of the fluid, in lbs., multiplied by the specific heat of the fluid, in Btu/lb-°F.

__________________ = SYSTEM-FLUID or S-FLU (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	________	U-name	-	-	-
INDUC-MODE-SCH	I-M-SCH	=	________	U-name	Note 1	-	-
MIN-FLUID-T	MIN-F-T	=	________	°F	Note 2	40.	80.
MAX-FLUID-T	MAX-F-T	=	________	°F	Note 2	60.	150.
FLUID-HEAT-CAP	F-H-C	=	________	Btu/°F	Note 2	1.	$1. \times 10^9$

1) This keyword is appropriate to the TPIU system only.

2) This entry is required for the Unitary Hydronic Heat Pump (HP) system. It is not applicable to other systems; therefore, no default is listed.

11. SYSTEM-EQUIPMENT

For the simulation to proceed, the program must know the details of the operating performance of all equipment. This includes air flow rates (specified in ZONE-AIR and SYSTEM-AIR), control systems (specified in ZONE-CONTROL and SYSTEM-CONTROL), and design, as well as off-design, capacity and energy input requirements (specified here in the SYSTEM-EQUIPMENT subcommand). These quantities can either be defaulted or explicitly specified by the user.

If the user is satisfied with the default equipment performance data built into the program, it may not be necessary to specify any keyword values in the SYSTEM-EQUIPMENT subcommand.

Equipment operating characteristics are specified in two parts: first, the design ARI* capacity and consumption are given; next, the off-design to design functional relationship is specified. For example, the hourly available cooling capacity from a unit is,

$$CAP_T = \text{available total cooling capacity} = CAP_{ARI} * CAP(WBT,DBT),$$

where CAP(WBT,DBT) is the modifier function to account for off-design WBT and DBT.

In keyword form, the equation is expressed as

$$CAP_T = \text{COOLING-CAPACITY} * \text{COOL-CAP-FT}(WBT,DBT),$$

where WBT and DBT are the wet- and dry-bulb temperatures of air entering the coil for water coils and entering air wet-bulb and outdoor dry-bulb for direct expansion (DX) units.

For cooling capacity, it is necessary also to know the sensible part of the total capacity. This is, in a similar manner,

$$SCAP_T = SCAP_{ARI} * SCAP(WBT,DBT)$$

or in keyword form,

$$SCAP_T = \text{COOL-SH-CAP} * \text{COOL-SH-FT}(WBT,DBT).$$

For all types, $SCAP_T$ is not allowed to exceed CAP_T, and for DX units, $SCAP_T$ is also corrected for entering dry-bulb temperatures other than at the ARI rating point (the ARI rating point is: wet-bulb entering = 67°F, dry-bulb entering = 80°F, and dry-bulb outdoor = 95°F).

* Air-Conditioning and Refrigeration Institute standards for the design, fabrication, and installation of heating, ventilating, and air conditioning equipment.

To calculate the energy input to produce the available output, a similar rated value and modifier function is used.

EIR_T = electric input to cooling output

$EIR_T = EIR_{ARI} * EIR(WBT,DBT) * EIR(PLR)$,

or in keyword form,

EIR_T = COOLING-EIR * COOL-EIR-FT(WBT,DBT) * COOL-EIR-FPLR(PLR).

The PLR is the ratio of actual load output to full load output at the operating point. Thus, the electrical input to the unit is

$QE = CAP_T * EIR_T$.

Similar relationships are used for heat pumps where the ARI point is changed (outdoor dry-bulb = 47°F and entering dry-bulb = 70°F). For hot water and electric coils, the capacity is assumed to be independent of operating conditions. For gas and oil furnaces, the input is simply a function of the part-load output and the capacity is assumed to be constant.

In summary, for all equipment:

Cooling

1. Chilled water systems (SZRH, DDS, MZS, TPIU, FPIU, TPFC, FPFC, CBVAV, VAVS, RHFS, HVSYS)

   CAP_T = COOLING-CAPACITY * COOL-CAP-FT(EWB,EDB)

   $SCAP_T$ = COOL-SH-CAP * COOL-SH-FT(EWB,EDB) or CAP_T, whichever is smaller,

   CBF = COIL-BF * COIL-BF-FT(EWB,EDB) * COIL-BF-FCFM(CFMPLR).

2. DX systems (HP, RESYS, PSZ, PMZS, PVAVS, PTAC)

   CAP_T = COOLING-CAPACITY * COOL-CAP-FT(EWB,ODB),

   $SCAP_T$ = COOL-SH-CAP * COOL-SH-FT(EWB,ODB) + [1.08 * (SUPPLY-CFM) * (1 - COIL-BF) * (EDB - 80)] or CAP_T, whichever is smaller,

$$CBF = COIL\text{-}BF * COIL\text{-}BF\text{-}FT(EWB,ODB) * COIL\text{-}BF\text{-}FCFM(CFMPLR),$$

$$EIR_T = COOLING\text{-}EIR * COOL\text{-}EIR\text{-}FT(EWB,ODB) * COOL\text{-}EIR\text{-}FPLR(PLR),$$

$$QE = CAP_T * EIR_T.$$

Heating

1. Electric resistance (HEAT-SOURCE = ELECTRIC)

$$CAP_T = HEATING\text{-}CAPACITY$$

$$QE = \text{Heating load}$$

2. Electric heat pump (HEAT-SOURCE = HEAT-PUMP)

$$CAP_T = HEATING\text{-}CAPACITY * HEAT\text{-}CAP\text{-}FT(ODB,EDB)$$

$$EIR_T = HEATING\text{-}EIR * HEAT\text{-}EIR\text{-}FT(ODB,EDB) * HEAT\text{-}EIR\text{-}FPLR(PLR)$$

$$QE = CAP_T = EIR_T.$$

3. Gas or oil furnace (HEAT-SOURCE = GAS-FURNACE or OIL-FURNACE)

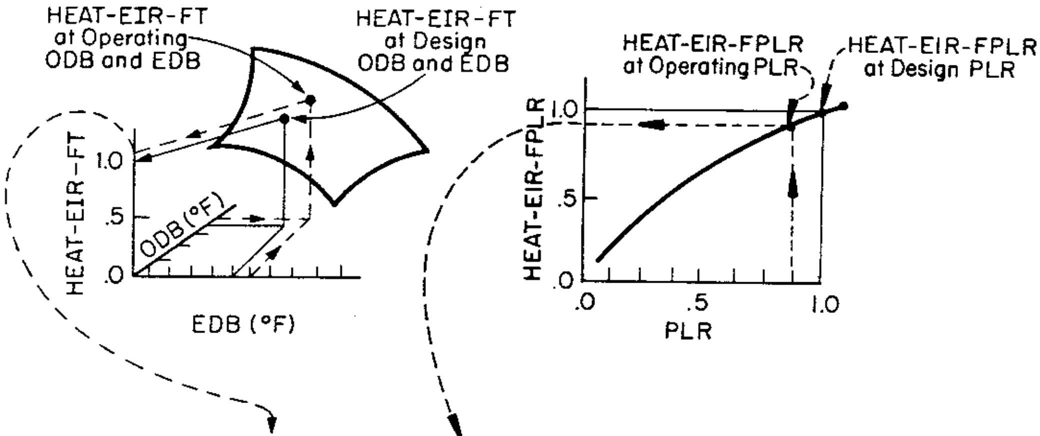
$$CAP_T = HEATING\text{-}CAPACITY$$

$$HIR_T = FURNACE\text{-}HIR * FURNACE\text{-}HIR\text{-}FPLR(PLR)$$

$$QE = CAP_T * HIR_T.$$

Additional modifier functions are available to allow adjustment for flow rates other than those for which rating information is published (RATED-CCAP-FCFM, RATED-SH-FCFM, RATED-CEIR-FCFM, RATED-HCAP-FCFM, RATED-HEIR-FCFM), for defrosting heat pumps (DEFROST-DEGRADE), and furnace induced losses (FURNACE-OFF-LOSS).

Example 1:



HEATING-EIR x HEAT-EIR-FT x HEAT-EIR-FPLR = Operating Heating-EIR

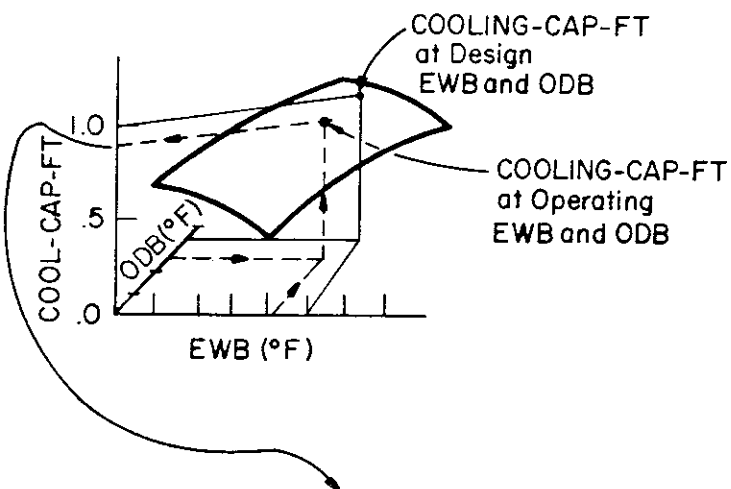
or

.45 Btu/Btu x 1.050 x .945 = .446 Btu/Btu

and therefore,

Electrical In = HEATING-CAPACITY x HEAT-CAP-FT x Operating Heating-EIR

Example 2:



COOLING-CAPACITY x COOL-CAP-FT = Total Operating Capacity

or

50,000 Btu/hr x .95 = 47,500 Btu/hr

Sensible Operating Capacity = Smaller of Total Operating Capacity or [COOL-SH-CAP x COOL-SH-FT] + [(1 - COIL-BF) x SUPPLY-CFM x (T_{enter} - 80)]

Fig. IV.24. Correcting performance to operating conditions.

In both the preceeding examples both items of equipment are assumed to be running at their RATED-CFM. Otherwise, an additional correction would have been made in Example 1 using RATED-HEIR-FCFM and an additional correction would have been made in Example 2 using RATED-CCAP-FCFM.

SYSTEM-EQUIPMENT informs the SDL processor that the data to follow are related to the system characteristics. A unique user-defined name must be entered in the U-name field of each SYSTEM-EQUIPMENT instruction. Omission of this entry in the "subcommand" will cause an error.

COOLING-CAPACITY is the total capacity (at ARI rated conditions) of either the chilled water cooling coil or the direct expansion cooling system, depending upon which the user is attempting to specify. Note: When specifying COOLING-CAPACITY for packaged DX cooling units with drawthrough fans, SUPPLY-EFF and SUPPLY-STATIC (see SYSTEM-FANS subcommand) should be omitted and SUPPLY-DELTA-T should be set equal to zero <u>if</u> the COOLING-CAPACITY being defined <u>includes</u> cooling of the fan motor. Otherwise, double accounting for supply fan motor heat will be experienced. For better latent simulation the SUPPLY-DELTA-T should be specified and the COOLING-CAPACITY adjusted to describe the unit without the fan. The program-designed COOLING-CAPACITY (for DX systems) is at ARI rated conditions and fan power and heat are not included.

COOL-CAP-FT * is the U-name of a bi-linear or bi-quadratic equation that describes the cooling coil, or cooling system, capacity (dependent variable) as a function of entering wet-bulb temperature (independent variable) and outside dry-bulb temperature (independent variable) for <u>direct expansion</u> coils <u>or</u> entering wet-bulb temperature (independent variable) and entering dry-bulb temperature (independent variable) for <u>chilled water</u> coils. If the bi-linear or bi-quadratic <u>being specified</u> is for a Unitary Hydronic Heat Pump System (HP), the equation is describing the coil cooling capacity (dependent variable) as a function of entering wet-bulb temperature (independent variable) and entering water temperature (independent variable). The bi-linear or bi-quadratic equation must be input to the program and U-named in a CURVE-FIT instruction. Since the cooling coil, or system, will seldom operate at the ARI rated conditions, the equation identified by COOL-CAP-FT is necessary to describe the "shape of the change" in the rated capacity.

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

TABLE IV.39

SYSTEM-EQUIPMENT DEFAULT CURVES

Equations are assumed to take the form:
linear, or $z = a + bx$
bi-linear, or $z = a + bx + dy$
quadratic, or $z = a + bx + cx^2$
bi-quadratic, or $z = a + bx + cx^2 + dy + ey^2 + fxy$
cubic, or $z = a + bx + cx^2 + dx^3$

Default Curve U-name	Keyword	Independent Variable(s)*	Applicable SYSTEM-TYPE	Default Curve Coefficients a	b	c	d	e	f
SDL-C1	COOL-CAP-FT	WB/ODB	RESYS	0.59815404	0.01329987	0.0	-0.00514995	0.0	0.0
SDL-C2	COOL-CAP-FT	WB/ODB	PTAC	0.41905	0.01715	0.0	-0.00598	0.0	0.0
SDL-C3	COOL-CAP-FT	WB/ODB	PSZ,PMZS,PVAVS	0.418943	0.017421	0.0	-0.00617	0.0	0.0
SDL-C5	COOL-CAP-FT	WB/WT	HP	0.56735	0.0137	0.0	-0.00647	0.0	0.0
SDL-C7	COOL-CAP-FT	WB/DB	Builtup	-2.733941	0.0520215	0.0	0.00310625	0.0	0.0
SDL-C10	COOL-CAP-FT	WB/DB	TPFC,FPFC	-2.95444	0.05372	0.0	0.00444	0.0	0.0
SDL-C11	COOL-EIR-FT	WB/ODB	RESYS	0.49957503	-0.00765992	0.0	0.01066989	0.0	0.0
SDL-C12	COOL-EIR-FT	WB/ODB	PTAC	0.282094	-0.005832	0.0	0.01167	0.0	0.0
SDL-C13	COOL-EIR-FT	WB/ODB	PSZ,PMZS,PVAVS	0.282094	-0.005832	0.0	0.01167	0.0	0.0
SDL-C15	COOL-EIR-FT	WB/WT	HP	0.41766475	-0.0044505	0.0	0.01174025	0.0	0.0
SDL-C16	COOL-EIR-FPLR	PLR	RESYS	0.125	0.875	0.0	0.0	0.0	0.0
SDL-C17	COOL-EIR-FPLR	PLR	PTAC	0.125	0.875	0.0	0.0	0.0	0.0
SDL-C18	COOL-EIR-FPLR	PLR	PSZ,PMZS,PVAVS	0.29333333	0.70666667	0.0	0.0	0.0	0.0
SDL-C20	COOL-EIR-FPLR	PLR	HP	0.125	0.875	0.0	0.0	0.0	0.0
SDL-C21	COOL-SH-FT	WB/ODB	RESYS	4.26472718	-0.04557954	0.0	-0.00221998	0.0	0.0
SDL-C22	COOL-SH-FT	WB/ODB	PTAC	2.68689	-0.01667	0.0	-0.006	0.0	0.0
SDL-C23	COOL-SH-FT	WB/ODB	PSZ,PMZS,PVAVS	4.4222	-0.0464365	0.0	-0.0032733	0.0	0.0
SDL-C25	COOL-SH-FT	WB/WT	HP	3.932182	-0.0399	0.0	-0.0034478	0.0	0.0
SDL-C27	COOL-SH-FT	WB/DB	Builtup	-0.785625	-0.016325	0.0	0.0359925	0.0	0.0
SDL-C30	COOL-SH-FT	WB/DB	TPFC,FPFC	-0.785625	-0.016325	0.0	0.0359925	0.0	0.0
SDL-C31	COIL-BF-FCFM	CFM-PLR	RESYS	0.0	1.0	0.0	0.0	0.0	0.0
SDL-C32	COIL-BF-FCFM	CFM-PLR	PTAC	0.0	1.0	0.0	0.0	0.0	0.0
SDL-C33	COIL-BF-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	0.0	1.0	0.0	0.0	0.0	0.0
SDL-C35	COIL-BF-FCFM	CFM-PLR	HP	0.0	1.0	0.0	0.0	0.0	0.0
SDL-C37	COIL-BF-FCFM	CFM-PLR	Builtup	0.0	1.0	0.0	0.0	0.0	0.0
SDL-C40	COIL-BF-FCFM	CFM-PLR	TPFC,FPFC	0.0	1.0	0.0	0.0	0.0	0.0
SDL-C41	COIL-BF-FT	WB/DB	RESYS	1.0	0.0	0.0	0.0	0.0	0.0
SDL-C42	COIL-BF-FT	WB/DB	PTAC	1.0	0.0	0.0	0.0	0.0	0.0
SDL-C43	COIL-BF-FT	WB/DB	PSZ,PMZS,PVAVS	1.0	0.0	0.0	0.0	0.0	0.0
SDL-C45	COIL-BF-FT	WB/DB	HP	1.0	0.0	0.0	0.0	0.0	0.0
SDL-C50	COIL-BF-FT	WB/DB	TPFC,FPFC	1.0	0.0	0.0	0.0	0.0	0.0
SDL-C51	HEAT-CAP-FT	ODB/DB	RESYS	0.34148808	0.00894102	0.00010787	0.0	0.0	0.0
SDL-C52	HEAT-CAP-FT	ODB/DB	PTAC	0.28795	0.01515	0.0	0.0	0.0	0.0
SDL-C55	HEAT-CAP-FT	DB/WT	HP	0.67772	-0.004996	0.0	0.0112	0.0	0.0

TABLE IV.39 (cont)

Default Curve U-name	Keyword	Independent Variable(s)*	Applicable SYSTEM-TYPE	Default Curve Coefficients a	b	c	d	e	f
SDL-C56	HEAT-EIR-FT	ODB/DB	RESYS	2.03914613	-0.03906753	0.00045617	-0.00000203	0.0	0.0
SDL-C57	HEAT-EIR-FT	ODB/DB	PTAC	1.288862	-0.006146	0.0	0.0	0.0	0.0
SDL-C60	HEAT-EIR-FT	DB/WT	HP	0.97246	0.0	0.0	0.000459	0.0	0.0
SDL-C61	HEAT-EIR-FPLR	PLR	RESYS	0.10969333	0.89030667	0.0	0.0	0.0	0.0
SDL-C62	HEAT-EIR-FPLR	PLR	PTAC	0.10969333	0.89030667	0.0	0.0	0.0	0.0
SDL-C65	HEAT-EIR-FPLR	PLR	HP	0.10969333	0.89030667	0.0	0.0	0.0	0.0
SDL-C66	DEFROST-DEGRADE	OWB/ODB	RESYS,PTAC	0.033	0.0	0.0	0.0	0.0	0.0
SDL-C76	RATED-CCAP-FCFM	CFM-PLR	RESYS	0.94015	0.05985	0.0	0.0	0.0	0.0
SDL-C77	RATED-CCAP-FCFM	CFM-PLR	PTAC	0.94015	0.05985	0.0	0.0	0.0	0.0
SDL-C78	RATED-CCAP-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	0.69717199	0.39555	-0.092727	0.0	0.0	
SDL-C79	RATED-CCAP-FCFM	CFM-PLR	HP	0.7	0.3	0.0	0.0	0.0	0.0
SDL-C80	RATED-CCAP-FCFM	CFM-PLR	Builtup	0.3	0.7	0.0	0.0	0.0	0.0
SDL-C81	RATED-CCAP-FCFM	CFM-PLR	TPFC,FPFC	0.36	0.64	0.0	0.0	0.0	0.0
SDL-C83	RATED-SH-FCFM	CFM-PLR	RESYS	0.9379	0.0621	0.0	0.0	0.0	0.0
SDL-C84	RATED-SH-FCFM	CFM-PLR	PTAC	0.9379	0.0621	0.0	0.0	0.0	0.0
SDL-C85	RATED-SH-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	0.37188	0.73956	-0.11144	0.0	0.0	0.0
SDL-C86	RATED-SH-FCFM	CFM-PLR	HP	0.5	0.5	0.0	0.0	0.0	0.0
SDL-C87	RATED-SH-FCFM	CFM-PLR	Builtup	0.2	0.8	0.0	0.0	0.0	0.0
SDL-C88	RATED-SH-FCFM	CFM-PLR	TPFC,FPFC	0.28	0.72	0.0	0.0	0.0	0.0
SDL-C91	RATED-CEIR-FCFM	CFM-PLR	RESYS	1.13318	-0.13318	0.0	0.0	0.0	0.0
SDL-C92	RATED-CEIR-FCFM	CFM-PLR	PTAC	1.13318	-0.13318	0.0	0.0	0.0	0.0
SDL-C93	RATED-CEIR-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	1.13318	-0.13318	0.0	0.0	0.0	0.0
SDL-C94	RATED-CEIR-FCFM	CFM-PLR	HP	1.13318	-0.13318	0.0	0.0	0.0	0.0
SDL-C98	RATED-HCAP-FCFM	CFM-PLR	RESYS	0.8913	0.1087	0.0	0.0	0.0	0.0
SDL-C99	RATED-HCAP-FCFM	CFM-PLR	PTAC	0.8913	0.1087	0.0	0.0	0.0	0.0
SDL-C100	RATED-HCAP-FCFM	CFM-PLR	PSZ,PMZS,PVAVS	--					
SDL-C101	RATED-HCAP-FCFM	CFM-PLR	HP	0.7	0.3	0.0	0.0	0.0	0.0
SDL-C102	RATED-HCAP-FCFM	CFM-PLR	TPFC,FPFC	--					
SDL-C105	RATED-HEIR-FCFM	CFM-PLR	RESYS	1.13318	-0.13318	0.0	0.0	0.0	0.0
SDL-C106	RATED-HEIR-FCFM	CFM-PLR	PTAC	1.13318	-0.13318	0.0	0.0	0.0	0.0
SDL-C108	RATED-HEIR-FCFM	CFM-PLR	HP	--					
SDL-C111	FURNACE-HIR-FPLR	PLR	All Types	0.01861	1.094209	-0.112819	0.0	0.0	0.0

* WB = entering wet-bulb temperature (°F)
ODB = outside dry-bulb temperature (°F)
WT = entering water temperature (°F)
OWB = outside wet-bulb temperature (°F)
DB = entering dry-bulb temperature (°F)
PLR = part-load ratio (fraction)
CFM-PLR = change in full load capacity as a function of supply air flow rate

for other temperature values. The equation should be normalized so that at rated conditions its value is 1.0 (that is, where the total cooling capacity equals COOLING-CAPACITY). If this keyword is specified, the user should also specify COOL-SH-CAP.

COOLING-EIR — is the Electric Input Ratio, or 1/Coefficient of Performance, for the cooling unit at ARI rated conditions. Electric Input Ratio is defined in DOE-2 to be the ratio of the electric energy input (in Btu/hr) to the rated capacity (in Btu/hr). This EIR is at the ARI rated conditions, that is, without corrections for different temperatures and part loads. Note: If the fan electric energy consumption is included in this user-specified COOLING-EIR, SUPPLY-KW in SYSTEM-FANS should be set equal to zero (and SUPPLY-STATIC, SUPPLY-EFF, and SUPPLY-DELTA-T should be omitted). Otherwise, double accounting for supply fan electrical energy will be experienced. The default COOLING-EIR (for commercial systems) already includes compressor and outdoor fan energy, but not indoor fan energy.

COOL-EIR-FT * — is the U-name of a bi-linear or bi-quadratic equation that describes the Electric Input Ratio for cooling (dependent variable) as a function of entering wet-bulb temperature (independent variable) and outdoor dry-bulb temperature (independent variable) for direct expansion systems or entering wet-bulb temperature (independent variable) and entering water temperature (independent variable) for an HP, water-to-air heat pump, system. The equation should be normalized so that at rated conditions its value is 1.0 (that is, where the full load rated electric input ratio for cooling equals COOLING-EIR). The keyword is unused with chilled water coils.

COOL-EIR-FPLR * — is the U-name of a linear, quadratic, or cubic equation that describes the Electric Input Ratio for cooling (dependent variable) as a function of part load ratio, PLR, (independent variable). The keyword is unused with chilled water coils. The linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at rated conditions its value is 1.0.

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

COOL-SH-CAP — is the sensible heat removal capacity of the air cooling device at ARI rated conditions (the sensible part of COOLING-CAPACITY). At non-ARI rated conditions the value will be corrected by COOL-SH-FT, either by default or by user-supplied data for COOL-SH-FT. Note: The sensible capacity is always less than or equal to the total capacity.

COOL-SH-FT * — is the U-name of a bi-linear or bi-quadratic equation that described the sensible heat removal capacity (dependent variable) of the air cooling device as a function of entering wet-bulb temperature (independent variable) and outdoor dry-bulb temperature (independent variable) for direct expansion. If the bi-linear or bi-quadratic being specified is for a Unitary Hydronic Heat Pump System (HP), the equation is describing the sensible heat removal capacity (dependent variable) as a function of entering wet-bulb temperature (independent variable) and entering water temperature (independent variable). The bi-linear or bi-quadratic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at rated conditions its value is 1.0 (that is, where the sensible heat removal capacity equals COOL-SH-CAP). The user should assure that the data introduced to produce this curve does not result in a sensible heat ratio of greater than 1.0.

COOL-FT-MIN — is the minimum outside dry-bulb temperature for the curves referenced by the keywords COOL-CAP-FT, COOL-EIR-FT, and COOL-SH-FT (and their associated CURVE-FIT instructions). This is the minimum extrapolation point. As the outside dry-bulb temperature (one of the two independent variables in each of the three equations) drops below this point the accuracy of the three equations is degraded. The program assumes that the second dependent variable, in each of the three equations, remains constant at all outside dry-bulb temperatures below this value. The program assumes that the corresponding cut-off wet-bulb temperature is 60°F.

If the RATED-CFM (see SYSTEM-AIR or ZONE-AIR) of the supply air fan is different than the SUPPLY-CFM (see SYSTEM-AIR) or ASSIGNED-CFM (see ZONE-AIR), the user may choose to enter values for the following three keywords. If, however, the user omits entries for the following three keywords, the program will calculate their polynomials as a function of SUPPLY-CFM/RATED-CFM for central systems and as a function of ASSIGNED-CFM/RATED-CFM for zonal systems.

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

RATED-CCAP-FCFM * is the U-name of a linear, quadratic, or cubic equation that describes the rated cooling capacity (dependent variable) as a function of supply air flow rate/rated cfm (independent variable). The linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at RATED-CFM its value is 1.0.

RATED-CEIR-FCFM * is the U-name of a linear, quadratic, or cubic equation that describes the rated Electric Input Ratio for cooling (dependent variable) as a function of supply air flow rate/rated cfm (independent variable). The linear, quadratic or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at RATED-CFM its value is 1.0.

RATED-SH-FCFM * is the U-name of a linear, quadratic, or cubic equation that describes the rated sensible cooling capacity (dependent variable) as a function of supply air flow rate/rated cfm (independent variable). The linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at RATED-CFM its value is 1.0.

COIL-BF is the cooling coil full load rated bypass factor. This value is used to characterize the performance of a cooling coil. Using the bypass model, the exit air stream from a coil is characterized as being composed of two components: one component leaves the coil at the coil surface temperature and at or below the corresponding saturation humidity ratio (depending upon whether the entering air humidity ratio was above or below this saturation value); the other component leaves at the same temperature and humidity ratio as the entering air stream (thus the bypass name). The fraction of the total air flow in the bypassed component is the bypass factor. The graphical representation is shown in Fig. IV.25.

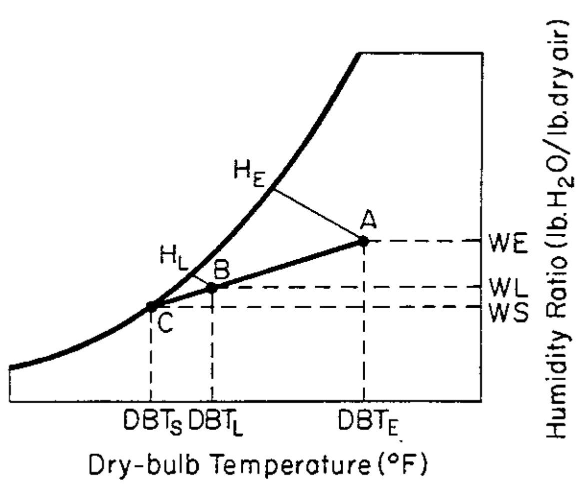


Fig. IV.25. Determining the coil bypass factor.

A = coil entering condition,
B = coil leaving condition,
C = coil surface condition,
WE = coil entering humidity ratio,
WL = coil leaving humidity ratio,
WS = coil surface saturation humidity ratio,
H_E = coil entering enthalpy,
H_L = coil leaving enthalpy,

$$\text{BYPASS FACTOR} = \frac{DBT_S - DBT_L}{DBT_S - DBT_E},$$

$$H_L = H_E - \frac{\text{COOLING-CAPACITY}}{4.5 * \text{CFM}}, \text{ and}$$

$$DBT_L = DBT_E - \frac{\text{COOL-SH-CAP}}{1.08 * \text{CFM}}.$$

The bypass factor can be calculated by plotting, on the psychrometric chart, the ARI and other entering conditions (A). Then, using the capacity and air flow rate at these conditions, plot the leaving conditions (B). If a line is drawn between these points and extended to the saturation line, it will intersect the saturation line at the coil surface condition (C). One can then calculate the bypass factor for each pair of points. If WE is less than or equal to WL, there is only sensible cooling, and the bypass factor is unused. Thus, the bypass factor and its associated curves should only be produced for conditions when WE > WL.

COIL-BF-FCFM * — is the U-name of a linear, quadratic, or cubic equation that describes the coil bypass factor (dependent variable) as a function of total supply air (independent variable). The linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at rated conditions its value is 1.0.

COIL-BF-FT * — is the U-name of a bi-linear or bi-quadratic equation that describes the coil bypass factor (dependent variable) as a

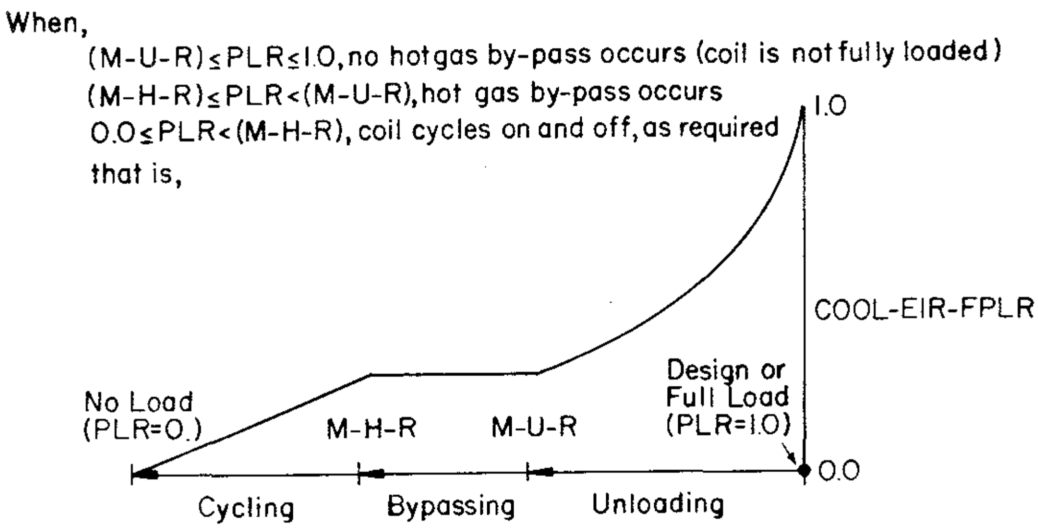
* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

function of the entering wet-bulb temperature (independent variable) and entering dry-bulb temperature (independent variable. The bi-linear or bi-quadratic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at rated conditions its value is 1.0.

COOL-CTRL-RANGE — is the throttling range of the cooling coil controller and it is represented by $T_{max}-T_{min}$ where T_{max} is the temperature of the coil when it is fully loaded and T_{min} is the temperature of the coil when it is fully unloaded.

MIN-UNLOAD-RATIO — is the point, expressed as a part load ratio (PLR), at which compressor unloading stops and hot gas bypass or cycling begins (see M-U-R in Fig. IV.26). The COOL-EIR-FPLR applies in the range of PLR's between MIN-UNLOAD-RATIO and 1.0, that is, the range designated as "Unloading" in Fig. IV.26.

MIN-HGB-RATIO — is the point, expressed as a part load ratio (PLR), below which hot gas bypass stops and unit cycling begins. Below this point the unit cycles on and off to meet the load. MIN-HGB-RATIO is always equal to or less than MIN-UNLOAD-RATIO (see M-H-R in Fig. IV.26).



Note: If (M-U-R) = (M-H-R), there is no hot gas bypass capability, and the unit moves from unloading immediately to cycling as the PLR drops below this ratio. If (M-U-R) = (M-H-R) = 1.0, the unit does not unload and cycles from full load down to zero load.

Fig. IV.26. Cooling coil operating strategy.

MAX-COND-RCVRY — is the fraction of the heat produced in the condenser that is to be recovered and is to replace active heating.

CRANKCASE-HEAT — is the amount of electrical energy, measured in kW, used to heat the crankcase of direct expansion (DX) and heat pump compressors. The crankcase heater is on only when the compressor is off.

CRANKCASE-MAX-T — is the outdoor dry-bulb temperature above which the crankcase heater, if present, is not allowed to operate.

OUTSIDE-FAN-KW — is the amount of electrical energy, measured in kW, used to operate the outside fan (condenser fan when cooling or evaporator fan when heating).

OUTSIDE-FAN-T — is the outside temperature below which the condenser fan(s) are not permitted to operate.

OUTSIDE-FAN-MODE — Input for this keyword is the code-word which describes whether the outside fan operates continuously (CONTINUOUS) or only when the compressor is on (INTERMITTENT). This keyword is appropriate only to RESYS, PSZ, PMZS, and PVAVS. Its default is INTERMITTENT.

COMPRESSOR-TYPE — Input for this keyword is the code-word which describes whether the compressor operates at only one speed (SINGLE-SPEED) or two speeds (DUAL-SPEED). This keyword is appropriate only to RESYS.

HEATING-CAPACITY — is the total capacity of the heating system (for RESYS this HEATING-CAPACITY is at ARI rated conditions). Note that the input value is a negative value. If the minus sign is omitted an ERROR will occur. The program-designed HEATING-CAPACITY does not include fan power and heat.

HEAT-CAP-FT* — is the U-name of a bi-linear or bi-quadratic equation that describes the heat pump heating capacity (dependent variable) as a function of outdoor dry-bulb temperature and entering dry-bulb temperature (independent variables). The bi-linear or bi-quadratic equation must be input to the program and U-named in a CURVE-FIT instruction. Because the heat pump will seldom operate at the rated heating rate, the equation identified by HEAT-CAP-FT is necessary to describe the "shape of the change" in the rated

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

capacity for other temperature values. The equation should be normalized so that at rated conditions its value is 1.0 (that is, where total heating capacity equals HEATING-CAPACITY). This keyword is always appropriate to the HP system and is appropriate to the RESYS and PTAC systems when HEAT-SOURCE = HEAT-PUMP.

HEATING-EIR — is the Electric Input Ratio, or 1/heating Coefficient of Performance for the heat pump. This EIR is at ARI rated conditions, that is, without corrections for temperature and part load. The program-designed HEATING-EIR does not include fan power and heat. This keyword is appropriate only to HP, RESYS, and PTAC systems.

HEAT-EIR-FT * — is the U-name of a bi-linear or bi-quadratic equation that describes the heat pump Electric Input Ratio (dependent variable) as a function of outdoor dry-bulb temperature and entering dry-bulb temperature (independent variables). The bi-linear or bi-quadratic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at rated conditions its value is 1.0 (that is, where the full load electric input ratio for heating equals HEATING-EIR). This keyword is appropriate only to HP, RESYS, and PTAC systems.

HEAT-EIR-FPLR * — is the U-name of a linear, quadratic, or cubic equation that describes the heat pump Electric Input Ratio for heating (dependent variable) as a function of part load ratio, PLR, (independent variable). The linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at rated conditions its value is 1.0. This key word is appropriate only to HP, RESYS, and PTAC systems.

If the RATED-CFM (see SYSTEM-AIR or ZONE-AIR) of the supply air fan is different from the SUPPLY-CFM (see SYSTEM-AIR) or ASSIGNED-CFM (see ZONE-AIR), the user may choose to enter values for the following two keywords. If however, the user omits entries for the following two keywords, the program will calculate their polynomials as a function of SUPPLY-CFM/ RATED-CFM for central systems and as a function of ASSIGNED-CFM/RATED-CFM for zonal systems.

RATED-HCAP-FCFM * — is the U-name of a linear, quadratic, or cubic equation that describes the rated heating capacity (dependent

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

variable) as a function of supply air flow rate/rated cfm (independent variable). The linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at RATED-CFM its value is 1.0.

RATED-HEIR-FCFM * — is the U-name of a linear, quadratic, or cubic equation that describes the rated Electric Input Ratio for heating (dependent variable) as a function of supply air flow rate/rated cfm (independent variable). The bi-linear or bi-quadratic equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at RATED-CFM its value is 1.0.

ELEC-HEAT-CAP — is the design total heat capacity of the auxiliary electric resistance heater within the heat pump. Note that input for this keyword must be a negative value to avoid an ERROR.

MIN-HP-T — is the outdoor dry-bulb temperature below which the heat pump turns off.

MAX-ELEC-T — is the maximum outdoor dry-bulb temperature above which the electric resistance heating is turned off. This keyword is appropriate only to RESYS or PTAC where HEAT-SOURCE = HEAT-PUMP.

DEFROST-T — is the outdoor temperature below which the heat pump defrosts itself (during its heating mode of operation). This keyword is appropriate only to RESYS and PTAC systems, assuming they are equipped with a heat pump.

DEFROST-DEGRADE * — is the U-name of a linear, quadratic, or cubic equation that describes the ratio of defrost time to heating-on time (dependent variable) as a function of outdoor wet-bulb temperature and outdoor dry-bulb temperature (independent variables). If the user wishes anything other than the default, a linear, quadratic, or cubic equation must be input to the program and U-named in a CURVE-FIT instruction. This keyword is appropriate only to RESYS and PTAC systems, assuming they are equipped with a heat pump. The default, which is optional, is 3 minutes of defrost time for each 90 minutes of operation if the outdoor dry-bulb temperature is less than DEFROST-T.

HCOIL-WIPE-FCFM — applies only to MZS, DDS, and PMZS systems. When some dual duct systems are in the predominately cooling mode, some of the supply air passes over, or wipes, the main hot deck before entering the cold deck (or mixing box). This is caused by the location of the heating coil in the unit. This keyword is used to account for the effect of partially

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

heating the air. Input for this keyword is the U-name of a linear, quadratic, or cubic equation which describes the fraction of air (dependent variable) heated to the hot deck temperature as a function of the ratio (independent variable) of cfm through the cold deck to the total cfm. If the user wishes to account for this effect, a linear, quadratic, or cubic equation must be previously input to the program and U-named in a CURVE-FIT instruction. There is no default value or curve.

FURNACE-HIR — is the ratio of Btus of fuel used to Btus of heating energy produced. It is expressed as a number equal to or greater than 1.0 (although the Range Maximum shown on the User Worksheet for this command is 1.75, a number in excess of this value will not result in an ERROR). FURNACE-HIR should include the pilot energy.

FURNACE-AUX — When HEAT-SOURCE = GAS-FURNACE, FURNACE-AUX is the energy, expressed in Btu/hr, that is consumed by the gas pilot light of a gas furnace during the hours when there is no load on the furnace. It is assumed by the program that the pilot light consumption during the hours that the furnace is "on" is included in FURNACE-HIR-FPLR.

When HEAT-SOURCE = OIL-FURNACE, FURNACE-AUX is the energy, expressed in Btu/hr, that is consumed by the spark ignition and the fuel pumping system during the hours when there is a load on the furnace. The energy consumed is the furnace part-load-ratio times the value of FURNACE-AUX in Btu/hr. The program assumes that no energy is consumed when there is no load on the furnace.

FURNACE-OFF-LOSS — is the U-name of a linear, quadratic, or cubic equation that describes the fraction of the unused furnace capacity that is an induced load (dependent variable) as a function of outdoor dry-bulb temperature. The unused furnace capacity (HEATING-CAPACITY minus the furnace load, assuming no loss) is multiplied by this function and the result is added to the furnace load. The loss is only added during the hour the furnace operated. This loss is usually caused by infiltration induced by a non-outside air supplied burner or off-cycle furnace cooling. There is no default value or curve.

FURNACE-HIR-FPLR * — accepts the U-name of a linear, quadratic, or cubic equation that defines the dependence of FURNACE-HIR on part-load ratio. The equation must be input to the program and U-named in a CURVE-FIT instruction. The equation should be normalized so that at full load its value is 1.0.

* Input for this keyword should be made only if the user is not satisfied with the default values built into the program. Additionally, if the user decides to specify a U-name, it should not be one of the reserved "Default Curve U-names" in Table IV.39. Furthermore, these U-names are applicable only to the SYSTEM-TYPEs stated in the table.

________________ = SYSTEM-EQUIPMENT or S-EQ (User Worksheet)

U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	__________	U-name	-	-	-
COOLING-CAPACITY	C-CAP	=	__________	Btu/hr	Note 1	0.	$1.x10^8$
COOL-CAP-FT	C-C-FT	=	__________	U-name of a bi-linear or bi-quadratic	Note 1	-	-
COOLING-EIR	C-EIR	=	__________	Btu/Btu	Note 1	0.	1.
COOL-EIR-FT	C-E-FT	=	__________	U-name of a bi-linear or bi-quadratic	Note 1	-	-
COOL-EIR-FPLR	C-E-FP	=	__________	U-name of a linear, quadratic, or cubic	Note 1	-	-
COOL-SH-CAP	-	=	__________	Btu/hr	Note 1	0.	$1.x10^8$
COOL-SH-FT	C-S-FT	=	__________	U-name of bi-linear or bi-quadratic	Note 1	-	-
COOL-FT-MIN	C-FT-MIN	=	__________	°F	Note 1	0.	120.
RATED-CCAP-FCFM	R-CC-FC	=	__________	U-name of a linear, quadratic, or cubic	Note 1	-	-
RATED-CEIR-FCFM	R-CE-FC	=	__________	U-name of a linear, quadratic, or cubic	Note 1	-	-

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
RATED-SH-FCFM	R-S-FC	= ______	U-name of a linear, quadratic, or cubic	Note 1	-	-
COIL-BF	C-BF	= ______	cfm/cfm	Note 1	0.	.99
COIL-BF-FCFM	C-BF-FC	= ______	U-name of a linear, quadratic, or cubic	Note 1	-	-
COIL-BF-FT	C-BF-FT	= ______	U-name of a linear, quadratic, or cubic	Note 1	-	-
COOL-CTRL-RANGE	C-C-R	= ______	°F	Note 1	0.	15.
MIN-UNLOAD-RATIO	M-U-R	= ______	fraction	Note 1	0.	1.
MIN-HGB-RATIO	M-H-R	= ______	fraction	Note 1	0.	1.
MAX-COND-RCVRY	M-C-R	= ______	number	Note 1	.0	1.
CRANKCASE-HEAT	C-H	= ______	kW	Note 1	.0	1.
CRANKCASE-MAX-T	C-M-T	= ______	°F	Note 1	0.	100.
OUTSIDE-FAN-KW	O-F-KW	= ______	kW	Note 1	.0	20.
OUTSIDE-FAN-T	O-F-T	= ______	°F	Note 1	.0	200.
OUTSIDE-FAN-MODE	O-F-M	= ______	code-word	Note 1	-	-
COMPRESSOR-TYPE	C-TYPE	= ______	code-word	Note 1	-	-
HEATING-CAPACITY	H-CAP	= ______	(-)Btu/hr	Note 1	$-1.x10^8$	0.
HEAT-CAP-FT	H-C-FT	= ______	U-name of a bi-linear or bi-quadratic	Note 1	-	-

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
HEATING-EIR	H-EIR	=	________	Btu/Btu	Note 1	0.	2.
HEAT-EIR-FT	H-E-FT	=	________	U-name of a bi-linear or bi-quadratic	Note 1	-	-
HEAT-EIR-FPLR	H-E-FP	=	________	U-name of a linear, quadratic, or cubic	Note 1	-	-
RATED-HCAP-FCFM	R-HC-FC	=	________	U-name of a linear, quadratic, or cubic	Note 1	-	-
RATED-HEIR-FCFM	R-HE-FC	=	________	U-name of a linear, quadratic, or cubic	Note 1	-	-
ELEC-HEAT-CAP	E-H-C	=	________	(-)Btu/hr	Note 1	$-1.x10^9$	0.
MIN-HP-T	M-H-T	=	________	^oF	Note 1	-30.	70.
MAX-ELEC-T	M-E-T	=	________	^oF	Note 1	-30.	70.
DEFROST-T	D-T	=	________	^oF	Note 1	0.	70.
DEFROST-DEGRADE	D-D	=	________	U-name of a linear, quadratic, or cubic	Note 1	-	-
HCOIL-WIPE-FCFM	H-W-FC	=	________	U-name of a linear, quadratic, or cubic	Note 2	-	-
FURNACE-HIR	F-HIR	=	________	Btu/Btu	Note 3	1.	1.75
FURNACE-AUX	F-A	=	________	Btu/hr	Note 3	0.	$1.x10^4$

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
FURNACE-OFF-LOSS	F-O-L	= ______________	U-name of a linear, quadratic, or cubic	Note 3	-	-
FURNACE-HIR-FPLR	F-H-FP	= ______________	U-name of a linear, quadratic, or cubic	Note 3	-	-

1) See the proper Applicability Table (Sec. B.4 of this chapter) for default curve U-name or default value. If the keyword is not listed in the table, it is not applicable to the system being specified. See Table IV.39 for default curve coefficients.

   Note that for "zonal" systems (UHT, UVT, TPFC, FPFC, TPIU, FPIU, HP, and PTAC) the keywords COOLING-CAPACITY, HEATING-CAPACITY, and COOL-SH-CAP may be specified here in the SYSTEM-EQUIPMENT subcommand or in the ZONE instruction, or both. If an entry is not made in a ZONE instruction, the entry made here in SYSTEM-EQUIPMENT will be used. If an entry is made both in ZONE and here in SYSTEM-EQUIPMENT, the entry made in ZONE takes precedence. If an entry is made only here in SYSTEM-EQUIPMENT, it applies to every ZONE in the SYSTEM.

2) This keyword is applicable only to MZS, DDS, and PMZS. There is no default.

3) The user may specify an auxilliary furnace here in the SYSTEMS Chapter. Alternatively, or additionally, an auxilliary furnace may be specified in PLANT. There is no default for FURNACE-OFF-LOSS. Note: In addition to specifying the above furnace keyword values, it is necessary to specify HEAT-SOURCE equal to either GAS-FURNACE or OIL-FURNACE in the SYSTEM command.

12. SYSTEM

The function of the SYSTEM instruction is to provide specifications of the secondary HVAC distribution system to be simulated. 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 identify "subcommands" (SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, SYSTEM-TERMINAL, SYSTEM-FLUID, and SYSTEM-EQUIPMENT) that contain the needed information. If this approach is not chosen, omit the SYSTEM-XXXXX keywords here in SYSTEM.

The DOE-2 SYSTEMS Program simulates a number of commonly used energy distribution systems. In addition, numerous optional features can be specified for these systems. Individual SDL instructions and/or individual keywords in these instructions may be required, optional, or not applicable, depending on the type of system and the options being specified. A discussion of the features of each system is included in Sec. B of this chapter.

The facility being studied may contain (or require) a number of systems, of the same or different types, each serving different spaces within the facility. In addition, for comparison studies, more than one system may be specified and assigned to serve the same space (see PLANT-ASSIGNMENT instruction). If more than one PLANT-ASSIGNMENT is used, each system must be referenced in a PLANT-ASSIGNMENT in order to be simulated. Care must be taken that each zone is included once, and only once, in each total facility simulation. A system can only be referenced by a single PLANT-ASSIGNMENT.

SYSTEM — informs the SDL Processor that the data to follow are related to the design and operation of a specific energy distribution system serving one or more zones of the facility. A unique user-defined name must be entered in the U-name field of each SYSTEM instruction. Omission of this entry will cause an error.

SYSTEM-TYPE — Input for this keyword is a code-word that identifies the type of system to be simulated. The user must select one of twenty-one (21) types of commonly used energy distribution systems. A discussion of the features of each system and an Applicability Table are included in Sec. B of this chapter.

The available SYSTEM-TYPE's in DOE-2 have been categorized into different generic types, built-up systems _versus_ packaged systems and central systems _versus_ zonal systems.

Built-up Systems - Built-up systems, depending upon the SYSTEM-TYPE chosen, simulate preheat coils, main heating coils, zone (reheat) coils, cooling 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 the

PLANT Program. 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 that is operating on purchased or renewable utilities.

Packaged Systems - Packaged systems are usually self-contained units, which may be considered as hybrid systems/plants. These units are normally produced as one or more modular pieces of equipment, which have been prematched, and require only installation. They normally possess all the necessary equipment for energy conversion and distribution. They too produce a utility demand for electricity, gas, and/or oil.

Zonal vs. Central Systems - Occasionally throughout this text, reference is made to "zonal system." This term is defined in this context to mean any system that has an air handling unit in each zone, which is controlled by a thermostat in that zone. The system 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). The zonal systems are UHT, UVT, TPFC, FPFC, TPIU, FPIU, HP, and PTAC. (The TPIU and FPIU are included in this list only because their zone coils are sized individually for each zone, although a portion of the heating and cooling is supplied by a primary system).

The available DOE-2 systems and their code-words are listed in Table IV.40. The first listed code-word (SUM) does not actually simulate a system, but it is a diagnostic that is used to provide a summation of zone loads.

SYSTEM-CONTROL is a U-name previously assigned under the instruction SYSTEM-CONTROL. The common U-name matches the correct "system control" to each "system". No data entry here will result in default to the values specified under the instruction SYSTEM-CONTROL.

An alternative mode for data entry is to complete and enter SYSTEM-CONTROL keyword instructions directly into SYSTEM (if this approach is chosen, omit the SYSTEM-CONTROL instruction here in SYSTEM.)

TABLE IV.40

Code-Word	SYSTEM-TYPE	Generic Type
SUM	Sums Building Loads (no system simulation).	-
SZRH	Single Zone Fan System w/Optional Subzone Reheat. . .	Built-up/central
MZS	Multizone Fan System.	Built-up/central
DDS	Dual Duct Fan System.	Built-up/central
SZCI	Single Zone Fan System w/Induction Mixing Boxes . . .	Built-up/central
UHT	Unit Heater	Built-up/zonal
UVT	Unit Ventilator	Built-up/zonal
FPH	Floor Panel Heating System.	Built-up
TPFC	Two Pipe Fan Coil System.	Built-up/zonal
FPFC	Four Pipe Fan Coil System	Built-up/zonal
TPIU	Two Pipe Induction Unit System.	Built-up/zonal
FPIU	Four Pipe Induction Unit System	Built-up/zonal
VAVS	Variable Volume Fan System w/optional reheat.	Built-up/central
RHFS	Constant Volume Reheat Fan System	Built-up/central
HP	Unitary Hydronic Heat Pump System	Built-up/zonal
HVSYS	Heating and Ventilating System.	Built-up/central
CBVAV	Ceiling Bypass Variable Volume.	Built-up/central
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

SYSTEM-AIR)
SYSTEM-FANS)
SYSTEM-TERMINAL)
SYSTEM-FLUID)
SYSTEM-EQUIPMENT)

The preceding discussion for the keyword SYSTEM-CONTROL applies equally to these keywords when the keyword names are interchanged.

HEAT-SOURCE

Input for this keyword is the code-word that identifies the heat source for the main heating coils. See Table IV.41 for the applicable code-words, and Table IV.42 for defaults. (Note: This is the appropriate keyword for UHT, UVT, TPFC, FPFC and PTAC, even though these systems, in the output reports (and CBS), will report these loads as zone loads rather than central, or main heating loads.

TABLE IV.41

Code-Word	HEAT-SOURCE, ZONE-HEAT-SOURCE, PREHEAT-SOURCE, and BASEBOARD-SOURCE
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. (It is possible to utilize solar energy by using the HEAT-RECOVERY command in PLANT).
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 here in SYSTEMS.
OIL-FURNACE	The source of heat is an oil-fired furnace, which will be simulated here 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 and PTAC systems. It should not be used for any other systems (see the HP system).
HOT-WATER/SOLAR	The source of heat (total or assist) is either hot-water provided by conventional plant equipment <u>or</u> hot water/air provided by solar equipment, if present. If there is no solar equipment present, the source will be treated just as simply HOT-WATER. This code-word is appropriate for central heating coils, preheat coils, and zone heating coils. Sources of the solar type are passed to CBS (in PLANT) via the PLANT-1 component. This code-word is not appropriate to the HP system.

TABLE IV.42

Default Heating Sources by SYSTEM-TYPE

SYSTEM-TYPE	HEAT-SOURCE	ZONE-HEAT-SOURCE	PREHEAT SOURCE	BASEBOARD SOURCE
SUM	–	–	–	–
SZRH	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
MZS	HOT-WATER/SOLAR	–	HOT-WATER/SOLAR	HOT-WATER
DDS	HOT-WATER/SOLAR	–	HOT-WATER/SOLAR	HOT-WATER
SZCI	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
UHT	HOT-WATER/SOLAR	–	–	HOT-WATER
UVT	HOT-WATER/SOLAR	–	–	HOT-WATER
FPH	HOT-WATER/SOLAR	–	–	–
TPFC	HOT-WATER/SOLAR	–	–	HOT-WATER
FPFC	HOT-WATER/SOLAR	–	–	HOT-WATER
TPIU	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
FPIU	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
VAVS	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
RHFS	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
HP	–	–	–	HOT-WATER
HVSYS	HOT-WATER/SOLAR	HOT-WATER/SOLAR	–	HOT-WATER
CBVAV	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER/SOLAR	HOT-WATER
RESYS	GAS FURNACE	–	–	ELECTRIC
PSZ	GAS-FURNACE	ELECTRIC	–	ELECTRIC
PMZS	GAS-FURNACE	–	–	ELECTRIC
PVAVS	HOT-WATER/SOLAR	HOT-WATER/SOLAR	–	ELECTRIC
PTAC	ELECTRIC	–	–	ELECTRIC

– = Not applicable.

ZONE-HEAT-SOURCE — Input for this keyword is the code-word that identifies the heat source for the zone heating coils in central air handler systems (reheat coils). See Table IV.41 for the applicable code-words, and Table IV.42 for defaults.

PREHEAT-SOURCE — Input for this keyword is the code-word that identifies the heat source for the preheat coils. See Table IV.41 for the applicable code-words, and Table IV.42 for defaults.

BASEBOARD-SOURCE — Input for this keyword is the code-word that identifies the heat source for the baseboard heaters. See Table IV.41 for the applicable code-words, and Table IV.42 for defaults. Note: HOT-WATER/SOLAR should not be used as a code-word for BASEBOARD-SOURCE.

SIZING-RATIO — is used to deliberately oversize or undersize all equipment in the system. The input for this keyword is the ratio of the maximum capacity (or size) of the simulated system and its zones to either (1) the capacity assigned in the appropriate SDL instructions or (2) the capacity required to meet peak (or design day) loads calculated by the program. The ratio can be more than, equal to, or less than unity (1.00 is the default value). The SIZING-RATIO does not modify the heating/cooling data that are passed from LOADS to SYSTEMS. It only modifies the equipment sizes in SYSTEMS. This modification, however, will probably change the responsiveness of the system, either faster or slower depending upon whether the equipment is being oversized or undersized. Likewise, the alteration of equipment size can change the demands, placed by the system, upon the PLANT equipment. The latter change may render the PLANT equipment inadequate in size (if assigned) or may result in excessively large equipment. The judicious use of the SIZING-RATIO option can be a useful tool in cost tradeoff studies.

Warning: The following keyword is not to be confused with a keyword by the same name in the ZONE command.

SIZING-OPTION — accepts a code-word as input, either COINCIDENT, meaning block or building peak load, or NON-COINCIDENT, meaning the sum of the individual zone peak loads. Depending on the entered code-word, the SUPPLY-CFM will be sized by the coincident or the non-coincident peak (see SUPPLY-CFM keyword in the SYSTEM-AIR instruction). For COINCIDENT sizing there must be only one SYSTEM in the PLANT-ASSIGNMENT command and MIN-FAN-RATIO must be less than 1.0.

RETURN-AIR-PATH — Input for this keyword is the code-word that describes the route that return air takes in getting back to the air handling unit. See Table IV.43 for the code-words and a brief description of how the program responds to each. This entry may be omitted if air returns to the air handling unit without absorbing any plenum or light heat (code-word DIRECT is default value).

TABLE IV.43

Code-Word	RETURN-AIR-PATH
DIRECT	This code-word is used when the return air flows back to the air handler or relief point (central exhaust) via hallways and stairwells. All heat from lights specified in LOADS should go 100 per cent into the ZONE air or it is lost. Only return fan heat is added to the air stream.
DUCT	Use of this code-word causes the heat from lights (1 - LIGHT-TO-SPACE in the LOADS program), in addition to return fan heat, to be added to the air stream. This code-word is used in two main cases: (1) when return air duct work actually exists in the building and (2) when the return air passes through a plenum, but little heat gain or loss is experienced in this plenum. The second case allows great simplification of input. The user specifies the conditioned areas and ignores the specification of the plenum areas. The heat of lights exhausted to the plenum (specified in the LOADS program) is still added to the return air. When using this option and also specifying a non-return air plenum, the plenum should be specified as ZONE-TYPE = UNCONDITIONED.
PLENUM-ZONES	This code-word is used when the user wishes to simulate heat exchange between the return air stream and the plenum wall mass. Heat from lights is added to the air stream, then it is allowed to interact with the ZONEs (attached to this SYSTEM) that are specified as ZONE-TYPE = PLENUM and are listed in PLENUM-NAMES. After heat exchange is calculated with the plenum ZONEs, the return fan heat (if any) is added. Use of this code-word requires at least one ZONE (but not more than three) specified as ZONE-TYPE = PLENUM in the PLENUM-NAMES list.

PLENUM-NAMES

is a listing of the U-names (maximum of 3) of those ZONEs assigned to this SYSTEM that are return air plenums. The SYSTEMS program recalculates the cooling/heating loads and temperatures in the plenum zones as for other zones, except that the effect of return air flow through the plenum is considered in lieu of direct air supply.

Note that the U-name of at least one ZONE instruction must be entered for this keyword if the code-word PLENUM-ZONES has been entered for the keyword RETURN-AIR-PATH. Note also, that the code-word PLENUM must be entered for the keyword ZONE-TYPE in each ZONE instruction named here.

ZONE-NAMES

is a listing of the U-names (maximum of 64) of all the ZONEs (CONDITIONED, UNCONDITIONED, and PLENUM) that are assigned to this SYSTEM. The UNCONDITIONED and PLENUM ZONES must be listed, so that the temperature and interactions with surrounding ZONEs may be tracked.

This data entry, with the U-name of at least one CONDITIONED ZONE, is required.

Note: If the SYSTEM being simulated is the type that serves both a central ZONE and one or more subZONEs (i.e., SZRH, PSZ and RESYS), the U-name of the control ZONE must be listed first and, naturally, that ZONE must be CONDITIONED.

Warning: ZONEs that share INTERIOR-WALLs cannot be assigned to different PLANT-ASSIGNMENTs.

______________________ = SYSTEM or SYST (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=	______	U-name	-	-	-
SYSTEM-TYPE	S-TYPE	=	______	code-word	*	-	-
SYSTEM-CONTROL	S-C	=	______	U-name	Note 1	-	-
SYSTEM-AIR	S-A	=	______	U-name	Note 1	-	-
SYSTEM-FANS	S-FANS	=	______	U-name	Note 1	-	-
SYSTEM-TERMINAL	S-T	=	______	U-name	Note 1	-	-
SYSTEM-FLUID	S-FLU	=	______	U-name	Note 1	-	-
SYSTEM-EQUIPMENT	S-EQ	=	______	U-name	Note 1	-	-
HEAT-SOURCE	HEAT-S	=	______	code-word	See Table IV.42	-	-
ZONE-HEAT-SOURCE	Z-H-S	=	______	code-word	See Table IV.42	-	-
PREHEAT-SOURCE	PREHEAT	=	______	code-word	See Table IV.42	-	-
BASEBOARD-SOURCE	BASEB-S	=	______	code-word	See Table IV.42	-	-
SIZING-RATIO	S-R	=	______	number	1.	0.1	2.
SIZING-OPTION	S-O	=	______	code-word	Note 3	-	-
RETURN-AIR-PATH	R-A-P	=	______	code-word	DIRECT	-	-

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
PLENUM-NAMES	P-N	=	( )	list of U-names (3 max)	–	–	–
ZONE-NAMES	Z-N	=	( )	list of U-names	–	–	–

..

Plus any keywords under the SYSTEM-AIR, SYSTEM-CONTROL, SYSTEM-FANS, SYSTEM-FLUID, SYSTEM-EQUIPMENT, and SYSTEM-TERMINAL commands.

---

* Mandatory keyword.

1) A data entry for this keyword is required to reference a subcommand.

2) Use with MZS, DDS, and PMZS systems only. There is no default.

3) See proper Applicability Table (Sec. IV.B.4) for applicability or default value. If the keyword is not listed in the table, it is not applicable to the system being specified.

13. PLANT-ASSIGNMENT

A special feature of the SYSTEMS program permits specifying, for purposes of comparison, alternative sets of SYSTEMs for a PLANT. Calculations for all specified alternatives are done in one pass through the program, thus minimizing computation costs. The function of the PLANT-ASSIGNMENT instruction is to identify the system, or group of systems, that compose each alternative PLANT. A separate PLANT-ASSIGNMENT instruction is required for each comparison study desired. If no PLANT-ASSIGNMENT is specified, a default PLANT-ASSIGNMENT named DEFAULT-PLANT will be assigned and it will include all of the specified SYSTEMS.

Note that certain SYSTEMS program hourly reports can be obtained by referencing a PLANT-ASSIGNMENT U-name in a REPORT-BLOCK instruction.

PLANT-ASSIGNMENT — informs the SDL Processor that the data to follow will identify the SYSTEM(s), assigned to a PLANT. Up to four different PLANT-ASSIGNMENTs, each with a different U-name, may be specified for comparison study purposes. If a PLANT-ASSIGNMENT is made here in SYSTEMS, a similarly U-named PLANT-ASSIGNMENT must be made in PLANT also (in PLANT only one PLANT-ASSIGNMENT will be processed per computer run).

SYSTEM-NAMES — is a list of the U-names (from the applicable SYSTEM instructions) of those systems (one or more) that make up this particular plant assignment. A maximum of 40 U-names is permitted per plant assignment.

Rules:

1. The same system may not be entered in more than one PLANT-ASSIGNMENT.
2. The assignment of ZONEs to SYSTEMs must be done such that in each PLANT-ASSIGNMENT no ZONE is included more than once.
3. ZONEs that share INTERIOR-WALLs cannot be assigned to different PLANT-ASSIGNMENTs.

Example:

The system illustrated in Fig. IV.1 (Sec. A of this chapter) may be described by the following two instructions.

```
PA-1 = PLANT-ASSIGNMENT

       SYSTEM-NAMES = (S-1, S-2)   ..

PA-2 = PLANT-ASSIGNMENT

       SYSTEM-NAMES = (S-3, S-4)   ..
```

____________________ = PLANT-ASSIGNMENT or P-A (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
SYSTEM-NAMES	S-N	=	(________) ..	list of U-names	*	-	-

*Mandatory keyword.

14. SYSTEMS-REPORT

The function of the SYSTEMS-REPORT instruction is to specify which of the standard verification and summary reports are to be printed. The total of the combined verification and summary reports must not exceed 200 for all zones, systems, and plants. Examples of these reports along with a description of each can be found in Chap. VII of this manual.

The time period(s) covered in the SYSTEMS-REPORTs are the RUN-PERIOD interval(s), see RUN-PERIOD instruction, Chap. III Sec.B.2.

SYSTEMS-REPORT — informs the SDL processor that the data to follow will identify the standard reports that are to be printed. The data entry is the command word itself, no U-name identifier is required or permitted.

VERIFICATION — Input for this keyword is the code-word list that identifies if the standard verification report is to be printed. See Table IV.44 for the code-words and a description of the report each represents.

SUMMARY — Input for this keyword is the code-word list that identifies which of the standard summary reports are to be printed. See Table IV.45 for the code-words and a description of the report each represents. This entry can be omitted if only SS-A, the default report, is desired.

TABLE IV.44

Code-Word	VERIFICATION
SV-A	"System Design Parameters" prints out design parameters for each SYSTEM and each ZONE-within-SYSTEM. These parameters are user-assigned and/or calculated by the program. System parameters include supply fan and return fan cfm, fan power consumption, and duct temperature change. Also provided at the SYSTEM level are outside air cfm, total cooling capacity, sensible cooling capacity, COOLING-EIR, heating capacity, HEATING-EIR, and altitude multiplier. At the ZONE level the following are provided for each ZONE: supply and exhaust fan cfm and power consumption, MIN-CFM-RATIO, outside air cfm, total cooling capacity, sensible cooling capacity, heat extraction rate, heating capacity, heating addition rate, and ZONE multiplier.
REPORT-ONLY	Requested verification report is printed but the program does not proceed with the actual hour-by-hour simulation. If this code-word is specified, no PLANT simulation can be requested following this SYSTEM input because no SYSTEM simulation is performed. This is a convenient way of getting only the equipment sizing information without paying for a complete simulation.

TABLE IV.45

Code-Word	SUMMARY
SS-A	SYSTEM MONTHLY LOADS SUMMARY - Summarizes, by month and year, the heating, cooling, and electrical consumption of each total system (central system plus associated zone systems). For each month there are listed maximum hourly load, the time of maximum hourly load (with exterior wet- and dry-bulb temperatures), and the cumulative loads on the PLANT by this system.
SS-B	SYSTEM MONTHLY LOADS SUMMARY - Summarizes, by month and year, the heating and cooling consumption of the HVAC-equipment located in all the zones of each system (that is HVAC equipment that is remote to the central system such as zone heating and cooling coils). For each month there are listed the maximum hourly load, the cumulative load, the baseboard heating cumulative and maximum loads, and the preheat cumulative and maximum loads.
SS-C	SYSTEM MONTHLY LOAD HOURS - Summarizes, by month, the number of cooling load hours, heating load hours, and concurrent heating/cooling hours. Also summarized by month are the heating load at the time of the cooling peak and the electric load at the time of the cooling peak.
SS-D	PLANT MONTHLY LOADS SUMMARY - Summarizes, by month and year, the heating, cooling, and electrical consumption of all systems associated with the plant (or each PLANT-ASSIGNMENT since a maximum of four PLANT-ASSIGNMENTs may be made for a single computer run). For each month there are listed the maximum hourly load, the time of maximum hourly load (with exterior wet- and dry-bulb temperatures), and the cumulative loads.
SS-E	PLANT MONTHLY LOAD HOURS - Summarizes for all systems in the plant (or PLANT-ASSIGNMENT), by month, the number of cooling load hours, heating load hours, and concurrent heating/cooling hours. Also summarized by month are the heating loads at the time of the cooling peak and the electric loads at the time of the cooling peak.
SS-F	ZONE MONTHLY DEMAND SUMMARY - Summarizes, by month, for each zone of each system named in a PLANT-ASSIGNMENT instruction, the heating and cooling loads, the baseboard heating cumulative and maximum hourly loads, the maximum zone temperature, the minimum zone temperature, and the number of hours that the loads were not met (that is, underheated and/or undercooled).

TABLE IV.45 (contd)

SS-G	ZONE MONTHLY LOADS SUMMARY - Summarizes, by month and year, the heating, cooling, and electrical consumption of each zone of each system named in the PLANT-ASSIGNMENT instruction. For each month there are listed the maximum hourly load, the time of maximum hourly load (with wet- and dry-bulb temperatures), and the cumulative loads.
SS-H	SYSTEM MONTHLY LOADS SUMMARY - Summarizes, by month and year, the maximum hourly fan load and the cumulative fan load, the maximum and cumulative gas or oil used for heating, plus the maximum and cumulative electric energy used for both heating and cooling.
SS-I	SYSTEM MONTHLY COOLING LOAD SUMMARY - Summarizes, by month and year, the cumulative cooling loads for each SYSTEM in the building. Summarized for each month are sensible cooling load, latent cooling load, maximum hourly cooling load (sensible plus latent) and the corresponding sensible heat ratio during the maximum, and the day and hour of the month that the maximum cooling occurs.
SS-J	SYSTEM PEAK HEATING AND COOLING DAYS - Gives an hourly profile of the peak cooling day and the peak heating day for each SYSTEM in the building. The peak cooling day is defined as that day, during the RUN-PERIOD, which contains the hour with the maximum cooling load; the peak heating day is similarly defined. The items reported for each hour of the peak cooling day are cooling energy, sensible heat ratio, outdoor dry-bulb temperature, and outdoor wet-bulb temperature. The items reported for each hour of the peak heating day are heating energy, outdoor dry-bulb temperature, and outdoor wet-bulb temperature.
ALL-SUMMARY	Produces reports SS-A through SS-J.

SYSTEMS-REPORT or S-R (User Worksheet)

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
VERIFICATION	V	=	(____________)	list of code-words	SV-A	-	-
SUMMARY	S	=	(____________)	list of code-words	SS-A	-	-
			..				

15. HOURLY-REPORT

The HOURLY-REPORT instruction directs the program to print the hourly values of all variables specified in one or more REPORT-BLOCK instructions.

HOURLY-REPORT — This command tells the program that the data to follow specify hourly output reports on the simulation data.

REPORT-SCHEDULE — is the U-name of a previously specified schedule which will be used here for report generation purposes. An hourly schedule value of zero (0) indicates no report values this hour; one (1) indicates print report values this hour.

REPORT-BLOCK — Input for this keyword is a code-word list of U-names that have been specified under one or more REPORT-BLOCK instructions. The total number of variables under all REPORT-BLOCKs listed must not exceed 60.

Note: If DAYLIGHT-SAVINGS = YES, summer hours will reflect standard time, not daylight saving time.

For more information on HOURLY-REPORT see Chap. II (BDL) and for information on plotted output see HOURLY-REPORT in Chap. III (LOADS).

____________________ = HOURLY-REPORT or H-R (User Worksheet)
U-name**

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Max.
LIKE	-	=	__________	U-name	-	-	-
REPORT-SCHEDULE	R-SCH	=	__________	U-name	**	-	-
REPORT-BLOCK	R-B	=	(__________)	list of U-names*	**	-	-
OPTION	O	=	__________	code-word	PRINT	-	-
AXIS-ASSIGN	A-A	=	(__________)	list of integers	1	1	2
AXIS-TITLES	A-T	=	(__________)	list of literals	-	-	-
AXIS-MAX	A-MAX	=	(__________)	list of numbers	-	-	-
AXIS-MIN	A-MIN	=	(__________)	list of numbers	-	-	-
DIVIDE	-	=	(__________)	list of numbers	1.	-	-

..

* Maximum of 30.
** Mandatory keyword, if HOURLY-REPORT is specified.

16. REPORT-BLOCK

The REPORT-BLOCK instruction is used to specify a group of variables for an hourly output report.

REPORT-BLOCK	This command tells the program that the data to follow specify the variables to be included in an HOURLY-REPORT.
VARIABLE-TYPE	is a code-word or a U-name, depending upon which VARIABLE-TYPE is chosen. All variables are classified by VARIABLE-TYPE and appear in Tables IV.46 through IV.49. Permissible values are GLOBAL, U-name of a defined ZONE, U-name of a defined SYSTEM, or U-name of a defined PLANT-ASSIGNMENT.
VARIABLE-LIST	is a list of code-numbers which designate which variables are to be included in the HOURLY-REPORT (see tables of VARIABLE-TYPE). Not all variables are appropriate to every SYSTEM-TYPE or system configuration. Some of the variables are intended for code debugging purposes only. The user should not request HOURLY-REPORTs on unappropriate variables because meaningless data will appear in the HOURLY-REPORTs. To assist the user in selecting the appropriate variables, a table, which relates the variables to SYSTEM-TYPE, has been included at the end of each VARIABLE-TYPE listing. The variables are printed in the order specified in this list.

For more information on REPORT-BLOCK see Chap. II (BDL).

____________________ = REPORT-BLOCK or R-B (User Worksheet)
U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	–	=	________	U-name	–	–	–
VARIABLE-TYPE	V-T	=	________	code-word or U-name	*	–	–
VARIABLE-LIST	V-L	=	(________) ..	list of code-numbers	*	1.	75.

*Mandatory keyword, if REPORT-BLOCK is specified.

TABLE IV.46

VARIABLE-TYPE = GLOBAL

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	IYR	Year of simulation run
2	IMO	Month of simulation run
3	IDAY	Day of simulation run
4	IHR	Hour of simulation run
5	ISCDAY	Day-of-the-week for simulation run (1-7 = Sun-Sat; 8 = holiday)
6	ISCHR	Current hour of simulation run plus daylight saving time flag. (Hour of schedule to be used.)
7	WBT	Outdoor wet-bulb temperature (°F)
8	DBT	Outdoor dry-bulb temperature (°F)
9	PATM	Outdoor atmospheric pressure (in-Hg)
10	HUMRAT	Outdoor humidity ratio (lb H_2O/lb dry air)
11	DENSTY	Outdoor air density (lb/ft^3)
12	ENTHAL	Outdoor air enthalpy (Btu/lb)

The above variables are appropriate to all SYSTEM-TYPEs.

TABLE IV.47

VARIABLE-TYPE = U-name of ZONE

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	<QS>	Sensible load at constant temp - from LOADS (Btu)
2	<QL>	Latent load at constant temp, excluding infiltration - from LOADS (Btu)
3	<ZKW>	Zone electrical load - from LOADS (kW)
4	<QP>	Plenum load - from LOADS (Btu)
5	<CFMINF>	Outdoor air infiltration rate from LOADS (cfm)
6	<TNOW>	Current hour zone temp (°F)
7	<TSET>	Current hour zone thermostat setting - a diagnostic variable that is not meaningful when <TNOW> is not within HEAT-TEMP-SCH or COOL-TEMP-SCH throttling range (°F)
8	<QNOW>	Current hour heat extraction rate - a diagnostic variable that is not meaningful when <TNOW> is not within HEAT-TEMP-SCH or COOL-TEMP-SCH throttling range (Btu)
9	<CONDUCHR>	Sum of exterior wall + interior wall thermal conductances from LOADS
10	Unused	Unused
11	EXCFM	Exhaust air flow rate (cfm)
12	FH	Hot air flow rate (cfm)
13	FC	Cold air flow rate (cfm)
14	CFMZ	Zone design supply air rate (cfm)
15	QHBZ	Baseboard heat output to zone (Btu)
16	QOVER	Amount of extra heat extraction needed to hold set point (Btu)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
17	THZ	Thermostat set point for heating (°F)
18	TCZ	Thermostat set point for cooling (°F)
19	ERMAX	Maximum heat extraction rate - meaningful only within the current thermostat band (Btu/hr)
20	ERMIN	Minimum heat extraction rate - meaningful only within the current thermostat band (-Btu/hr)
21	TRY	Trial zone temperature (if no zone coil activity) (°F)
22	FTD	F in TEMDEV (Btu/hr)
23	CORINT	A part of the correction in SYSTEMS for the contribution to the zone load from adjacent zones (partially calculated in LOADS) (Btu/hr)
24	G0	Air temperature weighting factors
25	G1	Air temperature weighting factors
26	G2	Air temperature weighting factors
27	G3	Air temperature weighting factors
28	SIGMAG	G0 + G1 + G2 + G3
29	TL	Induced air temperature for TPIU, FPIU, SZCI (°F)
30	ZQHR	Portion of reheat load that would bring the supply temperature to the zone temperature (Btu)
31	TAVE	The average temperature during this hour (°F) This is the value used for the energy calculation
32	ZQH	Zone coil heating (Btu)
33	ZQC	Zone coil cooling (Btu)

VARIABLE-TYPE = U-name of ZONE (cont)

VARIABLE-LIST Number		Variable in FORTRAN Code					Description
		The following 15 variables apply only to the systems indicated:					
		TPFC FPFC	HP	UHT	UVT	PTAC	
34	FCHPS (1)	TC	TS	–	TS	TS	Cold deck temperature (°F)
35	FCHPS (2)	QH	ZQH	ZQH	ZQH	ZQH	Total and zone heating (Btu)
36	FCHPS (3)	QC	ZQC	–	–	ZQC	Total and zone cooling (Btu)
37	FCHPS (4)	SFKW+RFKW	ZFANKW	ZFANKW	ZFANKW	ZFANKW	Total and zone fan energy (Btu)
38	FCHPS (5)	TM	TM	–	TM	TM	Temperature of mixed air (°F)
39	FCHPS (6)	WR	TC	–	–	TC	WR = return humidity ratio and TC is coil leaving temperature
40	FCHPS (7)	WM	WM	–	–	WM	Mixed air humidity ratio (lb H_2O/lb dry air)
41	FCHPS (8)	WCOIL	WCOIL	–	–	WCOIL	Humidity ratio of air leaving cooling coil (lb H_2O/lb dry air)
42	FCHPS (9)	PO	PO	–	PO	PO	Ratio of outside air to total supply air
43	FCHPS(10)	QCLAT	QCLATZ	–	–	QCLATZ	Latent load (Btu)
44	FCHPS(11)	PLRC	PLRC	–	–	PLRC	Capacity part load ratio (cooling)
45	FCHPS(12)	–	PLRH	–	–	PLRH	Capacity part load ratio (heating)
46	FCHPS(13)	–	EIR	–	–	EIR	Electric input ratio
47	FCHPS(14)	WBTZ	WBTZ	–	–	WBTZ	Zone wet-bulb temperature (°F)
48	FCHPS(15)	–	–	–	–	EIRM3	Defrost
49	ACFM						Weighted plenum cfm
50	ZKW						Total zone electrical (kW)
51	TCMINZ						Minimum supply temperature for the zone (°F)
52	THMAXZ						Maximum supply temperature for the zone (°F)
53	ERMAXM		All air systems				The extraction rate (Btu/hr) at the top of the dead band
54	ERMINM		All air systems				The extraction rate at the bottom of the dead band (Btu/hr)
55	THR		All air systems				(THROTTLING-RANGE)/2.0

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of ZONE

V-L No.-->	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SYSTEM -TYPE	SENSIBLE LOAD-IN	LATENT LOAD-IN	ELECTRIC LOAD-IN	PLENUM LOAD-IN	INFILTRN CFM	ZONE TEMP	THERMOST SETPOINT	EXTRACTN RATE	TOTAL UA FOR HOUR	ITEM 10	EXHAUST CFM	HOT DECK CFM	CLD DECK CFM	SUPPLY CFM
SUM	A	A	A	A	A	A	A	A	A	N	N	N	N	N
SZRH	A	A	A	A	A	A	A	A	A	N	A	N	N	A
MZS	A	A	A	A	A	A	A	A	A	N	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	N	A	A	A	A
SZCI	A	A	A	A	A	A	A	A	A	N	A	N	N	A
UHT	A	A	A	A	A	A	A	A	A	N	N	A	N	A
UVT	A	A	A	A	A	A	A	A	A	N	N	A	N	A
FPH	A	A	A	A	A	A	A	A	A	N	N	N	N	N
TPFC	A	A	A	A	A	A	A	A	A	N	A	N	N	A
FPFC	A	A	A	A	A	A	A	A	A	N	A	N	N	A
TPIU	A	A	A	A	A	A	A	A	A	N	A	N	N	A
FPIU	A	A	A	A	A	A	A	A	A	N	A	N	N	A
VAVS	A	A	A	A	A	A	A	A	A	N	A	N	N	A
RHFS	A	A	A	A	A	A	A	A	A	N	A	N	N	A
HP	A	A	A	A	A	A	A	A	A	N	A	A	A	A
HVSYS	A	A	A	A	A	A	A	A	A	N	A	N	N	A
CBVAV	A	A	A	A	A	A	A	A	A	N	A	N	N	A
RESYS	A	A	A	A	A	A	A	A	A	N	N	N	N	N
PSZ	A	A	A	A	A	A	A	A	A	N	A	N	N	A
PMZS	A	A	A	A	A	A	A	A	A	N	A	A	A	A
PVAVS	A	A	A	A	A	A	A	A	A	N	A	N	N	A
PTAC	A	A	A	A	A	A	A	A	A	N	N	A	A	A

Legend:
- A = Appropriate
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- S = System (or configuration) dependent
- D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of ZONE (cont.)

V-L No.--> SYSTEM -TYPE	15 BASEBRD HTG RATE	16 LOAD NOT MET	17 HTG SET POINT	18 CLG SET POINT	19 MAXIMUM COOLING	20 MAXIMUM HEATING	21 FLOAT TEMP	22 F IN TEMDEV	23 INT TRAN TO ZONE	24 TEMDEV VAR G0	25 TEMDEV VAR G1	26 TEMDEV VAR G2	27 TEMDEV VAR G3	28 TEMDEV SIGMAG
SUM	A	A	A	A	A	A	A	D	A	D	D	D	D	D
SZRH	A	A	A	A	A	A	A	D	A	D	D	D	D	D
MZS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
DDS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
SZCI	A	A	A	A	A	A	A	D	A	D	D	D	D	D
UHT	A	A	A	A	A	A	A	D	A	D	D	D	D	D
UVT	A	A	A	A	A	A	A	D	A	D	D	D	D	D
FPH	A	A	A	A	A	A	A	D	A	D	D	D	D	D
TPFC	A	A	A	A	A	A	A	D	A	D	D	D	D	D
FPFC	A	A	A	A	A	A	A	D	A	D	D	D	D	D
TPIU	A	A	A	A	A	A	A	D	A	D	D	D	D	D
FPIU	A	A	A	A	A	A	A	D	A	D	D	D	D	D
VAVS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
RHFS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
HP	A	A	A	A	A	A	A	D	A	D	D	D	D	D
HVSYS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
CBVAV	A	A	A	A	A	A	A	D	A	D	D	D	D	D
RESYS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
PSZ	A	A	A	A	A	A	A	D	A	D	D	D	D	D
PMZS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
PVAVS	A	A	A	A	A	A	A	D	A	D	D	D	D	D
PTAC	A	A	A	A	A	A	A	D	A	D	D	D	D	D

Legend:
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D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of ZONE (cont.)

V-L No.-->	29	30	31	32	33	34	35	36	37	38	39	40	41	42
SYSTEM -TYPE	IND UNIT AIR TEMP	HEAT TO ZONE T	COOL TO ZONE T	HEATING BY COILS	COOLING BY COILS	UNIT SUP TEMP	UNIT HEATING	UNIT COOLING	UNIT FAN KW	UNIT MIX TEMP	UNIT WR OR TC	UNIT MIX HUM	UNIT COIL HUM	UNIT OA-RATIO
SUM	N	N	N	N	N	N	N	N	N	N	N	N	N	N
SZRH	N	A	N	A	N	N	N	N	N	N	N	N	N	N
MZS	N	N	N	N	N	N	N	N	N	N	N	N	N	N
DDS	N	N	N	N	N	N	N	N	N	N	N	N	N	N
SZCI	A	A	N	A	N	N	N	N	N	N	N	N	N	N
UHT	N	N	N	A	A	A	A	A	A	A	S	A	A	A
UVT	N	N	N	A	A	A	A	A	A	A	S	A	A	A
FPH	N	N	N	A	N	N	N	N	N	N	N	N	N	N
TPFC	N	N	N	A	A	A	A	A	A	A	S	A	A	A
FPFC	N	N	N	A	A	A	A	A	A	A	S	A	A	A
TPIU	A	N	N	A	N	N	N	N	N	N	N	N	N	N
FPIU	A	N	N	A	N	N	N	N	N	N	N	N	N	N
VAVS	N	A	N	A	N	N	N	N	N	N	N	N	N	N
RHFS	N	A	N	A	N	N	N	N	N	N	N	N	N	N
HP	N	N	N	A	A	A	A	A	A	A	A	A	A	A
HVSYS	N	A	N	A	N	N	N	N	N	N	N	N	N	N
CBVAV	N	A	N	A	N	N	N	N	N	N	N	N	N	N
RESYS	N	N	N	N	N	N	N	N	N	N	N	N	N	N
PSZ	N	A	N	A	N	N	N	N	N	N	N	N	N	N
PMZS	N	N	N	N	N	N	N	N	N	N	N	N	N	N
PVAVS	N	A	N	A	N	N	N	N	N	N	N	N	N	N
PTAC	N	N	N	A	A	A	A	A	A	A	S	A	A	A

Legend:
A = Appropriate
N = Not appropriate
S = System (or configuration) dependent
D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of ZONE (cont.)

V-L No.---> SYSTEM -TYPE	43 UNIT LAT COOL	44 UNIT COOL PLR	45 UNIT HEAT PLR	46 UNIT EIR	47 UNIT WETBULB	48 UNIT DEFROST	49 WEIGHTED CFM	50 TOTAL ELEC	51 MINIMUM COOL T	52 MAXIMUM HEAT T	53 DEADBAND MAX EXTR	54 DEADBAND MIN EXTR	55 THROTTLE OVER TWO
SUM	N	N	N	N	N	N	N	A	N	N	N	N	N
SZRH	N	N	N	N	N	N	A	A	A	A	A	A	A
MZS	N	N	N	N	N	N	A	A	A	A	A	A	A
DDS	N	N	N	N	N	N	A	A	A	A	A	A	A
SZCI	N	N	N	N	N	N	A	A	A	A	A	A	A
UHT	A	A	A	A	A	N	N	A	A	A	A	A	A
UVT	A	A	A	A	A	N	N	A	A	A	A	A	A
FPH	N	N	N	N	N	N	N	A	N	N	N	N	N
TPFC	A	A	A	A	A	N	N	A	A	A	A	A	A
FPFC	A	A	A	A	A	N	N	A	A	A	A	A	A
TPIU	N	N	N	N	N	N	A	A	A	A	A	A	A
FPIU	N	N	N	N	N	N	A	A	A	A	A	A	A
VAVS	N	N	N	N	N	N	A	A	A	A	A	A	A
RHFS	N	N	N	N	N	N	A	A	A	A	A	A	A
HP	A	A	A	A	A	A	N	A	A	A	A	A	A
HVSYS	N	N	N	N	N	N	A	A	A	A	A	A	A
CBVAV	N	N	N	N	N	N	A	A	A	A	A	A	A
RESYS	N	N	N	N	N	N	N	A	A	A	A	A	A
PSZ	N	N	N	N	N	N	A	A	A	A	A	A	A
PMZS	N	N	N	N	N	N	A	A	A	A	A	A	A
PVAVS	N	N	N	N	N	N	A	A	A	A	A	A	A
PTAC	A	A	A	A	A	A	N	A	A	A	A	A	A

Legend:
A = Appropriate
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D = For program code debugging only

TABLE IV.48

VARIABLE-TYPE = U-name of SYSTEM

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	TH	Temperature of air leaving heating coil - hot deck temperature (°F)
2	TC	Temperature of air leaving cooling coil - cold deck temperature (°F)
3	TM	Temperature of air entering coil (°F)
4	TR	Return air temperature on the downstream side of the return fan and plenums (°F)
5	QH	Total central heating coil energy input (Btu)
6	QC	Total central cooling coil energy input (Btu)
7	QHZ	Total zone heating energy input (Btu)
8	QCZ	Total zone cooling energy input (Btu). Note: For SYSTEM-TYPE = RESYS this is the total of mechanical cooling and cooling by natural ventilation
9	QHB	Total baseboard heating energy input (Btu)
10	QHP	Total preheat coil energy input (Btu)
11	QHUM	Humidification energy input (electrical resistance heat load for RESYS) (Btu)
12	QDHUM	Sensible dehumidification reheat input (defrost load for RESYS) (Btu)
13	TCMIN	Minimum temperature air handler could supply (°F)
14	THMAX	Maximum temperature air handler could supply (°F)
15	QLSUM	Total system latent heat load from LOADS (Btu)
16	QPSUM	Total system plenum heat load (Btu)
17	CFM	Total system supply air flow rate (cfm)
18	CFMH	Total system hot supply air flow rate (DDS, MZS, PMZS) (cfm)
19	CFMC	Total system cold supply air flow rate (DDS, MZS, PMZS) (cfm)
20	RCFM	Total system return air flow rate (cfm)
21	ECFM	Total system exhaust air flow rate (cfm)
22	CINF	Outside air infiltration rate (cfm)

VARIABLE-TYPE = U-name of SYSTEM (cont)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
23	FON	Fan on/off flag (1 = on, 0 = off, -1 = cannot cycle on for NIGHT-CYCLE-CTRL)
24	HON	Heating on/off flag (1 = on, 0 = off)
25	CON	Cooling on/off flag (1 = on, 0 = off)
26	BON	Baseboard heater on-off flag (ratio from RESET-SCHEDULE)
27	CONS(1)	in the equation Q = CONS(1) * CFM * ΔT CONS(1) = (.24 + .44*HUMRAT)*60.0/V(DBT, HUMRAT, PATM) = 1.08 at standard conditions
28	CONS(2)	in the equation CONS(2) = 1061.0 * 60.0/V(DBT, HUMRAT, PATM) = 4790. at standard conditions
29	CONS(3)	in the equation CONS(3) = .3996/CONS(1) = .363 at standard conditions
30	PH	For dual duct systems: Ratio of hot duct cfm to total cfm
31	PC	For dual duct systems: Ratio of cold duct cfm to total cfm
32	SKW	Hourly total electrical consumption (kW)
33	FANKW	Total of supply fan, return fan, and exhaust fan electrical consumption (kW)
34	DTREC	Makeup air temperature obtainable from recovery system (F$^\circ$)
35	WR	Return air humidity ratio (lb H_2O/lb dry air)
36	WM	Mix air humidity ratio (lb H_2O/lb dry air)
37	WCOIL	Humidity ratio of air leaving cooling coil (lb H_2O/lb dry air)
38	WW	Moisture added or removed from air for (de)humidification (lb H_2O)
39	PO	Ratio of outside air to total supply air
40	D	Density of air x 60 min/hr (lb/ft^3 x min/hr)
41	FTEMP	Temperature of circulating fluid for HP system ($^\circ$F)
42	TCR	Effect of controller on cooling coil set point
43	QHR	Heat pump capacity this hour for RESYS (Btu)

VARIABLE-TYPE = U-name of SYSTEM (cont)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
44	QCR	Unused
45	SGAS	Total gas heating (Btu)
46	SKWQH	Electrical input to heating (kW)
47	SKWQC	Electrical input to cooling (kW)
48	QCLAT	Latent part of total cooling (Btu)
49	SFKW	Supply fan electrical (kW)
50	RFKW	Return fan electrical (kW)
51	FONNGT	If system cycled on at night, = -1 for heating, = 0 for no cycle, = +1 for cooling
52	WSURF	Humidity ratio at saturation at coil surface temperature
53	WSURFM	WSURF for coil temperature TSURFM
54	TSURF	coil surface temperature at supply set point (°F)
55	TSURFM	Minimum obtainable surface temperature for humidity control (°F)
56	CBF	Coil bypass factor: (COIL-BF) * CBF1 * CBF2
57	CBF1	Temperature correction to COIL-BF
58	CBF2	Cfm correction to COIL-BF
59	SOIL	Oil consumption by system
60	PLRCFM	(Current hour cfm)/(design cfm)
61	PLRC	Capacity part load ratio for cooling
62	PLRH	Capacity part load ratio for heating
63	QCM1	Temperature correction to COOLING-CAPACITY
64	QCM2	Temperature correction to COOL-SH-CAP
65	QHM1	Temperature correction to HEATING-CAPACITY
66	EIRM1	Temperature correction to COOLING-EIR
67	EIRM2	Part load correction to COOLING-EIR
68	EIR	(COOLING-EIR) * EIRM1 * EIRM2 (Btu/Btu)
69	OFKW	Outside fan energy
70	QCT	Total cooling capacity (Btu/hr)
71	QCS	Sensible cooling capacity (Btu/hr)

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
72	WRMAX	Maximum humidity set point (lbs. water/lbs. air)
73	WRMIN	Minimum humidity set point (lbs. water/lbs. air)
74	CFMRAT	Maximum ratio of zone cfm that can be obtained this hour (mainly for COINCIDENT-sized fans)
75	PCH	For DDS, MZS, and PMZS the current hour value of HCOIL-WIPE-FCFM. For RESYS the value of 1. indicates venting and the value of 0. indicates no venting
76	unused	
77	unused	
78*	QHT	The total heating capacity
79*	TPOMIN	The mixed air temperature for minimum OA damper position
80*	POMIN	The minimum OA damper position

*These variable do not apply to SUM, FPH, or any zonal SYSTEM-TYPEs.

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of SYSTEM

V-L No.--> SYSTEM -TYPE	1 HTG COIL AIR TEMP	2 CLG COIL AIR TEMP	3 MIXED AIR TEMP	4 RETURN AIR TEMP	5 TOT HTG COIL BTU	6 TOT CLG COIL BTU	7 TOT ZONE HTG BTU	8 TOT ZONE CLG BTU	9 TOT BSBD ENERGY	10 TOT PREH ENERGY	11 HUMIDCN HEATING	12 DEHUMID REHEAT	13 MIN SUP T	14 MAX SUP T
SUM	N	N	N	N	A	A	N	N	N	N	N	N	N	N
SZRH	N	A	A	A	A	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	A	N	N	A	A	A	A	A	A
DDS	A	A	A	A	A	A	N	N	A	A	A	A	A	A
SZCI	N	A	A	A	A	A	A	A	A	A	A	A	A	A
UHT	N	N	N	N	A	A	A	N	A	N	N	N	N	N
UVT	N	N	N	N	A	A	A	N	A	N	N	N	N	N
FPH	N	N	N	N	A	N	A	N	A	N	N	N	N	N
TPFC	N	N	N	N	A	A	A	A	A	N	A	A	N	N
FPFC	N	N	N	N	A	A	A	A	A	N	A	A	N	N
TPIU	N	A	A	A	A	A	A	A	A	A	A	A	A	A
FPIU	N	A	A	A	A	A	A	A	A	A	A	A	A	A
VAVS	N	A	A	A	A	A	A	A	A	A	A	A	A	A
RHFS	N	A	A	A	A	A	A	A	A	A	A	A	A	A
HP	N	N	N	N	A	A	A	A	A	N	N	N	N	N
HVSYS	A	N	A	A	A	N	A	N	A	A	A	N	A	A
CBVAV	N	A	A	A	A	A	A	A	A	A	A	A	A	A
RESYS	A	A	A	A	A	A	A	A	A	A	S	S	A	A
PSZ	N	A	A	A	A	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	N	N	A	A	A	A	A	A
PVAVS	N	A	A	A	A	A	A	A	A	A	A	A	A	A
PTAC	A	N	N	N	A	A	A	A	A	N	N	N	N	N

Legend:
A = Appropriate
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S = System (or configuration) dependent
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VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of SYSTEM (cont.)

V-L No.-->	15	16	17	18	19	20	21	22	23	24	25	26	27	28
SYSTEM -TYPE	SUM ZONE LAT HEAT	SUM ZONE PLN HEAT	TOT SYST CFM	TOT HOT CFM	TOT COLD CFM	RETURN CFM	EXHAUST CFM	INFILTRN CFM	FANS ON-OFF	HEAT ON-OFF	COOL ON-OFF	BSBD SCH RATIO	CONSTANT (1.08)	CONSTANT (.6890)
SUM	A	A	N	N	N	N	N	A	A	A	A	N	N	N
SZRH	A	A	A	N	N	A	A	A	A	A	A	A	A	A
MZS	A	A	A	A	A	A	A	A	A	A	A	A	A	A
DDS	A	A	A	A	A	A	A	A	A	A	A	A	A	A
SZCI	A	A	A	N	N	A	A	A	A	A	A	A	A	A
UHT	N	N	N	N	N	N	N	N	A	A	A	A	A	A
UVT	N	N	N	N	N	N	N	N	A	A	A	A	A	A
FPH	N	N	N	N	N	N	N	N	N	A	N	A	N	N
TPFC	N	N	N	N	N	N	N	N	A	A	A	A	A	A
FPFC	N	N	N	N	N	N	N	N	A	A	A	A	A	A
TPIU	A	A	A	N	N	A	A	A	A	A	A	A	A	A
FPIU	A	A	A	N	N	A	A	A	A	A	A	A	A	A
VAVS	A	A	A	N	N	A	A	A	A	A	A	A	A	A
RHFS	A	A	A	N	N	A	A	A	A	A	A	A	A	A
HP	N	N	N	N	N	N	N	N	A	A	A	A	A	A
HVSYS	A	A	A	N	N	A	A	A	A	A	A	A	A	A
CBVAV	A	A	A	N	N	A	A	A	A	A	A	A	A	A
RESYS	A	A	A	N	N	N	N	A	A	A	A	A	A	A
PSZ	A	A	A	N	N	A	A	A	A	A	A	A	A	A
PMZS	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PVAVS	A	A	A	N	N	A	A	A	A	A	A	A	A	A
PTAC	N	N	N	N	N	N	N	N	A	A	A	A	A	A

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VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of SYSTEM (cont.)

V-L No.--> SYSTEM -TYPE	29 CONSTANT (.363)	30 HOT AIR FRACTION	31 COLD AIR FRACTION	32 TOTAL ELEC KW	33 TOTAL FAN ELEC	34 DELTA-T RECOVERY	35 RETURN HUMID	36 MIX HUMID	37 HUMIDITY LVG COIL	38 MOIST CHANGE	39 OUTSIDE/ TOT CFM	40 DENSITY AIR*60	41 TEMP OF FLUID	42 COOL-CTR EFFECT
SUM	N	N	N	A	N	N	N	N	N	N	N	N	N	N
SZRH	A	N	N	A	A	A	A	A	A	A	A	A	N	A
MZS	A	A	A	A	A	A	A	A	A	A	A	A	N	A
DDS	A	A	A	A	A	A	A	A	A	A	A	A	N	A
SZCI	A	N	N	A	A	A	A	A	A	A	A	A	N	A
UHT	A	N	N	A	A	N	N	N	N	N	N	N	N	N
UVT	A	N	N	A	A	N	N	N	N	N	N	N	N	N
FPH	N	N	N	A	N	N	N	N	N	N	N	N	N	N
TPFC	A	N	N	A	A	N	N	N	N	N	N	N	N	N
FPFC	A	N	N	A	A	N	N	N	N	N	N	N	N	N
TPIU	A	N	N	A	A	A	A	A	A	A	A	A	N	A
FPIU	A	N	N	A	A	A	A	A	A	A	A	A	N	A
VAVS	A	N	N	A	A	A	A	A	A	A	A	A	N	A
RHFS	A	N	N	A	A	A	A	A	A	A	A	A	N	A
HP	A	N	N	A	A	N	N	N	N	N	N	N	A	N
HVSYS	A	N	N	A	A	A	A	A	A	A	A	A	N	N
CBVAV	A	N	N	A	A	A	A	A	A	A	A	A	N	A
RESYS	A	N	N	A	A	N	N	A	A	A	N	N	N	N
PSZ	A	N	N	A	A	A	A	A	A	A	A	A	N	A
PMZS	A	A	A	A	A	A	A	A	A	A	A	A	N	A
PVAVS	A	N	N	A	A	A	A	A	A	A	A	A	N	A
PTAC	A	N	N	A	A	N	N	N	N	N	N	N	N	N

Legend:
A = Appropriate
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S = System (or configuration) dependent
D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of SYSTEM (cont.)

V-L No.-->	43	44	45	46	47	48	49	50	51	52	53	54	55	56
SYSTEM -TYPE	QHR	QCR	HEATING GAS	HEATING ELEC	COOLING ELEC	LATENT COOLING	SUPPLY ELEC	RETURN ELEC	CYCLE ON H/OFF/C	SURFACE HUMIDITY	SURFACE MIN HUM	SURFACE TEMP	SURFACE MIN TEMP	BYPASS FACTOR
SUM	N	N	A	A	N	N	N	N	A	N	N	N	N	N
SZRH	A	N	A	A	A	A	A	A	A	A	A	A	A	A
MZS	N	N	A	A	A	A	A	A	A	A	A	A	A	A
DDS	N	N	A	A	A	A	A	A	A	A	A	A	A	A
SZCI	A	N	A	A	A	A	A	A	A	A	A	A	A	A
UHT	N	N	A	A	N	N	N	N	A	N	N	N	N	N
UVT	N	N	A	A	N	N	N	N	A	N	N	N	N	N
FPH	N	N	N	A	N	N	N	N	A	N	N	N	N	N
TPFC	N	N	A	A	N	A	N	N	A	N	N	N	N	N
FPFC	N	N	A	A	N	A	N	N	A	N	N	N	N	N
TPIU	N	N	A	A	N	A	A	A	A	A	A	A	A	A
FPIU	N	N	A	A	N	A	A	A	A	A	A	A	A	A
VAVS	A	N	A	A	N	A	A	A	A	A	A	A	A	A
RHFS	A	N	A	A	N	A	A	A	A	A	A	A	A	A
HP	N	N	N	A	A	A	A	N	A	N	N	N	N	N
HVSYS	N	N	A	A	N	N	A	A	A	N	N	N	N	N
CBVAV	A	N	A	A	N	A	A	A	A	A	A	A	A	A
RESYS	N	N	A	A	A	A	A	N	A	A	A	A	A	A
PSZ	A	N	A	A	A	A	A	A	A	A	A	A	A	A
PMZS	A	N	A	A	A	A	A	A	A	A	A	A	A	A
PVAVS	A	N	A	A	A	A	A	A	A	A	A	A	A	A
PTAC	N	N	A	A	A	A	N	N	A	N	N	N	N	N

Legend:
A = Appropriate
N = Not appropriate
S = System (or configuration) dependent
D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of SYSTEM (cont.)

V-L No.-->	57	58	59	60	61	62	63	64	65	66	67	68	69	70
SYSTEM -TYPE	CBF F(WB,DB)	CBF F(CFM)	HEATING OIL	PLR CFM	PLR COOLING	PLR HEATING	COOL-CAP F(WB,DB)	COOL-SH F(WB,DB)	HEAT-CAP F(TEMP)	EIR F(WB,DB)	EIR F(PLR)	EIR	OUTSIDE FAN KW	COOLING CAPACITY
SUM	N	N	A	N	N	N	N	N	N	N	N	N	N	N
SZRH	A	A	A	A	A	N	A	A	N	N	N	N	N	A
MZS	A	A	A	A	A	N	A	A	N	N	N	N	N	A
DDS	A	A	A	A	A	N	A	A	N	N	N	N	N	A
SZCI	A	A	A	A	A	N	A	A	N	N	N	N	N	A
UHT	N	N	A	N	N	N	N	N	N	N	N	N	N	N
UVT	N	N	A	N	N	N	N	N	N	N	N	N	N	N
FPH	N	N	A	N	N	N	N	N	N	N	N	N	N	N
TPFC	N	N	A	N	N	N	N	N	N	N	N	N	N	N
FPFC	N	N	A	N	N	N	N	N	N	N	N	N	N	N
TPIU	A	A	A	A	A	N	A	A	N	N	N	N	N	A
FPIU	A	A	A	A	A	N	A	A	N	N	N	N	N	A
VAVS	A	A	A	A	A	N	A	A	N	N	N	N	N	A
RHFS	A	A	A	A	A	N	A	A	N	N	N	N	N	A
HP	N	N	A	N	N	N	N	N	N	N	N	N	N	N
HVSYS	N	N	A	N	N	N	N	N	N	N	N	N	N	A
CBVAV	A	A	A	A	A	N	A	A	N	N	N	N	N	A
RESYS	A	A	A	A	A	A	A	A	A	A	A	A	A	A
PSZ	A	A	A	A	A	N	A	A	N	A	A	A	A	A
PMZS	A	A	A	A	A	N	A	A	N	A	A	A	A	A
PVAVS	A	A	A	A	A	N	A	A	N	A	A	A	A	A
PTAC	N	N	A	N	N	N	N	N	N	N	N	N	N	A

Legend:
A = Appropriate
N = Not appropriate
S = System (or configuration) dependent
D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of SYSTEM (cont.)

V-L No.--->	71	72	73	74	75	76	77	78	79	80
SYSTEM -TYPE	SENSIBLE CAPACITY	MAX-HUMD SETPOINT	MIN-HUMD SETPOINT	VAV MAX CFM RAT	ITEM 75	UNUSED		HEATING CAPACITY	TEMP AT MIN OA	MINIMUM OA EST
SUM	N	N	N	N	N			N	N	N
SZRH	A	A	A	A	N			A	A	A
MZS	A	A	A	A	S			A	A	A
DDS	A	A	A	A	S			A	A	A
SZCI	A	A	A	N	N			A	A	A
UHT	N	N	N	N	N			N	N	N
UVT	N	N	N	N	N			N	N	N
FPH	N	N	N	N	N			N	N	N
TPFC	N	N	N	N	N			N	N	N
FPFC	N	N	N	N	N			N	N	N
TPIU	A	A	A	N	N			A	A	A
FPIU	A	A	A	N	N			A	A	A
VAVS	A	A	A	A	N			A	A	A
RHFS	A	A	A	A	N			A	A	A
HP	N	N	N	N	N			N	N	N
HVSYS	A	A	A	N	N			A	A	A
CBVAV	A	A	A	N	N			A	A	A
RESYS	A	A	A	N	A			N	N	N
PSZ	A	A	A	A	N			A	A	A
PMZS	A	A	A	A	S			A	A	A
PVAVS	A	A	A	A	N			A	A	A
PTAC	A	A	A	N	N			N	N	N

Legend:
A = Appropriate
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TABLE IV.49

VARIABLE-TYPE = U-name of PLANT-ASSIGNMENT

VARIABLE-LIST Number	Variable in FORTRAN Code	Description
1	<QCPL>	Total cooling load (Btu)
2	<QHPL>	Total heating load (Btu)
3	<PKW>	Total electrical load (kW)
4	<PGAS>	Total gas load (Btu)
5	<PKWQH>	Portion of <PKW> used for heating
6	<PKWQC>	Portion of <PKW> used for cooling
7	<PFANKW>	Portion of <PKW> used for fans
8	<POIL>	Total oil load (Btu)
9		unused
10		unused
11	QHMP	Main coil heating load (Btu)
12	TMP	Main coil average entering temperature (°F)
13	CFMP	Main coil cfm
14	QHPP	Preheat coil heating load (Btu)
15	CFMPP	Preheat coil cfm (if in outside air duct)
16	QHZP	Zone coil load (Btu)
17	TZP	Zone coil average entering temperature (°F)*
18	CFMZP	Zone coil cfm
19	QHBP	Baseboard load (Btu)**
20		unused

* Loop temperature for HP or zone temperature for RESYS.

** Includes HP load for loop.

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of PLANT-ASSIGNMENT

V-L No.-->	1	2	3	4	5	6	7	8	9	10	11	12	13	14
SYSTEM -TYPE	COOLING LOAD	HEATING LOAD	ELECT KW LOAD	HEATING GAS	HEATING ELEC KW	COOLING ELEC KW	FANS ELEC KW	HEATING OIL	ITEM 9	ITEM 10	MAIN HC CBS LOAD	MAIN HC CBS TEMP	MAIN HC CBS CFM	PREHEAT CBS LOAD
SUM	A	A	A	A	A	N	N	A	N	N	N	N	N	N
SZRH	A	A	A	A	A	N	A	A	N	N	A	A	A	A
MZS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
DDS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
SZCI	A	A	A	A	A	N	A	A	N	N	A	A	A	A
UHT	A	A	A	A	A	N	A	A	N	N	N	N	N	N
UVT	A	A	A	A	A	N	A	A	N	N	N	N	N	N
FPH	A	A	A	A	A	N	N	A	N	N	N	N	N	N
TPFC	A	A	A	A	A	N	A	A	N	N	N	N	N	N
FPFC	A	A	A	A	A	N	A	A	N	N	N	N	N	N
TPIU	A	A	A	A	A	N	A	A	N	N	A	A	A	A
FPIU	A	A	A	A	A	N	A	A	N	N	A	A	A	A
VAVS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
RHFS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
HP	A	A	A	A	A	A	A	A	N	N	N	N	N	N
HVSYS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
CBVAV	A	A	A	A	A	N	A	A	N	N	A	A	A	A
RESYS	A	A	A	A	A	A	A	A	N	N	A	A	A	N
PSZ	A	A	A	A	A	N	A	A	N	N	A	A	A	A
PMZS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
PVAVS	A	A	A	A	A	N	A	A	N	N	A	A	A	A
PTAC	A	A	A	A	A	A	A	A	N	N	N	N	N	N

Legend:
A = Appropriate
N = Not appropriate
S = System (or configuration) dependent
D = For program code debugging only

VARIABLES BY SYSTEM-TYPE FOR VARIABLE-TYPE = U-name of PLANT-ASSIGNMENT (cont.)

V-L No.-->	15	16	17	18	19
SYSTEM -TYPE	PREHEAT CBS CFM	ZONEHEAT CBS LOAD	ZONEHEAT CBS TEMP	ZONEHEAT CBS CFM	BASEBRD CBS LOAD
SUM	N	N	N	N	N
SZRH	A	A	A	A	A
MZS	A	N	A	A	A
DDS	A	N	A	A	A
SZCI	A	A	A	A	A
UHT	N	A	A	A	A
UVT	N	A	A	A	A
FPH	N	N	N	N	N
TPFC	N	A	A	A	A
FPFC	N	A	A	A	A
TPIU	A	A	A	A	A
FPIU	A	A	A	A	A
VAVS	A	A	A	A	A
RHFS	A	A	A	A	A
HP	N	N	N	N	A
HVSYS	A	A	A	A	A
CBVAV	A	A	A	A	A
RESYS	N	A	A	A	A
PSZ	A	A	A	A	A
PMZS	A	A	A	A	A
PVAVS	A	A	A	A	A
PTAC	N	A	A	A	A

Legend:
A = Appropriate
N = Not appropriate
S = System (or configuration) dependent
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D. SIMULATION METHODOLOGY

1. System Design Calculations

The following explains how the SYSTEMS simulator utilizes the user-specified data (plus data from LOADS) to first size the HVAC equipment and then to simulate the performance of the system.

There are many ways that the system equipment sizing can be performed by the program in conjunction with the user, but all the available methods fall between two extremes:

a) at one end of this sizing spectrum, the user supplies to SYSTEMS a minimum amount of data and then allows SYSTEMS to size the equipment and simulate the behavior of the system. In this approach, the user supplies values for only the required (mandatory) commands and keywords. The SYSTEMS design routine supplies all the missing values (by default). Of course, there are some keywords that are optional and have no default values. These keywords will be ignored and the associated optional features for the HVAC system will be missing. In this mode of operation the design routine has the most freedom of design.

b) at the opposite end of the sizing spectrum the user supplies the maximum amount of data, thus restricting the use of default values. In this approach, the user is limiting the freedom of the sizing routine. It is very important for the user to realize that all keywords are not of equal importance or priority. Some keywords have a greater effect than other keywords in restricting the freedom of the SYSTEMS design routine. Unless the user understands the effect and/or priority of each keyword in SYSTEMS, the system being simulated may or may not be that intended by the user.

All other equipment sizing approaches lie between extreme a) and extreme b). As the user supplies more and more values for optional keywords, the sizing method moves from a) toward b). Most users will elect to use some intermediate method. The SYSTEMS design routine permits the user to supply those parameters which are deemed important to the user and the routine provides the rest from its design strategy. It is therefore necessary for the user to understand the design strategy built into SYSTEMS. In this section that strategy will be described, along with suggestions of how the user may override the strategy, should that be deemed necessary. The results of this cooperative interaction between the user and the design routine are shown in the VERIFICATION report, SV-A.

To size a heating/cooling system, the following quantities must be determined:

a. the maximum quantity of air supplied to each zone

b. the minimum amount of outside (ventilation) air required by each zone

c. the maximum and minimum air temperatures of each zone

d. heating coil design capacity

e. cooling coil total design capacity

f. cooling coil sensible design capacity

g. maximum and minimum coil temperatures

h. fan electrical consumption at design conditions

i. and, for central systems:

   1. minimum outside (ventilation) air quantity

   2. maximum and minimum supply air quantities

   3. minimum zone air quantities

The following required keywords will provide the least amount of information that the SYSTEMS design routine requires to be able to size a system:

SYSTEM-TYPE
ZONE-NAMES
DESIGN-HEAT-T
DESIGN-COOL-T
MAX-SUPPLY-T (except for SYSTEM-TYPE = FPH, VAVS, RHFS, CBVAV, or PVAVS)
MIN-SUPPLY-T (except for SYSTEM-TYPE = UHT, UVT, FPH, or HVSYS)
INDUCTION-RATIO (for SYSTEM-TYPE = TPIU or FPIU only)
REHEAT-DELTA-T (for SYSTEM-TYPE = RHFS only)
MAX-FLUID-T (for SYSTEM-TYPE = HP only)
MIN-FLUID-T (for SYSTEM-TYPE = HP only)

Obviously, design routine must know the type of system (SYSTEM-TYPE) to be modeled and the names of the zones (ZONE-NAMES) to be included within the system. The next two keywords (DESIGN-HEAT-T and DESIGN-COOL-T) are defined at the zone level. They are the temperatures in the heating and cooling modes, respectively, to which the system is to be designed. Ordinarily, they should be the heating and cooling set points (from HEAT-TEMP-SCH and COOL-TEMP-SCH, respectively) during the occupied hours. <u>The SYSTEMS design routine does not look at schedules to determine anything. A general rule is that any information the user wants the design routine to know about must appear in a Keyword = Value form.</u> The schedules are utilized only for the simulation.

For SYSTEM-TYPE = VAVS, RHFS, CBVAV, or PVAVS,
MAX-SUPPLY-T = (MIN-SUPPLY-T) + (REHEAT-DELTA-T).

The basic equation used by the design routine describes the relationship between the heat addition (or extraction) rate, the air-flow rate, and the difference between the desired zone temperature and the supply air temperature:

$$Q = 1.08 \times CFM \times \Delta T. \qquad (A)$$

Much of the discussion that follows is related to the consequences of requiring this equation to hold true and to be internally consistent. The basic equation, (A), appears in the following forms:

$$CFM = \frac{\text{(-) heat addition rate}}{1.08 \times [(\text{DESIGN-HEAT-T}) - (\text{MAX-SUPPLY-T})]} \quad (B)$$

$$CFM = \frac{\text{heat extraction rate}}{1.08 \times [(\text{DESIGN-COOL-T}) - (\text{MIN-SUPPLY-T})]} \quad (C)$$

$$CFM = \frac{\text{heating capacity}}{1.08. \times [(\text{mixed air temp.}) - (\text{air temp. off heating coil})]} \quad (D)$$

$$CFM = \frac{\text{sensible cooling capacity}}{1.08 \times [(\text{mixed air temp.}) - (\text{air temp. off cooling coil})]} \quad (E)$$

where the mixed (return and outside ventilation) air temperatures and the air temperatures off the coils are calculated at the peak heating/ventilating and peak cooling/ventilating conditions.

a. Zone and System Supply Air Flow Rate

If the user specifies no keywords that size the system, such as cfm's, capacities, or addition/extraction rates, the program will look for the peak heating and cooling loads and will use equations (B) or (C) to determine the CFM in each zone. If the user specifies <u>only</u> the outside air quantity and/or the exhaust cfm for a zone, the CFM determined for the zone will be the maximum of the values calculated from (B), (C), the outside air, and the exhaust air. In either case, the maximum heating and cooling capacities are then determined from (D) and (E).

The only way for the user to absolutely specify the zone air quantity is to use the ASSIGNED-CFM keyword. Any other choice may be overridden by the design routine in its insistence on obeying the First Law of Thermodynamics, as it applies to equations (A) through (E). Even the value of ASSIGNED-CFM will be changed at least to account for the difference between the altitude of the building and sea level. It will also be multiplied by the SIZING-RATIO whose default is 1.0. If other user-specified data cause equations (D) or (E) to be over specified, i.e., each of the variables is supplied by the user in a manner that does not satisfy (D) or (E), the air temperatures off the coils are adjusted to bring the equations back into balance. To illustrate this in a slightly over-simplified way, suppose the user has entered values for DESIGN-HEAT-T, MAX-SUPPLY-T, ASSIGNED-CFM, and HEATING-CAPACITY for a zonal system. The design routine will calculate a mixed air temperature for the zone by using (a) the outside dry-bulb temperature at the time of the peak heating load for the building, (b) the minimum outside ventilation air that was specified elsewhere in the input, and (c) the DESIGN-HEAT-T. Similarly, the design routine will calculate the air temperature off the coil by using (a) the temperature drop in the ducts and (b) the temperature increase caused by the fans. If these two calculated values (mixed air temperature and air temperature off the coil) are entered into (D), along with ASSIGNED-CFM and HEATING-CAPACITY, it is probable that the left hand side and the right hand side of the equation will not be consistent. If and when this happens, the design routine will change MAX-SUPPLY-T until the equation is consistent. This change will always be made in a downward direction, never upward.

If the user specifies a value for AIR-CHANGES/HR and/or CFM/SQFT, the design routine will accept them, unless either (D) or (E) is made inconsistent by them. In this case, the specified value(s) will be changed to make equation (E) consistent; that is, the cooling equation will be made consistent because it has priority over the heating equation (D). If there is no peak cooling load, the CFM will be determined by equation (D). The other possibility of these values being changed occurs in the central systems when SUPPLY-CFM is also entered (this is discussed later).

If any of ASSIGNED-CFM, CFM/SQFT, or AIR-CHANGES/HR are entered along with MAX-HEAT-RATE (i.e., heat addition rate) or MAX-COOL-RATE (i.e., heat extraction rate), there is a possibility that equation (B) or (C) is violated. In this case, MAX-HEAT-RATE or MAX-COOL-RATE is altered to make the equation(s) consistent. If only MAX-HEAT-RATE and MAX-COOL-RATE are specified, i.e., no air quantity is specified at the zone level, the design routine will take the value of CFM from (B) or (C), with the larger CFM from (B) or (C) taking precedence. If the user has also specified HEATING-CAPACITY or COOLING-CAPACITY for zonal systems, again an inconsistency can arise with (D) or (E). The CFM just computed from (B) or (C) may not fit with the values of the capacities. In this case the capacities win out over the heating/cooling rates. In other words, MAX-HEAT-RATE and MAX-COOL-RATE should only be used when no other sizing information is given and the user wants to override the maximum heating and cooling loads from LOADS.

The above discussion must be modified slightly for variable air volume systems, since there is now a distinction between the CFM for cooling and the CFM for heating. Based on the MIN-CFM-RATIO and the user's choice, or not, of reverse-action thermostat strategy, there will be for each zone a maximum CFM and CFMH, where the latter describes the cfm for heating.

For central constant volume systems the maximum air capacity of the fans is taken as the sum of the zone cfm's (CFM) determined above, unless the user has entered SUPPLY-CFM. Again, unless the user has entered SUPPLY-CFM, the air capacity for variable air volume systems will be calculated from equations like (B) and (C), where DESIGN-HEAT-T and DESIGN-COOL-T are replaced by their averages over all the zones and the coincident building loads from LOADS are entered for the extraction rates. For a number of systems (see the Applicability Tables) this method of sizing the central fans may be overridden with the use of the SIZING-OPTION keyword, where the code-word NON-COINCIDENT sums the peak load CFMs for the individual zone loads, while the code-word COINCIDENT uses the building coincident load (block load).

If SUPPLY-CFM is entered and if all the zones were given ASSIGNED-CFMs, it is assumed that the user intends the values to remain as entered. If not all the zones are given an ASSIGNED-CFM, the cfms of the remaining zones are reapportioned to balance the zone air with the SUPPLY-AIR.

b. Outside Air Flow Rate

If OUTSIDE-AIR-CFM is defined, it is taken as the amount of ventilation air for that zone. Otherwise, the program takes the larger of (OA-CHANGES) x (Zone Volume)/60 min. per hr. and (OA-CFM/PER) x number of people as the amount of ventilation air for the zone. If these are not specified at the zone level for zonal systems, the program multiplies the MIN-OUTSIDE-AIR fraction times the zone CFM to arrive at a value of the ventilation air for the design calculation. During the simulation, the MIN-AIR-SCH will also be operative; it is ignored for the design calculation and the other specifications are used.

For central systems the design outside air ratio is taken to be the value of (a) MIN-OUTSIDE-AIR, (b) the ratio of the sum of the zone ventilation air to the SUPPLY-CFM, or (c) the ratio of the sum of the zone exhaust air to the SUPPLY-CFM. In other words, if the user enters EXHAUST-CFM at the zone level and leaves out all other references to outside air, the program will still create an outside air ratio adequate to account for the exhausted air. Zone level specifications take precedence over SYSTEM level MIN-OUTSIDE-AIR.

The last consideration with regard to the air supply is the minimum cfm ratio associated with variable air volume systems. If for zonal systems MIN-CFM-RATIO is not defined at the zone level, the value of MIN-CFM-RATIO defined at the system level is assumed to apply to the units located in each zone. If MIN-CFM-RATIO is not specified, it is calculated as the larger of (a) the minimum cfm ratio needed to account for the ventilation and (b) the minimum cfm ratio needed to meet the heating requirements. If the MIN-CFM-RATIO is specified as less than the value specified for outside air (exhaust or ventilation), a 100 per cent outside air variable air volume system is simulated below the minimum outside air point.

c. Heating and Cooling Capacities and Extraction Rates

If the user has specified the HEATING-CAPACITY, the input value is adjusted for off-rated cfm using the RATED-CFM value and the RATED-HCAP-FCFM function. This adjustment factor is 1.0, if the keyword RATED-CFM is not entered. The heat addition rate, printed in the VERIFICATION report SV-A, is computed from this heating capacity, using the conditions at the peak heating load to subtract the ventilation load. The heat addition rate shown in SV-A includes the baseboard heating rate, in addition to the air system heating rate.

If the user has not specified the HEATING-CAPACITY, the heat addition rate is computed from MAX-HEAT-RATE or the peak heating load, while the HEATING-CAPACITY, which includes the ventilation load, is computed from (a) the airflow rate, (b) the temperature of the mixed return air and outside ventilation air, and (c) the off-coil air temperature, based on the conditions at the peak heating load. The user should know that the value of the heat addition rate printed in SV-A is shown for illustrative purposes only. The actual heat addition rate is calculated anew each hour during the simulation.

The situation for cooling is similar, except that the program must treat the water balance in the air (both return air and outside ventilation air), in addition to the sensible cooling load. Again, the weather conditions at the time of the cooling peak loads are used in the calculation of the total and sensible cooling capacities and the heat extraction rate. If the user has specified a MAX-HUMIDITY that cannot be achieved by the capacity of the coil, as defined at the peak cooling load conditions, a WARNING message is printed and the value of MAX-HUMIDITY may not be held during the simulation.

When applicable, the corresponding adjustment for off-rated conditions is made for the electric input ratios as was made for the capacities.

d. Fan Electrical Consumption

The electrical consumption of the system fans is governed by the value specified for SUPPLY-KW and RETURN-KW along with the specified or calculated flow rates, which describe the electrical energy consumed per cfm by the supply and return fans, respectively. If the user supplies a value for SUPPLY-EFF and/or RETURN-EFF, the program ignores the defaults for SUPPLY-KW and/or RETURN-KW and calculates the electrical consumption from the efficiency, static pressures (SUPPLY-STATIC and/or RETURN-STATIC), and flow rates.

V. PLANT PROGRAM

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V. PLANT EQUIPMENT SIMULATION PROGRAM

A. INTRODUCTION

1. Program Description

The PLANT program simulates the primary equipment that uses energy (e.g., oil, gas, electricity, or sunshine) to provide heating and cooling. Plant equipment may include on-site electric generating and heat recovery capabilities that meet the coincident electrical, heating, and cooling demands of the building. Conventional central plant equipment (e.g., boilers, chillers) or selective energy plants (a hybrid configuration having utility electricity, steam, or chilled water and on-site electric generation capability) can be simulated using this program.

The PLANT program receives, as input, a list of the hourly loads for the building from the SYSTEMS program, and requires a sequence of user-defined PDL input instructions that specify the plant. Each instruction (or class of data) has its own PDL command word for identification and a keyword for each item of information.

The program can be run with minimal specification of plant equipment, consisting only of the type and size of equipment, the total number of installed units, and the maximum number of units simultaneously available. If no other data are entered, the preprogrammed default value will be used for each variable.

The program uses the hourly demands and other hourly information, received from the SYSTEMS program, to calculate the energy consumption of the specified equipment on an hourly basis and summarize it by month and by year. The input data to the PLANT program from the SYSTEMS program consist of the following:

> Heating load, cooling load, electric load, process heat or domestic hot water load, baseboard load, gas and oil consumption from SYSTEMS and LOADS, ambient air and wet-bulb temperatures (for simulation of chillers, cooling towers, generating equipment, etc.), heating and cooling equipment on-off flags in SYSTEMS.
>
> Preheat load, main coil load, zone-coil load; outside air cfm, main coil cfm, and system cfm; main coil or cooling coil discharge temperature and the mixed air temperature (for solar simulation).

Energy use is simulated on the basis of a full load input/output ratio and/or a representative quadratic curve fit of part-load performance for each class of equipment. The default values for these parameters are shown in Tables V.4 and V.6 in Sec. B of this chapter. Some typical curves are shown and discussed in the DOE-2 Engineers Manual. The user should examine the default values carefully before accepting them. If values can be obtained that more accurately represent the performance of a particular item of equipment, they should be entered, using the CURVE-FIT, EQUIPMENT-QUAD, and/or PART-LOAD-RATIO instructions.

Additional information required for simulation of energy use is provided by the PLANT-PARAMETERS instruction. For example, keywords HCIRC-MOTOR-EFF, CCIRC-MOTOR-EFF, and TWR-MOTOR-EFF define, in that order, the motor efficiency for heating pumps, for cooling pumps, and for cooling tower pumps. Default values for all the keywords of the PLANT-PARAMETERS instruction are shown in the PLANT-PARAMETERS user worksheet. Again, the user is advised to examine these defaults and use the PLANT-PARAMETERS instruction to enter more accurate values whenever they are available.

The PLANT program also calculates the economics of plant equipment. The methodology is discussed in Sec. A.2 of this chapter.

The solar simulator portion of the PLANT program is discussed in Sec. C, including the CBSDL Input Instructions. Note that these instructions are in a somewhat different format than the other PLANT program instructions and those for the other calculation programs (LOADS, SYSTEMS, and ECONOMICS). For this reason, they are not included in Sec. B, but rather are presented in a separate section.

2. PLANT Economics

Calculations related to the economics of plant equipment are made in the PLANT program. The first costs and subsequent replacement costs are combined to calculate the investment. Annual maintenance, periodic overhauls, and energy costs are combined to evaluate savings.

All costs of equipment and energy for the life of the facility are calculated as present value. The results of these calculations are passed to the ECONOMICS program, where they are combined with costs related to nonplant components and investment statistics (savings-to-investment ratio, discounted payback period, and Btu savings per annual investment dollar) are determined. For a description of these statistics and a detailed discussion of the present-value concept, see Chap. VI, ECONOMICS. It should be noted that present-valuing diminishes the effect of costs and savings that occur in the future, compared to those that are immediate.

The life-cycle costs of a plant are influenced by the discount rate and differential escalation rates (the amounts by which these rates differ from the general inflation rate) for energy, labor, and material. These rates must be specified or defaulted in the PLANT program. However, it is not necessary to know the general inflation rate to calculate present value. Only the differential escalation rate needs to be specified here and for ECONOMICS program calculations.

The PLANT program calculates the present value of life-cycle costs for (1) purchase, installation, and maintenance of plant equipment, and (2) the fuel and electricity used by the facility. The user input data required for these calculations are entered by using four PDL instructions.

PLANT-EQUIPMENT
ENERGY-COST
PLANT-COSTS
REFERENCE-COSTS

Only one configuration of building and equipment can be evaluated by the PLANT program in a single run. The costs calculated for this configuration are passed to the ECONOMICS program, where the user enters the additional cost data necessary to perform tradeoff studies. If a comparison between the project and a baseline (i.e., the existing building or an alternative design concept) is being made, cost data on the baseline must be entered. These cost data can be obtained from the PLANT economics output reports of a separate run simulating the baseline conditions. They must be entered with the ECONOMICS program input for each alternative studied.

3. Suggested Procedure for Use of the PLANT Program

The PLANT program can be used to obtain improved design configurations for total energy plants, conventional energy plants, and selective energy plants (hybrid combinations of the first two). The effective use of the program depends upon an understanding of the problem. Because the execution time of PLANT is small, parametric studies to determine "optimal" or near optimal configuration are relatively inexpensive. The user can make a number of PLANT runs, each simulating equipment type and/or size variations, and can use the output reports to zero-in on the preferred arrangement. SYSTEMS program output files from the initial run should be saved to avoid the cost of rerunning that program (and the LOADS program) for each PLANT run. See the local site manual for the method of saving these files.

Users will undoubtedly develop their own methods of using PLANT effectively. The following summarizes one method for using the PLANT program.

a. Run the LOADS and SYSTEMS programs to produce the hourly energy extraction rates. As indicated above, save the SYSTEMS output file for use in the PLANT program runs.

b. Identify all physical and environmental constraints and list them to eliminate impractical configurations (for example, diesel engines may be unacceptable on the top floor of a hospital because of noise level).

c. Identify types of equipment under consideration and their available sizes. On the basis of the results of items a. and b., estimate maximum loads as a guide to choosing equipment for the initial test run.

d. Identify all known applicable quantities for the proposed installation, and prepare input data to override default values. For example, if the boiler operates by schedule, running in a standby mode when the schedule is "on", even if there is no load, BOILER-CONTROL should be set to STANDBY in the PLANT-PARAMETERS instruction. If no actual values for data items are known, no entry is necessary; default values will be supplied by the program.

e. If a specific brand of equipment is under consideration, compare its performance coefficients with the model in the program. If they differ significantly, use the PART-LOAD-RATIO and PLANT-PARAMETERS, and then, if necessary, the EQUIPMENT-QUAD and CURVE-FIT instructions to override built-in default values.

f. Define the strategy for equipment operation. The questions that must be answered are the following: For equipment of the same type, which equipment operates first; when should the equipment operate, i.e., seasonally, hourly, or based upon load.

g. Case A. If more than one configuration is to be simulated and each configuration has been identified by type of components, sizes (capacities), and number of units, prepare separate decks containing equipment size and availability cards. A single run of each deck will produce outputs for each configuration; compare results and choose the best one.

h. Case B. The unit sizes and the number of units may also be determined by using program output. This can be done best by successively running PLANT for a specific operating strategy, and using the information obtained in each run to decide the input for the next. The first run is primarily to determine the maximum load on each type of equipment and, thus, the total capacity needed in each type of component. In successive runs, break the total capacity into various sizes and consider different operating strategies. The tradeoff here is that, although smaller sizes increase total cost, they will usually decrease energy consumption because the equipment is more likely to be more efficient. This is a trial-and-error procedure. After each run, the average operating part-load ratios (the first row of the Report PS-C) can be examined to determine the effect of partitioning the total capacity of the current run by comparing it to previous ones. The objective is to come as close as possible to optimum operating ratios. If the average operating ratio is too low for a particular type of equipment, add at least one small equipment unit.

   Operating hours are also a good indicator of equipment use. For example, if a double-bundle chiller is operated for too few hours, the additional first cost cannot be justified. This is easily determined from an examination of operating hours, and that equipment is eliminated from consideration in the following runs.

   After this trial-and-error procedure with equipment size assignments, Case B will turn into Case A, and the reasoning given above will apply.

Any of the above cases will produce several computer outputs, which will have to be evaluated further for final selection.

i. The PLANT program output reports contain a number of information items useful for making a final decision on plant configuration. For instance, the life-cycle cost can be taken as an objective function to be mini- mized, while imposing constraints on first cost, and total fuel input. Alternatively, minimizing initial cost, annual fuel use, or electricity needed from a utility might be more desirable. Only the user can know which of these is more and which less important for each specific problem.

The primary purpose of the plant is to supply the building with heating, cooling, and electricity. Heating may be obtained from a steam utility, boiler, a furnace, a double-bundle chiller, solar collectors, heat recovered from diesel and gas turbine generators, and stored heat as well as hot water heating; cooling from cold water tanks, compression chillers, reciprocating chillers, absorption chillers, double-bundle chillers or utility chilled water; electricity from the utility or from diesel, gas, or steam turbines. The user selects the types of equipment that are to satisfy the loads.

Each piece of plant equipment may be supplied with energy in usable form from one or more sources. The boiler is supplied with fuel and/or electricity. Compression chillers may be supplied with electricity from the utility and/or on-site generator(s). Absorption chillers may be supplied with heat from (1) the steam utility, (2) solar collectors, (3) a boiler, (4) electricity, and/or (5) waste heat. The waste heat may be recovered from diesel and gas turbines, and possibly, with a small amount of heat recovered from blowdown. Diesel and gas turbines may be supplied with fuel, steam turbines with steam from the steam utility, a boiler, and/or waste heat from diesel and/or gas turbines. Cooling towers receive electricity from the utility and/or on-site generator(s), and the hot-water storage tank is provided with heat from a boiler or waste heat from a recoverable source.

Figure V.1 shows the plant energy flow described above. Heat recovery can occur if the user specifies equipment that can supply and use recovered heat. Heat recovery can take place at five different temperature levels, Level 1 being the highest. Details about heat recovery equipment or processes and the flow of energy are shown in Tables V.9, V.10, and V.11 in Sec. B of this chapter.

4. Suggested Sequence of PLANT Program Input

For the PLANT program to run, there must be more RUN-PERIOD intervals than DESIGN-DAY instructions entered in the LOADS input (see Sec. III.B.2 and III.B.3). The PLANT simulation will size equipment based on the worst case of the DESIGN-DAY or the weather tape. Energy usage will then be calculated for the remaining RUN-PERIOD intervals.

To use the PLANT program, the user must first enter an

INPUT PLANT ..

instruction. (The PARAMETRIC-INPUT PLANT instruction is only used for subsequent parametric runs.) The BDL processor will expect a

PLANT-EQUIPMENT ..

instruction next. At least one PLANT-EQUIPMENT instruction must be entered to inform the Processor which piece of equipment is to be simulated. The following instructions may then be entered as desired or required by the user.

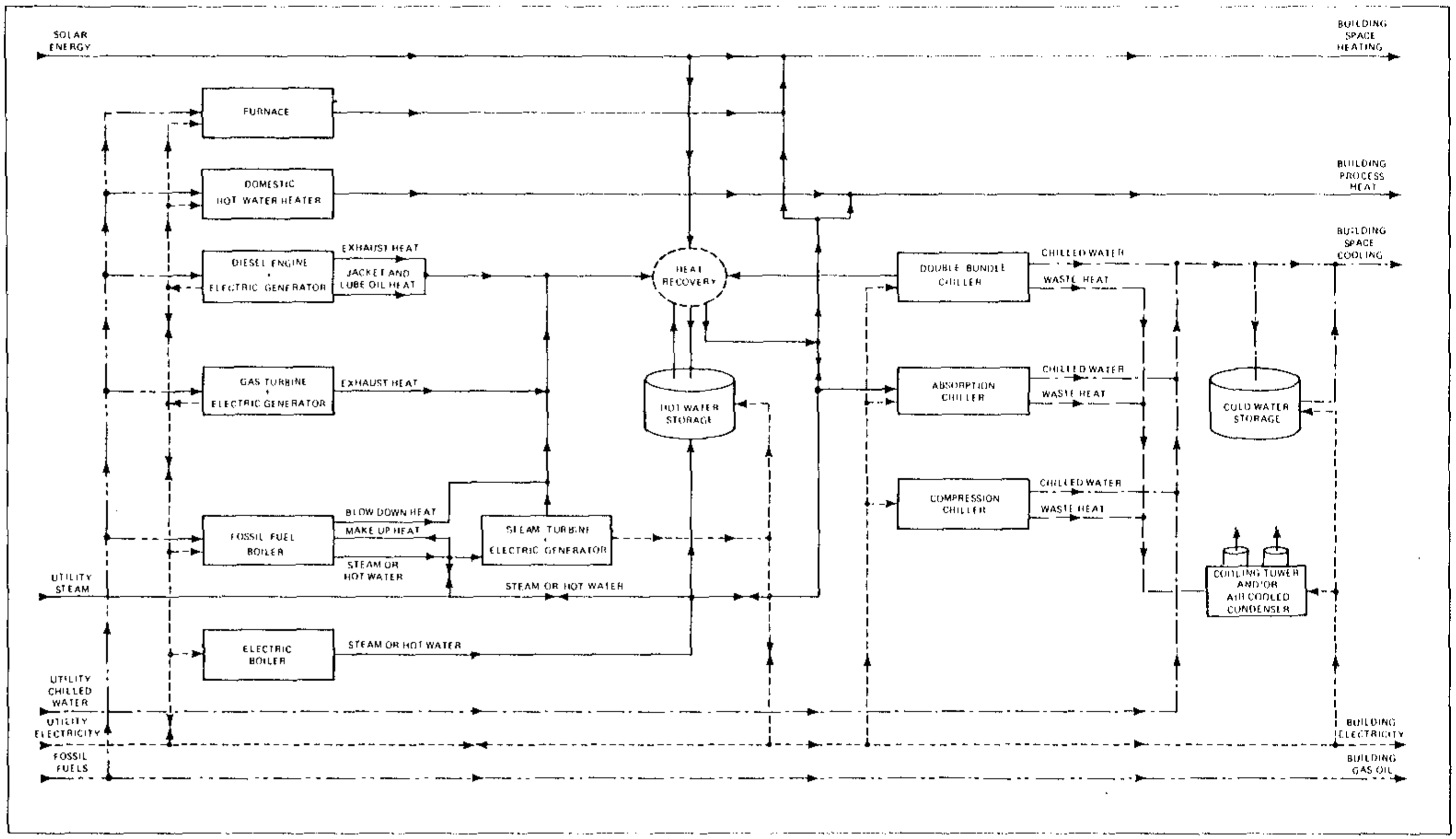

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Fig. V.1. PLANT Program energy flow diagram.

PART-LOAD-RATIO
PLANT-PARAMETERS
CURVE-FIT
EQUIPMENT-QUAD
HEAT-RECOVERY
ENERGY-STORAGE
LOAD-ASSIGNMENT
DAY-ASSIGN-SCH
LOAD-MANAGEMENT
PLANT-ASSIGNMENT
DAY-SCHEDULE
WEEK-SCHEDULE
SCHEDULE

Next, the following COST instructions are entered.

ENERGY-COST
PLANT-COSTS
REFERENCE-COSTS

Then the following REPORT instructions are entered.

PLANT-REPORT
HOURLY-REPORT
REPORT-BLOCK

If the solar equipment simulation program is desired, it is necessary to enter one instruction requesting solar equipment.

SOLAR-EQUIPMENT ..

Section C, "Solar Simulator," provides a description of the instructions used to specify a liquid or air solar heating/cooling system.

Following the specification of the keywords and values required by the above instructions, an instruction is entered to indicate that the input data is finished. An instruction must then be entered that instructs the PLANT program to perform the desired computations.

END ..
COMPUTE PLANT ..

If the ECONOMICS program is not to be run, the last instruction must be

STOP ..

The user worksheets (found within the description of each PDL instruction) have been provided to help in the organization of the data-input effort. They provide a space for the entry of a label or a value for each command word and keyword. It is suggested that the applicable worksheets can be filled out in any convenient order, but should be arranged in the sequence described in the paragraphs above.

5. PDL and CBS Input Instruction Limitations

For DOE-2, the maximum number of PDL instructions that can be used for specifying the required data for the PLANT program is as follows:

Instruction	Maximum Number
DAY-SCHEDULE	60
WEEK-SCHEDULE	40
SCHEDULE	40
PARAMETER	50*
SET-DEFAULT	100*
TITLE	5*
PLANT-EQUIPMENT	6 for each equipment type
PART-LOAD-RATIO	1 for each equipment type
PLANT-PARAMETERS	1
EQUIPMENT-QUAD	1
LOAD-ASSIGNMENT	50
LOAD-MANAGEMENT	1
HEAT-RECOVERY	1
ENERGY-STORAGE (hot tank)	1
ENERGY-STORAGE (cold tank)	1
ENERGY-COST	5
REFERENCE-COSTS	25
PLANT COSTS	1
PLANT-ASSIGNMENT	40**
PLANT-REPORT	1 command
HOURLY-REPORT	16
REPORT-BLOCK	64
U-names	118***
Solar Simulator	
SOLAR-EQUIPMENT	1
COMPONENT	40
CONNECT	No. of components
ITERATIONS	1
SYSTEM	1
TRACE	No. of components
DAY-SCHEDULE	20
WEEK-SCHEDULE	20
SCHEDULE	20

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

** This maximum number refers to the total number of different PLANT runs allowed in a single submittal. Only one PLANT-ASSIGNMENT is allowed for each PLANT simulation.

*** The use of the advanced scheduling technique (described in Chapter II) 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 PDL. Also, specifying an output report by code-word (PV-A, PS-A, etc.) will result in the use of one U-name internally specified by PDL.

B. PDL INPUT INSTRUCTIONS

1. PLANT-EQUIPMENT

The PLANT-EQUIPMENT instruction is used to specify the type, size, and number of plant components, as well as related specific economic information to each TYPE of equipment. At least one PLANT-EQUIPMENT instruction must be specified for the PLANT program to run.

Should the user elect to use default values for the cost input, the program will assign cost data to the specified size of each type of equipment using the cost data references in Table V.1 and the scaling law:

$$CP = (CP)_{ref} \times [SIZE/(SIZE)_{ref}]^{P}$$

where

CP	=	one of the nine cost parameters listed in Table V.1 (excluding SIZE)
CP_{ref}	=	corresponding reference default value (see Table V.1)
SIZE	=	actual equipment size
$(SIZE)_{ref}$	=	reference equipment size (see Table V.1)
P	=	0.67 for FIRST-COST, MINOR-OVHL-COST and MAJOR-OVHL-COST
	=	0.4 for CONSUMABLES
	=	0.2 for MAINTENANCE, MINOR-OVHL-INT, and MAJOR-OVHL-INT
	=	0.1 for EQUIPMENT-LIFE
	=	0.0 for INSTALLATION

However, the above default assignments can be adjusted by specifying new reference cost parameters, (CP_{ref}) or reference sizes ($SIZE_{ref}$) in the REFERENCE-COSTS instruction.

The user is forewarned to examine Table V.1 carefully before accepting default equipment costs because there can be considerable variation in cost within a generic type depending on location, design conditions, design features, etc. Entry of the actual cost of a commercially available equipment item of the type and size specified is always preferred for improved life-cycle costing accuracy. Note that the default costs are several years out of date.

TABLE V.1

Equipment Cost Reference Default Values

Equipment TYPE Code-Word	SIZE (10^6 Btu/hr)	FIRST COST ($)	INSTALLATION Cost Factor	CONSUMABLES ($/hr)	MAINTENANCE (hrs/yr)	EQUIPMENT-LIFE (hrs)	MINOR-OVHL-INT Interval (hrs)	MINOR-OVHL-COST each ($)	MAJOR-OVHL-INT Interval (hrs)	MAJOR-OVHL-COST each ($)
STM-BOILER	40.0	300,000	1.4	0.0	8	220000	10000	2000	50000	25000
HW-BOILER	40.0	300,000	1.4	0.0	8	220000	10000	2000	50000	25000
ELEC-STM-BOILER	40.0	300,000	1.4	0.0	8	220000	10000	2000	50000	25000
ELEC-HW-BOILER	40.0	300,000	1.4	0.0	8	220000	10000	2000	50000	25000
FURNACE[a]										
DHW-HEATER[a]										
ELEC-DHW-HEATER[a]										
OPEN-CENT-CHLR	12.0	150,000	1.2	0.0	25	100000	20000	5000	50000	15000
OPEN-REC-CHLR	12.0	100,000	1.2	0.0	16	100000	20000	5000	50000	15000
HERM-CENT-CHLR	12.0	120,000	1.2	0.0	25	100000	20000	5000	50000	15000
HERM-REC-CHLR	12.0	100,000	1.2	0.0	16	100000	20000	5000	50000	15000
DBUN-CHLR	12.0	200,000	1.3	0.0	25	100000	20000	5000	50000	15000
ABSOR1-CHLR	12.0	110,000	1.2	0.0	25	100000	20000	8000	50000	15000
ABSOR2-CHLR	12.0	160,000	1.2	0.0	25	100000	20000	8000	50000	15000
ABSORS-CHLR	12.0	170,000	1.2	0.0	25	100000	20000	8000	50000	15000
COOLING-TWR	12.0	60,000	1.3	0.0	80	100000	5000	5000	50000	15000
CERAMIC-TWR	12.0	90,000	1.2	0.0	40	220000	10000	5000	50000	15000
HTANK-STORAGE	10.0[b]	10,000	1.2	0.0	16	250000	0	0	0	0
CTANK-STORAGE	10.0[b]	25,000	1.2	0.0	16	250000	0	0	0	0
DIESEL-GEN	8.5	750,000	1.2	1.5	150	100000	24000	9000	50000	21000
GTURB-GEN	8.5	600,000	1.2	1.2	100	220000	0	0	30000	12000
STURB-GEN	8.5	450,000	1.3	1.0	100	220000	0	0	40000	20000

[a]There are no defaults for these TYPEs.
[b]Size is in MBtu's and not MBtuh.

U-name — Any unique user-defined name may be entered to identify this instruction, but none is required.

<u>PLANT-EQUIPMENT</u> — This command word informs the PDL Processor that the data to follow will specify plant equipment. If at least one PLANT-EQUIPMENT instruction is not entered, the PLANT program will generate an error message.

TYPE — is a code-word selected from Table V.2 that identifies the type of equipment to be used in the simulation calculations. (For circulating pumps, see PLANT-PARAMETERS instruction and explanation for the 10 keywords associated with pumps.).

SIZE — is the nominal rated output capacity, expressed in units of one million Btu's per hour (MBtu) 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-ton. A ten million Btu/hr boiler is specified as SIZE = 10.0. A 10,000 gallon hot water tank with HTANK-T-RANGE = 180°F (see ENERGY-STORAGE instruction) is specified as SIZE = 15.0.

The SIZE of a storage tank is the useful capacity, i.e., SIZE = (size in gallons) * 8.34 lb/gal * 10^{-6} MBtu/lb-°F * DT, where DT = HTANK-T-RANGE or CTANK-T-RANGE. The definitions of these last two keywords are found under the ENERGY-STORAGE command.

If SIZE = -999 is entered, the PLANT program will automatically size, 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 <u>always</u> 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:

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

where Design-Load is the peak heating or cooling load calculated by SYSTEMS and passed to PLANT. The symbol X in the above equations is replaced by HCIRC for hot water pumps and CCIRC for chilled water pumps to produce the appropriate PLANT-PARAMETERS keyword. These keywords may be specified or allowed to default.

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 = 3.0.

MAX-NUMBER-AVAIL is the total number of units of the type and size previously specified that are available for simultaneous operation. The value of this keyword is a number that can equal, but not exceed, the value entered for keyword INSTALLED-NUMBER (i.e., it is an error to specify that five units are available if only four are installed). The user should enter a value for this keyword if he is going to have the program size the equipment, unless the default of 1 or INSTALLED-NUMBER is acceptable.

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TABLE V.2

Equipment TYPE Code-Words

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
Furnace	FURNACE
Cooling	
One-stage absorption chiller	ABSOR1-CHLR
Two-stage absorption chiller with economizer	ABSOR2-CHLR
Absorption chiller with solar assist	ABSORS-CHLR
Open centrifugal compression chiller	OPEN-CENT-CHLR
Hermetic centrifugal compression chiller	HERM-CENT-CHLR
Open reciprocating compression chiller	OPEN-REC-CHLR
Hermetic reciprocating compression chiller	HERM-REC-CHLR
Double bundle chiller	DBUN-CHLR
Cooling tower	COOLING-TWR
Ceramic cooling tower	CERAMIC-TWR
Electrical Generating Equipment	
Diesel engine	DIESEL-GEN
Steam turbine	STURB-GEN
Gas turbine	GTURB-GEN
Storage	
Hot water tank	HTANK-STORAGE
Cold water tank	CTANK-STORAGE
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 on the SOURCE-BTU/HR keyword in the SPACE-CONDITIONS subcommand will be passed with other heating demands to other heating equipment except these loads will not be passed to a furnace. If no heating equipment is defined, the domestic hot water demand will appear as a load not met.

As an example, if three 100-ton one-stage absorption chillers are to be installed, and a maximum of two can be used simultaneously, and the user decides to name a PLANT-EQUIPMENT instruction "CHILLERS-1" the entry would be:

```
CHILLERS-1 = PLANT-EQUIPMENT TYPE = ABSOR1-CHLR
     SIZE = 1.2
     INSTALLED-NUMBER = 3
     MAX-NUMBER-AVAIL = 2 ..
```

FIRST-COST — specifies the first cost for one unit of the type and size referenced above, not including installation costs.

This cost must be entered in dollars referenced to the same point in time as all other input. For example, if energy costs refer to January 1979, this cost must be converted to January 1979 dollars before it is entered regardless of the actual expenditure date. If the money is spent before start up and operation, the present value is increased by the lost opportunity value over the time interval between spending and start up.

The PLANT program is not capable of calculating this increased value. The user is required to calculate this increased value before entering the cost. This is the present value of the cost and it may be approximated by the following equation:

$$C_{P_V} = C_r \, (1 + D/100)_N$$

where: C_{P_V} = present value of cost,

C_r = cost in reference dollars,
D = real discount rate in per cent per time interval, and
N = number of time intervals from expenditure to start up.

INSTALLATION — specifies the multiplier on equipment FIRST-COST to estimate first cost per unit installed. For example, if installation cost is 20 per cent of first cost, then INSTALLATION = 1.2.

CONSUMABLES — specifies the cost (in \$ per operating hour per unit) of those items consumed during operation (excluding primary fuel). For example, diesel fuel for an engine is not under the consumable category, but lubricating oil is.

MAINTENANCE	specifies the hours per year of required on-site maintenance for the referenced item of equipment. The program will use this value along with the user input (or default) value for labor cost (see keyword LABOR in the PLANT-COSTS instruction) to calculate yearly maintenance costs for the referenced equipment item. Maintenance refers to the standard level of upkeep by on-site personnel, excluding overhaul of any kind.
EQUIPMENT-LIFE	specifies the number of operating hours from the time the equipment is new until it must be replaced. Note that this number is the same for new and existing building simulation.
MINOR-OVHL-INT	specifies the expected number of operating hours between minor overhauls for the referenced item of equipment.
MINOR-OVHL-COST	specifies the cost (in dollars per unit) for a minor overhaul of the referenced item of equipment.
MAJOR-OVHL-INT	specifies the expected number of operating hours between major overhauls for the referenced item of equipment.
MAJOR-OVHL-COST	specifies the cost (in dollars per unit) for a major overhaul of the referenced item of equipment.
HOURS-USED	is required for simulation of existing buildings and equipment. The number of hours entered should equal the operating hours already on the equipment. It is important that the number of hours used is not equal to or greater than the value entered or defaulted for keyword EQUIPMENT-LIFE as this will result in calculation error. If the actual hours used is equal to or greater than the EQUIPMENT-LIFE input, estimate the remaining useful life. Subtract the remaining useful life from the value entered or defaulted for EQUIPMENT-LIFE and enter the difference for HOURS-USED. Note that a non-zero value implies that the equipment is not new, so no first-cost data will appear in output reports except on replacements.

Rules:

1. At least one PLANT-EQUIPMENT instruction must be entered for each computer run of PLANT Program.
2. A separate PLANT-EQUIPMENT instruction is required for each TYPE and SIZE of equipment specified.
3. Up to six PLANT-EQUIPMENT instructions may be specified for each TYPE of equipment.
4. All sizes must be specified in MBtuh (10^6 Btu/hr), with the exception of a storage tank, which must be specified in MBtu (10^6 Btu).

5. If a LOAD-ASSIGNMENT instruction is not defined the PLANT program will attempt optimization by allowing only one type of absorption chiller, one type of compression chiller (other than double bundle chillers), and one type of cooling tower to be simulated in one run of the program. However, more than one type of each may be specified, in which case, regardless of the number entered as being available, certain types will not be "put in operation." This may be useful if an older equipment model is being installed purely as a standby. Its cost will be computed by the program, despite the fact that it never operates. The rule employed by the program to determine which equipment type to operate is a precedence rule based purely on equipment types as shown in Table V.3. If the user specifies LOAD-ASSIGNMENTs, the different types of equipment may be mixed, but with not more than 3 types under a given LOAD-RANGE.

TABLE V.3

EQUIPMENT PRECEDENCE RULE

Precedence Rule:

If no LOAD-ASSIGNMENT instruction is defined, each equipment TYPE excludes those equipment TYPES, listed below it. The precedence rule applies only to the listed equipment TYPEs.

Equipment Type

Boilers	Absorption Chillers	Compression Chillers	Cooling Towers
1)Steam boiler	1)One-stage solar absorption	1)Hermetic reciprocating	1)Ceramic
2)Hot-water boiler		2)Hermetic centrifugal	
3)Electric steam boiler	2)Two-stage absorption	3)Open reciprocating	2)Nonceramic
4)Electric hot-water boiler	3)One-stage absorption	4)Open centrifugal	

6. The storage tanks will not operate unless a LOAD-ASSIGNMENT instruction is specified for their operation.

7. Only one size of cooling tower can be entered per computer run. That is, the program cannot simulate the operation of a number of different sized towers or a single tower with different sized cells. All cells or units must be the same size. Note that, for the tower, SIZE refers to the cell size, and INSTALLED-NUMBER is the number of cells. It is recommended that the user allow the program to default both the SIZE and MAX-NUMBER-AVAIL for the cooling towers.

8. Utilities are never specified by a PLANT-EQUIPMENT instruction, but they are referred to by the LOAD-ASSIGNMENT instruction. Economic data are specified by the ENERGY-COST instruction.

9. Purchased steam and purchased chilled water are disallowed unless the keyword UNIT in the ENERGY-COST instruction is set to a non-zero number.

10. The electric utility is assumed to be allowed unless UNIT in the ENERGY-COST instruction is set to zero.

11. If both an electric and a fossil-fuel boiler are to be available, a LOAD-ASSIGNMENT instruction must specify their operation. Otherwise, the program assumes that only the fossil-fuel boiler is available.

12. FURNACE, DHW-HEATER, and ELEC-DHW-HEATER cannot be entered in LOAD-ASSIGNMENTs. If a furnace is specified, all the space heating load is assumed to go to the furnace. If a DHW-HEATER is specified, all hot water load, domestic and process hot water (specified in LOADS) are assumed to go to the DHW-HEATER. If MAX-NUMBER-AVAIL is greater than 1, all the units of the FURNACE and/or the DHW-HEATER and ELEC-DHW-HEATER are assumed to run simultaneously.

Note: To zero out the cost of a piece of equipment, the user should assign small, non-zero values, as follows:

FIRST-COST = 0.001
CONSUMABLES = 0.001
MAINTENANCE = 0.001
MINOR-OVHL-COST = 0.001
MAJOR-OVHL-COST = 0.001

(If zero values are assigned, the program will calculate cost based on equipment size.)

________________ = PLANT-EQUIPMENT+ or P-E (User Worksheet)
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
TYPE	TYPE	=	________	code-word	-	-	-
SIZE	SIZE	=	________	10^6Btu/hr	0.	-1000.	100.
INSTALLED-NUMBER	I-N	=	________	number	1	1	10
MAX-NUMBER-AVAIL	M-N-A	=	________	number	1	1	10
FIRST-COST	F-C	=	________	$	*	0.	$1.x10^7$
INSTALLATION	I	=	________	number	*	0.	100.
CONSUMABLES	C	=	________	$/hr	*	0.	$1.x10^3$
MAINTENANCE	M	=	________	hrs/yr	*	0.	$1.x10^3$
EQUIPMENT-LIFE	E-L	=	________	hrs	*	0.	$4.x10^5$
MINOR-OVHL-INT	MIN-O-I	=	________	hrs	*	0.	$1.x10^5$
MINOR-OVHL-COST	MIN-O-C	=	________	$	*	0.	$1.x10^4$
MAJOR-OVHL-INT	MAJ-O-I	=	________	hrs	*	0.	$1.x10^5$
MAJOR-OVHL-COST	MAJ-O-C	=	________	$	*	0.	$1.x10^4$
HOURS-USED	H-U	=	________	hrs	0.	0.	$4.x10^5$

+Mandatory Entry

* Default value for this keyword depends on the size and type of equipment being specified. See Table V.1 and scaling formula described in text under PLANT-EQUIPMENT instruction.

2. PART-LOAD-RATIO

The equipment PART-LOAD-RATIO instruction specifies the minimum, maximum and preferred operating conditions for one piece of equipment, and the nominal electric power input ratio to operate the equipment and supporting electric auxiliaries.

The PART-LOAD-RATIO instruction is optional. If data entry for the instruction is omitted, the default values shown in Table V.4 are used for each TYPE of equipment.

PART-LOAD-RATIO — This command word informs 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 V.4 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.

MIN-RATIO — is the minimum fraction of nominal rated load at which the equipment item being specified can operate continually. That is, if the item of equipment is scheduled to operate and the demand is more than zero but less than the MIN-RATIO, the program will cycle the machine on and off. However, diesel generators and gas turbine generators will turn off, not cycle, below MIN-RATIO.

Default values of MIN-RATIO for each type of equipment are shown on Table V.4.

MAX-RATIO — is the maximum fraction of loading or overloading allowed, if any. If the maximum load is the nominal rated load (SIZE), and no overload is allowed, the user should specify:

MAX-RATIO = 1.0

The default values of MAX-RATIO for each type of equipment are shown in Table V.4.

OPERATING-RATIO — is the point, usually taken from a performance curve, that represents the most desirable operating condition. If a LOAD-ASSIGNMENT instruction is not entered to specify the sequence of equipment operation, the program will determine this sequence by operating the equipment as near as possible to the OPERATING-RATIO.

TABLE V.4

Equipment PART-LOAD-RATIO Default Values

TYPE Code-Word		Part-Load Ratios Min.	Max.	Operating	Electric Input to Nominal Capacity
	Heating Equipment				
ELEC-STM-BOILER	Electric boiler	0.01	1.00	1.00	1.000
STM-BOILER	Steam boiler	0.25	1.20	1.00	0.022
HW-BOILER	Hot water boiler	0.25	1.20	1.00	0.022
ELEC-HW-BOILER	Electric hot water boiler	0.01	1.00	1.00	1.000
FURNACE	Furnace*	-	-	-	0.023
	Cooling Equipment				
ABSOR1-CHLR	One-stage absorption chiller	0.10	1.15	1.00	0.004
ABSOR2-CHLR	Two-stage absorption chiller with economizer	0.10	1.15	0.70	0.007
ABSORS-CHLR	Solar-driven absorption chiller	—	—	—	—
OPEN-CENT-CHLR	Open centrifugal chiller	0.10	1.00	0.80	0.210
OPEN-REC-CHLR	Open reciprocating chiller	0.25	1.00	1.00	0.260
HERM-CENT-CHLR	Hermetic centrifugal chiller	0.10	1.00	0.80	0.220
HERM-REC-CHLR	Hermetic reciprocating chiller	0.25	1.00	1.00	0.274
DBUN-CHLR	Double-bundle chiller	0.10	1.00	1.00	0.220
COOLING-TWR	Cooling tower**	-	-	-	0.000
CERAMIC-TWR	Ceramic cooling tower**	-	-	-	0.000
	Electric Generating Equipment				
DIESEL-GEN	Diesel engine	0.02	1.05	0.60	-
STURB-GEN	Steam turbine	0.02	1.10	0.90	-
GTURB-GEN	Gas turbine	0.02	1.05	0.60	-
	Tanks				
HTANK-STORAGE	Hot water tank	-	-	-	0.000
CTANK-STORAGE	Cold water tank	-	-	-	0.000
	Domestic Hot Water				
DHW-HEATER	Water heater	-	-	-	0.000
ELEC-DHW-HEATER	Electric water heater	-	-	-	1.000

* Note that this default does not accurately model an oil-fired furnace with a fuel pump. This type of furnace should not be allowed to default.

** Fan energy per cell is calculated based on the quadratic function TWR-FAN-ELEC-FTU if the electric input ratio is not greater than zero.

ELEC-INPUT-RATIO The electric input to nominal capacity ratio is expressed as

$$\text{ratio} = \frac{\text{electric power input to electric auxiliaries (Btu/hr)}}{\text{nominal capacity of equipment being defined (Btu/hr)}}$$

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 refrigerant circulator must be considered. Similarly for a fossil-fueled boiler, the electric power input to the boiler draft fan and stokers must be considered. However, when defining the ELEC-INPUT-RATIO for this equipment, the user should ignore the electric power delivered to the hot, chilled, and condenser water pumps (see PLANT-PARAMETERS).

The cooling tower fan power is based on the tower size and TWR-FAN-ELEC-FTU (see EQUIPMENT-QUAD) or the value of ELEC-INPUT-RATIO, if specified.

The pumping energy associated with the storage tank is calculated as the ELEC-INPUT-RATIO times the maximum of the COOL-STORE-RATE, HEAT-STORE-RATE, COOL-SUPPLY-RATE, and HEAT-SUPPLY-RATE.

PART-LOAD-RATIO or P-L-R (User Worksheet)

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
TYPE	TYPE	=	________	code-word	–	–	–
MIN-RATIO	MIN-R	=	________	number	*	0.+**	1.
MAX-RATIO	MAX-R	=	________	number	*	1.	2.
OPERATING-RATIO	O-R	=	________	number	*	0.+	2.
ELEC-INPUT-RATIO	E-I-R	=	________	Btu/hr / Btu/hr	*	0.	10.

..

+ Mandatory entry.

* Default values are shown in Table V.4.

** A minimum of "0.+" means that any positive number in the range is acceptable, but zero itself is not, as this value may be used as a divisor.

3. 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. The variables are listed by category or function in the PLANT-PARAMETERS User Worksheet. Any variable (keyword) listed in the user worksheet may be specified and its value assigned by the user. PLANT-PARAMETERS are used together with other PLANT variables and EQUIPMENT-QUAD functions. The user is urged to carefully review the equipment simulation descriptions in the DOE-2 Engineers Manual before changing any of the PLANT-PARAMETERS default values.

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. Additional discussion of specific keywords is provided in the text that follows. A summary of these keywords is presented in Table V.5.

PLANT-PARAMETERS — This command word informs the PDL Processor that the data to follow will specify a new default value for one or more of the variables.

Chillers

CHILLER-CONTROL — accepts a code-word that defines the chiller control scheme. Default is DEMAND-ONLY, and the alternative is STANDBY (see BOILER-CONTROL keyword description). The STANDBY mode is normal for central systems.

CHILL-WTR-T — specifies the chilled water temperature at the middle of the throttling range for chillers. Default is 44°F.

CHILL-WTR-THROTTLE — is the throttling range of the temperature controller on the chiller.

COMP-TO-TWR-WTR — specifies the ratio of cooling tower water flow (gpm) to compression chiller capacity (ton).

MIN-COND-AIR-T — specifies 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.

DBUN-TO-TWR-WTR — specifies the ratio of cooling tower water flow (gpm) to double-bundled chiller capacity (ton).

ABSOR1-HIR — specifies 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 — specifies the full-load heat input ratio for a 2-stage absorption chiller with an economizer (see ABSOR1-HIR).

ABSORS-HIR — specifies the full-load heat input ratio for a solar-driven absorption chiller. (see ABSOR1-HIR).

TABLE V.5

PLANT-PARAMETERS KEYWORDS

Chillers

Chiller control scheme	CHILLER-CONTROL
Chiller water temperature, mid-throttling range	CHILL-WTR-T
Chiller temperature controller throttling range	CHILL-WTR-THROTTLE
Cooling tower water flow/Compression chiller capacity	COMP-TO-TWR-WTR
Minimum entering air temp., air-cooled condenser	MIN-COND-AIR-T
Double-bundled Chiller to Tower Water	DBUN-TO-TWR-WTR
Full-load heat input ratio, 1-stage absorption chiller	ABSOR1-HIR
Full-load heat input ratio, 2-stage absorption chiller	ABSOR2-HIR
Full-load heat input ratio, solar-driver absorption chiller	ABSORS-HIR
Cooling tower water flow/Absorption chiller capacity	ABSOR-TO-TWR-WTR
Fan electric power/Hermetic centrifugal chiller capacity	HERM-CENT-COND-PWR
Condenser type, hermetic centrifugal chiller	HERM-CENT-COND-TYPE
Maximum PLR for hot gas bypass, hermetic centrifugal chiller	HERM-CENT-UNL-RAT
Fan electric power/Hermetic reciprocating chiller	HERM-REC-COND-PWR
Condenser type, hermetic reciprocating chiller	HERM-REC-COND-TYPE
Maximum PLR for hot gas bypass, hermetic reciprocating chiller	HERM-REC-UNL-RAT
Fan electric power/Open centrifugal chiller capacity	OPEN-CENT-COND-PWR
Condenser type, open centrifugal chiller	OPEN-CENT-COND-TYPE
Compressor motor efficiency, open centrifugal chiller	OPEN-CENT-MOTOR-EFF
Maximum PLR for hot gas bypass, open centrifugal chiller	OPEN-CENT-UNL-RAT
Fan electric power /Open reciprocating chiller capacity	OPEN-REC-COND-PWR
Condenser type, open reciprocating chiller	OPEN-REC-COND-TYPE
Compressor motor efficiency, open reciprocating chiller	OPEN-REC-MOTOR-EFF
Maximum PLR for hot gas bypass, open reciprocating chiller	OPEN-REC-UNL-RAT
Capacity correction factor, double-bundle chiller, w/heat recovery	DBUN-CAP-COR-REC
Entering condenser temperature at design w/o heat recovery, double-bundle chiller	DBUN-COND-T-ENT
Leaving condenser temperature w/heat recovery, double-bundle chiller	DBUN-COND-T-REC
Power correction factor w/heat recovery, double-bundle chiller	DBUN-EIR-COR-REC
Recoverable heat/Total heat rejection at full load, w/heat recovery, double-bundle chiller	DBUN-HT-REC-RAT
Minimum PLR to operate w/o hot gas bypass, w/o heat recovery, double-bundle chiller	DBUN-UNL-RAT-DES
Minimum PLR to operate w/o hot gas bypass, w/heat recovery, double-bundle chiller	DBUN-UNL-RAT-REC

Cooling Tower

Minimum temperature, leaving tower cooling water	MIN-TWR-WTR-T
Exponent used to modify rating factor for off-design airflows	RFACT-CFM-EXPONENT
Maximum water flow per cell/Design flow per cell	TWR-CELL-MAX-GPM
Wet-bulb temperature	TWR-DESIGN-WETBULB

Tower fan: one-speed or two-speed	TWR-FAN-CONTROL
Fan-low-speed airflow rate/fan-high-speed airflow rate	TWR-FAN-LOW-CFM
Fan power at low speed/Fan power at high speed	TWR-FAN-LOW-ELEC
Natural convection airflow rate/design airflow rate	TWR-FAN-OFF-CFM
Circulation pump efficiency	TWR-IMPELLER-EFF
Tower pump motor efficiency	TWR-MOTOR-EFF
Pressure head in tower water circulation loop	TWR-PUMP-HEAD
Exiting water temperature floating or fixed	TWR-TEMP-CONTROL
Exiting water temperature when set to "fixed"	TWR-WTR-SET-POINT
Effective throttling range about water set point	TWR-WTR-THROTTLE
Direct cooling control scheme	DIRECT-COOL-MODE
Maximum outdoor dry-bulb temperature for which direct cooling is allowed	DC-MAX-T
Schedule for direct cooling availability	DIRECT-COOL-SCH
Maximum chilled water temperature for which direct cooling is allowed	DC-CHILL-WTR-T
Direct cooling auxiliary equipment electric demand	DIRECT-COOL-KW
Boilers	
Boiler blowdown flow rate as fraction of steam turbine steam losses	BOILER-BLOW-RAT
Boiler control: demand-only or standby	BOILER-CONTROL
Fuel used for boiler	BOILER-FUEL
Fraction of total capacity of electric hot-water boiler lost through skin or leads, while operating	E-HW-BOILER-LOSS
Fraction of total capacity of electric steam boiler lost through skin or leads, while operating	E-STM-BOILER-LOSS
Heat input ratio, hot water boiler	HW-BOILER-HIR
Makeup water temperature	MAKEUP-WTR-T
Effectiveness of blowdown heat recovery, steam boiler	RECVR-HEAT/BLOW
Heat input ratio, steam boiler	STM-BOILER-HIR
Domestic Hot-Water Heaters	
Heat input ratio, domestic hot-water heater	DHW-HIR
Fuel used by domestic hot-water heater	DWH-HEATER-FUEL
Fraction of total capacity of electric hot-water heater lost through skin or leads, while operating	ELEC-DHW-LOSS
Furnaces	
Heat input ratio for the furnace	FURNACE-HIR
Fuel used by the furnace	FURNACE-FUEL
Fuel consumption of a pilot light when a gas furnace is not firing	FURNACE-AUX
Generators	
Fuel used by diesel generator	DIESEL-FUEL
Maximum exhaust flow/electric output, diesel generator	MAX-DIESEL-EXH
Fuel used by gas turbine	GTURB-FUEL
Maximum exhaust flow/electric output, gas turbine	MAX-GTURB-EXH
Exhaust steam pressure, steam turbine	STURB-EXH-PRES
Entering steam pressure, steam turbine	STURB-PRES
Rpm of steam turbine at nominal capacity	STURB-SPEED

TABLE V.5 (cont)

Entering steam temperature, steam turbine	STURB-T
Condenser feedwater flow/nominal steam rate, steam turbine	STURB-WTR-RETURN
Boiler steam pressure	STM-PRES
Steam saturation temperature	STM-SATURATION-T

Solar

Minimum solar storage tank temperature for cooling	MIN-SOL-COOL-T
Minimum solar storage tank temperature for heating	MIN-SOL-HEAT-T
Minimum solar storage tank temperature for process load	MIN-SOL-PROCESS-T

Circulation Pumps (not condenser pumps)

Temperature drop at design, chilled water loop	CCIRC-DESIGN-T-DROP
Head pressure, chilled water loop	CCIRC-HEAD
Pump impeller efficiency, chilled water loop	CCIRC-IMPELLER-EFF
Fraction of chilled water design load lost to environment	CCIRC-LOSS
Pump motor efficiency, chilled water loop	CCIRC-MOTOR-EFF
Temperature drop at design, hot water loop	HCIRC-DESIGN-T-DROP
Head pressure, hot water loop	HCIRC-HEAD
Pump impeller efficiency, hot water loop	HCIRC-IMPELLER-EFF
Fraction of hot water design load lost to environment	HCIRC-LOSS
Pump motor efficiency, hot water loop	HCIRC-MOTOR-EFF

ABSOR-TO-TWR-WTR	specifies the ratio of cooling tower water flow (gpm) to absorption chiller capacity (ton).
HERM-CENT-COND-PWR	is the ratio of fan electric energy (Btu) to the operating capacity of a hermetic centrifugal chiller. This keyword is used only when the chiller condenser type is AIR.
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 code-word is AIR, which implies a heat exchanger with a condenser.
HERM-CENT-UNL-RAT	is the maximum part-load ratio of a hermetic centrifugal chiller at which hot gas bypass occurs. Above this value, the machine adjusts capacity by unloading. Between MIN-RATIO (from the PART-LOAD-RATIO instruction) and this ratio, the machine has unloaded as far as it can and is using hot gas bypass to make up the difference. Below MIN-RATIO, the machine cycles on and off.
HERM-REC-COND-PWR	specifies fan electric energy/hermetic reciprocating chiller capacity (see HERM-CENT-COND-PWR keyword description).
HERM-REC-COND-TYPE	specifies the hermetic reciprocating chiller condenser type by code-word (see HERM-CENT-COND-TYPE keyword description).
HERM-REC-UNL-RAT	specifies the maximum part-load ratio of a reciprocating chiller at which hot gas bypass occurs (see HERM-CENT-UNL-RAT keyword description).
OPEN-CENT-COND-PWR	specifies fan electric energy/open centrifugal chiller capacity (see HERM-CENT-COND-PWR keyword description).
OPEN-CENT-COND-TYPE	specifies, by keyword, the type of condenser of an open centrifugal chiller (see HERM-CENT-COND-TYPE keyword description).
OPEN-CENT-MOTOR-EFF	specifies the fraction of open centrifugal chiller compressor electrical input energy that is converted to heat and rejected by the cooling tower. This is an expression of the efficiency of the compressor motor.
OPEN-CENT-UNL-RAT	specifies the maximum part-load ratio of an open centrifugal chiller at which hot gas bypass occurs (see HERM-CENT-UNL-RAT keyword description).

OPEN-REC-COND-PWR — specifies fan electric energy/open reciprocating chiller capacity (see HERM-CENT-COND-PWR keyword description).

OPEN-REC-COND-TYPE — specifies the open reciprocating chiller condenser type by code-word (see HERM-CENT-COND-TYPE keyword description).

OPEN-REC-MOTOR-EFF — specifies compressor motor efficiency for a open reciprocating chiller (see OPEN-CENT-MOTOR-EFF keyword description).

OPEN-REC-UNL-RAT — specifies the maximum part-load ratio of an open reciprocating chiller at which hot gas bypass occurs (see HERM-CENT-UNL-RAT keyword description).

DBUN-CAP-COR-REC — is the capacity correction factor based on the condenser temperature rise when in the heat recovery mode. If the user inputs a value for this parameters, then the function DBUN-CAP-FTRISE is overridden, and this constant parameter is used in its place.

DBUN-COND-T-ENT — is the entering condenser temperature at the design conditions in the non-heat-recovery mode. When the chiller is in the heat recovery mode, this parameter is used in place of the calculated entering condenser temperature in the functions DBUN-CAP-FT and DBUN-EIR-FT. In so doing, the effects of the entering condenser temperature on the capacity and the electric input ratio are eliminated, when in the heat recovery mode.

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 the heat recovery mode and the leaving condenser temperature in the non-heat-recovery mode at the design point (calculated from DBUN-COND-T-ENT, ELEC-INPUT-RATIO, and DBUN-TO-TWR-WTR) are 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.

DBUN-EIR-COR-REC — is the power correction factor based on the condenser temperature rise when in the heat recovery mode. If the user inputs a value for this parameter, then the function DBUN-EIR-FTRISE is overridden, and this constant parameter is used in its place.

DBUN-HT-REC-RAT — is the ratio of the recoverable heat to the total heat rejection at full load when in the heat recovery mode.

DBUN-UNL-RAT-DES — is the minimum part load ratio at which the chiller can operate without hot gas bypass when in the non-heat-recovery mode.

DBUN-UNL-RAT-REC — is the minimum part load ratio at which the chiller can operate without hot gas bypass when in the heat recovery mode.

<u>Cooling Tower</u>

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.

RFACT-CFM-EXPONENT — is the exponent used to modify the tower rating factor for off-design airflows as shown in the following equation.

$$\text{Rating Factor} = (\text{Rating Factor})_{\text{design-cfm}} * \left[\frac{\text{design cfm}}{\text{actual cfm}}\right]^{n}$$

where n is given by RFACT-CFM-EXPONENT.

TWR-CELL-MAX-GPM — specifies the ratio of the maximum water flow per tower cell to the design water flow per cell.

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-FAN-LOW-CFM — specifies the air flow rate through the tower when the fans are on low speed, divided by the flow rate at high speed. This keyword is used only when TWR-FAN-CONTROL is set to TWO-SPEED.

TWR-FAN-LOW-ELEC — specifies the ratio of the power consumed by the fans at low speed to the power consumed at high speed. This keyword is used only when TWR-FAN-CONTROL is set to TWO-SPEED.

TWR-FAN-OFF-CFM — is the air flow rate through the tower when the fans are off. That is, this is the flow rate caused by natural convection, divided by the design air flow rate.

TWR-IMPELLER-EFF — specifies the efficiency for the tower circulation pump.

TWR-MOTOR-EFF — specifies the efficiency of the tower pump motor.

TWR-PUMP-HEAD — is the pressure head in the tower water circulation loop.

TWR-TEMP-CONTROL — accepts a keyword 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 set point when TWR-TEMP-CONTROL is set to FIXED.

TWR-WTR-THROTTLE — is the effective throttling range about the set point defined in TWR-WTR-SET-POINT. This is used only when TWR-TEMP-CONTROL has been set to FIXED. Often, in centrifugal chillers, the tower temperature controller is set to maintain a fixed temperature at full load and to allow the temperature to drop at partial loads. In that case, this keyword is the difference between the temperature setting at full load and the temperature setting at no load.

DIRECT-COOL-MODE — accepts a code-word that defines the direct cooling control scheme, if any. The default is NOT-AVAILABLE. Code-word STRAINER-CYCLE allows cooling tower water to be passed directly into the chilled water loop. Code-word THERMO-CYCLE simulates the use of the compression chillers as heat exchangers without electric input to the compressor.

DC-MAX-T — specifies the maximum outdoor dry-bulb temperature for which direct cooling is allowed. (°F)

DC-CHILL-WTR-T — specifies the maximum chilled water temperature for which direct cooling is allowed. (°F)

DIRECT-COOL-SCH — accepts a U-name of a schedule. When the hourly value specified in the schedule is 1.0, direct cooling is available. When the value is 0, direct cooling is not available. (U-name)

DIRECT-COOL-KW — specifies the electrical input to direct cooling auxiliary equipment. If DIRECT-COOL-MODE = THERMO-CYCLE, the user should specify DIRECT-COOL-KW as kW/ton of operating capacity for the period during which the compression chillers are operating in this mode. In the THERMO-CYCLE mode of operation, the chiller electrical input is assumed to be DIRECT-COOL-KW multiplied by the operating capacity multiplied by the part load ratio. If DIRECT-COOL-MODE = STRAINER-CYCLE, the user should specify DIRECT-COOL-KW as the electrical input to the condenser water pumps (and other added equipment), calculated as kW/ton of SYSTEMS peak cooling load. In the STRAINER-CYCLE mode of operation, the condenser water pumping energy is calculated using only the value of DIRECT-COOL-KW as the kW/ton (using the SYSTEMS load for the tonnage) and the flow rate is assumed to be equal to the chilled water loop.

For both modes of direct cooling, THERMO-CYCLE and STRAINER-CYCLE, the chilled water pumps are assumed to run as usual. (kW/ton of installed cooling capacity)

Boilers

BOILER-BLOW-RAT	specifies the boiler blowdown flow rate as a fraction of steam losses from a steam turbine (i.e., steam entering the turbine less condensation pumped from the condenser into the feedwater system). If no steam turbine is specified, then the blowdown calculated by this parameter is zero.
BOILER-CONTROL	accepts a code-word that defines the boiler control scheme. If the boiler operates only when a boiler load is passed from SYSTEMS, the code-word should be DEMAND-ONLY, which is the default. If the boiler operates in a standby mode whenever the HEATING-SCHEDULE in SYSTEMS is "on", even if there is no load, the appropriate code-word is STANDBY.
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.
E-HW-BOILER-LOSS	is the fraction of the total capacity of the electric hot-water boiler lost through skin or leads while it is operating (does not include circulation losses).
E-STM-BOILER-LOSS	is the fraction of the total capacity of an electric steam boiler lost through skin or leads while it is operating (does not include circulation losses).
HW-BOILER-HIR	is, for a hot-water boiler, the ratio of fuel input (Btu) to heat energy output at full load.
MAKEUP-WTR-T	specifies the makeup water temperature for a boiler (°F).
RECVR-HEAT/BLOW	specifies the effectiveness of blowdown heat recovery for a steam boiler.
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.

ELEC-DHW-LOSS — is the fraction of the total capacity of the electric domestic hot water heater lost through the skin or leads while it is operating (does not include circulation losses).

Furnaces

FURNACE-HIR — is, for a furnace, the ratio of fuel input (Btu) to heat energy output at full load.

FURNACE-FUEL — accepts a code-word that defines the fuel used by a furnace. The default is NATURAL-GAS. The allowable code-words are DIESEL-OIL, NATURAL-GAS, FUEL-OIL, LPG, COAL, METHANOL, and BIOMASS.

FURNACE-AUX — is the fuel consumption of a gas furnace pilot-light when the furnace is not firing (Btu/hr). For an oil furnace, there is no energy consumption when the furnace is off. Therefore, the keyword ELEC-INPUT-RATIO should include both the electrical energy used by the pumps and the ignition systems of an oil furnace.

Generators

DIESEL-FUEL — accepts a code-word that specifies the type of fuel used in diesel engine equipment. Only one fuel RESOURCE (see ENERGY-COST command) may be specified for all diesel engine equipment. The allowable code-words are DIESEL-OIL (the default), NATURAL-GAS, FUEL-OIL, LPG, COAL, METHANOL, and BIOMASS.

MAX-DIESEL-EXH — specifies a diesel engine ratio of maximum exhaust flow/electric output (lb/kW).

GTURB-FUEL — accepts a code-word that specifies the type of fuel used in gas turbine equipment. Only one fuel RESOURCE (see ENERGY-COST command) may be specified for all gas turbine equipment. The allowable code-words are DIESEL-OIL, NATURAL-GAS (the default), FUEL-OIL, LPG, COAL, METHANOL, and BIOMASS.

MAX-GTURB-EXH — specifies a gas turbine ratio of maximum exhaust flow/electric output (lb/kW).

STURB-EXH-PRES — specifies the exhaust steam pressure of the steam turbine generator (psig).

STURB-PRES — specifies the pressure of the steam entering the steam-turbine generator. If no entry is made for this keyword, the value of STURB-PRES will default to STM-PRES if STM-PRES is less than 150 psig or to 150 psig if STM-PRES is greater than or equal to 150 psig.

STURB-SPEED — specifies the speed (rpm) of the steam turbine generator when it is operating at nominal capacity.

STURB-T — specifies the temperature of the steam entering the steam-turbine generator. If no entry is made for this keyword, the value of STURB-T will default to STM-SATURATION-T plus 125°F.

STURB-WTR-RETURN — is the ratio of the condensate-feedwater flow to the nominal steam rate for the steam turbine generator (lb/lb).

STM-PRES — specifies the boiler steam pressure. If no entry is made, the value of STM-PRES will default to 15 psig unless a two-stage absorption cooler or steam-turbine generator is specified. In this case, the program will use a default value of 150 psig. The value is used to calculate STM-SATURATION-T and STURB-PRES if these values are not input.

STM-SATURATION-T — specifies the saturation temperature of boiler steam. Any value entered within the range will be used by the program, even if inconsistent with values entered for keyword STM-PRES. If no entry is made, the program will calculate STM-SATURATION-T for saturated steam at STM-PRES. This value is used by the diesel and gas turbine simulation routines to calculate the amount of heat recoverable from exhaust gas.

<u>Solar</u>

MIN-SOL-COOL-T — specifies the minimum solar storage tank temperature for solar space cooling. Solar space cooling can only be accomplished through the use of the HEAT-RECOVERY instructions.

MIN-SOL-HEAT-T — specifies the minimum solar storage tank temperature required for space heating through a HEAT-RECOVERY instruction. Solar space heating which is accomplished in the solar simulation is unaffected by this specification.

MIN-SOL-PROCESS-T — specifies the minimum solar storage tank temperature required for a process or domestic hot water through a HEAT-RECOVERY instruction.

Pumps

CCIRC-DESIGN-T-DROP is the temperature drop in the chilled water circulation loop at design, and 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-IMPELLER-EFF is the efficiency of the pump impeller in the chilled water circulation loop.

CCIRC-LOSS is the fraction of the design load that is lost to the environment and does no useful cooling.

CCIRC-MOTOR-EFF is the efficiency of the pump motor in the chilled water circulation loop.

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.

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-IMPELLER-EFF* specifies the efficiency of the pump impeller in the hot water circulation loop.

HCIRC-LOSS is the fraction of the design load that is lost to the environment from the 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.

HCIRC-MOTOR-EFF* specifies the efficiency of the pump motor in the hot water circulation loop.

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* 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.

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
Chillers						
CHILLER-CONTROL		= ________	code-word	DEMAND-ONLY	-	-
CHILL-WTR-T		= ________	°F	44.	32.	80.
CHILL-WTR-THROTTLE		= ________	°F	2.5	1.	15.
COMP-TO-TWR-WTR		= ________	gpm/ton	3.	1.	5.
MIN-COND-AIR-T		= ________	°F	65.	0.+ (Note 1)	100.
DBUN-TO-TWR-WTR		= ________	gpm/ton	3.	1.	5.
ABSOR1-HIR		= ________	Btu/Btu	1.6	0.+	3.
ABSOR2-HIR		= ________	Btu/Btu	1.0	0.+	3.
ABSORS-HIR		= ________	Btu/Btu	1.6	0.+	3.
ABSOR-TO-TWR-WTR		= ________	gpm/ton	3.6	0.+	100.
HERM-CENT-COND-PWR		= ________	Btu/Btu	0.	0.	1.
HERM-CENT-COND-TYPE		= ________	code-word	TOWER	-	-
HERM-CENT-UNL-RAT		= ________	ratio	0.1	0.	1.
HERM-REC-COND-PWR		= ________	Btu/Btu	0.03	0.	1.
HERM-REC-COND-TYPE		= ________	code-word	TOWER	-	-
HERM-REC-UNL-RAT		= ________	ratio	0.25	0.	1.
OPEN-CENT-COND-PWR		= ________	Btu/Btu	0.	0.	1.
OPEN-CENT-COND-TYPE		= ________	code-word	TOWER	-	-
OPEN-CENT-MOTOR-EFF		= ________	ratio	0.9	0.+	1.
OPEN-CENT-UNL-RAT		= ________	ratio	0.1	0.	1.
OPEN-REC-COND-PWR		= ________	Btu/Btu	0.03	0.	1.
OPEN-REC-COND-TYPE		= ________	code-word	TOWER	-	-
OPEN-REC-MOTOR-EFF		= ________	ratio	0.9	0.+	1.
OPEN-REC-UNL-RAT		= ________	ratio	0.25	0.	1.
DBUN-CAP-COR-REC		= ________	fraction	-	0.+	1.
DBUN-COND-T-ENT		= ________	°F	85.	60.	100.
DBUN-COND-T-REC		= ________	°F	105.	80.	120.
DBUN-EIR-COR-REC		= ________	fraction	-	1.	2

Notes:
1. A minimum of "0.+" means that any positive number in the range is acceptable, but zero itself is not, as this value may be used as a divisor.

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
DBUN-HT-REC-RAT		= ______	Btu/Btu	0.95	0.+ (Note 1)	1.
DBUN-UNL-RAT-DES		= ______	ratio	0.1	0.	1.
DBUN-UNL-RAT-REC		= ______	ratio	0.3	0.	1.
Cooling Tower						
MIN-TWR-WTR-T		= ______	°F	65.	32.	100.
RFACT-CFM-EXPONENT		= ______	number	0.9	0.+	2.
TWR-CELL-MAX-GPM		= ______	gpm/gpm	1.5	1.	3.
TWR-DESIGN-WETBULB		= ______	°F	75.	32.	100.
TWR-FAN-CONTROL		= ______	code-word	ONE-SPEED	-	-
TWR-FAN-LOW-CFM		= ______	cfm/cfm	0.5	0.+	1.
TWR-FAN-LOW-ELEC		= ______	kW/kW	0.125	0.+	1.
TWR-FAN-OFF-CFM		= ______	cfm/cfm	0.18	0.	1.
TWR-IMPELLER-EFF		= ______	fraction	0.77	0.+	1.
TWR-MOTOR-EFF		= ______	fraction	0.9	0.+	1.
TWR-PUMP-HEAD		= ______	ft	60.0	0.	100.
TWR-TEMP-CONTROL		= ______	code-word	FLOAT	-	-
TWR-WTR-SET-POINT		= ______	°F	80.	32.	100.
TWR-WTR-THROTTLE		= ______	°F	10.	1.	20.
DIRECT-COOL-MODE		= ______	code-word	NOT-AVAILABLE	-	-
DC-MAX-T		= ______	°F	55.	35.	65.
DC-CHILL-WTR-T		= ______	°F	50.	30.	60.
DIRECT-COOL-SCH		= ______	U-name	Note 2	-	-
DIRECT-COOL-KW		= ______	kW/ton	Note 3	0.0	1.0

Notes:

1. A minimum of "0.+" means that any positive number in the range is acceptable, but zero itself is not, as the value may be used as a divisor.
2. The schedule values default to one for all 24 hours of the day. This means that direct cooling is available all the time.
3. Defaults to 0.02 if DIRECT-COOL-MODE = THERMO-CYCLE and to 0.0 if DIRECT-COOL-MODE = STRAINER-CYCLE.

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
Boilers						
BOILER-BLOW-RAT		= ________	lb/lb	0.07	0.	1.
BOILER-CONTROL		= ________	code-word	DEMAND-ONLY	-	-
BOILER-FUEL		= ________	code-word	FUEL-OIL	-	-
E-HW-BOILER-LOSS		= ________	Btu/Btu	0.02	0.	1.
E-STM-BOILER-LOSS		= ________	Btu/Btu	0.02	0.	1.
HW-BOILER-HIR		= ________	fraction	1.25	0.+ (Note 1)	3.
MAKEUP-WTR-T		= ________	°F	55.	32.	212.
RECVR-HEAT/BLOW		= ________	Btu/Btu	0.5	0.+	1.
STM-BOILER-HIR		= ________	fraction	1.3	0.+	3.
Domestic Hot-Water Heaters						
DHW-HIR		= ________	fraction	1.39	0.+	3.
DHW-HEATER-FUEL		= ________	code-word	NATURAL-GAS	-	-
ELEC-DHW-LOSS		= ________	Btu/Btu	0.03	0.	1.
Furnaces						
FURNACE-HIR		= ________	fraction	1.35	0.+	1.75
FURNACE-FUEL		= ________	code-word	NATURAL-GAS	-	-
FURNACE-AUX		= ________	Btu/hr	800.	0.	2000.
Generators						
DIESEL-FUEL		= ________	code-word	DIESEL-OIL	-	-
MAX-DIESEL-EXH		= ________	lb/kW	15.	0.+	100.
GTURB-FUEL		= ________	code-word	NATURAL-GAS	-	-

Notes:

1. A minimum of "0.+" means that any positive number in the range is acceptable, but zero itself is not, as the value may be used as a divisor.
4. See keyword description for alternative default value.

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
MAX-GTURB-EXH		= ______	lb/kW	40.	0.+ (Note 1)	100.
STURB-EXH-PRES		= ______	psig	-12.7 (Note 4)	-15.	1000.
STURB-PRES		= ______	psig	15. (Note 4)	-15.	700.
STURB-SPEED		= ______	rpm	5000.	0.+	$1.x10^4$
STURB-T		= ______	°F	378.7 (Note 4)	212.	1000.
STURB-WTR-RETURN		= ______	lb/lb	0.97	0.+	1.
STM-PRES		= ______	psig	15. (Note 4)	-15.	700.
STM-SATURATION-T		= ______	°F	253.7 (Note 4)	212.	500.
Solar						
MIN-SOL-COOL-T		= ______	°F	180.	80.	212.
MIN-SOL-HEAT-T		= ______	°F	100.	60.	212.
MIN-SOL-PROCESS-T		= ______	°F	140.	60.	212.
Pumps						
CCIRC-DESIGN-T-DROP		= ______	°F	10.	0.+	20.
CCIRC-HEAD		= ______	ft	60.	0.	100.
CCIRC-IMPELLER-EFF		= ______	fraction	0.77	0.+	1.
CCIRC-LOSS		= ______	ratio	0.01	0.	1.
CCIRC-MOTOR-EFF		= ______	fraction	0.9	0.+	1.
HCIRC-DESIGN-T-DROP		= ______	°F	30.	0.+	100.
HCIRC-HEAD		= ______	ft	60.	0.	100.
HCIRC-IMPELLER-EFF		= ______	fraction	0.77	0.+	1.
HCIRC-LOSS		= ______	ratio	0.01	0.	1.
HCIRC-MOTOR-EFF		= ______	fraction	0.9	0.+	1.

Notes:

1. A minimum of "0.+" means that any positive number in the range is acceptable, but zero itself is not, as the value may be used as a divisor.

4. See keyword description for alternative default value.

4. EQUIPMENT-QUAD

The EQUIPMENT-QUAD instruction is used to access the equations defined in CURVE-FIT instructions*. If input, the EQUIPMENT-QUAD and CURVE-FIT instructions override the default curves used by the program to model equipment performance. Table V.6 contains a list of these curves and their default coefficient values. Any curve keyword listed in Table V.6 may be specified and its values redefined by the user by using the CURVE-FIT and EQUIPMENT-QUAD instructions. However, the default curves in the program are designed to represent existing, real-world, and typical equipment performance. The user, therefore, need not use the EQUIPMENT-QUAD instruction unless his equipment is significantly different than that modeled by the default curves. Before using these instructions he should also examine the performance simulation discussion in the DOE-2 Engineers Manual.

Note that for bi-linear or bi-quadratic functions, in which there are two independent variables, the order in which they are discussed and the order in which they are given in the tables is the order in which their respective coefficients or coordinates should be given in the curve fit instruction. For example, capacity of an absorption chiller may be defined as a function of exiting chilled water temperature and entering condenser water temperature, i.e., capacity = f(exit-T, entering-T). Capacity is the dependent variable, z, exit-T is x, and entering-T is y. Coordinates (x,y,z) input in CURVE-FIT should therefore be in the order (exit-T, entering-T, capacity). If coefficient values are used, they are input in the order defined in the CURVE-FIT instruction.

All the EQUIPMENT-QUAD keywords have been named according to the following naming scheme. The first "word" or two of the name (ABSOR1, OPEN-REC, etc.) identifies the equipment being defined. The next "word" describes the dependent variable (the "z" value) that will be described by the associated curve.* The last "word" in the keyword expresses the value or values upon which the function depends. Those dependent variable/ independent variable parts of each keyword that are used more than once are defined below.

(-CAP-FT) For the given equipment, the operating capacity correction factor will be expressed by a bi-linear or bi-quadratic function of the exiting chilled water temperature and the entering condenser water temperature. That is, the dependent variable, z, is the capacity; the independent variables, x and y, are exiting chilled water temperature and entering condenser water temperature, or

Capacity Correction Factor = f(exiting temperature, entering temperature).

This function should be normalized so that at design conditions the capacity correction factor is equal to 1.0.

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* See CURVE-FIT instruction in Chap. IV for a definition of these functions and variables.

(-EIR-FT) For the given equipment, the electric input ratio correction factor (ratio of electric input to nominal capacity) is a bi-linear or bi-quadratic function of the exiting chilled water temperature and the entering condenser water temperature.

(-EIR-FPLR) For the given equipment, the electric input ratio at full load will be multiplied by a linear or quadratic function of the part-load ratio to obtain the electric input to the equipment at part load. The calculation will look like this:

$$Elec_{in} = EIR_{full-load} \times (a + bPLR + cPLR^2) \times (-EIR-FT) \times SIZE \times (-CAP-FT).$$

It is important to note that the -FPLR functions are all multiplied by the available capacity, not the load. This means that the ratio of load to capacity (part load ratio, PLR) is embedded within these functions. Since the definition of COP is usually the ratio of load to energy input, the ratio of COP at full load to that at the actual load would have to be multiplied by the part load ratio to produce the -FPLR function.

$$Elec_{in} = \frac{load}{COP(load)} = \frac{PLR * Size * (-CAP-FT)}{COP_{full\ load} * COP(PLR) * COP(T)}$$

where COP(PLR) and COP(T) are modifier functions for part load and temperature.

Relating the two equations for $Elec_{in}$, it can be seen that

$$(-EIR-FPLR) = \frac{PLR}{COP(PLR)}\ .$$

Therefore, to input a constant efficiency unit, data points (0,0) and (1,1) or coefficients (0,1) should be input through the CURVE-FIT command. Note that the use of data points (0,1) and (1,1) or coefficients (1,0) does <u>not</u> represent a constant efficiency unit.

(-HIR-FT) This is like -EIR-FT except that, instead of the electric input ratio, the heat input ratio correction factor will be found. (This form is used with absorption chillers.)

(-HIR-FPLR) This is like -EIR-FPLR except that instead of the electric input ratio the heat input ratio correction factor will be found. (This form is used with absorption chillers.)

The relationship of this function to the commonly used part load efficiency can be expressed as:

$$(\text{-HIR-FPLR}) = \text{PLR} \times \frac{\text{EFF(at PLR=1)}}{\text{EFF(PLR)}} .$$

Therefore, to input a constant efficiency unit, data points (0,0) and (1,1) or coefficients (0,1) should be input through the CURVE-FIT command. Note that the use of data points (0,1) and (1,1) or coefficients (1,0) does not represent a constant efficiency unit.

(-I/O-FPLR) This form is used by electric generating equipment. The equation associated with this form will define the input/output ratio (energy input/energy output) as a linear or quadratic function of part-load ratio.

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(-STACK-FU) For a diesel generator or gas turbine generator, the UA of the exhaust heat recovery heat exchanger will be calculated as an exponential function of the nominal electrical output. This equation will take the rather unusual form:

UA = constant coef. x (electrical output)$^{\text{linear coef.}}$
or $z = ax^b$

(-TEX-FPLR) For a diesel or gas turbine generator, the temperature of the exhaust gas is calculated as a linear or quadratic function of the part-load ratio.

(-FPLR) For a boiler, the part-load efficiency is calculated as a linear or quadratic function of part-load ratio, as shown in the equation

$$Eff_{part} = Eff_{full} \times (a + bPLR + cPLR^2).$$

The keywords in the EQUIPMENT-QUAD instruction are defined below.

<u>EQUIPMENT-QUAD</u> This command word informs the PDL Processor that the data to follow will override defaults by associating performance equations, or curves, to designated performance keywords.

<u>Absorptions Chillers</u>

ABSOR1-CAP-FT accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation will be used to override the default equation and define the capacity correction factor of a one-stage absorption chiller. (see -CAP-FT above).

ABSOR1-HIR-FPLR accepts the U-name of a CURVE-FIT instruction that defines a cubic equation. That equation will be used to define the heat input ratio correction factor of a one-stage absorption chiller as a function of part-load ratio (see -HIR-FPLR above).

ABSOR1-HIR-FT accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation will be used to define the heat input ratio correction factor of a one-stage absorption chiller as a function of temperatures (see -HIR-FT above).

ABSOR2-CAP-FT is like ABSOR1-CAP-FT for a two-stage absorption chiller with economizer.

ABSOR2-HIR-FPLR is like ABSOR1-HIR-FPLR for a two-stage absorption chiller with economizer.

ABSOR2-HIR-FT is like ABSOR1-HIR-FT for a two-stage absorption chiller with economizer.

ABSORS-CAP-FT is like ABSOR1-CAP-FT for a solar-driven absorption chiller.

ABSORS-CAP-FTS accepts as input the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the capacity correction factor of a solar-driven absorption chiller as a function of the temperature of the hot water from the solar equipment.

ABSORS-HIR-FPLR is like ABSOR1-HIR-FPLR for a absorption chiller.

ABSORS-HIR-FT is like ABSOR1-HIR-FT for a absorption chiller.

ABSORS-HIR-FTS accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the heat input ratio correction factor of a solar-driven absorption chiller as a function of the temperature of the hot water from the solar equipment.

Compression Chillers

HERM-CENT-CAP-FT accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation will be used to express the correction factor for the capacity of a hermetic centrifugal compression chiller as a function of the exiting chilled water temperature and entering water temperature (see -CAP-FT). It is normalized to 1.0 at design conditions.

HERM-CENT-EIR-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the electric input ratio correction factor of a hermetic centrifugal compression chiller as a function of its part-load ratio (see -EIR-FPLR).

HERM-CENT-EIR-FT accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation will be used to express the electric input ratio correction factor of a hermetic centrifugal compression chiller as a function of exiting chilled water temperature and entering water temperature (see -EIR-FT).

HERM-REC-CAP-FT is the same as HERM-CENT-CAP-FT, but for a hermetic reciprocating compression chiller.

HERM-REC-EIR-FPLR is the same as HERM-CENT-EIR-FPLR, but for a hermetic reciprocating compression chiller.

HERM-REC-EIR-FT is the same as HERM-CENT-EIR-FT, but for a hermetic reciprocating compression chiller.

OPEN-CENT-CAP-FT is the same as HERM-CENT-CAP-FT, but for an open centrifugal compression chiller.

OPEN-CENT-EIR-FPLR is the same as HERM-CENT-EIR-FPLR, but for an open centrifugal compression chiller.

OPEN-CENT-EIR-FT is the same as HERM-CENT-EIR-FT, but for an open centrifugal compression chiller.

OPEN-REC-CAP-FT is the same as HERM-CENT-CAP-FT, but for an open reciprocating compression chiller.

OPEN-REC-EIR-FPLR is the same as HERM-CENT-EIR-FPLR, but for an open reciprocating compression chiller.

OPEN-REC-EIR-FT is the same as HERM-REC-EIR-FT, but for an open reciprocating compression chiller.

Double-Bundle Chillers

DBUN-CAP-FT accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. The equation will be used to describe the capacity of a double-bundle chiller as a function of exit water temperature and entering condenser water temperature. This function should be normalized so that f(CHILL-WTR-T, DBUN-COND-T-ENT) = 1.0. When in heat recovery mode, DBUN-COND-T-ENT is used in place of the actual entering condenser water temperature to eliminate the effect of the entering water temperature on the capacity.

DBUN-CAP-FTRISE accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation defines double-bundle chiller capacity correction factor as a function of the difference between the exiting condenser water temperatures in the heat recovery and non-heat-recovery modes. It is normalized so that if $\Delta T = 0$, it = 1.

DBUN-EIR-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. The equation will describe the electric-input ratio of a double-bundle chiller as a function of part-load ratio.

DBUN-EIR-FT accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. The equation will be used to describe the electric input ratio adjustment factor of a double-bundle chiller as a function of exit water temperature and entering condenser water temperature. This function should be normalized so that f(CHILL-WTR-T, DBUN-COND-T-ENT) = 1.0. When in the heat-recovery mode, DBUN-COND-T-ENT is used to eliminate the effect of the entering condenser water temperature on the electric input ratio.

DBUN-EIR-FTRISE accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. The equation will express electric input ratio as a function of "TRISE" (see DBUN-CAP-FTRISE).

TABLE V.6
EQUIPMENT-QUAD COEFFICIENT DEFAULT VALUES

Equations are assumed to take the following form: $F = a + bx + cx^2 + dy + ey^2 + fxy$ or $F = a + bx + cx^2 + dx^3$

Keyword	Independent Variables*	a	b	c	d	e	f	Default Curve U-name
		Cooling Equipment						
		Absorption Chillers						
ABSOR1-CAP-FT	Tout, Tin	0.723412	0.079006	-0.000897	-0.025285	-0.000048	0.000276	ACAPT1
ABSOR1-HIR-FPLR	PLR	0.098585	0.583850	0.560658	-0.243093	0.000000	0.000000	HIRPLR1
ABSOR1-HIR-FT	Tout, Tin	0.652273	0.000000	0.000000	-0.000545	0.000055	0.000000	HIRT1
ABSOR2-CAP-FT	Tout, Tin	-0.816039	-0.038707	0.000450	0.071491	-0.000636	0.000312	ACAPT2
ABSOR2-HIR-FPLR	PLR	0.013994	1.240449	-0.914883	0.660441	0.000000	0.000000	HIRPLR2
ABSOR2-HIR-FT	Tout, Tin	1.658750	0.000000	0.000000	-0.029000	0.000250	0.000000	HIRT2
ABSORS-CAP-FT	Tout, Tin	*0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	ACAPT4
ABSORS-CAP-FTS	HW-T	*0.000000	0.000000	0.000000	--	--	--	ACAPTS
ABSORS-HIR-FPLR	PLR	*0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	HIRPLR4
ABSORS-HIR-FT	Tout, Tin	*0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	HIRT4
ABSORS-HIR-FTS	HW-T	*0.000000	0.000000	0.000000	--	--	--	HIRTS
		Compression Chillers						
HERM-CENT-CAP-FT	Tout, Tin	-1.742040	0.029292	-0.000067	0.048054	-0.000291	-0.000106	CCAPT3
HERM-CENT-EIR-FPLR	PLR	0.222903	0.313387	0.463710	-	-	-	EIRPLR3
HERM-CENT-EIR-FT	Tout, Tin	3.117500	-0.109236	0.001389	0.003750	0.000150	-0.000375	EIRT3
HERM-REC-CAP-FT	Tout, Tin	-4.161461	0.207050	-0.00[illegible]193	0.004723	-0.000040	-0.000087	CCAPT4
HERM-REC-EIR-FPLR	PLR	0.088065	1.137742	-0.225806	-	-	-	EIRPLR4
HERM-REC-EIR-FT	Tout, Tin	4.720965	-0.187504	0.002192	0.009209	0.000098	-0.000322	EIRT4
OPEN-CENT-CAP-FT	Tout, Tin	-1.742040	0.029292	-0.000067	0.048054	-0.000291	-0.000106	CCAPT1
OPEN-CENT-EIR-FPLR	PLR	0.222903	0.313387	0.463710	-	-	-	EIRPLR1
OPEN-CENT-EIR-FT	Tout, Tin	3.117500	-0.109236	0.001389	0.003750	0.000150	-0.000375	EIRT1
OPEN-REC-CAP-FT	Tout, Tin	-4.161461	0.207050	-0.001931	0.004723	-0.000040	-0.000087	CCAPT2
OPEN-REC-EIR-FPLR	PLR	0.088065	1.137742	-0.225806	-	-	-	EIRPLR2
OPEN-REC-EIR-FT	Tout, Tin	4.720965	-0.187504	0.002192	0.009209	0.000098	-0.000322	EIRT2
		Double-Bundle Chillers						
DBUN-CAP-FT	Tout, Tin	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	DBCAPT
DBUN-CAP-FTRISE	Tdiff	1.000000	0.000000	0.000000	-	-	-	DBCAPREC
DBUN-EIR-FPLR	PLR	0.349032	0.263871	0.387097	-	-	-	DBEIRPLR
DBUN-EIR-FT	Tout, Tin	-0.714258	0.000000	0.000000	0.025103	-0.000058	0.000000	DBEIRT
DBUN-EIR-FTRISE	Tdiff	1.000000	0.000800	0.000360	-	-	-	DBEIRREC

* Appropriate default curves for the ABSORS chiller are not known. Unless the user can supply appropriate data, the user is advised to use ABSOR1 for solar absorption cooling.

TABLE V.6 - CONTINUED

Keyword	Independent Variables*	a	b	c	d	e	f	Default Curve U-name
		Heating Equipment						
DHW-HIR-FPLR	PLR	0.021826	0.977630	0.000543	-	-	-	
FURNACE-HIR-FPLR	PLR	0.018610	1.094209	-0.112819	-	-	-	
HW-BOILER-HIR-FPLR	PLR	0.082597	0.996764	-0.079361	-	-	-	
STM-BOILER-HIR-FPLR	PLR	0.082597	0.996764	-0.079361	-	-	-	
		Cooling Tower						
TWR-APP-FRFACT	RF	4.981467	-6.761789	24.709033	0.114499	-0.000612	-0.250651	APPRWB
TWR-FAN-ELEC-FTU	NTU	-395.140000	90.990000	-0.016000	--	--	--	ECELL
TWR-RFACT-FAT	APP,OWB	0.895328	-0.116550	0.001917	-0.001040	-0.000026	0.000398	RAPPWB
TWR-RFACT-FRT	APP,OWB	1.484326	0.129479	-0.004014	-0.054336	0.000312	-0.000147	RRNGWB
TC-CHLR-CAP-FT	T_{cond},T_{cw}	-0.351443	0.056583	-0.600054	-0.045625	-0.000043	-0.000012	CCAPT5
		Electric Generating Equipment						
	Diesel							
DIESEL-EXH-FPLR	PLR	0.314400	-0.135300	0.097260	-	-	-	REXD
DIESEL-I/O-FPLR	PLR	0.097550	0.631800	-0.416500	-	-	-	RELD
DIESEL-JAC-FPLR	PLR	0.392200	-0.436700	0.277960	-	-	-	RJACD
DIESEL-LUB-FPLR	PLR	0.088300	-0.137100	0.080300	-	-	-	RLUBD
DIESEL-STACK-FU	KWout	0.019026	0.900000	0.000000	-	-	-	UACD
DIESEL-TEX-FPLR	PLR	720.000000	60.000000	0.000000	-	-	-	TEXD
	Gas Turbine							
GTURB-EXH-FT	ODB	0.018226	0.000029	0.000000	-	-	-	FEXG
GTURB-I/O-FPLR	PLR	7.683000	-13.480000	8.000000	-	-	-	FUEL1G
GTURB-I/O-FT	ODB	1.882200	-0.004330	0.000014	-	-	-	FUEL2G
GTURB-STACK-FU	KWout	0.038051	0.900000	0.000000	-	-	-	UACG
GTURB-TEX-FPLR	PLR	1.000000	0.384500	0.028150	-	-	-	TEX1G
GTURB-TEX-FT	ODB	406.960000	0.631700	0.000224	-	-	-	TEX2G
	Steam Turbine							
STURB-I/O-FPLR	PLR	1.000000	0.000000	0.000000	-	-	-	RFSTUR

*Tout, Tin = exit temperature, entering temperature (°F, °F)

HW-T = temperature of solar heated water (°F)

PLR = part-load ratio (fraction)

Tdiff = difference between exit water temperatures with and without heat recovery (°F)

RF = rating factor

T_{cond} = temperature of condenser water (°F)

NTU = number of tower units per cell

APP = approach temperature (°F)

OWB = outside wet-bulb temperature (°F)

kWout = electrical output (kW)

ODB = outside dry-bulb temperature (°F)

Heating Equipment

DHW-HIR-FPLR — accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to correct the ratio (energy input/heat output) (DHW-HIR in the PLANT-PARAMETERS instruction) of a domestic hot water as a function of part-load ratio.

FURNACE-HIR-FPLR — accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to correct the ratio (energy input/heat output) (FURNACE-HIR in the PLANT-PARAMETERS instruction) of a furnace, including its pilot light, as a function of part-load ratio. See discussion of -HIR-FPLR.

HW-BOILER-HIR-FPLR is the same as DHW-HIR-FPLR for a hot-water boiler (HW-BOILER-HIR in the PLANT-PARAMETERS instruction).

STM-BOILER-HIR-FPLR — is the same as DHW-HIR-FPLR for a steam boiler (STM-BOILER-HIR in the PLANT-PARAMETERS instruction).

Cooling Tower

TWR-APP-FRFACT — accepts the U-name of a bi-linear or bi-quadratic equation. This is the inverse function to TWR-RFACT-FAT and expresses the approach as a function of the rating factor and the wet-bulb temperature. It is normalized to be the design approach at the design rating factor and wet-bulb.

TWR-FAN-ELEC-FTU — accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the tower fan electric consumption as a function of the number of tower units per cell.

TWR-RFACT-FAT — accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation is the logarithm of the tower rating factor as a function of the approach temperature and the ambient wet-bulb temperature. It is normalized so that it is equal to 0.0 at the design approach and wet-bulb temperature.

TWR-RFACT-FRT — accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation is the logarithm of the cooling tower rating factor as a function of the logarithm of the range, and the ambient wet-bulb temperature. It is normalized so that it is equal to 0.0 at the design range and wet-bulb.

TC-CHLR-CAP-FT — accepts the U-name of a CURVE-FIT instruction that defines a bi-linear or bi-quadratic equation. That equation will be used to express the compression chiller capacity as a function of condenser and chilled water temperatures while operating in the direct cooling, THERMO-CYCLE mode.

Diesel

DIESEL-EXH-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to describe the diesel engine exhaust heat as a function of its part-load ratio.

DIESEL-I/O-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to calculate a diesel engine energy input/output ratio as a function of its part-load ratio.

DIESEL-JAC-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to calculate diesel jacket heat as a function of part-load ratio.

DIESEL-LUB-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to calculate diesel lube-oil heat as a function of part-load ratio.

DIESEL-STACK-FU accepts the U-name of a CURVE-FIT instruction that defines the coefficients a and b of the equation $z = ax^b$. The user must use TYPE = QUADRATIC in the CURVE-FIT instruction and enter the coefficients as (a, b, 0). That equation will be used to calculate the UA of a diesel engine exhaust heat exchanger as a function of electric output (see -STACK-FU).

DIESEL-TEX-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to calculate a diesel engine exhaust gas temperature as a function of part-load ratio.

Gas Turbine

GTURB-EXH-FT accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the exhaust heat of a gas turbine as a function of ambient air temperature.

GTURB-I/O-FPLR accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. The equation will be used to express the energy input/output ratio of a gas turbine as a function of its part-load ratio.

GTURB-I/O-FT accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express a gas turbine energy input/output ratio as a function of ambient air temperature.

Gas Turbine (cont.)

GTURB-STACK-FU — accepts the U-name of a CURVE-FIT instruction that defines the coefficients a and b of the equation $z = ax^b$. The user must use TYPE = QUADRATIC in the CURVE-FIT instruction and enter the coefficients as (a, b, 0). That equation will be used to express the UA of a gas turbine exhaust heat exchanger as a function of electric output (see -STACK-FU).

GTURB-TEX-FPLR — accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the temperature of gas turbine exhaust gas as a function of its part-load ratio.

GTURB-TEX-FT — accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the gas turbine exhaust gas temperature as a function of ambient air temperature.

Steam Turbine

STURB-I/O-FPLR — accepts the U-name of a CURVE-FIT instruction that defines a linear or quadratic equation. That equation will be used to express the energy input/output ratio of a steam turbine generator as a function of its part-load ratio.

Keyword	Abbrev.	User Input	Input Desc.	Default*	Range Min.	Range Max.
			U-name of:			
Absorption Chillers						
ABSOR1-CAP-FT		=________	bi-linear or bi-quadratic	ACAPT1	–	
ABSOR1-HIR-FPLR		=________	cubic	HIRPLR1	–	–
ABSOR1-HIR-FT		=________	bi-linear or bi-quadratic	HIRT1	–	–
ABSOR2-CAP-FT		=________	bi-linear or bi-quadratic	ACAPT2	–	–
ABSOR2-HIR-FPLR		=________	cubic	HIRPLR2	–	–
ABSOR2-HIR-FT		=________	bi-linear or bi-quadratic	HIRT2	–	–
ABSORS-CAP-FT		=________	bi-linear or bi-quadratic	ACAPT4	–	–
ABSORS-CAP-FTS		=________	linear or quadratic	ACAPTS	–	–
ABSORS-HIR-FPLR		=________	cubic	HIRPLR4	–	–
ABSORS-HIR-FT		=________	bi-linear or bi-quadratic	HIRT4	–	–
ABSORS-HIR-FTS		=________	linear or quadratic	HIRTS	–	–
Compression Chillers						
HERM-CENT-CAP-FT		=________	bi-linear or bi-quadratic	CCAPT3	–	–
HERM-CENT-EIR-FPLR		=________	linear or quadratic	EIRPLR3	–	–
HERM-CENT-EIR-FT		=________	bi-linear or bi-quadratic	EIRT3 –	–	

*See Table V.6 for the default curve coefficients.

Keyword	Abbrev.	User Input	Input Desc.	Default*	Range Min.	Range Max.
			U-name of:			
Compression Chillers cont						
HERM-REC-CAP-FT		= ______	bi-linear or bi-quadratic	CCAPT4	–	–
HERM-REC-EIR-FPLR		= ______	linear or quadratic	EIRPLR4	–	–
HERM-REC-EIR-FT		= ______	bi-linear or bi-quadratic	EIRT4	–	–
OPEN-CENT-CAP-FT		= ______	bi-linear or bi-quadratic	CCAPT1	–	–
OPEN-CENT-EIR-FPLR		= ______	linear or quadratic	EIRPLR1	–	–
OPEN-CENT-EIR-FT		= ______	bi-linear or bi-quadratic	EIRT1	–	–
OPEN-REC-CAP-FT		= ______	bi-linear or bi-quadratic	CCAPT2	–	–
OPEN-REC-EIR-FPLR		= ______	linear or quadratic	EIRPLR2	–	–
OPEN-REC-EIR-FT		= ______	bi-linear or bi-quadratic	EIRT2	–	–
Double-Bundle Chillers						
DBUN-CAP-FT		= ______	bi-linear or bi-quadratic	DBCAPT	–	–
DBUN-CAP-FTRISE		= ______	linear or quadratic	DBCAPREC	–	–
DBUN-EIR-FPLR		= ______	linear or quadratic	DBEIRPLR	–	–
DBUN-EIR-FT		= ______	bi-linear or bi-quadratic	DBEIRT	–	–
DBUN-EIR-FTRISE		= ______	linear or quadratic	DBEIRREC	–	–

Keyword	Abbrev.	User Input	Input Desc.	Default*	Range Min.	Range Max.
			U-name of:			
Heating Equipment						
DHW-HIR-FPLR		=	linear or quadratic	DHWHIR	–	–
FURNACE-HIR-FPLR		=	linear or quadratic	FRNHIR	–	–
HW-BOILER-HIR-FPLR		=	linear or quadratic	BLRHIR2	–	–
STM-BOILER-HIR-FPLR		=	linear or quadratic	BLRHIR1	–	–
Cooling Tower						
TWR-APP-FRFACT		=	bi-linear or bi-quadratic	APPRWB	–	–
TWR-FAN-ELEC-FTU		=	linear or quadratic	ECELL	–	–
TWR-RFACT-FAT		=	bi-linear or bi-quadratic	RAPPWB	–	–
TWR-RFACT-FRT		=	bi-linear or bi-quadratic	RRNGWB	–	–
TC-CHLR-CAP-FT		=	bi-linear or bi-quadratic	CCAPT5	–	–
Diesel						
DIESEL-EXH-FPLR		=	linear or quadratic	REXD	–	–
DIESEL-I/O-FPLR		=	linear or quadratic	RELD	–	–
DIESEL-JAC-FPLR		=	linear or quadratic	RJACD	–	–

*See Table V.6 for the default curve coefficients.

Keyword Default*	Abbrev. Min.	Max.	Input U-name of:	User Input	Range Desc.	
Diesel cont.						
DIESEL-LUB-FPLR		=__________	linear or quadratic	RLUBD	-	-
DIESEL-STACK-FU		=__________	quadratic	UACD	-	-
DIESEL-TEX-FPLR		=__________	linear or quadratic	TEXD	-	-
Gas Turbine						
GTURB-EXH-FT		=__________	linear or quadratic	FEXG	-	-
GTURB-I/O-FPLR		=__________	linear or quadratic	FUEL1G	-	-
GTURB-I/O-FT		=__________	linear or quadratic	FUEL2G	-	-
GTURB-STACK-FU		=__________	quadratic	UACG	-	-
GTURB-TEX-FPLR		=__________	linear or quadratic	TEX1G	-	-
GTURB-TEX-FT		=__________	linear or quadratic	TEX2G	-	-
Steam Turbine						
STURB-I/O-FPLR		=__________	linear or quadratic	RFSTUR	-	-

*See Table V.6 for the default curve coefficients.

5. LOAD-ASSIGNMENT

The LOAD-ASSIGNMENT instruction is used to describe the sequence in which the PLANT-EQUIPMENT is to be assigned to serve the load. In addition, the LOAD-ASSIGNMENT instruction allows the user to specify the portion of the heating or electric load to be met by purchased steam or chilled water and electricity or by on-site generation.

A separate instruction is required for each type (heating, cooling, or electric) of load served by the equipment. If these data are omitted, the program will schedule the operation of equipment in an order that seeks to achieve operation at the OPERATING-RATIO (see PART-LOAD-RATIO instruction) for each piece of equipment. If the LOAD-ASSIGNMENT command is specified, it must be used in conjunction with a LOAD-MANAGEMENT command.

U-name	Any unique user-defined name must be entered to identify this instruction.
<u>LOAD-ASSIGNMENT</u>	This command word informs the PDL Processor that the data to follow will specify the sequence in which PLANT-EQUIPMENT is to be turned on and operated to meet variations in load.
TYPE	precedes a code-word selected from Table V.7 to describe the type of load served by the assigned equipment.
LOAD-RANGE	is the load range, in millions of Btu's per hour, that must be met by the assigned equipment. For example, if one unit is to provide the necessary cooling energy up to a maximum load of 500,000 Btu/hr, the user specifies LOAD-RANGE = 0.5. If a combination of two units is to supply the cooling load from 500,000 Btu/hr to 1,000,000 Btu/hr, the user would enter a second LOAD-RANGE instruction, having the following keyword specification: LOAD-RANGE = 1.0.

TABLE V.7

Load Assignment TYPE

Code-Word	Assigned Equipment
HEATING	Plant equipment and purchased steam assigned for heating load.
COOLING	Plant equipment and purchased chilled water assigned for space cooling load
ELECTRICAL	Plant equipment and purchased electricity assigned for electrical loads.

PLANT-EQUIPMENT identifies a U-named PLANT-EQUIPMENT instruction for the equipment assigned to meet the load. Up to three types of PLANT-EQUIPMENT may be assigned for each load range (see Example 1).

In addition to U-named pieces of PLANT-EQUIPMENT, this may designate either a steam, chilled water, or electric UTILITY as an item to meet all or part of the electric, heating, or cooling loads. If any of these options is exercised, the user must further authorize the use of purchased steam, cooling, or electricity through the ENERGY-COST instruction. The specification of the UNIT keyword in the ENERGY-COST instruction permits the use of any combination of electric, chilled water, and steam utilities. Since the ENERGY-COST instruction default for UNIT is nonzero for purchased electricity, but zero for purchased chilled water and steam, the utility automatically meets all electric loads not satisfied by on-site generation, but no heating or cooling loads will be met by a utility unless UNIT is defined for purchased chilled water and/or steam.

NUMBER identifies the number of units of the U-named equipment assigned to meet the load. For example, if two units of a single-stage machine named ABSOR1 are to be run along with a double-bundle chiller named DBUN1, the following specification is required.

```
PLANT-EQUIPMENT = ABSOR1
NUMBER = 2
PLANT-EQUIPMENT = DBUN1
NUMBER = 1
```

If utility steam, chilled water, and/or electricity is to be used, the user must specify the millions of Btu's of utility to be supplied. The user enters

PLANT-EQUIPMENT = UTILITY
NUMBER = 10

to order up to 10 million Btu's from an electric, chilled water, or steam utility.

OPERATION-MODE is associated with a code-word selected by the user from Table V.8 to describe the method of loading equipment.

TABLE V.8
Equipment OPERATION-MODE

Code-Word	Mode Description
RUN-ALL	Each unit of the assigned equipment meets a demand in the proportion of its capacity to the total capacity of the assigned equipment. All units are run simultaneously.
RUN-NEEDED	Each unit of the assigned equipment is turned on sequentially to meet the demand. The equipment operates in the order of listing.

Rules:

1. The number of LOAD-RANGEs times 2 plus the total of all PLANT-EQUIPMENTs in all ranges times 3 cannot exceed 130.

2. FURNACE, DHW-HEATER, and ELEC-DHW-HEATER cannot be specified in a LOAD-ASSIGNMENT.

Note: If the user has specified utilities other than electricity, i.e., steam or chilled water, but has not specified ENERGY-COST instructions for these utilities, energy usage and costs will not be reported by the program. Input for the ENERGY-COST instruction must include input for both keywords RESOURCE and UNIT.

Example 1:

Two boilers, BOILER-1 and BOILER-2, are defined by hypothetical PLANT-EQUIPMENT instructions to be capable of producing 5 MBtuh and 10 MBtuh of heat, respectively. If the small boiler is to be run for heating loads between 0-5 MBtuh, the larger one for loads between 5-10 MBtuh, and both for loads greater than 10 MBtuh, the user inputs:

```
BOILERS = LOAD-ASSIGNMENT
   TYPE = HEATING
   LOAD-RANGE = 5
       PLANT-EQUIPMENT = BOILER-1
       NUMBER = 1
   LOAD-RANGE = 10
       PLANT-EQUIPMENT = BOILER-2
       NUMBER = 1
   LOAD-RANGE = 15
       PLANT-EQUIPMENT = BOILER-1
       NUMBER = 1
       PLANT-EQUIPMENT = BOILER-2
       NUMBER = 1 ..
```

Since OPERATION-MODE is not defined in the above example, the equipment operates sequentially, i.e., RUN-NEEDED, to meet the heating load.

Another way of specifying the same operation for these boilers is as follows:

```
BOILERS = LOAD-ASSIGNMENT
     TYPE = HEATING
     LOAD-RANGE = 5
         PLANT-EQUIPMENT = BOILER-1
         NUMBER = 1
     LOAD-RANGE = 15
         PLANT-EQUIPMENT = BOILER-2
         NUMBER = 1
         PLANT-EQUIPMENT = BOILER-1
         NUMBER = 1 ..
```

Since defaulting the OPERATION-MODE instructs the program to operate the equipment sequentially, heating loads between 5 and 10 MBtuh will require only BOILER-2 to run. Loads above 10 MBtuh require the additional operation of BOILER-1. Defining OPERATION-MODE = RUN-ALL would force the simultaneous operation of both boilers when the load is greater than 5 MBtuh.

Example 2:

A diesel generator, DIESEL-1, is defined by a hypothetical PLANT-EQUIPMENT instruction to be capable of producing 10 MBtuh of electricity. If the user wishes to operate this unit whenever the electric load exceeds 20 MBtuh, the user specifies

```
ELEC = LOAD-ASSIGNMENT
     TYPE = ELECTRICAL
     LOAD-RANGE = 30
         PLANT-EQUIPMENT = UTILITY
         NUMBER = 20
         PLANT-EQUIPMENT = DIESEL-1
         NUMBER = 1  ..
```

In the example above, the electric utility will supply 20 MBtuh and the diesel generator 2 MBtuh if the electric load is 22 MBtuh. If the user wishes to start the diesel generator and operate it at full load whenever the electric load exceeds 20 MBtuh, then the user specifies

```
ELEC = LOAD-ASSIGNMENT
     TYPE = ELECTRICAL
     LOAD-RANGE = 20
         PLANT-EQUIPMENT = UTILITY
         NUMBER = 20
     LOAD-RANGE = 30
         PLANT-EQUIPMENT = DIESEL-1
         NUMBER = 1 ..
```

The diesel will now satisfy the first 10 MBtuh when the total electric load is above 20 MBtuh. The electric utility will, by default, supply the rest.

Example 3:

Two chillers, CENT-CHLR and ABSOR-CHLR, are defined by hypothetical PLANT-EQUIPMENT instructions to be an open centrifugal and single-stage absorption chiller, respectively, both capable of producing 10 MBtuh. If the user wishes to operate the absorption machine with the compression unit whenever the cooling load exceeds 10 MBtuh and at the same time minimize the electric load, the user specifies:

```
CHILLERS = LOAD-ASSIGNMENT
     TYPE = COOLING
     LOAD-RANGE = 10
         PLANT-EQUIPMENT = CENT-CHLR
         NUMBER = 1
     LOAD-RANGE = 20
         PLANT-EQUIPMENT = ABSOR-CHLR
         NUMBER = 1
         PLANT-EQUIPMENT = CENT-CHLR
         NUMBER = 1 ..
```

Example 4:

An open centrifugal chiller named CENT-CHLR and a cold water storage tank named COLD-TANK are defined by hypothetical PLANT-EQUIPMENT instructions to be capable of producing 10 MBtuh of cooling and storing 40 MBtu, respectively. In addition, a hypothetical ENERGY-STORAGE instruction permits the delivery of up to 10 MBtu of cold water per hour from the tank. If the user wishes to supply cold water from the storage tank whenever the cooling load is greater than the capacity of the chiller, the user specifies

```
CHILLER 1 = LOAD-ASSIGNMENT
     TYPE = COOLING
     LOAD-RANGE = 20
         PLANT-EQUIPMENT = CENT-CHLR
         NUMBER = 1
         PLANT-EQUIPMENT = COLD-TANK
         NUMBER = 1 ..
```

_________________ = LOAD-ASSIGNMENT or L-A**** (User Worksheet)
U-name*

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
TYPE	TYPE	=	______	code-word	-	-	-
OPERATION-MODE	O-M	=	______	code-word	**	-	-
LOAD-RANGE	L-R	=	______	10^6 Btu/hr	*	0.	1000.
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
LOAD-RANGE	L-R	=	______	10^6 Btu/hr	*	0.	1000.
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
LOAD-RANGE	L-R	=	______	10^6 Btu/hr	*	0.	1000.
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
LOAD-RANGE	L-R	=	______	10^6 Btu/hr	*	0.	1000.
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***
PLANT-EQUIPMENT	P-E	=	______	U-name	-	-	-
NUMBER	N	=	______	number	*	0.	1000.***

..

* This is a required data entry.

** The default is sequential operation, i.e., RUN-NEEDED.

*** When specifying units of equipment this maximum value is MAX-NUMBER-AVAIL in PLANT-EQUIPMENT instruction.

**** Note: Keyword entries in this instruction must be in the order shown.

6. LOAD-MANAGEMENT

The LOAD-MANAGEMENT instruction is used to schedule seasonal operation of plant equipment or for managing heating, cooling, or electric loads.

Each LOAD-ASSIGNMENT instruction must be referenced by the LOAD-MANAGEMENT instruction. If the LOAD-ASSIGNMENT and LOAD-MANAGEMENT instructions are omitted, the operation of heating, cooling, and electrical equipment will not be user-controlled. In this case, the program will schedule the operation of equipment in an order that seeks to achieve the OPERATING-RATIO (see PART-LOAD-RATIO instruction) for each piece of equipment.

<u>LOAD MANAGEMENT</u> This command word informs the PDL Processor that the data to follow are related to the scheduling of plant equipment or managing the heating, cooling, or electric loads.

HEAT-MULTIPLIER specifies the ratio of the managed power input to the nominal capacity of the normally assigned plant heating equipment. For example, if the electric load is being managed to reduce peak demands, the user enters the ratio

$$\text{ratio} = \frac{\text{electric power input (Btu/hr)}}{\text{nominal heating capacity (Btu/hr)}}$$

for the equipment normally assigned to meet the heating load. This entry should include the electric energy to move and control the working fluid, as well as the electric power input to the equipment.

COOL-MULTIPLIER specifies the ratio of the managed power input to the nominal capacity of the normally assigned plant cooling equipment. For example, if the electric load is to be managed to reduce peak demands, the user enters the ratio

$$\text{ratio} = \frac{\text{electric power input (Btu/hr)}}{\text{nominal cooling capacity (Btu/hr)}}$$

for the equipment normally assigned to meet the cooling load. This entry should include the electric energy to move and control the working fluid, as well as the electric input to the equipment.

If the user does not wish to manage a load, no entry is required.

ELEC-MULTIPLIER specifies the ratio of the managed power input to the nominal capacity of normally assigned plant electric generating equipment. For example, if the heating load is being managed to reduce natural gas peak consumption, the user enters the ratio

$$\text{ratio} = \frac{\text{heat input (Btu/hr)}}{\text{nominal electric capacity (Btu/hr)}}$$

for the equipment normally assigned to meet the electric load. This entry should include the heat power to move and control the working fluid as well as the heat to the normally assigned electric generating equipment.

If the user does not wish to manage a load, no entry is required.

PRED-LOAD-RANGE is the predicted load range of the managed load in which the assigned equipment operates.

ASSIGN-SCHEDULE identifies a list of three U-named SCHEDULE instructions that will schedule the assignment of the plant heating, cooling, and electric generation equipment. No entry is made if the LOAD-ASSIGNMENT keyword is defined for the PRED-LOAD-RANGE. The scheduling of heating, cooling, and electric equipment must not be combined in one SCHEDULE instruction.

LOAD-ASSIGNMENT identifies a list of three U-named LOAD-ASSIGNMENT instructions that specify the heating, cooling and electric generating equipment to be assigned to the PRED-LOAD-RANGE. No entry is made if the ASSIGN-SCHEDULE keyword has been defined for the PRED-LOAD-RANGE.

Rule: The total number of PRED-LOAD-RANGE keywords cannot exceed 10.

Example 1:

This example shows how the cooling equipment assigned in Example 3 of the LOAD-ASSIGNMENT discussion is used to meet the cooling loads.

```
LOAD-MANAGEMENT
     PRED-LOAD-RANGE = 999
     LOAD-ASSIGNMENT = (DEFAULT, CHILLERS, DEFAULT)  ..
```

By inputting DEFAULT where shown, the user allows the program to decide which heating and electric equipment to operate. If, however, the user wishes to assign the operation of heating equipment, as specified in Example 1 of the LOAD-ASSIGNMENT instruction, then the user specifies

```
LOAD-MANAGEMENT
     PRED-LOAD-RANGE = 999
     LOAD-ASSIGNMENT = (BOILERS,CHILLERS,DEFAULT)  ..
```

Example 2:

A double-bundle chiller, DBUN, and an open centrifugal chiller, OPEN-CENT, are defined by a hypothetical PLANT-EQUIPMENT instruction to be capable of producing 10 MBtuh of cooling. If the user prefers to operate the double-bundle chiller in the winter and the open centrifugal machine in the summer supplemented by the double-bundle chiller, the following steps should be taken.

First, define two LOAD-ASSIGNMENT instructions, one for winter and one for summer.

```
WINTER-CHLR = LOAD-ASSIGNMENT
     TYPE = COOLING
     LOAD-RANGE = 10
          PLANT-EQUIPMENT = DBUN
          NUMBER = 1 ..

SUMMER-CHLR = LOAD-ASSIGNMENT
     TYPE = COOLING
     LOAD-RANGE = 20
          PLANT-EQUIPMENT = OPEN-CENT
          NUMBER = 1
          PLANT-EQUIPMENT = DBUN
          NUMBER = 1 ..
```

Next, schedule the LOAD-ASSIGNMENT instructions.

```
WINTER-DAS = DAY-ASSIGN-SCH (1,24) (WINTER-CHLR) ..
WINTER-WS = WEEK-SCHEDULE (ALL) WINTER-DAS ..
SUMMER-DAS = DAY-ASSIGN-SCH (1,24) (SUMMER-CHLR) ..
SUMMER-WS = WEEK-SCHEDULE (ALL) SUMMER-DAS ..
CHILLER-SCH = SCHEDULE
     THRU APR 30 WINTER-WS
     THRU SEP 30 SUMMER-WS
     THRU DEC 31 WINTER-WS ..
```

Finally, specify a LOAD-MANAGEMENT instruction to schedule the operation of plant equipment.

```
LOAD-MANAGEMENT
    PRED-LOAD-RANGE = 999
    ASSIGN-SCHEDULE = (DEFAULT,CHILLER-SCH,DEFAULT) ..
```

Note that in scheduling equipment operation, DAY-ASSIGN-SCH is used instead of the usual DAY-SCHEDULE instruction. A DAY-SCHEDULE command only accepts numbers as values (i.e., 0., 0.5, 1.0), while a DAY-ASSIGN-SCH instruction accepts only U-names of appropriate LOAD-ASSIGNMENT instructions. This enables the hourly scheduling of the assignment of PLANT equipment.

Example 3:

In the following example, the LOAD-MANAGEMENT instruction is used to select the cooling equipment to be operated based upon the anticipated electric load. The program calculates the anticipated load as follows:

Predicted Load = (QH x A) + (QC x B) + (QE x C), where QH, QC, and QE are, respectively, the hourly heating, cooling, and electric loads transferred by the SYSTEMS program, and A, B, and C are the HEAT-MULTIPLIER, COOL-MULTIPLIER, and ELEC-MULTIPLIER keywords of the LOAD-MANAGEMENT instruction.

A building has a 10 Btuh open centrifugal chiller, OPEN-CENT, capable of meeting the cooling loads of the building. However, the peak load demand charges for this facility are quite expensive, so a 10 MBtuh absorption chiller, ABSOR, is purchased to operate in lieu of the compression chiller during periods of electrical demand that exceed 9 MBtuh. The user implements this strategy as follows:

```
NORMAL-COOL = LOAD-ASSIGNMENT
          TYPE = COOLING
          LOAD-RANGE = 10
               PLANT-EQUIPMENT = OPEN-CENT
               NUMBER 1  ..

PEAK-SHAVE = LOAD-ASSIGNMENT
          TYPE = COOLING
          LOAD-RANGE = 10
               PLANT-EQUIPMENT = ABSOR
               NUMBER = 1  ..
```

Next, the user instructs the program to operate the equipment specified by the LOAD-ASSIGNMENT instructions named NORMAL-COOL for predicted electric loads of 9 MBtuh or less, and PEAK-SHAVE for predicted electric loads greater than a 9 MBtuh.

```
LOAD-MANAGEMENT
          HEAT-MULTIPLIER = 0.0
          COOL-MULTIPLIER = 0.333
          ELEC-MULTIPLIER = 1.0
          PRED-LOAD-RANGE = 9
          LOAD-ASSIGNMENT = (DEFAULT,NORMAL-COOL,DEFAULT)

          PRED-LOAD-RANGE = 1000
          LOAD-ASSIGNMENT = (DEFAULT,PEAK-SHAVE,DEFAULT) ..
```

The significance of the predicted load is illustrated in the following discussion:

Assume that the heating, cooling, and electric loads passed from SYSTEMS are 0.2, 8 and 4 MBtuh, respectively. Thus,

$$\text{Predicted Load} = (0.2 \times 0) + (8 \times 0.333) + (4 \times 1)$$
$$= 6.66 \text{ MBtuh electric.}$$

Since the predicted load falls within the PRED-LOAD-RANGE = 9 (i.e., 0 to 9 MBtuh), the equipment selected for operation are the heating and electric equipment defined by DEFAULT and the open centrifugal chiller defined by NORMAL-COOL.

If, however, the heating, cooling, and electric loads passed from SYSTEMS are 0.1, 9.5, and 7 MBtuh, respectively, then

$$\text{Predicted Load} = (0.1 \times 0) + (9.5 \times 0.333) + (7 \times 1)$$
$$= 10.16 \text{ MBtuh electric.}$$

Now the predicted load falls within the PRED-LOAD-RANGE = 1000 (i.e., 9 to 1000 MBtuh). Therefore, the equipment selected for operation becomes the heating and electric equipment defined by DEFAULT and the absorption chiller defined by PEAK-SHAVE.

Note that the MULTIPLIER should be specified based on the equipment specified in <u>first</u> LOAD-ASSIGNMENT keyword (i.e., normally assigned equipment) of <u>the</u> LOAD-MANAGEMENT instruction.

The LOAD-MANAGEMENT multipliers in this example are specified to predict electric load. HEAT-MULTIPLIER = 0.0 because it is felt that the electric load imposed by the heating equipment is negligible. ELEC-MULTIPLIER = 1.0 because the total SYSTEMS electric load must be added to the PLANT equipment electric demand when the electric load is being managed. And finally, the COOL-MULTIPLIER = 0.333 is the user's estimate of number of Btu's of electric energy required for each Btu of cooling. This implies that the overall coefficient of performance for the centrifugal chiller and cooling tower combination is 3.0.

<u>Example 4</u>

A 10 MBtuh double-bundle chiller, DBUN, and a 10 MBtuh open centrifugal chiller, CENT, are specified in a hypothetical PLANT equipment instruction. Even though the double-bundle chiller is less efficient than the open centrifugal chiller, it is capable of supplying waste heat for space heating. Therefore, the user prefers to operate DBUN whenever the space heating load exceeds 2 MBtu. Thus, the user specifies

```
HTRECOVER = LOAD-ASSIGNMENT
     TYPE = COOLING
     LOAD-RANGE = 10
          PLANT-EQUIPMENT = DBUN
          NUMBER = 1

NORECOVER = LOAD-ASSIGNMENT
     TYPE = COOLING
     LOAD-RANGE = 10
          PLANT-EQUIPMENT = CENT
          NUMBER = 1 ..

LOAD-MANAGEMENT
     HEAT-MULTIPLIER = 1.0
     COOL-MULTIPLIER = 0.0
     ELEC-MULTIPLIER = 0.0
```

```
PRED-LOAD-RANGE = 2
   LOAD-ASSIGNMENT = (DEFAULT,NORECOVER,DEFAULT)

PRED-LOAD-RANGE = 1000
   LOAD-ASSIGNMENT = (DEFAULT,HTRECOVER,DEFAULT) ..
```

The example above illustrates the use of a LOAD-MANAGEMENT instruction in selecting equipment for operation based upon the predicted heating load. The predicted heat load is calculated exactly the same way as shown in Example 3, except that the LOAD-MANAGEMENT multipliers now refer to the heating load as the managed load.

LOAD-MANAGEMENT or L-M (User Worksheet)

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
HEAT-MULTIPLIER	H-M =	______	number	0.	0.	10.
COOL-MULTIPLIER	C-M =	______	number	0.	0.	10.
ELEC-MULTIPLIER	E-M =	______	number	1.	0.	10.
PRED-LOAD-RANGE	PRED-L-R=	______	10^6 Btu/hr	*	0.	1000.
ASSIGN-SCHEDULE	A-SCH=	(______)	list of U-names**	-	-	-
LOAD-ASSIGNMENT	L-A =	(______)	list of U-names**	-	-	-
PRED-LOAD-RANGE	PRED-L-R=	______	10^6Btu/hr	*	0.	1000.
ASSIGN-SCHEDULE	A-SCH=	(______)	list of U-names**	-	-	-
LOAD-ASSIGNMENT	L-A =	(______)	list of U-names**	-	-	-
PRED-LOAD-RANGE	PRED-L-R=	______	10^6 Btu/hr	*	0.	1000.
ASSIGN-SCHEDULE	A-SCH=	(______)	list of U-names**	-	-	-
LOAD-ASSIGNMENT	L-A =	(______)	list of U-names**	-	-	-
		..				

* This is a required data entry.

** The list of U-names should be ordered as follows: the assignment for heating first, cooling next, and electric last. The list need not assign cooling or electric equipment if only the heating load is being managed. However, the list must assign the heating and cooling equipment if the cooling load is managed, or the heating, cooling and electric generating equipment if the electric load is managed.

7. 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. With only one exception, no default values are available; if a double-bundle chiller is specified without defining a HEAT-RECOVERY instruction, the heat rejected from the double bundle is delivered to space heating. A maximum of five levels of recoverable heat supply and demand are permitted. See the DOE-2 Engineers Manual for a description of heat recovery in appropriate equipment simulations.

HEAT-RECOVERY — This command word informs the PDL Processor that the data to follow are related to recovered energy from plant equipment or processes.

SUPPLY-1 through SUPPLY-5 — The user enters a list of up to three code-words from Table V.9 that describe the equipment or process supplying recoverable heat. The specification

SUPPLY-1 = (DIESEL-GEN, HTANK-STORAGE)

assigns the waste heat from the exhaust of a diesel engine to the highest temperature level to meet demands. Similarly, the keywords SUPPLY-2 through SUPPLY-5 assign waste heat to successively lower temperature levels. The user must always define these keywords in arithmetic order, starting with SUPPLY-1.

DEMAND-1 through DEMAND-5 — The user enters a list of up to three code-words from Table V.10 that describe the equipment or process to which recoverable heat should go. The definition

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 in proportion to their loads. Similarly, the keywords DEMAND-2 through DEMAND-5 describe the successively lower priorities for use of recoverable heat. The user should never leave gaps in the numerical order of the demands, i.e., if DEMAND-1 and DEMAND-3 are entered, DEMAND-2 must also be entered.

TABLE V.9

HEAT-RECOVERY Suppliers

Equipment	Code-Word
Heating	
Fossil fuel boiler blowdown	STM-BOILER
Cooling	
Double-bundle chiller	DBUN-CHLR
Electric Generating Equipment	
Diesel engine exhaust	DIESEL-GEN
Diesel engine cooling jacket	DIESEL-JACKET
Steam turbine exhaust	STURB-GEN
Gas turbine exhaust	GTURB-GEN
Storage	
Hot water tank	HTANK-STORAGE
Solar Equipment	
Solar energy for space heating loads	SOL-SPACE-HEAT
Solar energy for process heating and domestic hot water loads	SOL-PROCESS-HEAT
Solar energy for space cooling loads	SOL-COOLING

TABLE V.10

HEAT-RECOVERY Demanders

Equipment or Process	Code-Word
Heating	
Steam boiler feedwater heating	STM-BOILER
Process and domestic hot water loads	PROCESS-HEAT
Space heating load	SPACE-HEAT
Cooling	
One-stage absorption chiller	ABSOR1-CHLR
Two-stage absorption chiller w/economizer	ABSOR2-CHLR
One-stage absorption chiller w/solar assist	ABSORS-CHLR
Electric Generating Equipment	
Steam turbine supply	STURB-GEN
Storage	
Hot water tank	HTANK-STORAGE

Rules:

1. Table V.11 illustrates the default hierarchy of temperatures of recoverable heat. Recoverable heat from equipment or processes in the supply column can be directed to the equipment or processes in the demand column, which are at a lower temperature. The effectiveness of the exchange is either specified by the appropriate PLANT-PARAMETER keyword or the heat exchanger is assumed to be large enough to exchange the recoverable heat. The user should not specify a demand if the stratum of the demand is greater than the supply stratum; however, the user may do so, if the Second Law of Thermodynamics is not violated. A warning will be issued when this default hierarchy is overridden.

   For example, the specification

   ```
   HEAT-RECOVERY
           SUPPLY-1 = (STURB-GEN)
           DEMAND-1 = (ABSOR1-CHLR)  ..
   ```

   will issue a warning because the 102°F exhaust temperature for a steam turbine (see the STURB-EXH-PRES keyword in the PLANT-PARAMETERS instruction) is insufficient to fire a single-stage absorption refrigeration unit requiring a minimum of 180°F. If, however, STURB-EXH-PRES is specified so that a 200°F exhaust temperature will be achieved, the warning can be ignored.

2. Rule 1 applies only to supplies and demands at the same priority level. There is no restriction that the supply at level 1 be at a higher temperature than the supply at level 2. The SUPPLY-1, DEMAND-1 keyword pair merely tells the PLANT simulation to treat that heat recovery operation before treating the heat recovery operation described in the SUPPLY-2, DEMAND-2 keyword pair.

3. If the supply exceeds demand at a given level, the demand is satisfied and the remaining available recoverable heat is rejected, unless either this supply equipment is respecified at a lower level or the supplying process is solar (SOL-SPACE-HEAT, SOL-PROCESS-HEAT, or SOL-COOLING). The solar source is assumed to be a storage tank that is left partially charged after meeting the demand. Excess demand from a level is met by the conventional PLANT heating equipment. Each equipment and process can be entered on as many levels (up to 5) as the user desires, and, within the restrictions of Tables V.9 and V.10, can be entered as both supply and demand.

Example:

```
HEAT-RECOVERY
        SUPPLY-1 = (DIESEL-JACKET)
        DEMAND-1 = (ABSOR1-CHLR)
        SUPPLY-2 = (DBUN-CHLR, DIESEL-JACKET)
        DEMAND-2 = (SPACE-HEAT, PROCESS-HEAT)  ..
```

TABLE V.11

Default HEAT-RECOVERY Temperature Hierarchy

Stratum	Supply Code-Word	Demand Code-Word
10	GTURB-GEN	
9	DIESEL-GEN	ABSOR2-CHLR1, STURB-GEN
8	DIESEL-JACKET	
7	SOL-COOLING	
6	STM-BOILER	ABSOR1-CHLR
5		STM-BOILER
4	SOL-PROCESS-HEAT	PROCESS-HEAT
3	DBUN-CHLR	
2	SOL-SPACE-HEAT	
1	STURB-GEN	SPACE-HEAT
*	HTANK-STORAGE	HTANK-STORAGE

* Depends upon its temperature, that is, its energy source.

The diesel engine supplies the absorption chiller on level 1. Any remaining recoverable heat from the diesel can be used on level 2. On level 2 the multiple demands are met by the supplies in proportion to their loads. The supplies on each level are used sequentially, i.e., the double-bundle chiller heat is used before the diesel jacket, because it is first in the list.

4. The default HEAT-RECOVERY (directing the condenser heat from a double-bundle chiller to satisfy space heating) is overridden whenever the HEAT-RECOVERY command is used. Therefore, if the user wants to enter HEAT-RECOVERY equipment and processes in addition to the DBUN-CHLR, the user must explicitly enter the DBUN-CHLR as a supply and SPACE-HEAT as its demand.

5. Only one solar supply is allowed at each level. The user must decide the purpose of the solar source for each level and cannot, for example, enter the following:

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

His intention, in this example, was to satisfy the domestic hot water or process heating demand first and to contribute to meeting the space heating demands after the hot water demand is met.

The correct input for achieving this purpose would be

```
HEAT-RECOVERY
        SUPPLY-1 = (SOL-PROCESS-HEAT)
        DEMAND-1 = (PROCESS-HEAT)
        SUPPLY-2 = (SOL-SPACE-HEAT)
        DEMAND-2 = (SPACE-HEAT)  ..
```

6. If the solar equipment is connected directly to the space heating coils by specifying or allowing the default for the keyword HEAT-SOURCE = HOT-WATER/SOLAR in SYSTEMS, then it is inappropriate to use SOL-SPACE-HEAT as a supply in the HEAT-RECOVERY command.

7. Rules applying to the user of a storage tank in HEAT-RECOVERY:

   a. The tank supply should always be the last entry of the SUPPLY-n keyword at any given level. The user may enter the tank at some other position, but the program will move the tank to the end of the list. This implies that tank storage will always be the last source of supply at a given level. Only when all other sources of recovered heat have been used up will the storage tank be called on to supply heat. Therefore, if the user enters

```
HEAT-RECOVERY
          SUPPLY-1 = (HTANK-STORAGE, DBUN-CHLR)
```

   the program will interpret it as

```
HEAT-RECOVERY
          SUPPLY-1 = (DBUN-CHLR, HTANK-STORAGE)
```

   b. The tank demand should always be on a level with no other demands. If the user enters HTANK-STORAGE as a demand among other demands at the same level, the program will move the tank demand to the lowest empty level. If there are no empty levels, the program will abort. Thus,

```
HEAT-RECOVERY
          SUPPLY-1 = (DIESEL-GEN, DBUN-CHLR, HTANK-STORAGE)
          DEMAND-1 = (SPACE-HEAT, HTANK-STORAGE)  ..
```

   will be rewritten within the program as

```
HEAT-RECOVERY
          SUPPLY-1 = (DIESEL-GEN, DBUN-CHLR, HTANK-STORAGE)
          DEMAND-1 = (SPACE-HEAT)
          SUPPLY-2 = (DIESEL-GEN, DBUN-CHLR)
          DEMAND-2 = (HTANK-STORAGE)  ..
```

   Note that HTANK-STORAGE was not placed as a supply on level 2, because a tank cannot supply itself.

c. A piece of equipment or a process cannot be re-entered as a demand, after being entered as a demand on a level with HTANK-STORAGE as a supply. (It could have been entered as a demand on a level before that having HTANK-STORAGE as a supply.) This is a consequence of the sequence of operations undertaken by the PLANT program. This should generally not constitute a problem for the user, because heat recovery should usually take place from all other sources before the hot tank is called on.

Example:

```
HEAT-RECOVERY
        SUPPLY-1 = (DIESEL-GEN)
        DEMAND-1 = (SPACE-HEAT)
        SUPPLY-2 = (GTURB-GEN, HTANK-STORAGE)
        DEMAND-2 = (SPACE-HEAT)
        SUPPLY-3 = (DIESEL-JACKET)
        DEMAND-3 = (PROCESS-HEAT) ..
```

is an acceptable entry. The following is <u>not</u> permitted:

```
HEAT-RECOVERY
        SUPPLY-1 = (DIESEL-GEN)
        DEMAND-1 = (PROCESS-HEAT)
        SUPPLY-2 = (GTURB-GEN, HTANK-STORAGE)
        DEMAND-2 = (SPACE-HEAT)
        SUPPLY-3 = (DIESEL-JACKET)
        DEMAND-3 = (SPACE-HEAT)  ..
```

because SPACE-HEAT was a demand at level 2 with HTANK-STORAGE as a supply, and then was entered again at level 3 as a demand.

d. HTANK-STORAGE may not be connected to space heat if a furnace is defined.

HTANK-STORAGE may not be connected to process heat if a domestic hot water heater is defined.

These rules do not apply, however, to a tank defined within the solar package.

HEAT-RECOVERY or HEAT-R (User Worksheet)

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
SUPPLY-1	S-1	=	( )	list of code-words	–	–	–
DEMAND-1	D-1	=	( )	list of code-words	–	–	–
SUPPLY-2	S-2	=	( )	list of code-words	–	–	–
DEMAND-2	D-2	=	( )	list of code-words	–	–	–
SUPPLY-3	S-3	=	( )	list of code-words	–	–	–
DEMAND-3	D-3	=	( )	list of code-words	–	–	–
SUPPLY-4	S-4	=	( )	list of code-words	–	–	–
DEMAND-4	D-4	=	( )	list of code-words	–	–	–
SUPPLY-5	S-5	=	( )	list of code-words	–	–	–
DEMAND-5	D-5	=	( )	list of code-words	–	–	–

..

8. ENERGY-STORAGE

The ENERGY-STORAGE instruction is used to define the useful hourly capacity of a hot and/or cold water storage tank and to schedule the introduction of hot or cold liquids in both. Furthermore, the rate at which energy can be stored in and delivered from these tanks is also specified.

The ENERGY-STORAGE instruction must always be accompanied by a PLANT-EQUIPMENT, SCHEDULE, LOAD-ASSIGNMENT, and LOAD-MANAGEMENT instruction. In addition, a HEAT-RECOVERY instruction must also be defined for a hot water storage tank.

The user is cautioned in using the defaults for this instruction because those that are zero will either prevent the storage of energy (see HEAT-STORE-RATE, COOL-STORE-RATE) or eliminate tank losses (see HTANK-LOSS-COEF and CTANK-LOSS-COEF).

ENERGY-STORAGE — This command word informs the PDL Processor that the data to follow are related to the storage of energy within a hot or cold water storage tank.

HEAT-STORE-RATE — is the rate at which energy is stored in the hot water storage tank. Actually, the real rate varies; a boiler is capable of transferring its rated capacity to a tank at one temperature only. If the temperature of that tank changes, so does the capacity of the boiler (see Fig V.2 and HTANK-T-RANGE). Therefore, the user is requested to enter a reasonable rate.

HEAT-SUPPLY-RATE — is the rate at which energy is withdrawn from the hot water storage tank and delivered to the demanding equipment or process. To make use of the stored energy over a specific period of time, the user may wish to limit this rate. If, however, no limit is desired, a large number should be entered.

COOL-STORE-RATE — is the rate at which the cold water storage tank is cooled. Actually, the real rate varies; a chiller is capable of removing its rated capacity from a storage tank at one temperature only. If the temperature of that tank changes, so does the capacity of the chiller (see Fig. V.3 and CTANK-T-RANGE). Therefore, the user is requested to enter a reasonable rate.

COOL-SUPPLY-RATE — is the rate of cooling that can be supplied from the cold water storage tank. In order to make use of the stored cooling capacity over a specific period of time, the user may wish to limit this rate. If, however, no limit is desired, a large number should be entered.

HEAT-STORE-SCH — identifies a U-named SCHEDULE instruction that schedules the delivery of energy to the hot water storage tank. The withdrawal of energy from this tank is scheduled by the LOAD-MANAGEMENT instruction.

COOL-STORE-SCH — identifies a U-named SCHEDULE instruction that schedules the delivery of cooling energy to the cold water storage tank. The withdrawal of cool water from this tank is scheduled by the LOAD-MANAGEMENT instruction.

HTANK-LOSS-COEF — specifies the overall conductance of heat from the hot water storage tank.

CTANK-LOSS-COEF — specifies the overall conductance of heat into the cold water storage tank.

HTANK-BASE-T — is the lowest temperature at which the working fluid can be delivered and still provide heat to the demanding equipment or process at the HEAT-SUPPLY-RATE. When multiple demands are to be made upon the stored heat, the user enters the highest minimum temperature demanded.

CTANK-BASE-T — is the highest temperature that the cooling fluid can achieve and still provide cooling at the COOL-SUPPLY-RATE.

HTANK-T-RANGE — is the difference between the maximum operating temperature of the hot water storage tank and HTANK-BASE-T. The maximum operating temperature is the highest temperature that can be achieved while storing energy at the HEAT-STORE-RATE (see Fig. V.2).

For example, a boiler is capable of delivering energy at the HEAT-STORE-RATE to a hot water storage tank at 175°F (maximum operating temperature). If water withdrawn from this tank for space heating must be delivered at a minimum of 140°F (i.e., HTANK-BASE-T), the user specifies

HTANK-T-RANGE = 35.0

CTANK-T-RANGE — is the difference between CTANK-BASE-T and the minimum operating temperature of the cold water storage tank. The minimum operating temperature is the lowest temperature that can be achieved while cooling the tank at the COOL-STORE-RATE (see Fig. V.3).

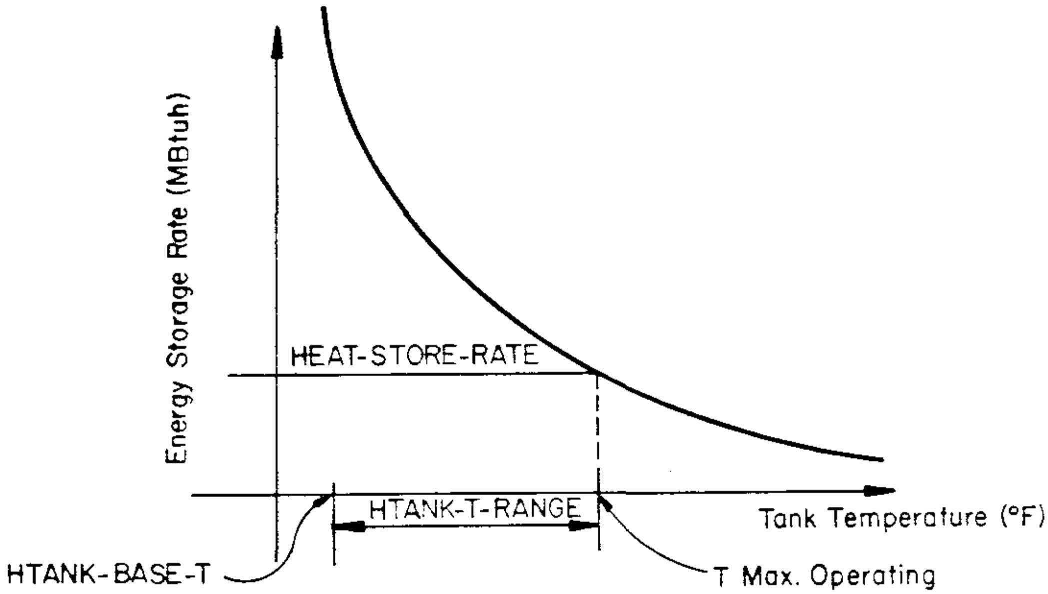

Fig. V.2. Energy storage rate vs tank temperature.

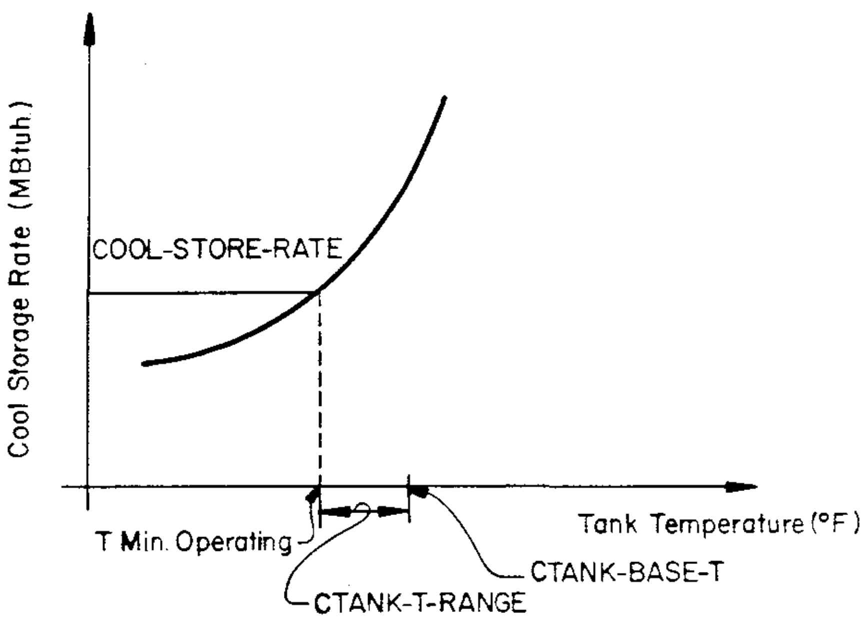

Fig. V.3. Cool storage rate vs tank temperature.

For example, a compression chiller is capable of supplying the COOL-STORE-RATE to a cold water storage tank at 44°F (minimum operating temperature). If water withdrawn from this for space cooling must not be delivered at a temperature greater than 60°F (i.e., CTANK-BASE-TEMP), the user specifies

CTANK-T-RANGE = 16.0

HTANK-ENV-T specifies the ambient temperature or temperature of the environment surrounding the hot water storage tank. If the user desires to use the outside hourly dry-bulb temperature (i.e., for a tank outdoors) rather than a constant value, the default should be taken. Any other value will instruct the program to compute the heat loss to a constant temperature.

CTANK-ENV-T specifies the ambient temperature or temperature of the environment surrounding the cold water storage tank. If the user desires to use the outside hourly dry-bulb temperatures (i.e., for a tank outdoors) rather than a constant value, the default should be taken. Any other value will instruct the program to compute the heat gain to a constant temperature.

HTANK-FREEZ-T specifies the temperature at which the fluid within the hot water storage tank freezes. The boiler automatically supplies heat to keep the tank from freezing.

CTANK-FREEZ-T specifies the temperature at which the fluid within the cold water storage tank freezes. The boiler automatically supplies heat to keep the tank from freezing.

Rules:

1. The cold water storage tank is considered to be a cooling load by the program, i.e., the assigned cooling equipment cools the storage tank, as well as meets the space cooling load. The storage tank is cooled at the COOL-STORE-RATE if the tank is not fully charged. The cooling capacity of this tank can only be used for space cooling.

2. The program will cool the cold water storage tank at the COOL-STORE-RATE unless the total of this rate and the space cooling load of the hour exceed the capacity of the assigned cooling equipment. If this occurs, the space cooling demands will be met first.

3. Waste heat delivered to a hot water storage tank in an hour will not exceed the HEAT-STORE-RATE; the excess is rejected.

4. Besides recovering waste heat in a hot water storage tank, the user may wish to precharge the tank with a boiler. This may be done by entering (-1) after the U-named DAY-SCHEDULE instruction referenced by the keyword HEAT-STORE-SCH. Energy from the combined source, i.e., waste heat and boiler is stored at the HEAT-STORE-RATE if this option is exercised.

If the user enters (1), only waste heat is supplied to the tank; a (0) entry signifies that no storage is to be accomplished.

5. Whenever the hot water storage tank is being charged, that is considered by the program to be a heating load.

6. Only one hot and/or cold water storage tank may be assigned per run.

7. A storage tank can never charge itself. Therefore, if a LOAD-ASSIGNMENT calls upon a tank, the program will first check to see if part of the load is caused by the storage tank charging. If it is, that part of the load is either reduced or eliminated so that the tank will not charge itself.

8. The E-I-R (see PART-LOAD-RATIO) for a storage tank is multiplied by the maximum of HEAT-STORE-RATE or HEAT-SUPPLY-RATE for hot tanks, or the maximum of COOL-STORE-RATE or COOL-SUPPLY-RATE for cold tanks, to determine the electric energy consumed by the storage circulating pumps.

Example 1:

This example will illustrate the use of a cold water storage tank. The tank, COLD-TANK, is capable of delivering 2 MBtuh of cooling when called upon. If the tank is not fully charged to its 10 MBtu capacity, it will be charged at night by a 7 MBtuh open centrifugal chiller, CHILLER, at the rate of 3 MBtuh. The tank is buried in the ground (ground temperature = 58°F) and has an overall heat conductance of 200 Btu/hr-°F. The tank is used for peak shaving.

```
$DEFINE THE COOLING EQUIPMENT$

CHILLER = PLANT-EQUIPMENT
       TYPE = OPEN-CENT-CHLR
       SIZE = 7
       INSTALLED NUMBER = 1
       MAX-NUMBER-AVAIL = 1 ..
COLD-TANK = PLANT-EQUIPMENT
       TYPE = CTANK-STORAGE
       SIZE = 10
       INSTALLED-NUMBER = 1  $ONLY 1 COLD TANK ALLOWED$
       MAX-NUMBER-AVAIL = 1 ..

$DEFINE STORAGE PARAMETERS$

ENERGY-STORAGE
       COOL-STORE-RATE = 3
       COOL-SUPPLY-RATE = 2
       COOL-STORE-SCH = TANK-SCH $DEFINED BELOW$
       CTANK-LOSS-COEF = 200
       CTANK-BASE-T = 55 $NO COOLING ALLOWED ABOVE 55F$
       CTANK-T-RANGE = 12 $FULLY CHARGED AT 43 F$
       CTANK-ENV-T = 58 ..
```

```
$DEFINE CHARGING SCHEDULES$

TANK-DS = DAY-SCHEDULE (1,7)(1)(8,20)(0)(21,24)(1) ..
TANK-WS = WEEK-SCHEDULE (all) TANK-DS ..
TANK-SCH = SCHEDULE THRU DEC 31 TANK-WS ..

$DEFINE USE STRATEGY$

COOLERS = LOAD-ASSSIGNMENT
       TYPE = COOLING
       LOAD-RANGE = 9
                PLANT-EQUIPMENT = CHILLER
                NUMBER = 1
                PLANT-EQUIPMENT = COLD-TANK
                NUMBER = 1 ..
                $COLD TANK CAN SUPPLY UP TO 2 MBTUH$

LOAD-MANAGEMENT
       PRED-LOAD-RANGE = 999
       LOAD-ASSIGNMENT = (DEFAULT,COOLERS,DEFAULT) ..
```

A typical scenario for nighttime operation is shown below.

Space Cooling Load	Tank Charging Rate	Total Load	Chiller Output	Tank Receives	Tank Delivers	Remarks
3	3	6	6	3	0	Rule 1
4	3	7	7	3	0	Rule 1
6	3	9	7	1	0	Rules 1 and 2
7	3	10	7	0	0	Rules 1 and 2
9	3	12	7	0	2	Rules 1 and 2
11	3	14	7	0	2	Overload by 2 MBtuh

Now let's assume that the user wants to charge the tank at night and base-load it during the day. The user might redefine the LOAD-ASSIGNMENT instruction as follows:

```
COOLERS = LOAD-ASSIGNMENT
       TYPE = COOLING
       LOAD-RANGE = 9
                PLANT-EQUIPMENT = COLD-TANK
                NUMBER = 1
                PLANT-EQUIPMENT = CHILLER
                NUMBER = 1 ..
```

But to do so would preclude the charging of the storage tank at night, since no cooling equipment is available to charge the tank (i.e., CHILLER is listed after COLD-TANK in the LOAD-ASSIGNMENT listing of PLANT-EQUIPMENT). Therefore, the scheduling of a charging period becomes imperative. (See Rule 7; this situation could also occur, in this example, if OPERATION-MODE = RUN-ALL.)

The user does this by specifying an additional LOAD-ASSIGNMENT instruction for nighttime charging and schedules the charging through a new LOAD-MANAGEMENT instruction.

```
TANK-CHARGE = LOAD-ASSIGNMENT
       TYPE = COOLING
       LOAD-RANGE = 7
       PLANT-EQUIPMENT = CHILLER
       NUMBER = 1 ..

CHILLER-DAS = DAY-ASSIGN-SCH
       (1,7)(TANK-CHARGE)
       (8,20)(COOLERS) $REDEFINED ABOVE$
       (21,24)(TANK-CHARGE) ..
CHILLER-WS = WEEK-SCHEDULE (all) CHILLER-DAS ..
CHILLER-SCH = SCHEDULE THRU DEC 31 CHILLER-WS ..

LOAD-MANAGEMENT
       PRED-LOAD-RANGE = 999
       ASSIGN-SCHEDULE = (DEFAULT,CHILLER-SCH,DEFAULT) ..
```

<u>Example 2</u>:

The use of a hot water storage tank is identical to a cold water storage tank except that two additional features are available. The hot water storage tank can be charged with waste heat as well as boiler heat, and it can deliver its stored energy to a number of different loads. These features are facilitated through the HEAT-RECOVERY instruction. Consider the following:

Waste heat from the jacket of a diesel engine is recovered for space heating or delivered to a hot water storage tank whenever the waste heat is in excess of the space heating demands. If the waste heat is insufficient to meet space heating demands, then energy stored in the hot tank can be provided at a rate of 4 MBtuh. A 7-MBtuh boiler is used as a supplementary heat source if the space heating demands are still unmet.

```
$DEFINE HEATING EQUIPMENT$

BOIL = PLANT-EQUIPMENT
       TYPE = BOILER
       SIZE = 7
       INSTALLED-NUMBER = 1
       MAX-NUMBER-AVAIL = 1 ..
```

```
HOT-TANK = PLANT-EQUIPMENT
       TYPE = HTANK-STORAGE
       SIZE = 10 $10 MBTU CAPACITY$
       INSTALLED-NUMBER = 1
       MAX-NUMBER-AVAIL = 1 ..

$DEFINE HEAT-RECOVERY LINKS$

HEAT-RECOVERY
       SUPPLY-1 = (DIESEL-JACKET,HTANK-STORAGE)
       DEMAND-1 = (SPACE-HEAT)
       SUPPLY-2 = (DIESEL-JACKET)
       DEMAND-2 = (HTANK-STORAGE)  ..

$DEFINE STORAGE PARAMETERS$

ENERGY-STORAGE
       HEAT-STORE-RATE = 7
       HEAT-SUPPLY-RATE = 4
       HEAT-STORE-SCH = TANK-SCH $DEFINED BELOW$
       HTANK-T-RANGE = 50 ..
       $DEFAULT THE REMAINING KEYWORDS$

$DEFINE CHARGING SCHEDULE$

TANK-DS = DAY-SCHEDULE (1,24)(1) ..
       $CHARGES TANK UP TO HEAT-STORE-RATE$
TANK-WS = WEEK-SCHEDULE (all) TANK-DS ..
TANK-SCH = SCHEDULE THRU DEC 31 TANK-WS ..
$HOT-TANK IS CHARGED IF NOT ALREADY FULLY CHARGED$

$DEFINE USE STRATEGY$

HEATERS = LOAD-ASSIGNMENT
       TYPE = HEATING
       LOAD-RANGE = 11
                PLANT-EQUIPMENT = HOT-TANK
                NUMBER = 1
                PLANT-EQUIPMENT = BOIL
                NUMBER = 1 ..
$THIS ENABLES THE USE OF THE HOT-TANK BEFORE THE BOILER$

LOAD-MANAGEMENT
       PRED-LOAD-RANGE = 999
       LOAD-ASSIGNMENT = (HEATERS,DEFAULT,DEFAULT) ..
```

Besides recovering waste heat in a hot water storage tank, the user may wish to precharge the tank with a boiler. This may be done by entering (-1) after the DAY-SCHEDULE referenced by the HEAT-STORE-SCH in the ENERGY-STORAGE instruction. Energy from the combined source, i.e., waste heat and boiler heat is stored at the HEAT-STORE-RATE if this option is exercised. Waste heat is stored preferentially, with the boiler charging the tank only when the waste heat is insufficient to satisfy the entire tank load.

To implement the precharging of the storage tank between the hours of 5 and 7 in the above example, the user redefines

```
TANK-DS = DAY-SCHEDULE (1,4)(1)(5,7)(-1)(8,24) 1 ..
```

and specifies an additional LOAD-ASSIGNMENT instruction for precharging. Furthermore, the user schedules the charging through a new LOAD-MANAGEMENT instruction.

```
PRECHARGE = LOAD-ASSIGNMENT
       TYPE = HEATING
       LOAD-RANGE = 7
       PLANT-EQUIPMENT = BOIL
       NUMBER = 1 ..

HEAT-DAS = DAY-ASSIGN-SCH
       (1,4) (HEATERS)
       (5,7) (PRECHARGE)
       (8,24) (HEATERS) ..
HEAT-WS = WEEK-SCHEDULE (ALL) HEAT-DAS ..
HEAT-SCH = SCHEDULE THRU DEC 31 HEAT-WS ..

LOAD-MANAGEMENT
       PRED-LOAD-RANGE = 999
       ASSIGN-SCHEDULE = (HEAT-SCH,DEFAULT,DEFAULT) ..
```

As in the case of the cold water storage tank, the hot water storage tank is considered by the program to be a heating load.

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
HEAT-STORE-RATE	H-ST-R	=	________	10^6 Btu/hr	0.	0.	1000.
HEAT-SUPPLY-RATE	H-SU-R	=	________	10^6 Btu/hr	0.	0.	1000.
COOL-STORE-RATE	C-ST-R	=	________	10^6 Btu/hr	0.	0.	1000.
COOL-SUPPLY-RATE	C-SU-R	=	________	10^6 Btu/hr	0.	0.	1000.
HEAT-STORE-SCH	H-ST-SCH	=	________	U-name	–	–	–
COOL-STORE-SCH	C-ST-SCH	=	________	U-name	–	–	–
HTANK-LOSS-COEF	H-L-C	=	________	Btu/hr-°F	0.	0.	$1.x10^5$
CTANK-LOSS-COEF	C-L-C	=	________	Btu/hr-°F	0.	0.	$1.x10^5$
HTANK-BASE-T	H-B-T	=	________	°F	100.	32.	212.
CTANK-BASE-T	C-B-T	=	________	°F	60.	32.	212.
HTANK-T-RANGE	H-T-R	=	________	°F	10.	0.	180.
CTANK-T-RANGE	C-T-R	=	________	°F	10.	0.	180.
HTANK-ENV-T	H-E-T	=	________	°F	Amb temp	0.	212.
CTANK-ENV-T	C-E-T	=	________	°F	Amb temp	0.	212.
HTANK-FREEZ-T	H-F-T	=	________	°F	32.	-30.	212.
CTANK-FREEZ-T	C-F-T	=	________	°F	32.	-30.	212.

9. ENERGY-COST

The ENERGY-COST instruction specifies the cost, or a schedule of costs, for the energy used by the facility. For the purpose of specifying costs, energy resources are divided into ten categories, as follows:

1. Electricity direct from a utility
2. Diesel oil
3. Natural gas
4. Fuel oil
5. Purchased steam
6. Liquified petroleum gas
7. Coal
8. Methanol
9. Purchased chilled water
10. Biomass

Unit energy costs may be uniform regardless of the quantity used, may vary in fixed-size blocks, or may vary in block sizes that are a function of the monthly peak loads.

If the cost of energy varies with the quantity of energy used, up to nine different rates may be entered, corresponding to nine blocks of energy. Demand surcharges are always calculated by the program and added to the cost of energy to determine the total energy-related cost.

A separate ENERGY-COST instruction is required for each energy resource category for which the user wishes to specify costs. If the user omits this instruction for any resource used by the facility, the program will use the default values shown in Table V.12. There can be significant energy cost differences based on location and size of installation, so the default values the program uses may not be realistic for the user's facility.

<u>ENERGY-COST</u> This command word informs the PDL Processor that the data to follow are the costs associated with a particular energy resource used by the facility.

RESOURCE is followed by the code-word that identifies the energy resource category for cost data. The code-words are:

ELECTRICITY	for electric energy purchased from a utility
DIESEL-OIL	for diesel oil
NATURAL-GAS	for natural gas
FUEL-OIL	for fuel oil
*STEAM	for steam purchased from an off-site source
LPG	for liquified petroleum gas (propane or butane)
COAL	for coal
METHANOL	for methyl alcohol
*CHILLED-WATER	for chilled water purchased from an off-site source
BIOMASS	for combustible solid waste

*If the user wishes to use a STEAM or CHILLED-WATER utility, an ENERGY-COST command must be entered for that RESOURCE.

TABLE V.12

ENERGY-COST Instruction Reference Default Values

Keyword	Code-Word for RESOURCE: ELECTRICITY	DIESEL-OIL	NATURAL-GAS	FUEL-OIL	STEAM*	LPG	COAL	METHANOL	CHILLED-WATER*	BIOMASS
UNIT (Btu)	3412.97	138700	1031.	138700	0.	95500	2.458×10^7	63500	0.	$1. \times 10^6$
UNIFORM-COST ($/UNIT)	.05	.48	.028	.48	7.30	.55	30.00	1.13	41.50	.95
ESCALATION (per cent/yr)	5.	5.	5.	5.	5.	5.	5.	5.	5.	5.
MIN-MONTHLY-CHG ($/month)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MIN-PEAK-LOAD (UNITS/h)	0	0	0	0	0	0	0	0	0	0
PEAK-LOAD-CHG ($/UNITS/h)	1.5	0.	0.	0.	0.	0.	0.	0.	0.	0.
SOURCE-SITE-EFF	.294	1.0	1.0	1.0	.7	1.0	1.0	1.0	.5	1.0
First BLOCK (kWh)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Second BLOCK	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Third BLOCK	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Fourth BLOCK	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Fifth BLOCK	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Sixth BLOCK thru Ninth BLOCK	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
First COST($/kWh)	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Second COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Third COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Fourth COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Fifth COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Sixth COST thru Ninth COST	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
First MULTIPLIER thru Ninth MULTIPLIER	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

*If the user wants to use these code-words he must enter UNIT = 1000000 to match the default UNIFORM-COST for these resources.

UNIT specifies the fuel content (in Btu) of a typical unit quantity of the fuel or energy source being specified. For example, entry of UNIT = 100000 corresponds to the typical fuel content of a 100 ft^3 unit (one therm) of natural gas; UNIT = 138700 corresponds to the typical fuel content of a gallon of oil, and UNIT = 3413 corresponds to one kilowatt-hour of electricity.

The PLANT program output reports provide tabulations of both the energy used at the boundary of the building and source energy use (see SOURCE-SITE-EFF). It is recognized that the raw energy required to produce a kilowatt-hour of electricity must reflect the power plant conversion efficiency. The program divides the Btu-per-unit electricity by a factor of SOURCE-SITE-EFF (default = 0.294) to evaluate source energy. The default value 1-kWh (3413 Btu) would yield a source energy of 10,240 Btu in the default situation.

UNIFORM-COST specifies the cost (in dollars) of a unit quantity of the energy resource being specified. This entry is used only if the cost per unit of an energy resource is uniform (i.e., does not depend on the number of units used). For example, a gallon of oil might be $0.40 regardless of the amount used. If the cost of energy depends on the number of units used, data entry for this keyword is omitted and the energy block entries described below are used. Energy block-related costs are generally applicable to electricity purchased from a utility, but may also be applicable to other energy forms, such as natural gas, or to mixed fuel applications where the alternative (generally more expensive) fuel must be used after the monthly allotment of primary fuel has been exhausted. It is important that energy costs refer to the same time frame as other cost inputs. For example, if equipment costs are based on January 1979 dollars, energy costs must reflect the price during January 1979 (see keyword FIRST-COST in the PLANT-EQUIPMENT instruction for additional pertinent discussion).

ESCALATION specifies the anticipated yearly percentage increase in cost for the RESOURCE being used over and above the increase resulting from general inflation (i.e, this is a differential or relative cost escalation, sometimes referred to as "real growth"). For example, ESCALATION = 5.0 will give an increase of 5 per cent per year (relative to general inflation) in cost per energy unit.

The fuel escalation rate depends on the availability of the resource in question; therefore, this rate depends on geographic region and on fuel type, and, in general, will vary from year to year. Because DOE-2 assumes the escalation rate per year to be constant, the user is advised to determine the sensitivity of his results to the assumed rate, by running the program with low, medium, and high values. Table V.13 lists the differential cost escalation rates recommended by DOE for life-cycle costing analysis of facilities, and is provided for guidance only. The local utility may be able to provide more accurate information, and should be consulted. Note that the table does not include recommended rates for Alaska, Delaware, Hawaii, and Missouri--information that was not readily available.

MIN-MONTHLY-CHG specifies the minimum cost (in dollars) per month, for the resource being specified, regardless of the amount of energy used. Data entry for this keyword is made only when this type of billing arrangement has been established by customer-utility agreement. The program calculates the monthly costs, based on both energy usage (uniform or block charges) and demand, compares these costs to the user input for MIN-MONTHLY-CHARGE, and uses the higher value.

MIN-PEAK-LOAD specifies the minimum peak load to be used in determining monthly demand charges. Data entry for this keyword is made only in the event that the customer-utility agreement specifies a minimum demand surcharge and is used by the program in the following manner: The PLANT program calculates a peak load for each month, then computes the value for a year on that basis. Then the peak load for that month is averaged each month with annual peak load and either the value thus obtained or the user-entered MIN-PEAK-LOAD, whichever is greater, is multiplied by the peak load unit cost (see keyword PEAK-LOAD-CHG, below) to obtain a demand-related surcharge, which is added to the basic energy charges.

PEAK-LOAD-CHG specifies the cost in dollars for each unit of demand. This cost is multiplied by the averaged monthly demand or the MIN-PEAK-LOAD (see keyword MIN-PEAK-LOAD above for discussion of how the program determines the average monthly demand to obtain the monthly demand-related surcharge).

TABLE V.13

DOE-Recommended Annual Energy Differential Escalation Rates for Life-Cycle Costing

Coal	5 per cent
Fuel Oil	8 per cent
Gas (Natural or LPG)	10 per cent

ELECTRICITY

Region

New England - 6.9 per cent
- Connecticut
- Maine
- Massachusetts
- New Hampshire
- Rhode Island
- Vermont

Middle Atlantic - 5.9 per cent
- New Jersey
- New York
- Pennsylvania

South Atlantic - 5.8 per cent
- District of Columbia
- Florida
- Georgia
- Maryland
- North Carolina
- South Carolina
- Virginia
- West Virginia

East South Central - 5.6 per cent
- Alabama
- Kentucky
- Mississippi
- Tennessee

Pacific - 7.3 per cent
- California
- Oregon
- Washington

Region

East North Central 5.6 per cent
- Illinois
- Indiana
- Michigan
- Ohio
- Wisconsin

West North Central - 5.6 per cent
- Iowa
- Minnesota
- Nebraska
- North Dakota
- South Dakota

West South Central - 7.5 per cent
- Arkansas
- Louisiana
- Oklahoma
- Texas

Mountain - 5.7 per cent
- Arizona
- Colorado
- Idaho
- Montana
- Nevada
- New Mexico
- Utah
- Wyoming

(Revised 5/81)

It is recognized that the program methodology for calculating demand surcharge calculation may not correspond to the method used by each utility. Results may be brought into closer agreement with the actual demand charges by adjusting the input for PEAK-LOAD-CHG.

BLOCK — is applicable only if charges for the resource being specified are nonuniform. It provides a method for specifying up to nine charge blocks. The user input is a list of the size, in energy units (see UNIT) of each block of energy used by the facility. In current practice, the first block of energy will generally be highest in cost, with the ensuing blocks having successively lower unit costs. The user specifies as many blocks as there are different unit rates in the cost schedule. For example, if the cost schedule has three charge blocks sized at 100, 1000, and 10,000 units, the data entry is

BLOCK = (100, 1000, 10000)

Once block sizes have been specified, the program uses these values, along with the specified unit energy costs for each block to calculate the monthly energy charge (see COST below).

MULTIPLIER — provides an alternative method for specifying up to nine charge blocks. MULTIPLIER specifies a list of numbers by which the program will multiply the monthly peak loads in order to determine the number of energy units assigned to the block of energy used by the facility. The user inputs a list of multipliers for each block of energy used by the facility, entering as many numbers as there are different unit rates in the cost schedule. For example, if the user enters

MULTIPLIER = (1, 10, 100)

and the PLANT program calculates a peak of 100 kW load for the month in question, the program will calculate block sizes as follows:

Size of the first block = 1 x 100 = 100 kWh
Size of the second block = 10 x 100 = 1000 kWh
Size of the third block = 100 x 100 = 10,000 kwh

When block sizes have been calculated, the program uses these values, along with the specified unit energy costs (see COST) for each block, to calculate the monthly energy charge.

COST — specifies unit costs for up to nine charge blocks. The cost entry is a list of dollar cost per unit of the blocks of energy used by the facility with the entries ordered to correlate with appropriate blocks. In current practice, the first block of energy will generally be highest in cost with the unit cost for the ensuing energy charge blocks successively lower. The user specifies as many unit costs as there are different unit rates in the cost schedule. For example, if the cost schedule has three charge blocks at unit costs of $0.03, $0.02, and $0.01, the data entry is

COST = (0.03, 0.02. 0.01)

The monthly energy cost will be the sum of the products of each block size multiplied by the assigned cost for that block. If the total energy used in the month exceeds the sum of the block sizes, the difference will be charged at the same cost rate as that of the last identified block.

SOURCE-SITE-EFF — is the overall efficiency of generating and delivering energy purchased from an off-site source to the site. SOURCE-SITE-EFF includes the generating and transmission losses (see Table V.12 for default values).

Example of ENERGY-COST Instruction:

```
ELECT1 = ENERGY-COST
       RESOURCE = ELECTRICITY
       UNIT = 3413
       UNIFORM-COST = 0.0
       MIN-MONTHLY-CHG = 0.0
       PEAK-LOAD-CHG = 0.0
       BLOCK = (20, 50, 80)
       COST = (0.02. 0.015, 0.010) ..
```

In this example, it is specified that the price of electricity from the utility is given in units of 3413 Btu (1 kWh); there is no uniform cost, minimum monthly or demand charges, and the differential escalation rate for electricity is 5 per cent. The cost per energy-unit (kWh) is $0.02 for the first 20 kWh in a month, $0.015 for the next 50 kWh, and $0.010 for the next 80 kWh or more.

ENERGY-COST or E-C (User Worksheet)

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
RESOURCE	R	=	______________	code-word	–	–	–
UNIT	U	=	______________	Btu	*	0.	$1.x10^6$
UNIFORM-COST	U-C	=	______________	$/unit	*	0.	$1.x10^3$
ESCALATION	E	=	______________	per cent/yr	*	0.	100.
MIN-MONTHLY-CHG	M-M-C	=	______________	$/month	*	0.	$1.x10^6$
MIN-PEAK-LOAD	M-P-L	=	______________	units/hr	*	0.	$1.x10^6$
PEAK-LOAD-CHG	P-L-C	=	______________	$/units/hr	*	0.	$1.x10^6$
SOURCE-SITE-EFF	S-S-E	=	______________	Btu/Btu	*	0.	1.
BLOCK	B	=	______________	No of units	*	0.	$1.x10^8$
MULTIPLIER	M	=	______________	number	*	0.	745.
COST	C	=	______________	$/unit	*	0.	$1.x10^8$

* Default values are given in Table V.11.

10. PLANT-COSTS

The PLANT-COSTS instruction specifies a number of parameters used by the PLANT program for calculation of plant equipment life-cycle costs. Additional information required for life-cycle costing is entered via the PLANT-EQUIPMENT and the ENERGY-COST instructions.

PLANT-COSTS — This command word informs the PDL Processor that the data to follow are related to life-cycle cost analysis.

DISCOUNT-RATE — specifies the discount rate (in per cent), which is the factor used in a present-value method of economic evaluation that accounts for the time value of money. It represents the "cost of capital" or "the opportunity to earn from normal investment activity," and is used to discount future recurring costs and/or benefits to present value in decision making. One way of understanding the concept of present value and discount rate is to think of a reduced sum of money being put aside today to cover future costs. The discount rate is the interest rate applied to that sum, compounded each year, to yield in the future an amount exactly equal to the future cost. The same concept is applied to future benefits, to find their present value.

LABOR-INFLTN — specifies the anticipated yearly percentage increase in the cost of labor, over and above the increase caused by general inflation (i.e., this is a differential or relative cost escalation).

The present version of the PLANT program applies the labor inflation rate only to the calculation of maintenance costs, but applies the materials inflation rate (see below) to the calculation of overhaul costs and replacement costs (including installation of the replacement unit).

MATERIALS-INFLTN — specifies the anticipated yearly percentage increase in the cost of materials, over and above the increase caused by general inflation (i.e., this is a differential or relative cost escalation).

The program applies the materials inflation rate to the calculation of cost for consumables and to the cost of procuring replacements. MATERIALS-INFLTN is also applied to overhaul costs and replacement installation costs.

PROJECT-LIFE — is the period over which life-cycle costs are calculated. This entry should not include the initial construction or installation period.

LABOR — specifies the dollar cost per hour of maintenance labor. The plant program multiplies this value by the annual maintenance hours (entered with the keyword MAINTENANCE, in the PLANT-EQUIPMENT instruction) to obtain annual maintenance costs.

SITE-FACTOR specifies a number that can be used to adjust annual equipment-related costs (specifically, the cost of maintenance and consumables) when these are affected by location. In calculating life-cycle costs, the program multiplies the cost of MAINTENANCE and CONSUMABLES entered with the PLANT-EQUIPMENT instruction (or obtained from default values) by the adjustment factor entered with SITE-FACTOR.

PLANT-COSTS or P-C (User Worksheet)

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
DISCOUNT-RATE	D-R	= ______	per cent/year	10.	0.	100.
LABOR-INFLTN	L-I	= ______	per cent/year	0.	0.	100.
MATERIALS-INFLTN	M-I	= ______	per cent/year	0.	0.	100.
PROJECT-LIFE	P-L	= ______	years	25.	1.	25.
LABOR	L	= ______	$/hr	25.	0.	100.
SITE-FACTOR	S-F	= ______	number	1.	0.	100.

11. REFERENCE-COSTS

If the user wishes to consider the economic tradeoff between various alternative designs or determine the cost of changing design parameters, it is imperative that realistic cost data be assigned to PLANT-EQUIPMENT instructions. Because the size of equipment is often unknown at the start of an alternative or parametric run (i.e., the user defines SIZE = -999 in the PLANT-EQUIPMENT instruction), the user cannot input actual costs, but must rely upon the defaults of PLANT-EQUIPMENT instruction and sub- sequent scaling relationships between equipment size and cost (see PLANT-EQUIPMENT) to approximate the actual costs. The standard defaults for the PLANT-EQUIPMENT instruction are not sufficient for these purposes because material and labor costs are continuously changing. The REFERENCE-COSTS instruction is used as a mechanism to adjust these default values so that reasonable costs can be determined.

Assigning a value to any of the keywords of the REFERENCE-COSTS instruction automatically replaces the appropriate standard default values of the PLANT-EQUIPMENT instruction. Such an assignment, however, will not supersede a PLANT-EQUIPMENT keyword explicitly defined by the user.

REFERENCE-COSTS	This command word informs the PDL Processor that the data to follow will redefine the default values for the PLANT-EQUIPMENT instructions.
TYPE	is a code-word selected from Table V.2 that identifies the PLANT-EQUIPMENT instructions whose default values are to be changed. The default values of all PLANT-EQUIPMENT instructions that identify the same TYPE of equipment will be redefined in accordance with the scaling law specified in the description of PLANT-EQUIPMENT.
SIZE-REF	specifies a new reference equipment size ($SIZE_{ref}$) for the parameter SIZE of Table V.1.
FIRST-COST-REF	specifies a new reference default value (CP_{ref}) for the cost parameter FIRST-COST of Table V.1.
INSTALLATION-REF	specifies a new reference default value (CP_{ref}) for the cost parameter INSTALLATION of Table V.1.
CONSUMABLES-REF	specifies a new reference default value (CP_{ref}) for the cost parameter CONSUMABLES of Table V.1.
MAINTENANCE-REF	specifies a new reference default value (CP_{ref}) for the cost parameter MAINTENANCE of Table V.1.
LIFE-REF	specifies a new reference default value (CP_{ref}) for the cost parameter EQUIPMENT-LIFE of Table V.1.
MIN-OVHL-INT-REF	specifies a new reference default value (CP_{ref}) for the cost parameter MINOR-OVHL-INTV of Table V.1.
MIN-OVHL-CST-REF	specifies a new reference default value (CP_{ref}) for the cost parameter MINOR-OVHL-COST of Table V.1.

MAJ-OVHL-INT-REF specifies a new reference default value (CP_{ref}) for the cost parameter MAJOR-OVHL-INTV of Table V.1.

MAJ-OVHL-CST-REF specifies a new reference default value (CP_{ref}) for the cost parameter MAJOR-OVHL-COST of Table V.1.

If $c_1, c_2, \ldots, c_n$ are the "look-up" costs for sizes

$s_1, s_2, \ldots, s_n$ take SIZE-REF $= \frac{s_n}{2}$ and

$$\text{then X-REF} = \text{SIZE-REF}^P \times \left(\frac{c_1}{s_1^P} \times \frac{c_2}{s_2^P} \times \ldots \times \frac{c_n}{s_n^P} \right)^{1/n},$$

where X-REF = FIRST-COST, INSTALLATION, etc., $c_1, c_2, \ldots, c_n$ are in dollars, and $s_1, s_2, \ldots, s_n$ are in Btu/hr.

and P is defined in PLANT-EQUIPMENT and Table V.1.

<u>Example:</u>

An absorption chiller is to be sized by the program to meet the space cooling loads of a building. In order to reduce the cooling loads, a number of parametric studies are undertaken. If the cost of single-stage absorption chillers rated at 300,000, 600,000, 1,200,000, and 1,800,000 Btu/hr is determined to be $15,000, $25,000, $40,000, and $50,000, respectively, the user inputs

```
ABS1 = PLANT-EQUIPMENT
          TYPE = ABSOR1-CHLR
          SIZE = -999
          INSTALLED-NUMBER = 1
          MAX-NUMBER-AVAIL = 1 ..

REFERENCE-COSTS
          TYPE = ABSOR1-CHLR
          SIZE-REF = 750000
          FIRST-COST-REF = 32050.0 ..
```

The program calculates the FIRST-COST of the 300,000, 600,000, 1,200,000, and 1,800,000 Btu/hr chillers to be $15,383, $24,475, $38,942, and $51,098, respectively, as opposed to $9,290, $14,781, $23,518, and $30,858, which would result by accepting the standard default for the PLANT-EQUIPMENT instruction.

REFERENCE-COSTS or R-C (User Worksheet)

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
TYPE	TYPE	= ________	code-word	-	-	-
SIZE-REF	S-R	= ________	Btu/hr	-	0.	$1.x10^9$
FIRST-COST-REF	F-C-R	= ________	$	-	0.	$1.x10^6$
INSTALLATION-REF	I-R	= ________	number	-	0.	100.
CONSUMABLES-REF	C-R	= ________	$/hr	-	0.	1000.
MAINTENANCE-REF	M-R	= ________	hrs/yr	-	0.	1000.
LIFE-REF	L-R	= ________	hrs	-	0.	$1.x10^6$
MIN-OVHL-INT-REF	MIN-O-I	= ________	hrs	-	0.	$1.x10^5$
MIN-OVHL-CST-REF	MIN-O-C	= ________	$	-	0.	$1.x10^4$
MAJ-OVHL-INT-REF	MAJ-O-I	= ________	hrs	-	0.	$1.x10^5$
MAJ-OVHL-CST-REF	MAJ-O-C	= ________	$	-	0.	$1.x10^4$

12. DAY-ASSIGN-SCH

The DAY-ASSIGN-SCH instruction is used to schedule a LOAD-ASSIGNMENT instruction.

Name	Command	Keyword	Terminator
U-name	DAY-ASSIGN-SCH or D-A-SCH	LIKE HOURS VALUES	..

This instruction is similar in usage to the DAY-SCHEDULE instruction except that instead of assigning a number by which each of the 24 hourly DAY-SCHEDULE values are multiplied (see the keyword SCALE for the DAY-SCHEDULE instruction), a literal specifying the U-name of a LOAD-ASSIGNMENT instruction is defined.

U-name — Any unique user-defined name must be entered to identify this instruction.

DAY-ASSIGN-SCH — This command word informs the PDL Processor that the data to follow will specify a daily schedule for the assignment of plant equipment.

LIKE, HOURS, VALUES — These keywords are defined in the BDL write-up for the DAY-SCHEDULE instruction (see Chap. II, Building Description Language).

Rules:

1. The DAY-ASSIGN-SCH instruction may only be referenced by a schedule listed in a LOAD-MANAGEMENT instruction.
2. DAY-ASSIGN-SCH cannot be nested.

Examples:

See the examples discussed in the LOAD-MANAGEMENT instruction.

13. PLANT-ASSIGNMENT

The special feature of the SYSTEMS program permitting the simulation of multiple HVAC system alternatives in a single computer run (see the PLANT-ASSIGNMENT instruction in Chap. IV) is not available in the PLANT program. A separate PLANT run must be executed for each of the HVAC alternatives under consideration. The function of the PLANT-ASSIGNMENT instruction in the PLANT input is to identify the HVAC system or systems to be supported by the plant equipment. A PLANT-ASSIGNMENT instruction must be specified for each separate PLANT run. A separate PLANT run is initiated each time the instruction INPUT PLANT .. is specified.

__________________________ = PLANT-ASSIGNMENT or P-A
U-name

U-name — The user must enter the U-name of the appropriate PLANT-ASSIGNMENT instruction defined in the SYSTEMS program input.

PLANT-ASSIGNMENT — This command word informs the PDL Processor that the energy demands of the HVAC system or systems referenced by U-name are to be met by PLANT equipment.

Rules:

1. A maximum of 40 different PLANT runs may be accomplished in a single submittal. These runs may reference any of the 4 U-names assigned in SYSTEMS.

2. If a building has more than one PLANT a separate simulation must be made for each PLANT. The results are not summed by the progam.

3. If a PLANT-ASSIGNMENT instruction is defined in SYSTEMS, a PLANT-ASSIGNMENT instruction is required in PLANT.

Example:

```
INPUT SYSTEMS ..
     .
     .
     .
  PA1 = PLANT-ASSIGNMENT
        SYSTEM-NAMES = (SYS-1, SYS-2) ..
  PA2 = PLANT-ASSIGNMENT
        SYSTEM-NAMES = (SYS-3) ..
END ..
COMPUTE SYSTEMS ..
INPUT PLANT ..
     .
     .
     .
```

```
PA1 = PLANT-ASSIGNMENT ..
END ..
COMPUTE PLANT ..
INPUT PLANT ..
PA2 = PLANT-ASSIGNMENT ..
END ..
COMPUTE PLANT ..
```

In the example above, three separate HVAC systems are specified. SYS-1 and SYS-2 will be supported by the PLANT equipment of the first run and SYS-3 by PLANT equipment in the second run.

14. PLANT-REPORT

The PLANT-REPORT instruction is used to select VERIFICATION and/or SUMMARY reports for the PLANT program.

The time period(s) covered in the PLANT-REPORTs are the RUN-PERIOD interval(s), see RUN-PERIOD instruction.

PLANT-REPORT	This command word informs the PDL Processor that the data to follow will select the PLANT program output reports that are to be printed.
VERIFICATION	specifies a list of code-words from Table V.14 that identify the VERIFICATION reports to be printed.
SUMMARY	specifies a list of code-words from Table V.14 that identify the SUMMARY reports to be printed.

Example:

The following example selects three PLANT VERIFICATION and five PLANT SUMMARY reports.

```
PLANT-REPORT
        VERIFICATION = (PV-A, PV-B, PV-C)
        SUMMARY = (BEPS, PS-A, PS-B, PS-C, PS-D) ..
```

PLANT-REPORT or P-R (User Worksheet)

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Max.	Range Min.
VERIFICATION	V	= ( )	list of code-words	PV-A	-	-
SUMMARY	S	= ( )	list of code-words	PS-A PS-B PS-D	-	-

..

TABLE V.14

PLANT Program Reports

Code-Word	VERIFICATION
PV-A	Equipment Sizes
PV-B	Cost Reference Data
PV-C	Equipment Costs
PV-D	Cost of Utilities
PV-E	Equipment Load Ratios
PV-G	Equipment Quadratics
PV-H	Life-Cycle Parameters
ALL-VERIFICATION	Print All Verification Reports
	SUMMARY
PS-A	Plant Energy Utilization Summary
PS-B	Monthly Peak and Total Energy Use
PS-C	Equipment Part Load Operation
PS-D	Plant Load Satisfied
PS-G	Electric Loads Scatter Plot
PS-H	Equipment Use Statistics
PS-I	Equipment Life-Cycle Costs
PS-J	Plant Life-Cycle Cost Summary
BEPS	Estimated Building Energy Performance
ALL-SUMMARY	Prints All Summary Reports

15. HOURLY-REPORT

The HOURLY-REPORT instruction directs the program to print the hourly values of all variables specified in one or more REPORT-BLOCK instructions. A general description of the HOURLY-REPORT instruction is given in Chap. II, Building Description Language.

HOURLY-REPORT	This command word informs the PDL processor that the data to follow are related to hourly output reports.
REPORT-SCHEDULE	is the U-name of a SCHEDULE instruction that defines the period for which the user wishes hourly output reports generated.
REPORT-BLOCK	specifies a list of U-named REPORT-BLOCK instructions that define the group of variables the user would like output in this HOURLY-REPORT.

For information on requesting plotted output of HOURLY-REPORT data see HOURLY-REPORT in LOADS.

All hourly report hours are in standard time.

_________________________ = HOURLY-REPORT or H-R (User Worksheet)

*U-name

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Max.	Range Min.
LIKE	–	= ____________	U-name	–	–	–
REPORT-SCHEDULE	R-SCH	= ____________	U-name	–	–	–
REPORT-BLOCK	R-B	=(____________)	List of U-names	–	–	–
OPTION	O	= ____________	code-word	PRINT	–	–
AXIS-ASSIGN	A-A	=(____________)	list of integers	1	1	2
AXIS-TITLES	A-T	=(____________)	list of literals	–	–	–
AXIS-MAX	A-MAX	=(____________)	list of numbers	–	–	–
AXIS-MIN	A-MIN	=(____________)	list of numbers	–	–	–
DIVIDE	–	=(____________)	list of numbers	1.00	–	–

*Mandatory entry if HOURLY-REPORT is specified.

16. REPORT-BLOCK

The REPORT-BLOCK instruction is used to select and specify a group of variables for an hourly output report. A general description of the REPORT-BLOCK instruction is given in Chap. II, Building Description Language.

REPORT-BLOCK	This command tells the program that the data to follow specify the variables to be included in an HOURLY-REPORT.
VARIABLE-TYPE	is a code-word selected from Tables V.15 through V.30 that defines the type of variables the user wishes to report. Each code-word is equated to the keyword VARIABLE-TYPE in these tables.
VARIABLE-LIST	is a list of code-numbers that designate which variables are to be included in the HOURLY-REPORT. (See tables of VARIABLE-TYPE.)

______________________ = REPORT-BLOCK or R-B (User Worksheet)

*U-name

Keyword	Abbrev.	User Input	Input Desc.	Default	Range Min.	Range Max.
LIKE	-	=______________	U-name	-	-	-
VARIABLE-TYPE	V-T	=______________	code-word	-	-	-
VARIABLE-LIST	V-L	=(______________) ..	list of code-numbers	-	-	-

*Mandatory entry if REPORT-BLOCK is specified.

TABLE V.15

VARIABLE-TYPE = GLOBAL

VARIABLE-LIST	FORTRAN Variable	Description
1		Ambient temperature, °F
2		Outside wet-bulb temperature, °F

TABLE V.16

VARIABLE-TYPE = PLANT

VARIABLE-LIST	FORTRAN Variable	Description
1		SYSTEMS heating load, Btu
2		SYSTEMS cooling load, Btu
3		SYSTEMS electric load, Btu
4	IHON	Standby heating flag
5	ICON	Standby cooling flag
6	--	--
7	--	--
8		Total PLANT heating load, Btu
9		Total PLANT cooling load, Btu
10		Total PLANT electric load, Btu
11	--	--
12		Total PLANT fuel use, Btu
13		Space heating load satisfied by solar, Btu
14		Heating LOAD-ASSIGNMENT pointer
15		Cooling LOAD-ASSIGNMENT pointer
16		Electric LOAD-ASSIGNMENT pointer
17		Gas and oil resource consumed elsewhere than PLANT, Btu
18		Hot water resource consumed elsewhere than PLANT, Btu

TABLE V.17

VARIABLE-TYPE = HEAT-RECOVERY

VARIABLE-LIST	FORTRAN Variable	Description
1		Demand at level 1
2		Demand at level 2
3		Demand at level 3
4		Demand at level 4
5		Demand at level 5
6		Heating load to be addressed by HEAT-RECOVERY. This load is the total heating load as reduced by the solar contribution to the space heating loads identified in Table V.31.
7		Heating load after all solar and heat recovery contribution, but before the hot water storage tank contributes
8		Total recovered energy from all levels
9		Total recoverable energy wasted
10		Wasted recoverable double-bundle chiller heat (reject to tower)
11		Recovered energy stored in hot water storage tank this hour
12		Energy demanded from boiler by hot water storage tank
13		Solar energy available for space heating
14		Solar energy available for process/dhw heating
15		Solar energy available for cooling
16		Solar energy supplied through heat recovery

TABLE V.18

VARIABLE-TYPE = STM-BOILER or HW-BOILER

VARIABLE-LIST	FORTRAN Variable	Description
1		Heating load, Btu
2	—	—
3		Electric input, Btu
4		Fuel input, Btu
5	—	—
6		Sizes running
7		Nominal capacity, Btu
8	PLR	Average part-load ratio
9	FRAC	Fraction of hour boiler was on
10	HIRCOR	Fuel consumption correction factor

TABLE V.19

VARIABLE-TYPE = ELEC-STM-BOILER, ELEC-HW-BOIILER, or ELEC-DHW-HEATER

VARIABLE-LIST	FORTRAN Variable	Description
1		Heating load, Btu
2	--	--
3		Electric energy consumption, Btu
4	--	--
5	--	--
6		Sizes running
7		Nominal capacity, Btu
8	LOSS	Losses from machine

TABLE V.20

VARIABLE-TYPE = ABSOR1-CHLR, ABSOR2-CHLR, or ABSORS-CHLR

VARIABLE-LIST	FORTRAN Variable	Description
1		Cooling load, Btu
2	--	--
3		Electric energy consumed, Btu
4		Steam energy input, Btu
5		Cooling tower load, Btu
6		Sizes running
7		Nominal capacity, Btu
8	RCAP	Available capacity ratio, Btu/Btu
9	CAP	Available capacity
10	PL	Average part-load ratio
11	PLR	Operating part-load ratio
12	TTOWR	Entering condenser temperature
13	CHWT	Leaving chilled water temperature
14	HIR1	Heat input ratio temperature correction
15	HIR2	Heat input ratio part-load correction
16	HIR	Adjusted heat input ratio
17	HIRS	Solar correction to heat input ratio

TABLE V.21

VARIABLE-TYPE = HERM-CENT-CHLR, OPEN-CENT-CHLR, OPEN REC-CHLR, HERM-REC-CHLR

VARIABLE-LIST	FORTRAN Variable	Description
1		Cooling load, Btu
2		False load, Btu
3		Electric energy consumed, Btu
4	--	--
5		Cooling tower load, Btu
6		Sizes running
7		Nominal capacity, Btu
8	RCAP	Available capacity ratio
9	CAP	Available capacity
10	PLR	Operating part-load ratio
11	FRAC	Fraction of hour machine ran
12	ECT	Entering condenser temperature
13	CHWT	Leaving chilled water temperature
14	EIR1	Electric input ratio temperature correction
15	EIR2	Electric input ratio part-load correction
16	EIRN	Adjusted electric input ratio
17	ELECH	Rejected electrical heat
18	FANE	Condenser fan energy

TABLE V.22

VARIABLE-TYPE = DBUN-CHLR

VARIABLE LIST	FORTRAN Variable	Description
1		Cooling load, Btu
2		False load, Btu
3		Electric energy consumption, Btu
4	--	--
5		Cooling tower load, Btu
6		Sizes running
7		Nominal capacity, Btu
8	RCAP	Available capacity ratio
9	CAP	Available capacity
10	PLR	Operating part-load ratio
11	FRAC	Fraction of hour machine ran
12	ECT	Entering condenser water temperature
13	CHWT	Leaving chilled water temperature
14	EIR1	Electric input ratio temperature correction factor
15	EIR2	Electric input ratio part-load correction factor
16	EIR3	Electric input ratio heat recovery correction factor
17	EIRW	Corrected electric input ratio
18	HTREC	Recoverable heat

TABLE V.23
VARIABLE-TYPE = COOLING-TWR, CERAMIC-TWR

VARIABLE-LIST	FORTRAN Variable	Description
1	EQDEM(1,ITOWR)	Cooling tower load, Btu
2	--	--
3	EQDEM(3,ITOWR	Electrical energy consumed, Btu
4,5	--	--
6	ISIZE	Number of cells running
7	OPCAP(ITOWR)	Nominal operating capacity, Btu
8	GPM	Water flow rate, gpm
9	MINCEL	Minimum number of cells that can run
10	RANGE	Temperature drop through tower, °F
11	APP	Approach to wet-bulb, °F
12	ISPEED	Fan speed index
13	R1	Rating factor correction for range
14	R2	Rating factor correction for approach and wet-bulb
15	RFACT	Rating factor at full cfm, TU/gpm
16	RF	Rating factor at actual cfm, TU/gpm
17	AREA	Tower area needed, TU
18	NCELL	Number of cells running
19	TTOWR	Tower temperature, °F
20	EFAN	Fan energy, Btu
21	EPUMP	Pump energy, Btu
22	RAPPLG	Approach needed when temperature floating
23	FRAC	Fraction of hour that fans ran at ISPEED
24	IDCSCH	Cooling tower direct cooling schedule
25	ISC	Cooling tower direct cooling flag

TABLE V.24

VARIABLE-TYPE = DIESEL-GEN

VARIABLE-LIST	FORTRAN Variable	Description
1		Electric load, Btu
2	—	False load, Btu
3	—	—
4		Fuel energy consumed, Btu
5	—	—
6		Sizes running
7		Nominal capacity, Btu
8		Actual output (includes false load), Btu
9		Part load ratio
10		Efficiency of diesel engine
11		Ratio of jacket heat/fuel energy
12		Jacket heat recoverable, Btu
13		Ratio of lube oil heat/fuel energy
14		Lube oil heat recoverable, Btu
15		Ratio of exhaust heat/fuel energy
16		Exhaust energy available, Btu
17		Engine exhaust temperature, °F
18		Exhaust flow, lbs
19		Exhaust heat exchange UA-factor, Btu/°F
20		Exhaust stack temperature, °F
21		Recoverable exhaust energy, Btu
22		Recoverable jacket + lube energy, Btu

TABLE V.25

VARIABLE-TYPE = GTURB-GEN

VARIABLE-LIST	FORTRAN Variable	Description
1		Electric load, Btu
2	—	—
3	—	—
4		Fuel energy consumed, Btu
5	—	—
6		Sizes running
7		Nominal capacity, Btu
8		Actual load (including false load), Btu
9		Part load ratio
10		Exhaust gas flow, lbs
11		Engine exhaust gas temperature, °F
12		Exhaust heat exchange UA-factor, Btu/°F
13		Exhaust stack temperature, °F
		Recoverable exhaust energy, Btu

TABLE V.26

VARIABLE-TYPE = STURB-GEN

VARIABLE-LIST	FORTRAN Variable	Description
1		Electric load, Btu
2	--	--
3	--	--
4		Steam energy input, Btu
5	--	--
6		Sizes running
7		Nominal capacity, Btu
8		Steam losses, lb
		Heat available for recovery, Btu

TABLE V.27

VARIABLE-TYPE = HTANK-STORAGE

VARIABLE-LIST	FORTRAN Variable	Description
1		Energy delivered, Btu
2	--	--
3		Electric energy consumed, Btu
4		Energy stored, Btu
5	--	--
6		Sizes running
7		Operating capacity, Btu
8		Heat available to be given out, Btu
9		Heat requested for storage, Btu
10		Heat needed to prevent freezing, Btu
11		Storage demand flag
12		Tank temperature, °F
13		Tank loss, Btu
14		Heat in tank (relative to 0°F), Btu
15		Useful heat in tank, Btu

TABLE V.28
VARIABLE-TYPE = CTANK-STORAGE

VARIABLE-LIST	FORTRAN Variable	Description
1		Cooling energy delivered, Btu
2	—	—
3		Electric energy consumed, Btu
4		Cooling energy stored, Btu
5	—	—
6		Sizes running
7		Operating capacity, Btu
8		Cooling energy available to be given out, Btu
9		Cooling energy requested for storage, Btu
10		Heat needed to prevent freezing, Btu
11		Tank temperature, °F
12		Tank loss, Btu
13		Heat in tank (relative to 0°F), Btu
14		Useful cold in tank, Btu

TABLE V.29
VARIABLE-TYPE = FURNACE

VARIABLE-LIST	FORTRAN Variable	Description
1	EQDEM(1,5)	Space heating load
2	—	—
3	EQDEM(3,5)	Electric energy consumed
4	EQDEM(4,5)	Fuel consumed
5	—	—
6	ISIZE	Sizes running
7	OPCAP(5)	Operating capacity
8	PLR	Average part load ratio
9	HIRCOR	Fuel consumption correction factor

TABLE V.30
VARIABLE-TYPE = DHW-HEATER

VARIABLE-LIST	FORTRAN Variable	Description
1	EQDEM(1,6)	Process or domestic hot water load
2	—	—
3	EQDEM(3,6)	Electricity consumed
4	EQDEM(4,6)	Fuel consumed
5	—	—
6	ISIZE	Sizes running
7	OPCAP(6)	Operating capacity
8	PLR	Part-load ratio
9	HIRCOR	Fuel consumption correction factor

VI. ECONOMICS PROGRAM

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VI. ECONOMICS PROGRAM

A. INTRODUCTION

1. Background.

The life-cycle costing methodology used in the DOE-2 economics evaluation is based on that described in DOE Manual ERDA-76/130, "Life Cycle Costing Emphasizing Energy Conservation" (Ref. 4). These guidelines were developed in response to rapidly rising energy costs and the resulting need to examine existing and proposed DOE buildings to determine what modifications would be both cost effective and energy conserving.

In the life-cycle costing method, the capital, operations, and energy costs of a building are calculated over the life-cycle of the building. For comparison of alternatives and retrofits, a few numbers, called "investment statistics," are also calculated. These statistics measure the cost-effectiveness compared to a reference or "baseline" case.

In DOE-2, cost calculations are made in both the PLANT and ECONOMICS programs. The PLANT program calculates energy costs and plant (primary) equipment capital and operating costs. The corresponding input data are entered in PDL using the PLANT-EQUIPMENT, PLANT-COSTS, and REFERENCE-COSTS instructions. PLANT passes the following information to ECONOMICS:

a. Discount rate (%)
b. Labor inflation rate (%)
c. Materials inflation rate (%)
d. Project lifetime (yrs)
e. Labor cost ($/hr)
f. Plant equipment cost ($)

(items a–f: specified by user in PDL)

g. Life-cycle cost for replacing plant equipment ($)
h. Annual energy use at the site (Btu)
i. Annual energy use at the source (Btu)
j. Present value of energy cost for each year of the project lifetime ($)
k. Present value of plant operating costs for each year of the project lifetime ($)

Costs for nonplant components, which can include secondary systems, insulation, control systems, solar collectors, etc., are calculated in the ECONOMICS program. Cost data for these items are entered by the user in EDL using COMPONENT-COST instructions. In the following, nonplant costs are sometimes referred to as "building costs" to distinguish them from plant costs.

ECONOMICS adds plant costs and building costs to arrive at an overall life-cycle cost. It also computes the following economic measures or "investment statistics."

- Investment
- Energy and non-energy cost savings

- Energy use savings
- Ratio of total cost savings to investment
- Ratio of energy use savings to investment
- Discounted payback period

These quantities are calculated by comparing costs and energy use for the project under analysis with those input by the user for a baseline case. Baseline data are entered in EDL using the BASELINE instruction.

Example runs illustrating the use of the ECONOMICS program may be found in the User's Guide and in the Sample Run Book.

2. Life-cycle Costing Methodology.

In this section, a brief description is given of the terminology and methodology used in the DOE-2 life-cycle cost calculations. Further details can be found in Ref. 4.

The project lifetime is the period, in years, over which the life-cycle cost analysis is made. In DOE-2 this can be between 1 and 25 years and is specified in PDL. The life-cycle cost is the total cost of an item over the project lifetime. For a cost that recurs every year, such as energy cost, the life-cycle cost (LCC) is

$$LCC = \sum_{n=1}^{N} C_n$$

where N is the project lifetime and C_n is the cost in the nth year.

Rather than use the actual cost in year "n", the program calculates the present value of the cost, which is given by

$$C_n \text{ (present value)} = C \left(\frac{1 + i}{1 + d}\right)^n$$

where C is the cost in current dollars, i is the cost inflation rate (relative to general inflation), and d is the discount rate. For example, if

Project lifetime = 25 years
Discount rate = 10%
Energy inflation rate = 5% (above general inflation)
C = $1000 (annual energy cost in today's dollars),

then the present value of the energy cost in year 10, say, would be

$$C_{10} \text{ (present value)} = \$1000 \left(\frac{1 + 0.05}{1 + 0.10}\right)^{10}$$

$$= \$1000 \ (0.955)^{10}$$
$$= \$1000 \ (0.628)$$
$$= \$ \ 628.$$

The present value of the energy cost over the project's life cycle would then be

$$LCC = \sum_{n=1}^{25} C\left(\frac{1 + i}{1 + d}\right)^n$$

$$= \sum_{n=1}^{25} 1000 \left(\frac{1.05}{1.10}\right)^n$$

$$= 1000\ (14.436)$$

$$= \$14,436$$

Note that without discounting (i.e., without present-valuing), the life-cycle cost would be 25 x $1000 = $25,000.

In DOE-2, non-energy costs are broken down into three categories.

- First cost
- Operations cost
- Replacement cost

The first cost is the purchase price of an item, including installation. Operations cost includes expenses, such as maintenance and overhauls required to keep the item in working condition. The replacement cost is the capital cost (including installation) of replacing an item at the end of its useful life. In DOE-2, the residual value (the fraction of remaining useful life times the capital cost) of the item at the end of the analysis period is not considered.

A primary application of DOE-2 is cost-benefit analysis of energy conservation projects (ENCOP's). In this type of analysis, a baseline building is first analyzed to determine its costs and energy use. The building is then modified to conserve energy and run through DOE-2 again. If the baseline energy use and cost data from the first run are entered in EDL of the second run (using the BASELINE instruction), then the program will assess the cost effectiveness of the ENCOP.

The quantities that enter the cost effectiveness analysis are the following.

- Investment
- Incremental investment
- Cost savings
- Energy savings
- Savings-to-investment ratio (SIR)
- Energy savings to investment ratio
- Discounted payback period.

The ENCOP investment is the sum of the life-cycle first cost and replacement cost for all plant and nonplant cost items.

ENCOP investment = (first cost) + (replacement cost) for all components

Subtracting from this the baseline first cost and baseline replacement cost gives the incremental investment.

Incremental investment = (ENCOP investment) - (baseline first cost) - (baseline replacement cost)

The cost savings is the difference between the life-cycle energy and operations cost of the baseline and that of the ENCOP.

$$\text{Cost savings} = (\text{energy cost} + \text{operations cost})_{\text{baseline}} - (\text{energy cost} + \text{operations cost})_{\text{ENCOP}}$$

The energy use in DOE-2 is calculated both at the site (i.e., at the building boundary) and at the source, and energy savings for both cases are calculated in ECONOMICS.

The savings-to-investment ratio (SIR) is just the cost savings divided by the incremental investment.

$$\text{SIR} = \frac{\text{cost savings}}{\text{incremental investment}} .$$

An SIR that is greater than 1.0 means that the ENCOP is cost effective. The higher the SIR, the more cost effective is the ENCOP.

The energy-savings-to-investment ratio gives the number of Btu's saved (over the project lifetime) per dollar invested.

$$\text{Energy-savings-to-investment ratio} = \frac{\text{energy savings}}{\text{incremental investment}}$$

The last quantity, discounted payback period, is the number of years it takes the accumulated cost savings to equal the incremental investment. For example, if the present value of the cost savings in years 1 through 5 is $1000, $900, $800, $700, and $600, respectively, and the incremental investment is $2700, then the payback period is 3.0 years.

A cost-effective ENCOP has a payback period that is less than the project lifetime. The shorter the payback period, the more cost-effective is the ENCOP.

3. Economics Description Language (EDL).

A general discussion of Building Description Language (BDL), including rules, syntax, notation, etc., can be found in Chap. II. The Economics Description Language (EDL) is that portion of BDL that is solely applicable to the ECONOMICS program. Section B of this chapter describes the EDL instructions (COMPONENT-COST, BASELINE, and ECONOMICS-REPORT).

4. Instruction Sequence

In general, the instructions for the ECONOMICS program may be arranged in any order the user desires. However, the following rules must be observed.

a. Data entry to the ECONOMICS program must begin with the program control instruction

   INPUT ECONOMICS ..

b. Any applicable EDL instructions can then be entered in any desired order.

c. To indicate that data entry is complete, the user must enter the program control instruction

   END ..

d. The processor is instructed to initiate calculations by the program control instruction

   COMPUTE ECONOMICS ..

e. Because the ECONOMICS program is the final module of the LSPE program sequence, the last instruction must be

   STOP ..

5. EDL Input Instruction Limitations.

The maximum number of EDL instructions that the program can accept in a single run is shown on Table VI.1 below.

TABLE VI.1

EDL LIMITATIONS

EDL Instruction	Maximum Number
COMPONENT-COST	15
BASELINE	1
ECONOMICS-REPORT	1
U-names	87*

---

* Specifying output reports by code-word (ES-A, ES-C, etc.) will result in the use of one of these U-names for each report.

B. EDL INPUT INSTRUCTIONS

1. COMPONENT-COST

This instruction is used to specify cost data for nonplant components (first cost, installation cost, annual cost, and cost of major and minor overhauls). Nonplant components are here defined a everything except the primary energy conversion equipment, such as boilers, chillers, diesel generators, gas turbines, storage tanks, etc. (see Chapter V). A nonplant component can be anything from roof insulation, to an HVAC system, to a solar collector system, to an entire buiding.

Cost for up to 15 different nonplant components can be specified, using a separate COMPONENT-COST instruction for each. The ECONOMICS program calculates the present value of the life-cycle costs for the components.

The User Worksheet for the COMPONENT-COST instruction is shown on the next page.

COMPONENT-COST This command word informs the EDL processor that the data to follow (and applicable default values) define the costs of a particular non-plant component. All costs entered with the following keywords should be in current dollars.

U-name is any unique user-defined name that may be entered to identify this instruction, but none is required.

UNIT-NAME is any word of sixteen or fewer characters, enclosed in asterisks, that describes the size or type of unit to which the unit costs subsequently specified are referenced, for example, SQFT, TONS, LBS, FEET. This data entry is for user convenience in identification of input data.

NUMBER-OF-UNITS specifies the number of units of type or size described above (see keyword UNIT-NAME) that are to be costed. The program multiplies the unit costs by this value to obtain the total cost of the component. This data entry may be omitted if the component specified is a single unit.

FIRST-COST specifies initial cost per unit, in dollars, excluding installation.

INSTALL-COST specifies unit maintenance (labor) and consumables (materials) cost per year for the component. The differential labor inflation rate is applied to annual cost if entry is made for keyword LABOR-INFLTN in the PLANTS-COSTS instruction in PDL.

COMPONENT-LIFE specifies the component's useful life, in years. The program uses this value to calculate life-cycle replacement costs. For example if COMPONENT-LIFE=n is specified.

____________________ = COMPONENT-COST or C-C

U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
UNIT-NAME	U-N	=	* ________ *	a	–	–	–
NUMBER-OF-UNITS	N-O-U	=	________	Number	1	0	$1x10^5$
FIRST-COST	F-C	=	________	$	0.	0.	$1.x10^7$
INSTALL-COST	I-C	=	________	$	0.	0.	$1.x10^6$
COMPONENT-LIFE	C-L	=	________	Years	999.	0.1	100.
ANNUAL-COST	A-C	=	________	$	0.	0.	$1.x10^4$
MIN-OVHL-INT	MIN-O-I	=	________	Years	999.	0.1	50.
MIN-OVHL-COST	MIN-O-C	=	________	$	0.	0.	$1.x10^5$
MAJ-OVHL-INT	MAJ-O-I	=	________	Years	999.	0.1	50.
MAJ-OVHL-COST	MAJ-O-C	=	________ ..	$	0.	0.	$2.x10^5$

[a] Any word of 16 characters or fewer, enclosed in asterisks, that describes the size or type of unit.

replacement and installation cost are calculated at intervals of n years, up to the lifetime of the project. The default value for COMPONENT-LIFE is 999 years, so that if this keyword is not specified, replacement costs will be ignored.

ANNUAL-COST specifies the unit maintenance (labor) and consumables (materials) cost per year for the component.

MIN-OVHL-INT specifies the anticipated time, in years, between minor overhauls of the component.

MIN-OVHL-COST specifies, in dollars, the cost of a minor overhaul of one unit of the component.

MAJ-OVHL-INT specifies, in years, the anticipated time between major overhauls for the component.

MAJ-OVHL-COST specifies, in dollars, the cost of a major overhaul of one unit of the component.

Example:

```
SOL-COL = COMPONENT-COST        UNIT-NAME = *SQFT*
                                NUMBER-OF-UNITS = 2000
                                FIRST-COST = 25
                                INSTALL-COST = 3
                                ANNUAL-COST = 0.50
                                COMPONENT-LIFE = 15 ..

SOL-TANK = COMPONENT-COST       FIRST-COST = 1500
                                INSTALL-COST = 200 ..

SOL-PUMP = COMPONENT-COST       FIRST-COST = 1000
                                INSTALL-COST = 100
                                COMPONENT-LIFE = 10
                                MINOR-OVHL-COST = 200
                                MIN-OVHL-INT = 2 ..
```

Cost data have been given for three components associated with a solar heating system: the collector, a storage tank, and a pump. The respective U-names for these cost items are SOL-COL, SOL-TANK, and SOL-PUMP.

The collector has an area of 2000 ft^2. A UNIT-NAME of SQFT has been chosen to remind the user that the costs to follow are "per square foot." The purchase price is \$25/ft^2, installation is \$3/ft^2, and annual maintenance costs \$0.50/ft^2. The collector will be replaced after 15 years. Major and minor overhauls do not apply, so that overhaul costs have been allowed to default to zero.

The storage tank has a purchase price of \$1500, and costs \$200 to install. As there is only one tank, the keyword NUMBER-OF-UNITS has been allowed to default to 1.0. The UNIT-NAME is omitted as it is for user convenience only in identifying the unit size. Annual costs and overhaul costs are assumed to be zero. The lifetime of the tank is unspecified and therefore will default to 999 years. Therefore, no replacements costs will be calculated.

The pump has a purchase price of $1000, costs $100 to install, has an annual maintenance cost of $100, and will last 10 years. It requires a minor overhaul every two years costing $200.

2. BASELINE

This instruction is used to specify the baseline condition against which an alternative energy conservation project can be evaluated. The baseline figures may have been obtained from a previous DOE-2 run, or they may be based on actual operating data for the building under consideration. In either case, the ECONOMICS program compares the calculated life-cycle costs of the present run with the baseline figures, to arrive at a dollar and energy savings relative to the baseline case. From this comparison, the program calculates the statistics described in Sec. A that provide a measure of the investment cost effectiveness of the energy conservation alternative under consideration.

The User Worksheet for the BASELINE instruction is reproduced on the next page.

BASELINE — This command word tells the EDL Processor that data defining the baseline or reference case follow.

U-name — is any unique user-defined name that may be entered to identify this instruction, but none is required.

FIRST-COST — specifies, in dollars, the total baseline initial costs, including installation. If the baseline is an existing, unmodified building, the value of FIRST-COST should be zero.

REPLACE-COST — specifies, in dollars, the present value of the life-cycle baseline replacement cost for plant and nonplant components.

OPERATIONS-COST — specifies a list, up to 25 values, of baseline operations costs (present value, in dollars) for each year of the project life. If the project life is N years (as specified in PDL) then N values of operations costs must be given sequentially for years 1, 2, ..., N.

________________ = BASELINE
U-name

Keyword	Abbrev.		User Input	Input Desc.	Default	Range Min.	Range Max.
FIRST-COST	F-C	=	________	$	0.	0.	$1.x10^6$
REPLACE-COST	R-C	=	________	$	0.	0.	$1.x10^6$
OPERATIONS-COST	O-C	=	(________)	list of $	0.	0.	$1.x10^5$
ENERGY-COST	E-C	=	(________)	list of $	0.	0.	$1.x10^6$
ENERGY-USE-SITE	E-U-SITE	=	________	10^6 Btu	0.	0.	$1.x10^8$
ENERGY-USE-SRC	E-U-SRC	=	________	10^6 Btu	0.	0.	$1.x10^8$

ENERGY-COST specifies a list, up to 25 values, of baseline energy costs (present value, in dollars) for each year of the project life. If the project life is N years (as specified in PDL), the N values of energy cost must be given sequentially for years 1, 2, ..., N.

ENERGY-USE-SITE specifies the baseline annual energy use, in 10^6 Btu at the site, i.e., at the building boundary.

ENERGY-USE-SRC specifies the baseline annual energy use, in 10^6 Btu at the source. For example, if electricity production by a utility has an overall efficiency, including transmission losses, of 1/3, then 1 kWh (3413 Btu) of electricity use at the site would correspond to 3 x 3413 = 10,239 Btu of energy use at the source.

Table VI.2 shows what output report to refer to for values of the above keywords if baseline data are to be taken from a previous DOE-2 run.

TABLE VI.2

OUTPUT REPORTS FOR BASELINE VALUES

Keyword	Output Report	Designation in Report
FIRST-COST	ECONOMICS, ES-B	FIRST-COST (INCLUDING INSTALLATION), TOTAL
REPLACE-COST	ECONOMICS, ES-B	REPLACEMENTS, TOTAL
OPERATIONS-COST	ECONOMICS, ES-A	OPRNS COST - THIS RUN, TOTAL, YEAR 1, 2, 3, etc.
ENERGY-COST	ECONOMICS, ES-A	ENERGY COST - THIS RUN, YEAR 1, 2, 3, etc.
ENERGY-USE-SITE	ECONOMICS, ES-C	ANNUAL ENERGY USE - THIS RUN, AT SITE
ENERGY-USE-SRC	ECONOMICS, ES-C	ANNUAL ENERGY USE - THIS RUN, AT SOURCE

Example:

```
BASELINE    FIRST-COST = 63000           REPLACE COST = 28500
     OPERATIONS COST = (10100, 9300, 8600, 7500, 6200,
                        5900, 4800, 4200, 3600, 3300)
     ENERGY-COST = (84300, 80480, 76900, 73400, 70100,
                    66900, 63900, 61100, 58300, 55700)
     ENERGY-USE-SITE = 10120
     ENERGY-USE-SRC = 20350 ..
```

Baseline data have been specified corresponding to a first-cost (including installation) of $63,000 and a present-value life-cycle replacement cost of $28,500. The present value of the annual operations costs for a 10-year project lifetime range from $10,100 in year 1 to $3300 in year 10. Similarly, the present value of the annual energy cost ranges from $84,300 for year 1 to $55,700 for year 10. The baseline annual energy use at the site is 10120 x 10^6 Btu, and at the source is 20350 x 10^6 Btu.

3. ECONOMICS-REPORT

The ECONOMICS program produces four output reports obtained by using the ECONOMICS-REPORT instruction (abbreviated E-R). The reports available are.

VERIFICATION (or V) =

EV-A	Life-cycle costing parameters and building component cost input data (default is EV-A)

SUMMARY (or S) =

ES-A	Annual energy and operations costs and savings
ES-B	Life-cycle building and plant non-energy costs
ES-C	Energy savings, investment statistics, and overall life-cycle costs.
ALL SUMMARY	All the summary reports, ES-A, ES-B, and ES-C. (Default is ES-A.)

4. Other EDL Commands

EDL also accepts the following commands.

TITLE
DIAGNOSTIC
ABORT
END
PARAMETER
PARAMETRIC-INPUT
SET-DEFAULT
INPUT
COMPUTE

C. ECONOMIC EVALUATION METHODS

DOE-2 can be used in three different ways to perform an economic analysis. In Method I, the total life cycle cost of different design alternatives is compared. Investment statistics such as payback period and savings-to-investment ratio do not apply. This method may be used to rank new building or retrofit alternatives. In Method II, retrofit alternatives are ranked on the basis of investment statistics. The building before retrofit is defined as the baseline. The investment is the cost of energy-saving modifications to the baseline building. The savings are given by the difference in life-cycle energy and operation cost of the modified building relative to the baseline. A DOE-2 run is made on the baseline and on each of the alternatives. Method III is similar to Method II except that new-building alternatives (rather than retrofit alternatives) are compared using investment statistics. In this case, the alternative with the smallest investment is used as a baseline.

1. Method I: Ranking by Life-Cycle Costs.

A separate DOE-2 run is made on each building design according to the following procedure.

A. Procedure.

1. Enter cost data for each building design.

    a. Enter central plant costs using the keywords FIRST-COST, INSTALLATION, CONSUMABLES, MAINTENANCE, EQUIPMENT-LIFE, MINOR-OVHL-INT, MINOR-OVHL-COST, MAJOR-OVHL-INT, and MAJOR-OVHL-COST in the PLANT-EQUIPMENT instruction in the PLANT program. For existing buildings, specify also HOURS-USED for each piece of plant equipment. If HOURS-USED is not specified, the equipment will be considered to be new, and the first cost of the equipment will be included in the life-cycle cost calculation. Note that the cost of a solar collector system is not included in PLANT and, therefore, must be entered by using the COMPONENT-COST instruction in the ECONOMICS program.

    b. In the PLANT input, enter fuel cost and escalation rate, using an ENERGY-COST instruction for each energy type.

    c. In the PLANT input, enter project lifetime, discount rate, etc., using the PLANT-COSTS instruction.

    d. Enter all other costs in the ECONOMICS program input using COMPONENT-COST instructions. These costs include the building envelope, secondary systems, solar collectors, control systems, etc. If the overall life-cycle cost of the building is desired, all relevant costs must be entered. If only the difference in life-cycle cost between alternatives is desired, only the cost items that differ between the alternatives need be entered.

2. Run DOE-2 for each building design.

3. Compare total life-cycle costs as given in ECONOMICS Report ES-B.

   Note: For this method, baseline data need not be specified. Also, the cost savings, investment, savings-to-investment ratio, etc., given in ECONOMICS Report ES-C, do not apply.

B. Example.

An example of Method I is given in the User Guide, Section 8.B.1, in which the life-cycle cost of a building with a packaged variable air volume system is compared with the life cycle cost of the same building with a heat pump system.

C. Cost Minimization by Parametric Runs.

Method I may be used to evaluate any parameter of the design by plotting the total life-cycle costs for several different values of the parameter. Sufficient runs should be made to produce a smooth curve in the neighborhood of the minimum total life-cycle cost. The optimum value for the parameter corresponds to this minimum.

2. Method II: Ranking Retrofit Alternatives Using Investment Statistics.

This method applies to an existing building that is being modified to make it energy efficient. The primary concern is whether the investment to modify the building is cost-effective. In other words, are the energy and operations cost savings over the project lifetime greater than the investment, or is the payback period (the number of years to recover the investment) short enough to be financially attractive. To use this method, DOE-2 is first run on the baseline building before modifications are made. The program is then run a second time on the modified building. Selected numbers from the first run are input in the ECONOMICS BASELINE instruction in the second run. ECONOMICS Report ES-C of the second run gives the investment statistics.

A. Procedure.

1. For the baseline run enter plant equipment costs, energy costs, nonplant costs, project lifetime, etc., as in Method I. Be sure to specify HOURS-USED for each plant component since this is an existing building. Also, be sure to get ECONOMICS Reports ES-A, ES-B, and ES-C.

2. Repeat step 1 for the modified building, with one exception: some numbers from ECONOMICS Report ES-A, ES-B, and ES-C of the baseline run must be entered in the BASELINE instruction in the ECONOMICS input for the modified building. The BASELINE keywords and the corresponding ES-A, ES-B, and ES-C quantities are listed in Table VI.2.

3. The investment statistics that determine whether the modification is cost-beneficial are given in ECONOMICS Report ES-C.

   Note: The ECONOMICS program need not be run for the baseline if the user does not wish to specify nonplant costs. In this case, the BASELINE input for subsequent runs can be obtained from PLANT Report PS-J of the baseline run.

B. Examples.

Examples of Method II are given in the Users Guide, Section 8.B.2, and in the Sample Run Book, Simple Structure Run 3 (baseline) and Simple Structure Run 3A (modification).

C. Special Case.

If the modification involves adding or replacing central plant equipment, that equipment must be entered under COMPONENT-COST in the ECONOMICS input of the modified building run. It is important that the cost of the alternative plant equipment not also be entered in the PLANT input. To avoid double counting, it is therefore necessary to set these costs to zero in the PLANT input, as shown in the following example.

Example:

Building modification consists of installing an additional boiler of 160,000 Btu/hr capacity to a plant with an existing boiler of 450,000 Btu/hr capacity.

In PLANT Simulator

```
INPUT PLANT ..

    EXISTING-BOILER     = PLANT-EQUIPMENT    TYPE = STM-BOILER
                                             SIZE = 0.45
                                             FIRST-COST = 5000
                                             INSTALLATION = 1.2
                                             EQUIPMENT-LIFE = 200000
                                             HOURS-USED = 50000 ..

    ADD-BOILER          = PLANT-EQUIPMENT    TYPE = STM-BOILER
                                             SIZE = 0.16
                                             FIRST-COST = 0
                                             CONSUMABLES = 0
                                             MAINTENANCE = 0
                                             MINOR-OVHL-COST = 0
                                             MAJOR-OVHL-COST = 0 ..

END ..
COMPUTE PLANT ..
```

In ECONOMICS Simulator

```
INPUT ECONOMICS ..

                        ECONOMICS-REPORT     SUMMARY = (ALL-SUMMARY) ..
    ADD-BOILER          = COMPONENT-COST     FIRST-COST = 3000
                                             INSTALL-COST = 600
                                             ANNUAL-COST = 300
                                             COMPONENT-LIFE = 10 ..

                        BASELINE             FIRST-COST = .... etc.
END ..
COMPUTE ECONOMICS ..
STOP ..
```

3. Method III: Comparison of New Building Designs Using Investment Statistics.

A. Procedure.

1. Run DOE-2, including ECONOMICS, on the alternative with the smallest investment. This is the baseline run.

2. Run DOE-2 on each of the remaining alternatives, using the results of 1 above, to obtain the appropriate input for the BASELINE instruction (see Table VI.2).

3. The investment statistics that determine whether the alternative is cost-beneficial, relative to the design with the smallest investment, are given in ECONOMICS Report ES-C.

LA-7689-M Ver. 2.1
LBL-8706 Rev. 1

DOE-2

REFERENCE MANUAL

PART 2

Version 2.1

Group WX-4, Program Support
Los Alamos Scientific Laboratory
Los Alamos, New Mexico

May 1980

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(Version 2.1A)

Part 2

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Part 2

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VII. REPORTS

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VII. REPORTS

A. INTRODUCTION

Two types of reports are available to DOE-2 users. Standard output reports are available for each of the four calculational programs, LOADS, SYSTEMS, PLANT, and ECONOMICS (LSPE). Hourly reports that print or plot the values of user-selected variables for particular hours of the year are available for the LOADS, SYSTEMS, and PLANT programs.

1. Standard Reports.

Each of the LSPE programs offers its own set of standard reports. Samples of these reports appear in the respective chapters of this manual. Two types of standard reports make up each set, input-verification reports and calculation-summary reports. These reports are designated LV-A, LV-B, etc., for LOADS verification reports, and LS-A, LS-B, etc., for LOADS summary reports. Similarly, SYSTEMS reports are designated SV-A or SS-A, PLANT reports are PV-A or PS-A, and ECONOMICS reports are EV-A or ES-A, for the verification and summary reports. See the discussions under Output Report Descriptions in Chaps. III, IV, V, and VI, respectively, for a discussion of the information given in each of the standard reports available for each of the LSPE programs.

2. Hourly Reports.

In addition to the information given in the standard reports, the user may wish to know the values of given variables for particular hours during a run. By using SCHEDULE instructions, he designates the hours for which he wishes the values to be printed or plotted, and with the REPORT-BLOCK instruction he chooses the variables, the values of which he wants to know. The HOURLY-REPORT instruction is used to connect particular REPORT-BLOCK instructions with the desired SCHEDULE instructions.

Detailed discussions on how to use the HOURLY-REPORT, REPORT-BLOCK, and SCHEDULE instructions are in Chap. II. See the sections on the REPORT-BLOCK instruction in Chaps. III, IV, and V for a list of the variables that may be printed, and their associated code-numbers, for the LOADS, SYSTEMS, and PLANT programs.

B. LOADS OUTPUT REPORT DESCRIPTIONS

To fully explain the following sample output reports from LOADS it is necessary first to display the input data.

Since the VERIFICATION reports for LOADS are basically self-explanatory (especially after having input the data) no attempt is made here to describe these particular reports. They simply echo back to the user the input data, as understood by the LOADS program.

The available SUMMARY reports and an example HOURLY-REPORT are displayed later in this section of the manual.

REPORT- LV-A GENERAL PROJECT AND BUILDING INPUT

PERIOD OF STUDY

STARTING DATE	ENDING DATE	NUMBER OF DAYS
1 JAN 1974	31 DEC 1974	365

SITE CHARACTERISTIC DATA

STATION NAME	LATITUDE (DEG)	LONGITUDE (DEG)	ALTITUDE (FT)	TIME ZONE	BUILDING AZIMUTH (DEG)
CHIC	42.0	88.0	610.		

REPORT- LV-B SUMMARY OF SPACES OCCURRING IN THE PROJECT

NUMBER OF SPACES 6 EXTERIOR 5 INTERIOR 1

SPACE	SPACE MULTIPLIER	SPACE TYPE	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
PLENUM-1	1.0	EXT	2.0	5000.	10000.
SPACE1-1	1.0	EXT	8.0	1056.	8448.
SPACE2-1	1.0	EXT	8.0	456.	3648.
SPACE3-1	1.0	EXT	8.0	1056.	8448.
SPACE4-1	1.0	EXT	8.0	456.	3648.
SPACE5-1	1.0	INT	8.0	1976.	15808.

REPORT- LV-C DETAILS OF SPACE PLENUM-1

DATA FOR SPACE PLENUM-1

LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
0.	0.	0.	0.	1.0	2.	5000.	10000.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
10	5	5	0

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
0	0	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
5.0	70.0

INTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACE
C1-1	1.0	1056.0	CLNG-1	.27	SPACE1-1
C2-1	1.0	456.0	CLNG-1	.27	SPACE2-1
C3-1	1.0	1056.0	CLNG-1	.27	SPACE3-1
C4-1	1.0	456.0	CLNG-1	.27	SPACE4-1
C5-1	1.0	1976.0	CLNG-1	.27	SPACE5-1

EXTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE TYPE
WALL-1PF	1.0	200.	100.00	2.00	WALL-1	.07	DELAYED
WALL-1PR	1.0	100.	50.00	2.00	WALL-1	.07	DELAYED
WALL-1PB	1.0	200.	100.00	2.00	WALL-1	.07	DELAYED

REPORT- LV-C DETAILS OF SPACE PLENUM-1

(CONTINUED)

EXTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE TYPE
WALL-1PL	1.0	100.	50.00	2.00	WALL-1	.07	DELAYED
TOP-1	1.0	5000.	100.00	50.00	ROOF-1	.05	DELAYED

			LOCATION OF ORIGIN IN BUILDING COORDINATES			LOCATION OF ORIGIN IN SPACE COORDINATES		
SURFACE	AZIMUTH (DEG)	TILT (DEG)	XB (FT)	YB (FT)	ZB (FT)	X (FT)	Y (FT)	Z (FT)
WALL-1PF	180.0	90.0	0.	0.	0.	0.	0.	0.
WALL-1PR	90.0	90.0	0.	0.	0.	0.	0.	0.
WALL-1PB	0.	90.0	0.	0.	0.	0.	0.	0.
WALL-1PL	270.0	90.0	0.	0.	0.	0.	0.	0.
TOP-1	180.0	0.	0.	0.	10.00	0.	0.	10.00

REPORT- LV-C DETAILS OF SPACE SPACE1-1 ---(CONTINUED)---

DATA FOR SPACE SPACE1-1

LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
0.	0.	0.	0.	1.0	8.	1056.	8448.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
6	1	4	1

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
2	2	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
70.0	70.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	CFM PER SQ FT	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFIL-SCH	AIR-CHANGE	0.	.25	0.

PEOPLE

SCHEDULE	NUMBER	AREA PER PERSON (SQ FT)	PEOPLE ACTIVITY (BTU/HR)	PEOPLE SENSIBLE (BTU/HR)	PEOPLE LATENT (BTU/HR)
OCCUPY-1	11.0	96.0	400.0	0.	0.

REPORT- LV-C DETAILS OF SPACE   SPACE1-1   (CONTINUED)

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	FRACTION OF LOAD TO SPACE
LIGHTS-1	REC-FLUOR-RV	3.00	0.	.80

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQ FT)	ELEC LOAD (KW)	FRACTION OF LOAD TO SPACE	
			SENSIBLE	LATENT
EQUIP-1	1.00	0.	1.00	0.

INTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACE
C1-1	1.0	1056.0	CLNG-1	.27	PLENUM-1
SB12	1.0	135.8	SB-U	10.00	SPACE2-1
SB14	1.0	135.8	SB-U	10.00	SPACE4-1
SB15	1.0	608.0	SB-U	10.00	SPACE5-1

EXTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE TYPE
FRONT-1	1.0	800.	100.00	8.00	WALL-1	.07	DELAYED

SURFACE	AZIMUTH (DEG)	TILT (DEG)	LOCATION OF ORIGIN IN BUILDING COORDINATES			LOCATION OF ORIGIN IN SPACE COORDINATES		
			XB (FT)	YB (FT)	ZB (FT)	X (FT)	Y (FT)	Z (FT)
FRONT-1	180.0	90.0	0.	0.	0.	0.	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE1-1

(CONTINUED)

UNDERGROUND SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)
F1-1	1.0	1056.	FLOOR-1	.05

WINDOWS

WINDOW	MULTIPLIER	AREA (SQ FT)	SHADING COEFF	NUMBER OF PANES	GLASS TYPE INDEX	SET-BACK (FT)	WIDTH (FT)	HEIGHT (FT)	SKY FORM FACTOR	GROUND FORM FACTOR
WF-1	1.0	180.	1.00	1	1	0.	45.00	4.00		
DF-1	1.0	64.	1.00	1	5	0.	8.00	8.00		

WINDOW	LOCATED IN SURFACE	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SURFACE COORDINATES X (FT)	Y (FT)
WF-1	FRONT-1	0.	0.	0.	0.	0.
DF-1	FRONT-1	0.	0.	0.	0.	0.

DATA FOR SPACE   SPACE2-1

LOCATION OF ORIGIN IN BUILDING COORDINATES

XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
0.	0.	0.	0.	1.0	8.	456.	3648.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
6	1	4	1

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
1	1	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
70.0	70.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	CFM PER SQ FT	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFIL-SCH	AIR-CHANGE	0.	.25	0.

PEOPLE

SCHEDULE	NUMBER	AREA PER PERSON (SQ FT)	PEOPLE ACTIVITY (BTU/HR)	PEOPLE SENSIBLE (BTU/HR)	PEOPLE LATENT (BTU/HR)
OCCUPY-1	5.0	91.2	400.0	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE2-1 -----(CONTINUED)-----

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	FRACTION OF LOAD TO SPACE
LIGHTS-1	REC-FLUOR-RV	3.00	0.	.80

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQ FT)	ELEC LOAD (KW)	FRACTION OF LOAD TO SPACE SENSIBLE	FRACTION OF LOAD TO SPACE LATENT
EQUIP-1	1.00	0.	1.00	0.

INTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACE
SB12	1.0	135.8	SB-U	10.00	SPACE1-1
C2-1	1.0	456.0	CLNG-1	.27	PLENUM-1
SB23	1.0	135.8	SB-U	10.00	SPACE3-1
SB25	1.0	208.0	SB-U	10.00	SPACE5-1

EXTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE TYPE
RIGHT-1	1.0	400.	50.00	8.00	WALL-1	.07	DELAYED

SURFACE	AZIMUTH (DEG)	TILT (DEG)	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SPACE COORDINATES X (FT)	Y (FT)	Z (FT)
RIGHT-1	90.0	90.0	100.00	0.	0.	100.00	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE2-1 ---(CONTINUED)---

UNDERGROUND SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)
F2-1	1.0	456.	FLOOR-1	.05

WINDOWS

WINDOW	MULTIPLIER	AREA (SQ FT)	SHADING COEFF	NUMBER OF PANES	GLASS TYPE INDEX	SET-BACK (FT)	WIDTH (FT)	HEIGHT (FT)	SKY FORM FACTOR	GROUND FORM FACTOR
WR-1	1.0	100.	1.00	1	1	0.	25.00	4.00		

		LOCATION OF ORIGIN IN BUILDING COORDINATES			LOCATION OF ORIGIN IN SURFACE COORDINATES	
WINDOW	LOCATED IN SURFACE	XB (FT)	YB (FT)	ZB (FT)	X (FT)	Y (FT)
WR-1	RIGHT-1	100.00	0.	0.	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE3-1 ---(CONTINUED)---

DATA FOR SPACE SPACE3-1

LOCATION OF ORIGIN IN BUILDING COORDINATES

XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
0.	0.	0.	0.	1.0	8.	1056.	8448.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
6	1	4	1

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
2	2	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
70.0	70.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	CFM PER SQ FT	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFIL-SCH	AIR-CHANGE	0.	.25	0.

PEOPLE

SCHEDULE	NUMBER	AREA PER PERSON (SQ FT)	PEOPLE ACTIVITY (BTU/HR)	PEOPLE SENSIBLE (BTU/HR)	PEOPLE LATENT (BTU/HR)
OCCUPY-1	11.0	96.0	400.0	0.	0.

EXAMPLE BUILDING 3A, CHICAGO   DOE-2.1   13 MAR 80   10.19.09   LDL RUN 1

REPORT- LV-C DETAILS OF SPACE   SPACE3-1

---(CONTINUED)--------

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	FRACTION OF LOAD TO SPACE
LIGHTS-1	REC-FLUOR-RV	3.00	0.	.80

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQ FT)	ELEC LOAD (KW)	FRACTION OF LOAD TO SPACE SENSIBLE	LATENT
EQUIP-1	1.00	0.	1.00	0.

INTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACE
SB23	1.0	135.8	SB-U	10.00	SPACE2-1
C3-1	1.0	1056.0	CLNG-1	.27	PLENUM-1
SB34	1.0	135.8	SB-U	10.00	SPACE4-1
SB35	1.0	608.0	SB-U	10.00	SPACE5-1

EXTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE TYPE
BACK-1	1.0	800.	100.00	8.00	WALL-1	.07	DELAYED

SURFACE	AZIMUTH (DEG)	TILT (DEG)	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SPACE COORDINATES X (FT)	Y (FT)	Z (FT)
BACK-1	0.	90.0	100.00	50.00	0.	100.00	50.00	0.

REPORT- LV-C DETAILS OF SPACE SPACE3-1 (CONTINUED)

UNDERGROUND SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)
F3-1	1.0	1056.	FLOOR-1	.05

WINDOWS

WINDOW	MULTIPLIER	AREA (SQ FT)	SHADING COEFF	NUMBER OF PANES	GLASS TYPE INDEX	SET-BACK (FT)	WIDTH (FT)	HEIGHT (FT)	SKY FORM FACTOR	GROUND FORM FACTOR
WB-1	1.0	180.	1.00	1	1	0.	45.00	4.00		
DB-1	1.0	49.	1.00	1	5	0.	7.00	7.00		

WINDOW	LOCATED IN SURFACE	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SURFACE COORDINATES X (FT)	Y (FT)
WB-1	BACK-1	100.00	50.00	0.	0.	0.
DB-1	BACK-1	100.00	50.00	0.	0.	0.

REPORT- LV-C DETAILS OF SPACE   SPACE4-1

--(CONTINUED)--------

DATA FOR SPACE   SPACE4-1

LOCATION OF ORIGIN IN BUILDING COORDINATES

XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
0.	0.	0.	0.	1.0	8.	456.	3648.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
6	1	4	1

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
1	1	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
70.0	70.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	CFM PER SQ FT	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFIL-SCH	AIR-CHANGE	0.	.25	0.

PEOPLE

SCHEDULE	NUMBER	AREA PER PERSON (SQ FT)	PEOPLE ACTIVITY (BTU/HR)	PEOPLE SENSIBLE (BTU/HR)	PEOPLE LATENT (BTU/HR)
OCCUPY-1	5.0	91.2	400.0	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE4-1 ----------(CONTINUED)--------

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	FRACTION OF LOAD TO SPACE
LIGHTS-1	REC-FLUOR-RV	3.00	0.	.80

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQ FT)	ELEC LOAD (KW)	FRACTION OF LOAD TO SPACE	
			SENSIBLE	LATENT
EQUIP-1	1.00	0.	1.00	0.

INTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACE
SB14	1.0	135.8	SB-U	10.00	SPACE1-1
SB34	1.0	135.8	SB-U	10.00	SPACE3-1
C4-1	1.0	456.0	CLNG-1	.27	PLENUM-1
SB45	1.0	208.0	SB-U	10.00	SPACE5-1

EXTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE TYPE
LEFT-1	1.0	400.	50.00	9.00	WALL-1	.07	DELAYED

SURFACE	AZIMUTH (DEG)	TILT (DEG)	LOCATION OF ORIGIN IN BUILDING COORDINATES			LOCATION OF ORIGIN IN SPACE COORDINATES		
			XB (FT)	YB (FT)	ZB (FT)	X (FT)	Y (FT)	Z (FT)
LEFT-1	270.0	90.0	0.	50.00	0.	0.	50.00	0.

REPORT- LV-C DETAILS OF SPACE SPACE4-1 ----------(CONTINUED)--------

UNDERGROUND SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)
F4-1	1.0	456.	FLOOR-1	.05

WINDOWS

WINDOW	MULTIPLIER	AREA (SQ FT)	SHADING COEFF	NUMBER OF PANES	GLASS TYPE INDEX	SET-BACK (FT)	WIDTH (FT)	HEIGHT (FT)	SKY FORM FACTOR	GROUND FORM FACTOR
WL-1	1.0	100.	1.00	1	1	0.	25.00	4.00		

WINDOW	LOCATED IN SURFACE	LOCATION OF ORIGIN IN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN IN SURFACE COORDINATES X (FT)	Y (FT)
WL-1	LEFT-1	0.	50.00	0.	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE5-1

-----(CONTINUED)-----

DATA FOR SPACE SPACE5-1

LOCATION OF ORIGIN IN BUILDING COORDINATES

XB (FT)	YB (FT)	ZB (FT)	SPACE AZIMUTH (DEG)	SPACE MULTIPLIER	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
0.	0.	0.	0.	1.0	8.	1976.	15808.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
6	0	5	1

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
0	0	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
70.0	70.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	CFM PER SQ FT	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFIL-SCH	AIR-CHANGE	0.	.25	0.

PEOPLE

SCHEDULE	NUMBER	AREA PER PERSON (SQ FT)	PEOPLE ACTIVITY (BTU/HR)	PEOPLE SENSIBLE (BTU/HR)	PEOPLE LATENT (BTU/HR)
OCCUPY-1	20.0	98.8	400.0	0.	0.

REPORT- LV-C DETAILS OF SPACE SPACE5-1

----------(CONTINUED)----------

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	FRACTION OF LOAD TO SPACE
LIGHTS-1	REC-FLUOR-RV	3.00	0.	.80

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQ FT)	ELEC LOAD (KW)	FRACTION OF LOAD TO SPACE SENSIBLE	LATENT
EQUIP-1	1.00	0.	1.00	0.

INTERIOR SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACE
SB15	1.0	608.0	SB-U	10.00	SPACE1-1
SB25	1.0	208.0	SB-U	10.00	SPACE2-1
SB35	1.0	608.0	SB-U	10.00	SPACE3-1
SB45	1.0	208.0	SB-U	10.00	SPACE4-1
C5-1	1.0	1976.0	CLNG-1	.27	PLENUM-1

UNDERGROUND SURFACES

SURFACE	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION	U-VALUE (BTU/SQ FT-HR-DEG F)
F5-1	1.0	1976.	FLOOR-1	.05

REPORT- LV-D DETAILS OF EXTERIOR SURFACES OCCURRING IN THE PROJECT

NUMBER OF EXTERIOR SURFACES 9 RECTANGULAR 9 OTHER 0

RECTANGULAR SURFACES

SURFACE NAME	MULTIPLIER	HEIGHT (FT)	WIDTH (FT)	AZIMUTH (DEG)	TILT (DEG)	GROUND REFLECT-TANCE	X-DIVISIONS	LOCATION OF ORIGIN IN SPACE COORDINATES X (FT)	Y (FT)	Z(FT)
WALL-1PF	1.0	2.00	100.00	180.	90.	.20	10	0.	0.	0.
WALL-1PR	1.0	2.00	50.00	90.	90.	.20	10	0.	0.	0.
WALL-1PB	1.0	2.00	100.00	0.	90.	.20	10	0.	0.	0.
WALL-1PL	1.0	2.00	50.00	270.	90.	.20	10	0.	0.	0.
TOP-1	1.0	50.00	100.00	180.	0.	0.	10	0.	0.	10.00
FRONT-1	1.0	8.00	100.00	180.	90.	.20	10	0.	0.	0.
RIGHT-1	1.0	8.00	50.00	90.	90.	.20	10	100.00	0.	0.
BACK-1	1.0	8.00	100.00	0.	90.	.20	10	100.00	50.00	0.
LEFT-1	1.0	8.00	50.00	270.	90.	.20	10	0.	50.00	0.

SURFACE NAME	CONSTRUCTION NAME	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	INFILTRATION FLOW COEFFICIENT	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
WALL-1PF	WALL-1	.07	.70	3	0.	DELAYED	9
WALL-1PR	WALL-1	.07	.70	3	0.	DELAYED	9
WALL-1PB	WALL-1	.07	.70	3	0.	DELAYED	9
WALL-1PL	WALL-1	.07	.70	3	0.	DELAYED	9
TOP-1	ROOF-1	.05	.70	3	0.	DELAYED	7
FRONT-1	WALL-1	.07	.70	3	0.	DELAYED	9
RIGHT-1	WALL-1	.07	.70	3	0.	DELAYED	9
BACK-1	WALL-1	.07	.70	3	0.	DELAYED	9
LEFT-1	WALL-1	.07	.70	3	0.	DELAYED	9

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80, 10.19.09 LDL RUN 1

REPORT- LV-E DETAILS OF UNDERGROUND SURFACES OCCURRING IN THE PROJECT

NUMBER OF UNDERGROUND SURFACES 5

SURFACE NAME	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION NAME	U-VALUE (BTU/SQ FT-HR-DEG F)
F1-1	1.0	1056.	FLOOR-1	.05
F2-1	1.0	456.	FLOOR-1	.05
F3-1	1.0	1056.	FLOOR-1	.05
F4-1	1.0	456.	FLOOR-1	.05
F5-1	1.0	1976.	FLOOR-1	.05

REPORT- LV-F DETAILS OF INTERIOR SURFACES OCCURRING IN THE PROJECT

NUMBER OF INTERIOR SURFACES 13

SURFACE NAME	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION NAME	U-VALUE (BTU/SQ FT-HR-DEG F)	ADJACENT SPACES SPACE-1	SPACE-2
C1-1	1.0	1056.	CLNG-1	.27	SPACE1-1	PLENUM-1
SB12	1.0	136.	SB-U	10.00	SPACE1-1	SPACE2-1
SB14	1.0	136.	SB-U	10.00	SPACE1-1	SPACE4-1
SB15	1.0	608.	SB-U	10.00	SPACE1-1	SPACE5-1
C2-1	1.0	456.	CLNG-1	.27	SPACE2-1	PLENUM-1
SB23	1.0	136.	SB-U	10.00	SPACE2-1	SPACE3-1
SB25	1.0	208.	SB-U	10.00	SPACE2-1	SPACE5-1
C3-1	1.0	1056.	CLNG-1	.27	SPACE3-1	PLENUM-1
SB34	1.0	136.	SB-U	10.00	SPACE3-1	SPACE4-1
SB35	1.0	608.	SB-U	10.00	SPACE3-1	SPACE5-1
C4-1	1.0	456.	CLNG-1	.27	SPACE4-1	PLENUM-1
SB45	1.0	208.	SB-U	10.00	SPACE4-1	SPACE5-1
C5-1	1.0	1976.	CLNG-1	.27	SPACE5-1	PLENUM-1

REPORT- LV-G DETAILS OF SCHEDULES OCCURRING IN THE PROJECT

NUMBER OF SCHEDULES 6

SCHEDULE OCCUPY-1

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

FOR DAYS MON TUE WED THU FRI

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	1.00	1.00	1.00	.80	.40	.80	1.00	1.00	1.00	1.00	.50	.10	.10	0.	0.	0.

SCHEDULE LIGHTS-1

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05	.05

FOR DAYS MON TUE WED THU FRI

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	.05	.05	.05	.05	.05	.05	.05	.05	.90	.95	1.00	.95	.80	.90	1.00	1.00	1.00	1.00	.60	.20	.20	.05	.05	.05

SCHEDULE EQUIP-1

THROUGH 31 12

REPORT- LV-G DETAILS OF SCHEDULES OCCURRING IN THE PROJECT

---(CONTINUED)--------

FOR DAYS SUN SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20	.20

FOR DAYS MON TUE WED THU FRI

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	.02	.02	.02	.02	.02	.02	.02	.02	.40	.90	.90	.90	.90	.90	.80	.70	.50	.50	.30	.30	.02	.02	.02	.02

SCHEDULE INFIL-SCH

THROUGH 31 3

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

THROUGH 31 10

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

THROUGH 31 12

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

SCHEDULE REPRTSCH

THROUGH 15 7

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

THROUGH 17 7

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

THROUGH 31 12

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

SCHEDULE PLTSCH

THROUGH 15 7

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

THROUGH 16 7

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

THROUGH 31 12

REPORT- LV-G DETAILS OF SCHEDULES OCCURRING IN THE PROJECT

---(CONTINUED)--------

FOR DAYS SUN MON TUE WED THU FRI SAT HOL

HOUR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 LDL RUN 1

REPORT- LV-H DETAILS OF WINDOWS OCCURRING IN THE PROJECT

NUMBER OF WINDOWS 6 RECTANGULAR 6 OTHER 0

RECTANGULAR WINDOWS

WINDOW NAME	MULTIPLIER	HEIGHT (FT)	WIDTH (FT)	LOCATION OF ORIGIN IN SURFACE COORDINATES X (FT)	Y (FT)
WF-1	1.0	4.00	45.00	0.	0.
DF-1	1.0	8.00	8.00	0.	0.
WR-1	1.0	4.00	25.00	0.	0.
WB-1	1.0	4.00	45.00	0.	0.
DB-1	1.0	7.00	7.00	0.	0.
WL-1	1.0	4.00	25.00	0.	0.

WINDOW NAME	SETBACK (FT)	X-DIVISIONS	SHADING COEFF	NUMBER OF PANES	GLASS TYPE CODE	INFILTRATION FLOW COEFF	SKY FORM FACTOR	GROUND FORM FACTOR
WF-1	0.	10	1.00	1	1	0.		
DF-1	0.	10	1.00	1	5	0.		
WR-1	0.	10	1.00	1	1	0.		
WB-1	0.	10	1.00	1	1	0.		
DB-1	0.	10	1.00	1	5	0.		
WL-1	0.	10	1.00	1	1	0.		

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 LDL RUN 1

REPORT- LV-I DETAILS OF CONSTRUCTIONS OCCURRING IN THE PROJECT

NUMBER OF CONSTRUCTIONS 5 DELAYED 2 QUICK 3

CONSTRUCTION NAME	U-VALUE (BTU/SQ FT-HR-DEG F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
WALL-1	.07	.70	3	DELAYED	9
ROOF-1	.05	.70	3	DELAYED	7
CLNG-1	.27	.70	3	QUICK	0
SB-U	10.00	.70	3	QUICK	0
FLOOR-1	.05	.70	3	QUICK	0

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 LDL RUN 1

REPORT- LV-J DETAILS OF BUILDING SHADES OCCURING IN THE PROJECT

NUMBER OF BUILDING SHADES 0 RECTANGULAR 0 OTHER 0

REPORT LV-K - WEIGHTING FACTOR SUMMARY

This report is automatically produced by a LIBRARY-INPUT LOADS run in which a Custom Weighting Factor library is created; it is also printed in an INPUT LOADS run if VERIFICATION = (LV-K) is specified in the LOADS-REPORT instruction. In the latter case, the entries in this report can be a combination of ASHRAE weighting factors, automatically calculated Custom Weighting Factors (for SPACEs with FLOOR-WEIGHT = 0), and Custom Weighting Factors from a previously created user library.

At the top of the report is the U-name of each SPACE (SP NAME) along with the U-name of the set of weighting factors for that space (WF NAME). WF NAME will be blank except for library creation runs and for those SPACEs in a LOADS run that use Custom Weighting Factors from a user library.

Down the left side of the report are six groupings of variable names that label the six types of weighting factors: solar, general lighting, task lighting, people/equipment, conduction, and air temperature.

REPORT- LV-K WEIGHTING FACTOR SUMMARY

SP NAME-- / WF NAME--	SPACE-1	SPACE-2	SPACE-3	SPACE-4
SOLAR				
V0	.20725	.18813	.20725	.15917
V1	-.12377	-.13318	-.12377	-.11462
V2	.00199	.00344	.00199	.00254
W1	1.16969	1.26171	1.16969	1.23544
W2	-.31352	-.35646	-.31352	-.32566
GENERAL LIGHTING				
V0	.48992	.48206	.48992	.45408
V1	-.48682	-.53237	-.48682	-.50644
V2	.10686	.12301	.10686	.11404
W1	1.17108	1.26777	1.17108	1.24340
W2	-.31548	-.36192	-.31548	-.33203
TASK LIGHTING				
V0	.45947	.45114	.45947	.42149
V1	-.44597	-.48847	-.44597	-.46244
V2	.09440	.10874	.09440	.10102
W1	1.17108	1.26777	1.17108	1.24340
W2	-.31548	-.36192	-.31548	-.33203
PEOPLE-EQUIPMENT				
V0	.46708	.45887	.46708	.42964
V1	-.45618	-.49944	-.45618	-.47344
V2	.09752	.11231	.09752	.10428
W1	1.17108	1.26777	1.17108	1.24340
W2	-.31548	-.36192	-.31548	-.33203
CONDUCTION				
V0	.53140	.52486	.53140	.49944
V1	-.54246	-.59314	-.54246	-.56767
V2	.12382	.14275	.12382	.13215
W1	1.17108	1.26777	1.17108	1.24340
W2	-.31548	-.36192	-.31548	-.33203
AIR TEMP				
G0*	.96260	1.14640	.96260	.67349
G1*	-1.46754	-1.76874	-1.46754	-.98792
G2*	.50566	.62413	.50566	.31539
G3*	-.00072	-.00179	-.00072	-.00097
P1	-1.21307	-1.30576	-1.21307	-1.26805
P2	.34642	.38867	.34642	.34978

REPORT LS-A - SPACE PEAK LOADS SUMMARY

This report (see next page) lists each space by U-name and the number of times each space is repeated (MULTIPLIER) on the left of the report.

The individual space peak sensible cooling load with the month, day and hour it occurred is reported in the center. The sum of the cooling loads for all spaces (which is the non-coincident building peak load) is also reported.

The coincident building peak cooling load (the "block" load) is reported directly below the non-coincident peak but it does not include the plenum load. The outside dry bulb and wet bulb temperatures are also reported for the time of the peak load in each space, and for the building. The peak heating load for PLENUM-1 is shown as 9:00 a.m. on JAN 12. All these hours are in standard time.

The heating peak loads are treated similarly on the right.

REPORT- LS-A SPACE PEAK LOADS SUMMARY

SPACE NAME	MULTIPLIER	COOLING LOAD (KBTU/HR)	TIME OF PEAK	DRY-BULB	WET-BULB	HEATING LOAD (KBTU/HR)	TIME OF PEAK	DRY-BULB	WET-BULB
PLENUM-1	1.	15.775	JUL 7 4 PM	88F	73F	-21.483	JAN 12 9 AM	-8F	-8F
SPACE1-1	1.	42.852	SEP 26 4 PM	82F	61F	-22.911	JAN 12 8 AM	-7F	-7F
SPACE2-1	1.	17.445	AUG 26 2 PM	90F	75F	-9.793	JAN 12 8 AM	-7F	-7F
SPACE3-1	1.	29.202	JUL 12 3 PM	85F	68F	-22.836	JAN 1 4 AM	3F	2F
SPACE4-1	1.	16.123	JUL 9 5 PM	97F	73F	-10.117	JAN 12 8 AM	-7F	-7F
SPACE5-1	1.	22.676	AUG 30 3 PM	82F	64F	-8.236	FEB 4 3 AM	10F	9F
SUM		144.073				-95.376			
BUILDING PEAK		119.763	AUG 12 3 PM	85F	72F	-71.205	FEB 4 6 AM	7F	6F

REPORT LS-B - SPACE PEAK LOAD COMPONENTS

The following multiple page report gives a breakdown of cooling and heating peak loads, according to the source of the load, for each space. There are several interesting points that the user should become acquainted with.

1. Roof loads are reported as ROOFS and for DOE-2 a ROOF is any external wall whose TILT is less than 45°. The WALLS and ROOF loads (sensible) are due to conduction.

2. GLASS CONDUCTION is the sum of the $UA\Delta T$ 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" and it is possible to have heat gains from GLASS SOLAR, for example, long after the sun has moved and no longer shines on the exposed walls of the space.

4. DOOR loads are those through external doors in the space.

5. INTERNAL SURFACES are partitions and drop ceilings. The load is negative if heat is leaving the space and positive if heat is entering the space. Warning:If the temperature is the same in a plenum and an adjoining space, no heat transfer will occur. Therefore, reported loads will not reflect seasonal conduction to and from the plenum.

6. UNDERGROUND SURFACES can be basement floors and walls or slabs on grade. The user should take care to adjust either the areas or U-factor to approach the heat transfer loss he anticipates. 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. The RUN 1 in the upper right hand corner of the report (and all of the other reports in this manual) refers to the fact that this was the first pass through the LOADS program. If the user were doing parametric runs as part of the same job, subsequent passes through LOADS, for example, would be recorded as RUN 2, RUN 3, etc.

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 LDL RUN 1

REPORT- LS-B SPACE PEAK LOAD COMPONENTS

SPACE PLENUM-1

MULTIPLIER	1.0			
FLOOR AREA	5000	SQFT	465	SQMT
VOLUME	10000	CUFT	283	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4PM		JAN 12 9AM	
DRY-BULB TEMP	88F	31C	-8F	-22C
WET-BULB TEMP	73F	23C	-8F	-22C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (MJ/H)	COOLING LATENT (KBTU/H)	COOLING LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	1.493	1.58	0.	0.	-3.009	-3.17
ROOFS	14.281	15.07	0.	0.	-18.475	-19.49
GLASS CONDUCTION	0.	0.	0.	0.	0.	0.
GLASS SOLAR	0.	0.	0.	0.	0.	0.
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	0.	0.	0.	0.	0.	0.
OCCUPANTS TO SPACE	0.	0.	0.	0.	0.	0.
LIGHT TO SPACE	0.	0.	0.	0.	0.	0.
EQUIPMENT TO SPACE	0.	0.	0.	0.	0.	0.
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	0.	0.
TOTAL	15.775	16.64	0.	0.	-21.483	-22.67

	COOLING		HEATING	
TOTAL LOAD	15.775 KBTU/H	16.64 MJ/H	-21.483 KBTU/H	-22.67 MJ/H
TOTAL LOAD / AREA	3.15 BTUH/SQFT	.03583 MJ/H-SQMT	4.30 BTUH/SQFT	.04880 MJ/H-SQMT

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

--(CONTINUED)--------

SPACE SPACE1-1

MULTIPLIER	1.0			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	SEP 26	4PM	JAN 12	8AM
DRY-BULB TEMP	82F	28C	-7F	-22C
WET-BULB TEMP	61F	16C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.831	.88	0.	0.	-2.661	-2.81
ROOFS	0.	0.	0.	0.	0.	0.
GLASS CONDUCTION	3.448	3.64	0.	0.	-18.932	-19.97
GLASS SOLAR	26.676	28.14	0.	0.	1.018	1.07
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	-.422	-.45	0.	0.	-1.531	-1.62
OCCUPANTS TO SPACE	2.879	3.04	1.020	1.08	.141	.15
LIGHT TO SPACE	7.549	7.96	0.	0.	.927	.98
EQUIPMENT TO SPACE	1.893	2.00	0.	0.	.761	.80
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	-2.634	-2.78
TOTAL	42.852	45.21	1.020	1.08	-22.911	-24.17

TOTAL LOAD	43.873 KBTU/H	46.29 MJ/H	-22.911 KBTU/H	-24.17 MJ/H
TOTAL LOAD / AREA	41.55 BTUH/SQFT	.47184 MJ/H-SQMT	21.70 BTUH/SQFT	.24640 MJ/H-SQMT

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*****************************************************************
*                                                               *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR     *
*  ----    LOADS                                                *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION        *
*          IN CONSIDERATION                                     *
*                                                               *
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SPACE SPACE2-1

MULTIPLIER	1.0			
FLOOR AREA	456	SQFT	42	SQMT
VOLUME	3648	CUFT	103	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 26 2PM		JAN 12 8AM	
DRY-BULB TEMP	90F	32C	-7F	-22C
WET-BULB TEMP	75F	24C	-7F	-22C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	.623	.66	0.	0.	-1.438	-1.52
ROOFS	0.	0.	0.	0.	0.	0.
GLASS CONDUCTION	1.956	2.06	0.	0.	-7.765	-8.19
GLASS SOLAR	9.667	10.20	0.	0.	.415	.44
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	-.160	-.17	0.	0.	-.661	-.70
OCCUPANTS TO SPACE	1.227	1.29	.464	.49	.064	.07
LIGHT TO SPACE	3.027	3.19	0.	0.	.400	.42
EQUIPMENT TO SPACE	1.104	1.16	0.	0.	.329	.35
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	-1.137	-1.20
TOTAL	17.445	18.41	.464	.49	-9.793	-10.33

TOTAL LOAD	17.909 KBTU/H	18.89 MJ/H	-9.793 KBTU/H	-10.33 MJ/H
TOTAL LOAD / AREA	39.27 BTUH/SQFT	.44602 MJ/H-SQMT	21.48 BTUH/SQFT	.24389 MJ/H-SQMT

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*****************************************************************
*                                                               *
*  NOTE   1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR     *
*  ----     LOADS                                               *
*         2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION       *
*           IN CONSIDERATION                                    *
*                                                               *
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REPORT- LS-B SPACE PEAK LOAD COMPONENTS

----------(CONTINUED)--------

SPACE SPACE3-1

MULTIPLIER	1.0			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 12 3PM		JAN 1 4AM	
DRY-BULB TEMP	85F	29C	3F	-16C
WET-BULB TEMP	68F	20C	2F	-17C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (MJ/H)	COOLING LATENT (KBTU/H)	COOLING LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.811	.86	0.	0.	-2.535	-2.67
ROOFS	0.	0.	0.	0.	0.	0.
GLASS CONDUCTION	3.369	3.55	0.	0.	-16.696	-17.62
GLASS SOLAR	12.929	13.64	0.	0.	.302	.32
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	-.475	-.50	0.	0.	-1.531	-1.62
OCCUPANTS TO SPACE	2.821	2.98	1.020	1.08	0.	0.
LIGHT TO SPACE	7.385	7.79	0.	0.	.432	.46
EQUIPMENT TO SPACE	2.363	2.49	0.	0.	.721	.76
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	-3.529	-3.72
TOTAL	29.202	30.81	1.020	1.08	-22.836	-24.09

	COOLING		HEATING	
TOTAL LOAD	30.222 KBTU/H	31.89 MJ/H	-22.836 KBTU/H	-24.09 MJ/H
TOTAL LOAD / AREA	28.62 BTUH/SQFT	.32503 MJ/H-SQMT	21.62 BTUH/SQFT	.24559 MJ/H-SQMT

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****************************************************************
*                                                              *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR     *
*  ----    LOADS                                               *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION       *
*          IN CONSIDERATION                                    *
*                                                              *
****************************************************************
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SPACE SPACE4-1

MULTIPLIER 1.0

FLOOR AREA	456	SQFT	42	SQMT
VOLUME	3648	CUFT	103	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5PM		JAN 12 8AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (MJ/H)	COOLING LATENT (KBTU/H)	COOLING LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.761	.80	0.	0.	-1.445	-1.52
ROOFS	0.	0.	0.	0.	0.	0.
GLASS CONDUCTION	2.758	2.91	0.	0.	-7.768	-8.20
GLASS SOLAR	7.347	7.75	0.	0.	.101	.11
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	-.205	-.22	0.	0.	-.661	-.70
OCCUPANTS TO SPACE	1.331	1.40	.464	.49	.064	.07
LIGHT TO SPACE	3.320	3.50	0.	0.	.400	.42
EQUIPMENT TO SPACE	.812	.86	0.	0.	.329	.35
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	-1.137	-1.20
TOTAL	16.123	17.01	.464	.49	-10.117	-10.67

TOTAL LOAD	16.587 KBTU/H	17.50 MJ/H	-10.117 KBTU/H	-10.67 MJ/H
TOTAL LOAD / AREA	36.38 BTUH/SQFT	.41311 MJ/H-SQMT	22.19 BTUH/SQFT	.25197 MJ/H-SQMT

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

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 LDL RUN 1

REPORT- LS-B SPACE PEAK LOAD COMPONENTS

--(CONTINUED)--------

SPACE SPACE5-1

MULTIPLIER 1.0

FLOOR AREA 1976 SQFT 184 SQMT
VOLUME 15808 CUFT 448 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 3PM		FEB 4 3AM	
DRY-BULB TEMP	82F	28C	10F	-12C
WET-BULB TEMP	64F	18C	9F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.	0.	0.	0.	0.	0.
ROOFS	0.	0.	0.	0.	0.	0.
GLASS CONDUCTION	0.	0.	0.	0.	0.	0.
GLASS SOLAR	0.	0.	0.	0.	0.	0.
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	-.692	-.73	0.	0.	-3.162	-3.34
OCCUPANTS TO SPACE	5.128	5.41	1.855	1.96	.001	.00
LIGHT TO SPACE	13.818	14.58	0.	0.	.812	.86
EQUIPMENT TO SPACE	4.421	4.66	0.	0.	.428	.45
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	-6.315	-6.66
TOTAL	22.676	23.92	1.855	1.96	-8.236	-8.69

	COOLING		HEATING	
TOTAL LOAD	24.531 KBTU/H	25.88 MJ/H	-8.236 KBTU/H	-8.69 MJ/H
TOTAL LOAD / AREA	12.41 BTUH/SQFT	.14099 MJ/H-SQMT	4.17 BTUH/SQFT	.04734 MJ/H-SQMT

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******************************************************************
*                                                                *
*  NOTE   1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR      *
*  ----     LOADS                                                *
*         2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION        *
*           IN CONSIDERATION                                     *
*                                                                *
******************************************************************
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REPORT LS-C - BUILDING PEAK LOAD COMPONENTS

The following report is similar in format to the preceding report (LS-B). The major difference is that this report is generated at the "building level," that is, all space loads are summed algebraically.

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 as 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, causing a temperature difference of 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

*** BUILDING ***

FLOOR AREA	5000	SQFT	465	SQMT
VOLUME	50000	CUFT	1416	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 12	3PM	FEB 4	6AM
DRY-BULB TEMP	85F	29C	7F	-14C
WET-BULB TEMP	72F	22C	6F	-14C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	2.706	2.85	0.	0.	-6.869	-7.25
ROOFS	0.	0.	0.	0.	0.	0.
GLASS CONDUCTION	10.881	11.48	0.	0.	-45.609	-48.12
GLASS SOLAR	49.471	52.19	0.	0.	2.049	2.16
DOOR	0.	0.	0.	0.	0.	0.
INTERNAL SURFACES	0.	0.	0.	0.	0.	0.
UNDERGROUND SURFACES	-1.750	-1.85	0.	0.	-8.000	-8.44
OCCUPANTS TO SPACE	13.115	13.84	4.824	5.09	.001	.00
LIGHT TO SPACE	34.198	36.08	0.	0.	2.052	2.16
EQUIPMENT TO SPACE	11.142	11.76	0.	0.	.830	.88
PROCESS TO SPACE	0.	0.	0.	0.	0.	0.
INFILTRATION	0.	0.	0.	0.	-15.660	-16.52
TOTAL	119.763	126.36	4.824	5.09	-71.205	-75.13
TOTAL LOAD	124.587 KBTU/H		131.45 MJ/H		-71.205 KBTU/H	-75.13 MJ/H
TOTAL LOAD / AREA	24.92 BTUH/SQFT		.28298 MJ/H-SQMT		14.24 BTUH/SQFT	.16173 MJ/H-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

The following report gives monthly summary of 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 totals for cooling load, heating load, and electrical load for the building.

9. MAX is the highest monthly peak cooling load, heating load, and electrical load.

REPORT- LS-D BUILDING MONTHLY LOADS SUMMARY

MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
	- - - - - - - - - C O O L I N G					- - - - - - - - -	- - - - - - - - - H E A T I N G					- - - - - - - - -	- - - E L E C	- - -
JAN	6.37527	25	16	48F	42F	58.199	-17.582	12	8	-7F	-7F	-69.879	4931.	19.5
FEB	5.63895	28	15	52F	42F	60.176	-16.384	4	6	7F	6F	-71.205	4310.	19.5
MAR	8.89742	5	17	57F	46F	70.430	-11.352	24	6	8F	7F	-68.284	4766.	19.5
APR	18.81738	26	15	78F	61F	95.613	-3.075	8	6	32F	29F	-33.455	4889.	19.5
MAY	23.76947	22	15	78F	68F	103.527	-1.024	6	6	38F	34F	-20.175	4931.	19.5
JUN	29.14907	20	15	90F	77F	116.347	-.126	23	5	52F	48F	-6.583	4559.	19.5
JUL	36.94970	12	15	85F	68F	117.551	-.000	1	5	60F	54F	-.235	4931.	19.5
AUG	34.05995	12	15	85F	72F	119.763	-.004	5	5	55F	54F	-2.015	4931.	19.5
SEP	24.41386	11	14	87F	72F	110.382	-.768	22	6	35F	31F	-19.494	4559.	19.5
OCT	18.52579	10	16	68F	53F	95.480	-2.678	21	6	30F	29F	-26.983	4931.	19.5
NOV	9.05334	1	16	72F	59F	85.397	-9.678	15	6	28F	26F	-46.876	4559.	19.5
DEC	6.03898	10	15	41F	35F	61.071	-16.413	8	20	18F	16F	-58.348	4766.	19.5
TOTAL	221.689						-79.083						57063.	
MAX						119.763						-71.205		19.5

REPORT LS-E - SPACE MONTHLY LOAD COMPONENTS IN MBTU

This report gives a breakdown of loads for each space on a monthly basis, according to the source of the load. All entries are in millions of Btus/month. Each load may be broken down into three types: heating (HEATNG), sensible cooling (SEN CL), and latent cooling (LAT CL). Latent cooling loads are accumulated only for those hours in each month that have a net sensible cooling load. Positive entries correspond to heat gain, negative entries correspond to heat loss, and all sensible loads are calculated as "delayed in time with weighting factors".

The load sources, listed across the top of the report, are described below. The corresponding headings from Report LS-B are given in brackets.

1. WALLS is the heat conduction through exterior walls with TILT greater than 45°, plus conduction through doors located in exterior walls. [WALLS plus DOOR]

2. ROOFS is the heat conduction through exterior walls with TILT less than 45°F. [ROOFS]

3. INT SUR is the heat conduction through interior walls. This entry will be non-zero only if there are one or more adjoining spaces with a loads calculation temperature that is different from that of the space being reported. [INTERNAL SURFACES]

4. UND SUR is the heat conduction through underground surfaces. [UNDERGROUND SURFACES]

5. INFIL is the load due to air infiltration. [INFILTRATION]

6. GL CON is the heat conduction through windows. [GLASS CONDUCTION]

7. GL SOL is the solar gain through windows. [GLASS SOLAR]

8. OCCUP is the heat gain from occupants. [OCCUPANTS TO SPACE]

9. LIGHTS is the heat gain from lights. [LIGHT TO SPACE]

10. EQUIP is the load resulting from equipment. These values are calculated from user-supplied entries for EQUIP-SCHEDULE, EQUIPMENT-KW, EQUIPMENT-W/SQFT, EQUIP-SENSIBLE and EQUIP-LATENT. [EQUIPMENT TO SPACE]

11. SOURCE is the load resulting from internal heating loads other than people, lights, or equipment. These values are calculated from the user-supplied entries for SOURCE-SCHEDULE, SOURCE-TYPE, SOURCE-BTU/HR, SOURCE-SENSIBLE, and SOURCE-LATENT. [PROCESS TO SPACE]

The LS-E Report will be printed once for the combined DESIGN-DAY RUN-PERIOD intervals (if one or more DESIGN-DAYs are specified) and once for the combined RUN-PERIOD intervals that use the weather file. For DESIGN DAYs, the months will be printed in the same order as they appear in the DESIGN-DAY RUN-PERIOD intervals.

To illustrate how the entries in this report are accumulated, consider a sequence of four hours in January in which the load components (in MBTU) from conduction through walls and heat from lights are as follows (the other load components are zero):

	walls	lights
hour 1:	-0.01	0.03
hour 2:	-0.02	0.03
hour 3:	-0.04	0.03
hour 4:	-0.05	0.03

In hours 1 and 2 the net loads are (-0.01 + 0.03) = 0.02, and (-0.02 + 0.03) = 0.01, respectively. Thus, both these hours have a net (sensible) cooling load. In hours 3 and 4, on the other hand, the net loads are (-0.04 + 0.03) = -0.01 and (-0.05 + 0.03) = -0.02, respectively. Thus, these hours have a net heating load. The entries in the LS-E Report for January would then be (assuming all other hours have zero loads):

		WALLS . . .	LIGHTS . . .	TOTAL	
	HEATNG	-0.03	0.06	0.03	← from hours 1 and 2
JAN	SEN CL	-0.09	0.06	-0.03	← from hours 3 and 4
	LAT CL	0.	0.	0.	

SIMPLE STRUCTURE RUN 3A, CHICAGO   DOE-2.1A   22 DEC 80   15.32.20   LDL RUN 1

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR PLENUM-1

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
	HEATNG	-1.27	-7.61	0.	0.	0.	0.	0.	0.	0.	0.	0.	-8.88
JAN	SEN CL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-1.08	-6.41	0.	0.	0.	0.	0.	0.	0.	0.	0.	-7.49
FEB	SEN CL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.86	-4.94	0.	0.	0.	0.	0.	0.	0.	0.	0.	-5.80
MAR	SEN CL	.00	.03	0.	0.	0.	0.	0.	0.	0.	0.	0.	.03
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.44	-2.56	0.	0.	0.	0.	0.	0.	0.	0.	0.	-3.00
APR	SEN CL	.02	.40	0.	0.	0.	0.	0.	0.	0.	0.	0.	.42
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.29	-1.74	0.	0.	0.	0.	0.	0.	0.	0.	0.	-2.03
MAY	SEN CL	.05	.69	0.	0.	0.	0.	0.	0.	0.	0.	0.	.74
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.10	-.73	0.	0.	0.	0.	0.	0.	0.	0.	0.	-.83
JUN	SEN CL	.18	1.59	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.77
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.02	-.25	0.	0.	0.	0.	0.	0.	0.	0.	0.	-.27
JUL	SEN CL	.39	2.93	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.31
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.03	-.36	0.	0.	0.	0.	0.	0.	0.	0.	0.	-.39
AUG	SEN CL	.29	2.15	0.	0.	0.	0.	0.	0.	0.	0.	0.	2.44
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.21	-1.46	0.	0.	0.	0.	0.	0.	0.	0.	0.	-1.67
SEP	SEN CL	.10	.89	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.00
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.42	-2.62	0.	0.	0.	0.	0.	0.	0.	0.	0.	-3.04
OCT	SEN CL	.02	.20	0.	0.	0.	0.	0.	0.	0.	0.	0.	.23
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-.78	-4.71	0.	0.	0.	0.	0.	0.	0.	0.	0.	-5.49
NOV	SEN CL	.01	.04	0.	0.	0.	0.	0.	0.	0.	0.	0.	.05
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-1.11	-6.52	0.	0.	0.	0.	0.	0.	0.	0.	0.	-7.62
DEC	SEN CL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	LAT CL					0.			0.		0.	0.	0.
	HEATNG	-6.61	-39.91	0.	0.	0.	0.	0.	0.	0.	0.	0.	-46.52
TOT	SEN CL	1.05	8.92	0.	0.	0.	0.	0.	0.	0.	0.	0.	9.97
	LAT CL					0.			0.		0.	0.	0.

SIMPLE STRUCTURE RUN 3A, CHICAGO DOE-2.1A 22 DEC 80 15.32.20 LDL RUN 1

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR SPACE1-1

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
	HEATNG	-.90	0.	0.	-.86	-.65	-5.90	1.72	.26	.96	.38	0.	-4.99
JAN	SEN CL	-.23	0.	0.	-.32	-.23	-1.77	1.99	.44	1.23	.43	0.	1.53
	LAT CL					0.			.15		0.	0.	.15
	HEATNG	-.77	0.	0.	-.85	-.31	-5.42	1.77	.25	.89	.36	0.	-4.58
FEB	SEN CL	-.19	0.	0.	-.32	-.25	-1.54	2.20	.36	1.02	.36	0.	1.63
	LAT CL					0.			.12		0.	0.	.12
	HEATNG	-.54	0.	0.	-.74	-.65	-3.99	1.78	.13	.59	.26	0.	-3.15
MAR	SEN CL	-.22	0.	0.	-.48	-.35	-1.86	2.81	.54	1.53	.54	0.	2.51
	LAT CL					.01			.19		0.	0.	.20
	HEATNG	-.22	0.	0.	-.31	0.	-1.56	.75	.05	.26	.09	0.	-.94
APR	SEN CL	-.15	0.	0.	-.68	0.	-1.51	4.66	.65	1.92	.70	0.	5.59
	LAT CL					0.			.21		0.	0.	.21
	HEATNG	-.11	0.	0.	-.16	0.	-.79	.49	.02	.14	.07	0.	-.34
MAY	SEN CL	-.05	0.	0.	-.59	0.	-1.27	5.17	.68	2.06	.74	0.	6.70
	LAT CL					0.			.22		0.	0.	.22
	HEATNG	-.02	0.	0.	-.03	0.	-.15	.11	.00	.03	.02	0.	-.04
JUN	SEN CL	.10	0.	0.	-.43	0.	.08	5.36	.63	2.00	.75	0.	8.49
	LAT CL					0.			.20		0.	0.	.20
	HEATNG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
JUL	SEN CL	.35	0.	0.	-.24	0.	1.60	5.65	.70	2.19	.81	0.	11.05
	LAT CL					0.			.22		0.	0.	.22
	HEATNG	-.00	0.	0.	-.00	0.	-.01	.00	.00	.00	.00	0.	-.00
AUG	SEN CL	.26	0.	0.	-.16	0.	.94	5.86	.70	2.20	.81	0.	10.61
	LAT CL					0.			.22		0.	0.	.22
	HEATNG	-.06	0.	0.	-.03	0.	-.42	.21	.01	.06	.04	0.	-.19
SEP	SEN CL	-.00	0.	0.	-.20	0.	-.63	5.55	.63	1.95	.73	0.	8.02
	LAT CL					0.			.20		0.	0.	.20
	HEATNG	-.18	0.	0.	-.12	0.	-1.25	.57	.03	.19	.10	0.	-.67
OCT	SEN CL	-.14	0.	0.	-.31	0.	-1.40	4.42	.67	2.01	.71	0.	5.97
	LAT CL					0.			.22		0.	0.	.22
	HEATNG	-.49	0.	0.	-.42	-.53	-3.51	1.14	.13	.58	.27	0.	-2.84
NOV	SEN CL	-.18	0.	0.	-.26	-.24	-1.54	2.51	.48	1.36	.49	0.	2.62
	LAT CL					.01			.17		0.	0.	.17
	HEATNG	-.77	0.	0.	-.72	-.75	-5.23	1.16	.20	.82	.35	0.	-5.05
DEC	SEN CL	-.22	0.	0.	-.26	-.23	-1.67	1.47	.46	1.28	.45	0.	1.28
	LAT CL					0.			.17		0.	0.	.17
	HEATNG	-4.06	0.	0.	-4.23	-3.38	-28.33	9.70	1.07	4.50	1.94	0.	-22.79
TOT	SEN CL	-.71	0.	0.	-4.25	-1.31	-10.58	47.67	6.92	20.75	7.50	0.	66.00
	LAT CL					.02			2.27		0.	0.	2.29

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR SPACE2-1

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
JAN	HEATNG	-.60	0.	0.	-2.54	-.35	-3.02	.84	.25	.78	.29	0.	-4.35
	SEN CL	-.03	0.	0.	-.20	-.03	-.18	.28	.06	.16	.06	0.	.11
	LAT CL					0.			.02		0.	0.	.02
FEB	HEATNG	-.50	0.	0.	-2.47	-.43	-2.71	.99	.21	.65	.25	0.	-4.00
	SEN CL	-.03	0.	0.	-.26	-.03	-.20	.34	.06	.17	.06	0.	.13
	LAT CL					0.			.02		0.	0.	.02
MAR	HEATNG	-.35	0.	0.	-2.22	-.34	-1.58	1.04	.13	.47	.19	0.	-3.05
	SEN CL	-.07	0.	0.	-.62	-.09	-.46	.79	.17	.45	.16	0.	.33
	LAT CL					.00			.06		0.	0.	.06
APR	HEATNG	-.15	0.	0.	-1.22	0.	-.87	.67	.05	.23	.08	0.	-1.20
	SEN CL	-.04	0.	0.	-1.08	0.	-.42	1.77	.27	.71	.26	0.	1.46
	LAT CL					0.			.09		0.	0.	.09
MAY	HEATNG	-.09	0.	0.	-.70	0.	-.51	.50	.03	.14	.06	0.	-.56
	SEN CL	-.01	0.	0.	-1.04	0.	-.37	2.25	.29	.80	.29	0.	2.22
	LAT CL					0.			.10		0.	0.	.10
JUN	HEATNG	-.02	0.	0.	-.17	0.	-.14	.16	.01	.04	.02	0.	-.10
	SEN CL	.08	0.	0.	-.89	0.	.08	2.56	.28	.83	.31	0.	3.25
	LAT CL					0.			.09		0.	0.	.09
JUL	HEATNG	-.00	0.	0.	-.01	0.	-.00	.01	.00	.00	.00	0.	-.00
	SEN CL	.21	0.	0.	-.55	0.	.64	2.96	.32	.94	.35	0.	4.87
	LAT CL					0.			.10		0.	0.	.10
AUG	HEATNG	-.00	0.	0.	-.00	0.	-.01	.01	.00	.00	.00	0.	-.00
	SEN CL	.16	0.	0.	-.36	0.	.35	2.73	.32	.95	.35	0.	4.49
	LAT CL					0.			.10		0.	0.	.10
SEP	HEATNG	-.05	0.	0.	-.12	0.	-.26	.17	.01	.06	.03	0.	-.16
	SEN CL	.02	0.	0.	-.41	0.	-.21	2.28	.28	.81	.30	0.	3.06
	LAT CL					0.			.09		0.	0.	.09
OCT	HEATNG	-.13	0.	0.	-.49	0.	-.75	.40	.03	.16	.08	0.	-.71
	SEN CL	-.04	0.	0.	-.52	0.	-.39	1.42	.29	.75	.27	0.	1.82
	LAT CL					0.			.10		0.	0.	.10
NOV	HEATNG	-.32	0.	0.	-1.23	-.28	-1.76	.62	.12	.44	.18	0.	-2.22
	SEN CL	-.05	0.	0.	-.36	-.05	-.36	.65	.15	.40	.14	0.	.52
	LAT CL					.00			.06		0.	0.	.06
DEC	HEATNG	-.51	0.	0.	-2.09	-.39	-2.68	.62	.23	.72	.27	0.	-3.81
	SEN CL	-.04	0.	0.	-.20	-.03	-.23	.29	.07	.18	.07	0.	.11
	LAT CL					0.			.03		0.	0.	.03
TOT	HEATNG	-2.72	0.	0.	-13.27	-1.79	-14.69	6.04	1.07	3.71	1.46	0.	-20.19
	SEN CL	.17	0.	0.	-6.50	-.24	-1.75	18.30	2.56	7.20	2.62	0.	22.37
	LAT CL					.00			.86		0.	0.	.86

SIMPLE STRUCTURE RUN 3A, CHICAGO DOE-2.1A 22 DEC 80 15.32.20 SDL RUN 1

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR SPACE3-1

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
JAN	HEATNG	-1.16	0.	0.	-1.04	-.79	-6.79	.59	.47	1.58	.61	0.	-6.52
	SEN CL	-.11	0.	0.	-.14	-.09	-.65	.17	.22	.61	.20	0.	.21
	LAT CL					0.			.08		0.	0.	.08
FEB	HEATNG	-.99	0.	0.	-1.04	-.97	-6.23	.80	.42	1.41	.55	0.	-6.06
	SEN CL	-.08	0.	0.	-.13	-.09	-.53	.21	.18	.50	.17	0.	.23
	LAT CL					0.			.07		0.	0.	.07
MAR	HEATNG	-.65	0.	0.	-.87	-.74	-4.30	1.03	.19	.81	.34	0.	-4.19
	SEN CL	-.20	0.	0.	-.35	-.25	-1.37	.85	.48	1.31	.46	0.	.92
	LAT CL					.01			.17		0.	0.	.18
APR	HEATNG	-.28	0.	0.	-.43	0.	-1.85	.69	.07	.38	.14	0.	-1.27
	SEN CL	-.15	0.	0.	-.56	0.	-1.20	2.12	.62	1.79	.65	0.	3.27
	LAT CL					0.			.21		0.	0.	.21
MAY	HEATNG	-.13	0.	0.	-.19	0.	-.85	.43	.03	.18	.08	0.	-.44
	SEN CL	-.12	0.	0.	-.56	0.	-1.19	3.67	.67	2.02	.73	0.	5.21
	LAT CL					0.			.22		0.	0.	.22
JUN	HEATNG	-.03	0.	0.	-.04	0.	-.20	.12	.00	.04	.03	0.	-.07
	SEN CL	.08	0.	0.	-.42	0.	.04	3.99	.63	1.98	.74	0.	7.04
	LAT CL					0.			.20		0.	0.	.20
JUL	HEATNG	-.00	0.	0.	-.00	0.	-.00	.00	.00	.00	.00	0.	-.00
	SEN CL	.32	0.	0.	-.24	0.	1.37	4.07	.70	2.19	.81	0.	9.21
	LAT CL					0.			.22		0.	0.	.22
AUG	HEATNG	-.00	0.	0.	-.00	0.	-.01	.01	.00	.00	.00	0.	-.00
	SEN CL	.20	0.	0.	-.16	0.	.70	3.51	.70	2.20	.81	0.	7.97
	LAT CL					0.			.22		0.	0.	.22
SEP	HEATNG	-.11	0.	0.	-.06	0.	-.73	.25	.02	.15	.09	0.	-.38
	SEN CL	-.05	0.	0.	-.17	0.	-.52	1.86	.61	1.86	.68	0.	4.27
	LAT CL					0.			.20		0.	0.	.20
OCT	HEATNG	-.28	0.	0.	-.21	0.	-1.79	.38	.06	.37	.18	0.	-1.28
	SEN CL	-.16	0.	0.	-.22	0.	-.58	.81	.63	1.82	.63	0.	2.54
	LAT CL					0.			.21		0.	0.	.21
NOV	HEATNG	-.63	0.	0.	-.52	-.62	-3.99	.49	.22	.88	.39	0.	-3.77
	SEN CL	-.15	0.	0.	-.16	-.15	-.97	.32	.38	1.06	.37	0.	.69
	LAT CL					.00			.14		0.	0.	.14
DEC	HEATNG	-.93	0.	0.	-.83	-.86	-5.81	.50	.37	1.30	.52	0.	-5.74
	SEN CL	-.15	0.	0.	-.15	-.11	-.91	.21	.29	.80	.27	0.	.24
	LAT CL					0.			.11		0.	0.	.11
TOT	HEATNG	-5.18	0.	0.	-5.22	-3.99	-32.55	5.30	1.87	7.11	2.93	0.	-29.72
	SEN CL	-.58	0.	0.	-3.26	-.69	-6.21	21.77	6.12	18.14	6.51	0.	41.80
	LAT CL					.01			2.04		0.	0.	2.05

SIMPLE STRUCTURE RUN 3A, CHICAGO   DOE-2.1A 22 DEC 80 15.32.20 LDL RUN 1

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR SPACE4-1

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
JAN	HEATNG	-.60	0.	0.	-.45	-.34	-2.95	.33	.21	.67	.26	0.	-2.87
	SEN CL	-.06	0.	0.	-.06	-.04	-.30	.10	.10	.27	.09	0.	.11
	LAT CL					0.			.04		0.	0.	.04
FEB	HEATNG	-.51	0.	0.	-.44	-.41	-2.66	.47	.17	.57	.23	0.	-2.58
	SEN CL	-.05	0.	0.	-.06	-.05	-.29	.15	.10	.26	.08	0.	.14
	LAT CL					0.			.04		0.	0.	.04
MAR	HEATNG	-.34	0.	0.	-.37	-.32	-1.86	.58	.09	.34	.14	0.	-1.74
	SEN CL	-.11	0.	0.	-.16	-.11	-.62	.50	.22	.58	.20	0.	.50
	LAT CL					.00			.08		0.	0.	.08
APR	HEATNG	-.14	0.	0.	-.16	0.	-.75	.32	.03	.14	.05	0.	-.51
	SEN CL	-.09	0.	0.	-.27	0.	-.59	1.30	.29	.80	.29	0.	1.74
	LAT CL					0.			.10		0.	0.	.10
MAY	HEATNG	-.06	0.	0.	-.07	0.	-.33	.20	.01	.06	.03	0.	-.15
	SEN CL	-.06	0.	0.	-.25	0.	-.58	1.96	.31	.89	.32	0.	2.58
	LAT CL					0.			.10		0.	0.	.10
JUN	HEATNG	-.01	0.	0.	-.01	0.	-.05	.04	.00	.01	.01	0.	-.01
	SEN CL	.04	0.	0.	-.19	0.	-.03	2.31	.29	.87	.33	0.	3.61
	LAT CL					0.			.09		0.	0.	.09
JUL	HEATNG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
	SEN CL	.18	0.	0.	-.10	0.	.58	2.35	.32	.94	.35	0.	4.62
	LAT CL					0.			.10		0.	0.	.10
AUG	HEATNG	-.00	0.	0.	-.00	0.	-.00	.00	.00	.00	.00	0.	-.00
	SEN CL	.11	0.	0.	-.07	0.	.29	2.00	.32	.95	.35	0.	3.95
	LAT CL					0.			.10		0.	0.	.10
SEP	HEATNG	-.05	0.	0.	-.02	0.	-.27	.12	.01	.05	.03	0.	-.13
	SEN CL	-.02	0.	0.	-.08	0.	-.27	1.23	.28	.82	.30	0.	2.26
	LAT CL					0.			.09		0.	0.	.09
OCT	HEATNG	-.14	0.	0.	-.08	0.	-.74	.23	.03	.14	.07	0.	-.49
	SEN CL	-.08	0.	0.	-.10	0.	-.46	.54	.29	.81	.28	0.	1.27
	LAT CL					0.			.10		0.	0.	.10
NOV	HEATNG	-.33	0.	0.	-.22	-.27	-1.73	.27	.10	.38	.17	0.	-1.64
	SEN CL	-.08	0.	0.	-.07	-.06	-.43	.19	.18	.46	.16	0.	.34
	LAT CL					.00			.06		0.	0.	.06
DEC	HEATNG	-.49	0.	0.	-.36	-.37	-2.55	.26	.17	.57	.23	0.	-2.54
	SEN CL	-.07	0.	0.	-.06	-.05	-.39	.11	.13	.33	.11	0.	.11
	LAT CL					0.			.05		0.	0.	.05
TOT	HEATNG	-2.65	0.	0.	-2.18	-1.70	-13.91	2.83	.81	2.92	1.21	0.	-12.66
	SEN CL	-.29	0.	0.	-1.48	-.32	-3.08	12.74	2.82	7.58	2.86	0.	21.23
	LAT CL					.01			.93		0.	0.	.94

SIMPLE STRUCTURE RUN 3A, CHICAGO DOE-2.1A 22 DEC 80 15.32.20 LDL RUN 1

REPORT- LS-E SPACE MONTHLY LOAD COMPONENTS IN MBTU FOR SPACE5-1

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
	HEATNG	0.	0.	0.	-1.13	-.88	0.	0.	.08	.59	.37	0.	-.98
JAN	SEN CL	0.	0.	0.	-1.07	-.76	0.	0.	1.19	3.50	1.14	0.	4.00
	LAT CL					0.			.40		0.	0.	.40
	HEATNG	0.	0.	0.	-1.27	-1.15	0.	0.	.10	.67	.39	0.	-1.26
FEB	SEN CL	0.	0.	0.	-.92	-.84	0.	0.	1.00	2.90	.96	0.	3.10
	LAT CL					0.			.34		0.	0.	.34
	HEATNG	0.	0.	0.	-1.25	-1.06	0.	0.	.09	.67	.40	0.	-1.14
MAR	SEN CL	0.	0.	0.	-1.03	-.80	0.	0.	1.12	3.30	1.09	0.	3.68
	LAT CL					.00			.38		0.	0.	.38
	HEATNG	0.	0.	0.	-.52	0.	0.	0.	.01	.20	.20	0.	-.10
APR	SEN CL	0.	0.	0.	-1.33	0.	0.	0.	1.25	3.87	1.28	0.	5.07
	LAT CL					0.			.40		0.	0.	.40
	HEATNG	0.	0.	0.	-.05	0.	0.	0.	.00	.02	.01	0.	-.02
MAY	SEN CL	0.	0.	0.	-1.35	0.	0.	0.	1.27	4.09	1.50	0.	5.51
	LAT CL					0.			.40		0.	0.	.40
	HEATNG	0.	0.	0.	-.01	0.	0.	0.	.00	.01	.00	0.	-.00
JUN	SEN CL	0.	0.	0.	-.84	0.	0.	0.	1.16	3.78	1.43	0.	5.53
	LAT CL					0.			.36		0.	0.	.36
	HEATNG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
JUL	SEN CL	0.	0.	0.	-.44	0.	0.	0.	1.26	4.09	1.51	0.	6.43
	LAT CL					0.			.40		0.	0.	.40
	HEATNG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
AUG	SEN CL	0.	0.	0.	-.29	0.	0.	0.	1.27	4.13	1.51	0.	6.62
	LAT CL					0.			.40		0.	0.	.40
	HEATNG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
SEP	SEN CL	0.	0.	0.	-.43	0.	0.	0.	1.15	3.76	1.43	0.	5.91
	LAT CL					0.			.36		0.	0.	.36
	HEATNG	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
OCT	SEN CL	0.	0.	0.	-.81	0.	0.	0.	1.27	4.11	1.51	0.	6.08
	LAT CL					0.			.40		0.	0.	.40
	HEATNG	0.	0.	0.	-.57	-.72	0.	0.	.04	.41	.33	0.	-.50
NOV	SEN CL	0.	0.	0.	-.71	-.72	0.	0.	1.06	3.22	1.08	0.	3.92
	LAT CL					.01			.34		0.	0.	.35
	HEATNG	0.	0.	0.	-.91	-1.04	0.	0.	.06	.52	.37	0.	-1.01
DEC	SEN CL	0.	0.	0.	-.92	-.78	0.	0.	1.15	3.41	1.12	0.	3.97
	LAT CL					0.			.38		0.	0.	.38
	HEATNG	0.	0.	0.	-5.72	-4.86	0.	0.	.39	3.10	2.08	0.	-5.01
TOT	SEN CL	0.	0.	0.	-10.15	-3.90	0.	0.	14.15	44.15	15.58	0.	59.82
	LAT CL					.01			4.53		0.	0.	4.55

REPORT LS-F - BUILDING MONTHLY LOAD COMPONENTS IN MBTU

This report gives a breakdown of loads on a monthly basis for the entire building, according to the source of the load. The loads in unconditioned spaces are not included. All entries are in millions of Btus/month.

As in Report LS-E, three types of loads are shown: heating (HEATNG), sensible cooling (SEN CL), and latent cooling (LAT CL). The reported sources of the load (WALLS, ROOFS, etc.) are defined in the LS-E report description.

For multizone buildings, the load components are obtained by summing the corresponding load components for each conditioned zone after multiplication by the zone MULTIPLIER. For example, consider a building with two zones, Z-1 and Z-2, with zone MULTIPLIERs of 2 and 3, respectively. If the heating load components in January due to glass conduction is -5.90 MBTU for Z-1 and -2.30 MBTU for Z-2, then the corresponding building load component is 2 x (-5.90) + 3 x (-2.30) = -18.70 MBTU.

The total monthly heating and sensible cooling loads in the last column of this report are the same as those given in Report LS-D, Building Monthly Loads Summary, under the headings HEATING ENERGY and COOLING ENERGY.

SIMPLE STRUCTURE RUN 3A, CHICAGO DOE-2.1A 22 DEC 80 15.22.20 LDL RUN 1

REPORT- LS-F BUILDING MONTHLY LOAD COMPONENTS IN MBTU

		WALLS	ROOFS	INT SUR	UND SUR	INFIL	GL CON	GL SOL	OCCUP	LIGHTS	EQUIP	SOURCE	TOTAL
JAN	HEATNG	-3.26	0.	0.	-6.03	-3.01	-18.67	3.49	1.28	4.58	1.91	0.	-19.70
	SEN CL	-.42	0.	0.	-1.79	-1.15	-2.90	2.53	2.01	5.77	1.92	0.	5.96
	LAT CL					0.			.69		0.	0.	.69
FEB	HEATNG	-2.77	0.	0.	-6.08	-3.77	-17.02	4.03	1.15	4.19	1.78	0.	-18.49
	SEN CL	-.35	0.	0.	-1.69	-1.27	-2.56	2.91	1.70	4.85	1.63	0.	5.23
	LAT CL					0.			.59		0.	0.	.59
MAR	HEATNG	-1.88	0.	0.	-5.44	-3.10	-12.13	4.43	.64	2.87	1.33	0.	-13.28
	SEN CL	-.60	0.	0.	-2.64	-1.60	-4.30	4.95	2.52	7.17	2.44	0.	7.94
	LAT CL					.02			.87		0.	0.	.90
APR	HEATNG	-.78	0.	0.	-2.64	0.	-5.03	2.43	.21	1.22	.57	0.	-4.02
	SEN CL	-.42	0.	0.	-3.92	0.	-3.73	9.85	3.08	9.09	3.18	0.	17.12
	LAT CL					0.			1.02		0.	0.	1.02
MAY	HEATNG	-.39	0.	0.	-1.17	0.	-2.48	1.63	.09	.55	.25	0.	-1.51
	SEN CL	-.28	0.	0.	-3.79	0.	-3.40	13.05	3.21	9.85	3.58	0.	22.22
	LAT CL					0.			1.03		0.	0.	1.03
JUN	HEATNG	-.08	0.	0.	-.26	0.	-.53	.44	.01	.13	.07	0.	-.22
	SEN CL	.30	0.	0.	-2.77	0.	.16	14.22	3.00	9.46	3.56	0.	27.92
	LAT CL					0.			.94		0.	0.	.94
JUL	HEATNG	-.00	0.	0.	-.01	0.	-.01	.01	.00	.00	.00	0.	-.00
	SEN CL	1.06	0.	0.	-1.56	0.	4.19	15.03	3.29	10.35	3.83	0.	36.18
	LAT CL					0.			1.03		0.	0.	1.03
AUG	HEATNG	-.00	0.	0.	-.01	0.	-.03	.02	.00	.01	.00	0.	-.01
	SEN CL	.73	0.	0.	-1.04	0.	2.29	14.09	3.31	10.43	3.83	0.	33.64
	LAT CL					0.			1.03		0.	0.	1.03
SEP	HEATNG	-.26	0.	0.	-.22	0.	-1.68	.76	.04	.31	.19	0.	-.87
	SEN CL	-.06	0.	0.	-1.29	0.	-1.64	10.92	2.95	9.20	3.44	0.	23.53
	LAT CL					0.			.94		0.	0.	.94
OCT	HEATNG	-.72	0.	0.	-.91	0.	-4.53	1.57	.15	.86	.43	0.	-3.15
	SEN CL	-.42	0.	0.	-1.96	0.	-3.22	7.19	3.15	9.53	3.40	0.	17.68
	LAT CL					0.			1.02		0.	0.	1.02
NOV	HEATNG	-1.77	0.	0.	-2.96	-2.42	-11.00	2.53	.61	2.68	1.34	0.	-10.97
	SEN CL	-.46	0.	0.	-1.58	-1.23	-3.30	3.67	2.25	6.50	2.24	0.	8.09
	LAT CL					.02			.76		0.	0.	.79
DEC	HEATNG	-2.70	0.	0.	-4.91	-3.41	-16.38	2.54	1.04	3.93	1.75	0.	-18.15
	SEN CL	-.48	0.	0.	-1.60	-1.21	-3.20	2.08	2.10	6.02	2.02	0.	5.72
	LAT CL					0.			.72		0.	0.	.72
TOT	HEATNG	-14.60	0.	0.	-30.62	-15.71	-89.48	23.88	5.21	21.34	9.62	0.	-90.37
	SEN CL	-1.40	0.	0.	-25.64	-6.45	-21.62	100.48	32.57	98.22	35.07	0.	211.23
	LAT CL					.05			10.64		0.	0.	10.69

HOURLY-REPORT

These optional reports are user-designed. The variables which are to be displayed are chosen by the user from the lists in this chapter (see REPORT-BLOCK).

1. MMDDHH	is the month, day, and hours of the simulation period. The "hours" values are in standard time, even if DAYLIGHT-SAVINGS = YES.
2. GLOBAL DRY BULB TEMP	Outdoor dry bulb temperature for each simulation hour.
3. GLOBAL WET BULB TEMP	Outdoor wet bulb (saturation) temperature for each simulation hour.
4. GLOBAL DIR SOL X CLDCOV	Direct solar radiation (in Btu) times the cloud cover (a fraction from 0. to 1.0).
5. GLOBAL DIF SOL X CLDCOV	Diffuse solar radiation (in Btu) times the cloud cover (a fraction from 0. to 1.0).
6. BUILDING SENSIBLE HTG LOAD	The total building sensible heating load in Btu for each hour. This load does not include heating of ventilation air and is based on a fixed TEMPERATURE for each space.
7. BUILDING WALL HTG LOAD	The contribution to the BUILDING HEATING LOAD from conduction of sensible heat (in Btu) through the exterior walls. The wall heating load does not include window heat conduction.
8. BUILDING GLS COND HTG LOAD	The contribution to the BUILDING HEATING LOAD from conduction of sensible heat (in Btu) through the windows. Sum of UAΔT and solar energy absorbed by glass and conducted into space.
9. BUILDING INT WALL COND-HTG	The contribution to the BUILDING HEATING LOAD from heat conduction (in Btu) through internal walls.
10. BUILDING SOURCE SENS-HTG	The contribution (in Btu) to sensible heating from sources, such as a process, within the building.
11. BUILDING INFILTRN LAT-HTG	The latent heat load to counteract infiltration of cold air.

12.	BUILDING LATENT CLG LOAD	The total building latent cooling load in Btu for each hour. The load does not include cooling of ventilation air and is based on a fixed TEMPERATURE for each space.
13.	BUILDING CEILING CLG LOAD	The contribution to the BUILDING COOLING LOAD from conduction of sensible heat (in Btu) through ceilings.
14.	BUILDING INFILTRN SENS-CLG	The contribution to the BUILDING COOLING LOAD from the sensible heat of air infiltration.
15.	BUILDING INT WALL COND-CLG	The contribution to the BUILDING COOLING LOAD from conduction through internal walls (Btu).
16.	BUILDING UNDERGND COND-CLG	The contribution to the BUILDING COOLING LOAD from conduction of heat (in Btu) through underground walls and floors.
17.	BUILDING LIGHTING CLG LOAD	The contribution to the BUILDING COOLING LOAD from sensible heat (in Btu) of lights in the building.
18.	BUILDING ELEC-EQP SENS-CLG	The contribution to the BUILDING COOLING LOAD from sensible heat (in Btu) of electrical equipment operating in the building.
19.	BUILDING SOURCE SENS-CLG	The contribution (in Btu) to the sensible cooling load from sources, such as a process, within the building.

MMDDHH	GLOBAL DRY BULB TEMP	GLOBAL WET BULB TEMP	GLOBAL DIR SOL X CLDCOV	GLOBAL DIF SOL X CLDCOV	BUILDING SENSIBLE HTG LOAD	BUILDING WALL HTG LOAD	BUILDING GLS COND HTG LOAD	BUILDING GLS SOL HTG LOAD	BUILDING INT WALL COND-HTG	BUILDING SOURCE SENS-HTG	BUILDING INFILTRN LAT-HTG
716 1	66.0	63.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
716 2	66.0	63.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
716 3	66.0	63.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
716 4	65.0	62.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
716 5	65.0	62.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
716 6	64.0	62.0	75.3	8.3	0.	0.	0.	0.	0.	0.	0.
716 7	66.0	62.0	128.8	19.2	0.	0.	0.	0.	0.	0.	0.
716 8	71.0	64.0	67.7	56.2	0.	0.	0.	0.	0.	0.	0.
716 9	74.0	65.0	99.0	65.3	0.	0.	0.	0.	0.	0.	0.
71610	76.0	65.0	259.9	37.1	0.	0.	0.	0.	0.	0.	0.
71611	77.0	56.0	186.7	108.9	0.	0.	0.	0.	0.	0.	0.
71612	78.0	56.0	188.8	113.7	0.	0.	0.	0.	0.	0.	0.
71613	78.0	56.0	188.8	95.2	0.	0.	0.	0.	0.	0.	0.
71614	79.0	66.0	186.4	91.0	0.	0.	0.	0.	0.	0.	0.
71615	80.0	67.0	207.3	62.7	0.	0.	0.	0.	0.	0.	0.
71616	80.0	57.0	221.6	0.	0.	0.	0.	0.	0.	0.	0.
71617	79.0	66.0	223.2	31.8	0.	0.	0.	0.	0.	0.	0.
71618	78.0	66.0	179.2	25.6	0.	0.	0.	0.	0.	0.	0.
71619	76.0	55.0	83.2	11.9	0.	0.	0.	0.	0.	0.	0.
71620	74.0	64.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71621	72.0	52.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71622	72.0	62.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71623	71.0	61.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71624	70.0	61.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
717 1	68.0	60.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
717 2	69.0	50.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
717 3	66.0	58.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
717 4	67.0	58.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
717 5	66.0	58.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
717 6	66.0	58.0	9.3	12.0	0.	0.	0.	0.	0.	0.	0.
717 7	67.0	59.0	36.7	36.8	0.	0.	0.	0.	0.	0.	0.
717 8	71.0	61.0	90.1	50.4	0.	0.	0.	0.	0.	0.	0.
717 9	76.0	64.0	74.2	73.4	0.	0.	0.	0.	0.	0.	0.
71710	79.0	56.0	78.0	150.5	0.	0.	0.	0.	0.	0.	0.
71711	83.0	68.0	53.3	175.5	0.	0.	0.	0.	0.	0.	0.
71712	84.0	59.0	80.9	176.8	0.	0.	0.	0.	0.	0.	0.
71713	87.0	70.0	188.7	76.7	0.	0.	0.	0.	0.	0.	0.
71714	88.0	70.0	159.8	96.2	0.	0.	0.	0.	0.	0.	0.
71715	89.0	71.0	155.5	87.2	0.	0.	0.	0.	0.	0.	0.
71716	90.0	71.0	123.1	29.5	0.	0.	0.	0.	0.	0.	0.
71717	87.0	70.0	44.6	40.0	0.	0.	0.	0.	0.	0.	0.
71718	87.0	70.0	35.8	24.8	0.	0.	0.	0.	0.	0.	0.
71719	87.0	70.0	8.2	10.2	0.	0.	0.	0.	0.	0.	0.
71720	85.0	69.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71721	82.0	58.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71722	79.0	67.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71723	77.0	57.0	0.	0.	0.	0.	0.	0.	0.	0.	0.
71724	77.0	57.0	0.	0.	0.	0.	0.	0.	0.	0.	0.

MMDDHH	BUILDING LATENT CLG LOAD	BUILDING CEILING CLG LOAD	BUILDING INFILTRN SENS-CLG	BUILDING INT WALL COND-CLG	BUILDING UNDERGND COND-CLG	BUILDING LIGHTING CLG LOAD	BUILDING ELEC-EQP SENS-CLG	BUILDING SOURCE SENS-CLG
716 1	0.	0.	0.	0.	-2250.00	7258.37	1623.11	0.
716 2	0.	0.	0.	0.	-2250.00	6580.99	1456.47	0.
716 3	0.	0.	0.	0.	-2250.00	5991.68	1311.50	0.
716 4	0.	0.	0.	0.	-2250.00	5478.97	1185.37	0.
716 5	0.	0.	0.	0.	-2250.00	5032.92	1075.64	0.
716 6	0.	0.	0.	0.	-2250.00	4644.86	980.18	0.
716 7	0.	0.	0.	0.	-2250.00	4307.24	897.13	0.
716 8	4824.	0.	0.	0.	-2250.00	24552.95	5240.95	0.
716 9	4824.	0.	0.	0.	-2250.00	27361.12	11257.64	0.
71610	4824.	0.	0.	0.	-2250.00	30070.44	11790.75	0.
71611	3859.	0.	0.	0.	-2250.00	30277.36	12254.56	0.
71612	1929.	0.	0.	0.	-2250.00	27774.76	12658.07	0.
71613	3859.	0.	0.	0.	-2250.00	30839.87	13009.13	0.
71614	4824.	0.	0.	0.	-2250.00	34038.94	12152.42	0.
71615	4824.	0.	0.	0.	-2250.00	34938.16	11185.24	0.
71616	4824.	0.	0.	0.	-2250.00	35720.48	8959.82	0.
71617	4824.	0.	0.	0.	-2250.00	36401.10	8904.27	0.
71618	2412.	0.	0.	0.	-2250.00	27327.62	6531.68	0.
71619	482.	0.	0.	0.	-2250.00	17303.98	6348.10	0.
71620	482.	0.	0.	0.	-2250.00	16119.32	2934.43	0.
71621	0.	0.	0.	0.	-2250.00	11464.06	2597.32	0.
71622	0.	0.	0.	0.	-2250.00	10239.94	2304.04	0.
71623	0.	0.	0.	0.	-2250.00	9174.97	2048.88	0.
71624	0.	0.	0.	0.	-2250.00	8248.43	1826.90	0.
717 1	0.	0.	0.	0.	-2250.00	7442.35	1633.77	0.
717 2	0.	0.	0.	0.	-2250.00	6741.06	1465.75	0.
717 3	0.	0.	0.	0.	-2250.00	6130.94	1319.57	0.
717 4	0.	0.	0.	0.	-2250.00	5600.13	1192.39	0.
717 5	0.	0.	0.	0.	-2250.00	5138.33	1081.75	0.
717 6	0.	0.	0.	0.	-2250.00	4736.56	985.49	0.
717 7	0.	0.	0.	0.	-2250.00	4387.02	901.75	0.
717 8	4824.	0.	0.	0.	-2250.00	24622.35	5244.97	0.
717 9	4824.	0.	0.	0.	-2250.00	27421.50	11261.14	0.
71710	4824.	0.	0.	0.	-2250.00	30122.98	11793.79	0.
71711	3859.	0.	0.	0.	-2250.00	30323.07	12257.21	0.
71712	1929.	0.	0.	0.	-2250.00	27814.53	12660.37	0.
71713	3859.	0.	0.	0.	-2250.00	30874.47	13011.13	0.
71714	4824.	0.	0.	0.	-2250.00	34069.04	12154.16	0.
71715	4824.	0.	0.	0.	-2250.00	34964.35	11186.75	0.
71716	4824.	0.	0.	0.	-2250.00	35743.26	8961.14	0.
71717	4824.	0.	0.	0.	-2250.00	36420.92	8905.42	0.
71718	2412.	0.	0.	0.	-2250.00	27344.86	6532.68	0.
71719	482.	0.	0.	0.	-2250.00	17318.98	6348.97	0.
71720	482.	0.	0.	0.	-2250.00	16132.37	2935.18	0.
71721	0.	0.	0.	0.	-2250.00	11475.41	2597.98	0.
71722	0.	0.	0.	0.	-2250.00	10249.82	2304.61	0.
71723	0.	0.	0.	0.	-2250.00	9183.56	2049.38	0.
71724	0.	0.	0.	0.	-2250.00	8255.91	1827.33	0.

LOADS HOURLY REPORT PLOT

The following example is an HOURLY-REPORT in graphic form. The month, day, and hours appear in the left-hand column. The next enter to the right is the first possible value. If this character is a period (.) this indicates no value at or below this value and if it is an asterisk (*) this indicates that two or more values occupy this position. The numerical values appearing on the plot are correlated to the symbol numbers in the table above the plot. Component name, in the table, is the VARIABLE-TYPE of which the variable is a part. If a value appears at the last possible position on the right it means either that the value is at this point or that the value is higher than this point.

The original input that created the following sample plot is repeated here

```
PLOTER1 = REPORT-BLOCK
          VARIABLE-TYPE = GLOBAL
          VARIABLE-LIST = (4,21)  ..   $DB TEMP AND DIR SOLAR$

PLOTER2 = REPORT-BLOCK
          VARIABLE-TYPE = BUILDING
          VARIABLE-LIST = (1,18)  ..   $HEATING AND COOLING LOAD$

PLOTD   = HOURLY-REPORT
          REPORT-SCHEDULE = PLTSCH
          REPORT-BLOCK    = (PLOTER1, PLOTER2)
          OPTION          = PLOT
          AXIS-ASSIGN     = (1,1,2,2)
          AXIS-TITLES     = (*DBT-F---DR-SOL*,
                            *HEAT-COOL LOADS*)
          AXIS-MAX        = (200, 40000)
          AXIS-MIN        = (0, 0)
          DIVIDE          = (1,1,-1,-1)  ..
```

For more information on specifying this type of report see HOURLY-REPORT in Chap. III.

SYMBOL	COMPONENT NAME	DESCRIPTION	AXIS
1	GLOBAL	DRY BULBTEMP	1
2	GLOBAL	DIR SOL X CLDCOV	1
3	BUILDING	SENSIBLEHTG LOAD	2
4	BUILDING	INFILTRNLAT-HTG	2

```
                                       HEAT-COOL LOADS
 0.                   .80000E+04          .16000E+05          .24000E+05          .32000E+05          .40000E+05
       I......... .........I......... .........I......... .........I......... .........I......... .........I
                                       DBT-F--DR-SOL
 0.                   .40000E+02          .80000E+02          .12000E+03          .16000E+03          .20000E+03
       I......... .........I......... .........I......... .........I......... .........I......... .........I
716  1 *                                1                                                                  .
716  2 *                                1                                                                  .
716  3 *                                1                                                                  .
716  4 *                               1                                                                   .
716  5 *                               1                                                                   .
716  6 *                               1     2                                                             .
716  7 *                                1                              2                                   .
716  8 *                                 21                                                                .
716  9 *                                    1            2                                                 .
716 10 *                                     1                                                             2
716 11 *                                     1                                                      2      .
716 12 *                                      1                                                      2     .
716 13 *                                      1                                                      2     .
716 14 *                                      1                                                     2      .
716 15 *                                       1                                                           2
716 16 *                                       1                                                           2
716 17 *                                      1                                                            2
716 18 *                                      1                                                  2         .
716 19 *                                     1   2                                                         .
716 20 *                                    1                                                              .
716 21 *                                   1                                                               .
716 22 *                                   1                                                               .
716 23 *                                  1                                                                .
716 24 *                                  1                                                                .
       I......... .........I......... .........I......... .........I......... .........I......... .........I
```

C. SYSTEMS OUTPUT REPORT DESCRIPTIONS

To fully explain the following sample output reports from SYSTEMS it is necessary first to display the input data. The first command of the input is, of course, INPUT SYSTEMS ..

The VERIFICATION report for SYSTEMS appears first followed by the available SUMMARY reports and an example HOURLY-REPORT.

For information on requesting plotted output of HOURLY-REPORT data see HOURLY-REPORT in LOADS.

```
SYSTEMS-REPORT  SUMMARY=(ALL-SUMMARY)
                VERIFICATION=(ALL-VERIFICATION)   ..


               $ SYSTEMS SCHEDULES $

FAN-1          =DAY-SCHEDULE       (1,8) (0) (9,18) (1) (19,24) (0)   ..
FAN-2          =DAY-SCHEDULE       (1,24) (0)   ..
FAN-COOL       =WEEK-SCHEDULE      (MON,FRI) FAN-1  (WEH) FAN-2   ..
FAN-3          =DAY-SCHEDULE       (1,24) (1)   ..
FAN-HEAT       =WEEK-SCHEDULE      (ALL) FAN-3   ..
FAN-SCHED      =SCHEDULE           THRU MAR 31, FAN-HEAT
                                   THRU OCT 31, FAN-COOL
                                   THRU DEC 31, FAN-HEAT  ..

 HEAT-1      =DAY-SCHEDULE    (1,8) (55)   (9,18) (69)  (19,24) (55)  ..
 HEAT-2      =DAY-SCHEDULE    (1,24) (55)    ..
 HEAT-WEEK   =WEEK-SCHEDULE   (MON,FRI)  HEAT-1   (WEH)  HEAT-2   ..
 HEAT-SCHED  =SCHEDULE        THRU DEC 31   HEAT-WEEK   ..
 COOL-1      =DAY-SCHEDULE    (1,8) (99)  (9,18) (71)  (19,24) (99)  ..
 COOL-2      =DAY-SCHEDULE    (1,24) (99)    ..
 COOL-WEEK   =WEEK-SCHEDULE   (MON,FRI)  COOL-1   (WEH)  COOL-2   ..
 COOL-SCHED  =SCHEDULE        THRU DEC 31   COOL-WEEK   ..

COOL-RES-DAY=DAY-RESET-SCH
                              SUPPLY-HI=60  OUTSIDE-LO=59
                              SUPPLY-LO=52  OUTSIDE-HI=90   ..
COOL-RES-WK =WEEK-SCHEDULE    (ALL) COOL-RES-DAY   ..
COOL-RES    =RESET-SCHEDULE   THRU DEC 31 COOL-RES-WK   ..

 $REPORT SCHEDULINGS
 WR1            = WEEK-SCHEDULE  (ALL)  (1,24)  (0.)   ..
 WR2            = WEEK-SCHEDULE  (ALL)  (1,24)  (1.)   ..
 REPRTSCH=SCH   THRU  JUL 15   WR1
                THRU  JUL 17   WR2   $ SUMMER 2 DAYS $
                THRU  DEC 31   WR1   ..
                     $ SYSTEM DESCRIPTIONS $

 AIR         =ZONE-AIR       OA-CFM/PER=7.    ..

 CONTROL     =ZONE-CONTROL   DESIGN-HEAT-T=69  DESIGN-COOL-T=71
                             HEAT-TEMP-SCH= HEAT-SCHED
                             COOL-TEMP-SCH= COOL-SCHED
                             THROTTLING-RANGE=2
                             THERMOSTAT-TYPE=PROPORTIONAL   ..

SPACE1-1     =ZONE           ZONE-TYPE=CONDITIONED
                             ZONE-AIR= AIR
                             ZONE-CONTROL= CONTROL   ..
SPACE2-1     =ZONE           LIKE SPACE1-1   ..
SPACE3-1     =ZONE           LIKE SPACE1-1   ..
SPACE4-1     =ZONE           LIKE SPACE1-1   ..
SPACE5-1     =ZONE           LIKE SPACE1-1  MAX-COOL-RATE=30000   ..
```

```
 $ THE USE OF MAX-COOL-RATE=30000 WAS NECESSARY DUE TO THE USE OF THE $
 $ COOLING COIL RESET SCHEDULE WHICH DID NOT ALLOW FOR SUFFICIENT     $
 $ HEAT EXTRACTION OF THE INTERIOR SPACE5-1                           $

PLENUM-1      =ZONE           ZONE-TYPE=PLENUM   ..

S-CONT        =SYSTEM-CONTROL  COOLING-SCHEDULE= FAN-SCHED
                               HEATING-SCHEDULE= FAN-SCHED
                               MAX-SUPPLY-T=110
                               MIN-SUPPLY-T=52
                               MAX-HUMIDITY=70
                               COOL-RESET-SCH=COOL-RES
                               COOL-CONTROL=RESET    ..

S-AIR         =SYSTEM-AIR           OA-CONTROL=TEMP  ..

S-FAN         =SYSTEM-FANS     FAN-SCHEDULE= FAN-SCHED
                               FAN-CONTROL=SPEED
                               SUPPLY-STATIC=2.0
                               SUPPLY-EFF=0.8    ..

S-TERM        =SYSTEM-TERMINAL REHEAT-DELTA-T=58
                               MIN-CFM-RATIO=0.3    ..

SYST-1        =SYSTEM          SYSTEM-TYPE=VAVS
                               SYSTEM-CONTROL= S-CONT
                               SYSTEM-FANS= S-FAN
                               SYSTEM-AIR= S-AIR
                               SYSTEM-TERMINAL= S-TERM
                               ECONO-LIMIT-T=65
                               RETURN-AIR-PATH=PLENUM-ZONES
                               PLENUM-NAMES=(PLENUM-1)
                               ZONE-NAMES=(SPACE5-1,SPACE1-1,SPACE2-1
                                          SPACE3-1,SPACE4-1,PLENUM-1)    ..

CONVENTIONAL =PLANT-ASSIGNMENT SYSTEM-NAMES=(SYST-1)  ..


     $ R E P O R T   B L O C K S   F O R   S Y S T E M S $


 SLTRP=REPORT-BLOCK
       VARIABLE-TYPE=  SYST-1          $TEMP AND HUMIDITY$
       VARIABLE-LIST=(1,2,3,4,)    ..


 SLCRP=REPORT-BLOCK
       VARIABLE-TYPE=  SYST-1          $SYSTEM CFM$
       VARIABLE-LIST=(17,20)     ..


 SCSRP=REPORT-BLOCK
       VARIABLE-TYPE=  SYST-1       $SHORT SYS SYS REPORT BLK$
       VARIABLE-LIST=(5,7,35,36,37)     ..


 RPT2=HOURLY-REPORT        $TEMP, HUMIDITY AND CFM$
      REPORT-SCHEDULE=REPRTSCH
      REPORT-BLOCK =(SCSRP,SLTRP,SLCRP)    ..
END  ..
COMPUTE SYSTEMS   ..
```

REPORT SV-A - SYSTEMS DESIGN PARAMETERS

The SV-A Report is produced by the program when the keyword VERIFICATION = (SV-A) is used. This report echoes the user's input to the program as interpreted by the SYSTEMS design routines. See Section IV.D for 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 selected by the user.

2. SUPPLY FAN (CFM) (5953.) 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 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 same 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 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 input at the zone level divided by the cfm in column 1. This item does not reflect larger values entered, possibly, through the MIN-AIR-SCH keyword, but may be determined from exhaust air entered at the zone level. For zonal systems, this value will be zero.

   When OUTSIDE AIR 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 and <u>not</u> in the amount specified by the user.

   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, he should also specify a value 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 (BTU/BTU) is the electric input ratio for cooling and is either taken from the user input or from the default. This value may be modified if the supply cfm differs from the RATED-CFM. The same is true for HEATING EIR.

11. SUPPLY CFM is the calculated or input cfm for each zone. Only if the user has specified a value for the ASSIGNED-CFM keyword in the ZONE instruction will the value here correspond to the user input. The other 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 CFM RATIO will reflect the user's input for the 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 those variable air volume systems for which it may be less than 1.0 from the minimum cfm needed to meet the peak loads or the user-specified or the calculated heating capacity.

14. OUTSIDE AIR CFM 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 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, or FPFC systems or at any conditions for FPIU or 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 value the extraction rate (cooling) would be at the 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.

SYSTEM NAME	ALTITUDE MULTIPLIER
SYST-1	1.02

SUPPLY FAN (CFM)	ELEC (KW)	DELTA-T (F)	RETURN FAN (CFM)	ELEC (KW)	DELTA-T (F)	OUTSIDE AIR	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	HEATING CAPACITY (KBTU/HR)	COOLING EIR (BTU/BTU)	HEATING EIR (BTU/BTU)
5953.	1.713	.9	0.	0.	0.	.07	239.42	.68	-128.32	0.	0.

ZONE NAME	SUPPLY CFM	EXHAUST CFM	FAN (KW)	MINIMUM CFM RATIO	OUTSIDE AIR CFM	COOLING CAPACITY (KBTU/HR)	SENSIBLE (SHR)	EXTRACTION RATE (KBTU/HR)	HEATING CAPACITY (KBTU/HR)	ADDITION RATE (KBTU/HR)	MULTIPLIER
SPACE5-1	1489.	0.	0.	.30	143.	0.	0.	30.00	-27.99	-19.78	1.0
SPACE1-1	2132.	0.	0.	.30	82.	0.	0.	42.85	-40.06	-28.32	1.0
SPACE2-1	867.	0.	0.	.30	41.	0.	0.	17.44	-16.29	-11.52	1.0
SPACE3-1	1448.	0.	0.	.30	82.	0.	0.	29.20	-27.22	-19.24	1.0
SPACE4-1	806.	0.	0.	.30	41.	0.	0.	16.12	-15.14	-10.70	1.0
PLENUM-1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1.0

REPORT SS-A - SYSTEM MONTHLY LOADS SUMMARY

This report is always generated by the program for each HVAC system modeled. The monthly peak cooling, heating, and electrical loads are printed along with the cooling, heating, and electrical energy demand for the system summarized. This report is for comparison of monthly cooling and heating needs for the HVAC system. DX cooling is reported here (for PSZ, PMZS, PVAVS, PTAC, and RESYS systems) but is 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. Because system start-up loads can be larger than continuous running maximum loads, often the start-up loads are shown in this column. 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.

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, and supply and return fans. 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, and fans for the zones served by the HVAC system.

9. TOTAL is the annual totals for cooling energy, heating energy, and electrical energy for the HVAC system.

10. MAX is the highest monthly peak cooling load, heating load, and electrical load.

EXAMPLE BUILDING 3A, CHICAGO   DOE-2.1   13 MAR 80   10.19.09   SDL RUN 1

REPORT- SS-A SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1

	- - - - - - - - - C O O L I N G - - - - - - - - -						- - - - - - - - - H E A T I N G - - - - - - - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.					0.	-21.336	2	9	4F	3F	-158.350	5271.	20.0
FEB	0.					0.	-16.130	4	9	7F	6F	-151.190	4617.	20.0
MAR	.64256	3	15	76F	65F	39.480	-7.972	25	9	18F	15F	-147.212	5109.	20.0
APR	3.85868	29	10	65F	61F	126.194	-1.065	1	9	46F	41F	-119.308	5095.	21.5
MAY	10.06973	21	12	87F	76F	151.553	-.016	9	8	43F	39F	-9.769	5279.	21.5
JUN	22.47838	20	16	90F	78F	172.520	0.					0.	4965.	21.5
JUL	34.73493	8	10	86F	74F	199.394	0.					0.	5380.	21.5
AUG	32.14807	12	16	86F	73F	180.551	0.					0.	5380.	21.5
SEP	15.01111	11	14	87F	72F	162.803	0.					0.	4917.	21.5
OCT	5.82594	4	16	78F	61F	102.619	-.453	21	8	31F	29F	-123.323	5137.	20.9
NOV	1.53729	1	16	72F	59F	99.000	-5.960	25	9	27F	25F	-126.175	4906.	20.8
DEC	0.					0.	-15.171	9	9	14F	13F	-144.665	5106.	20.0
TOTAL	126.307						-68.104						61161.	
MAX						199.394						-158.350		21.5

REPORT SS-B - SYSTEM MONTHLY LOADS SUMMARY

SS-B provides a summary of the heating and cooling required by all the zones (combined) served by the HVAC system. The items summarized are zone cooling, zone heating, zone baseboard heating, and preheat energy. Many HVAC systems have heating and cooling devices that serve only one zone. For example, in a single duct reheat system, there are reheat coils for each zone. This report lists, in addition, the preheat energy required and the peak preheat load. The preheat coils raise the temperature of the mixed air to a specified temperature. NOTE: When the user specifies baseboard heating in a zone, the modeling is similar to reheat coils, but the heating supplied is reported under the heading BASEBOARDS.

1. The user name of the HVAC system (SYST-1) is printed at the end of the report title.

2. ZONE COIL COOLING ENERGY (millions of Btu) and MAXIMUM ZONE COIL COOLING ENERGY (thousands of Btu/hr) are, respectively, the monthly total and peak sensible and latent cooling. This is cooling supplied by coils located in the zone(s). The cooling of the primary supply air in the system is summarized in Report SS-A. Loads met by DX units are reported here and an electrical demand is passed to PLANT. (For RESYS only: These columns report instead the cooling accomplished by natural ventilation.)

3. ZONE COIL HEATING ENERGY (millions of Btu) and MAXIMUM ZONE COIL HEATING ENERGY (thousands of Btu/hr) are the monthly totals and peak heating, respectively, supplied by coils or a furnace (oil- or gas-fired) in the zones. The furnace loads, met here in SYSTEMS, are not passed to PLANT but rather a utility demand for oil or gas is passed to PLANT. Baseboard heating is not included. In this example, the zone coils are electric resistance coils and the electrical demand will be passed to PLANT. (For RESYS only: These columns report the heating load on the furnace.)

4. BASEBOARD HEATING ENERGY (millions of Btu) and MAXIMUM BASEBOARD HEATING ENERGY (thousands of Btu/hr) are, respectively, the monthly totals and peak heating supplied by baseboard heaters in all the zones served by the system (SYST-1). These loads are passed to PLANT unless BASEBOARD-SOURCE is set equal to ELECTRIC, GAS-FURNACE, or OIL-FURNACE, in which case the load is met here in SYSTEMS and a utility demand is passed to PLANT.

5. PRE-HEAT COIL ENERGY (millions of Btu) and MAXIMUM PRE-HEAT COIL ENERGY (thousands of Btu/hr) are, respectively, the monthly totals and peak heating supplied by the preheat coil(s) to raise the temperature of the mixed air (return air plus makeup air) to a specified value, PREHEAT-T. These loads are passed to PLANT unless PREHEAT-SOURCE is set equal to ELECTRIC, GAS-FURNACE, or OIL-FURNACE, in which case the load is met here in SYSTEMS and a utility demand is passed to PLANT. (For RESYS only: The columns report instead the electrical input, in Btu's, for the furnace fan, when the fan is running.)

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-B SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1

	- - Z O N E C O O L I N G - -		- - Z O N E H E A T I N G -		- - B A S E B O A R D S - -		- - - - P R E - H E A T - - -	
MONTH	ZONE COIL COOLING ENERGY (MBTU)	MAXIMUM ZONE COIL COOLING ENERGY (KBTU/HR)	ZONE COIL HEATING ENERGY (MBTU)	MAXIMUM ZONE COIL HEATING ENERGY (KBTU/HR)	BASEBOARD HEATING ENERGY (MBTU)	MAXIMUM BASEBOARD HEATING ENERGY (KBTU/HR)	PRE-HEAT COIL ENERGY (MBTU)	MAXIMUM PRE-HEAT COIL ENERGY (KBTU/HR)
JAN	0.	0.	-15.89909	-125.500	0.	0.	-.23181	-8.205
FEB	0.	0.	-12.74968	-124.786	0.	0.	-.00188	-.704
MAR	0.	0.	-6.98577	-124.429	0.	0.	0.	0.
APR	0.	0.	-1.06509	-119.308	0.	0.	0.	0.
MAY	0.	0.	-.01566	-9.769	0.	0.	0.	0.
JUN	0.	0.	0.	0.	0.	0.	0.	0.
JUL	0.	0.	0.	0.	0.	0.	0.	0.
AUG	0.	0.	0.	0.	0.	0.	0.	0.
SEP	0.	0.	0.	0.	0.	0.	0.	0.
OCT	0.	0.	-.45335	-123.323	0.	0.	0.	0.
NOV	0.	0.	-5.84058	-122.034	0.	0.	0.	0.
DEC	0.	0.	-13.15425	-123.919	0.	0.	0.	0.
TOTAL	0.		-56.163		0.		-.234	
MAX		0.		-125.500		0.		-8.205

REPORT SS-C - SYSTEM MONTHLY LOAD HOURS

The number of cooling and heating hours for each month are reported for each system. Included are the hours when both heating and cooling are required. In addition, this report gives the heating and electrical loads at the time of the cooling peak.

1. NUMBER OF COOLING LOAD HOURS and NUMBER OF HEATING LOAD HOURS give the total hours in each month when the HVAC system is operating with a heating load or a cooling load.

2. CONCURRENT COOL-HEAT LOAD HOURS gives the number of hours in each month when the HVAC system is operating with simultaneous heating and cooling loads.

The above two numbers do not include hours when the only load was from pilot lights and crankcase heating.

3. HEATING LOAD AT TIME OF COOLING PEAK is self-explanatory. ELECTRIC LOAD AT TIME OF COOLING PEAK will be the electrical load at the last hour of the month if there was no cooling that month.

REPORT- SS-C SYSTEM MONTHLY LOAD HOURS FOR SYST-1

	----N U M B E R O F H O U R S-----			--C O I N C I D E N T L O A D S--	
MONTH	NUMBER OF COOLING LOAD HOURS	NUMBER OF HEATING LOAD HOURS	CONCURRENT COOL-HEAT LOAD HOURS	HEATING LOAD AT TIME OF COOLING PEAK (KBTU/HR)	ELECTRIC LOAD AT TIME OF COOLING PEAK (KW)
JAN	0	506	0	0.	1.307
FEB	0	470	0	0.	1.307
MAR	37	259	2	-.664	2.207
APR	80	41	5	0.	21.545
MAY	133	3	0	0.	18.281
JUN	197	0	0	0.	19.538
JUL	220	0	0	0.	21.545
AUG	220	0	0	0.	19.544
SEP	163	0	0	0.	21.035
OCT	108	21	0	0.	18.986
NOV	52	197	1	0.	20.138
DEC	0	440	0	0.	1.307

REPORT SS-D - PLANT MONTHLY LOADS SUMMARY

In the DOE-2 program multiple central plants, for serving the HVAC systems in the building, can be simulated. The PLANT-ASSIGNMENT command is used to assign HVAC systems to central plants. In the report shown, the user-defined name of the plant, CONVENTIONAL, is reported in the title line. The cooling, heating, and electrical energy required by the system(s) and zones served on 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.

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 and 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.

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 and 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 <u>zones</u> served by the plant. In addition, the electrical energy contains the fan energy requirement for the HVAC system. It does <u>not</u> include the electrical energy associated with pumps, cooling towers, chillers, and electrical heating. These are reported in the PLANT program.

10. MAXIMUM ELEC LOAD (kW) give the monthly peak electrical consumption in a one-hour period for lights and convenience outlets in the building <u>zones</u> served by the plant.

11. NUMBER OF HOURS and COINCIDENT LOADS are as in report SS-C for the whole plant.

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-D PLANT MONTHLY LOADS SUMMARY FOR CONVENTIONAL

MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
	- - - - - - - - C O O L I N G - - - - - - - -						- - - - - - - - H E A T I N G - - - - - - - -						- - - E L E C - - -	
JAN	0.					0.	-21.336	2	9	4F	3F	-158.350	5271.	20.0
FEB	0.					0.	-16.130	4	9	7F	6F	-151.190	4617.	20.0
MAR	.64256	3	15	76F	65F	39.480	-7.972	25	9	18F	15F	-147.212	5109.	20.0
APR	3.85868	29	10	65F	61F	126.194	-1.065	1	9	46F	41F	-119.308	5095.	21.5
MAY	10.06973	21	12	87F	76F	151.553	-.016	9	8	43F	39F	-9.769	5279.	21.5
JUN	22.47838	20	16	90F	78F	172.520	0.					0.	4965.	21.5
JUL	34.73493	8	10	86F	74F	199.394	0.					0.	5380.	21.5
AUG	32.14807	12	16	86F	73F	180.551	0.					0.	5380.	21.5
SEP	15.01111	11	14	87F	72F	162.803	0.					0.	4917.	21.5
OCT	5.82594	4	16	78F	61F	102.619	-.453	21	8	31F	29F	-123.323	5137.	20.9
NOV	1.53729	1	16	72F	59F	99.000	-5.960	25	9	27F	25F	-126.175	4906.	20.8
DEC	0.					0.	-15.171	9	9	14F	13F	-144.665	5106.	20.0
TOTAL	126.307						-68.104						61161.	
MAX						199.394						-158.350		21.5

REPORT SS-E - PLANT MONTHLY LOAD HOURS

Just as the monthly load hours are reported for a HVAC system in Report SS-C, the load hours for the plant named CONVENTIONAL are shown in Report SS-E. Heating and electrical loads for the plant at the time of the cooling peak are also reported.

1. NUMBER OF COOLING LOAD HOURS and NUMBER OF HEATING LOAD HOURS. These hours, reported monthly, are the required operation hours of the central plant for supplying heating or cooling to the HVAC systems served.

2. CONCURRENT COOL-HEAT LOAD HOURS gives the number of hours in each month when the central plant is operating with simultaneous heating and cooling loads.

3. HEATING LOAD AT TIME OF COOLING PEAK and ELECTRICAL LOAD AT TIME OF COOLING PEAK are self-explanatory.

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-E PLANT MONTHLY LOAD HOURS FOR CONVENTIONAL

	- - - - N U M B E R	O F H O U R S - - - - -		- - C O I N C I D E N T	L O A D S - -
MONTH	NUMBER OF COOLING LOAD HOURS	NUMBER OF HEATING LOAD HOURS	CONCURRENT COOL-HEAT LOAD HOURS	HEATING LOAD AT TIME OF COOLING PEAK (KBTU/HR)	ELECTRIC LOAD AT TIME OF COOLING PEAK (KW)
JAN	0	506	0	0.	1.307
FEB	0	470	0	0.	1.307
MAR	37	259	2	-.664	2.207
APR	80	41	5	0.	21.545
MAY	133	3	0	0.	18.281
JUN	197	0	0	0.	19.538
JUL	220	0	0	0.	21.545
AUG	220	0	0	0.	19.544
SEP	163	0	0	0.	21.035
OCT	108	21	0	0.	18.986
NOV	52	197	1	0.	20.138
DEC	0	440	0	0.	1.307

REPORT SS-F - ZONE MONTHLY DEMAND SUMMARY

This report gives monthly values of eight different zone-related quantities. The user-name of the zone (SPACE1-1) is given in the title of the report, along with the HVAC system (SYST-1) which serves this zone. Found in this report are the monthly sums for zone heating and cooling demands from the HVAC system, minimum and maximum zone air temperatures, and the number of hours the loads are not met in the zone. The report is presented zone-by-zone.

1. HEAT EXTRACTION LOAD and HEAT ADDITION LOAD (millions of Btu). These monthly totals are the sensible cooling and heating requirements, respectively, of this zone during the HVAC system operation hours. These loads are both sensible and latent. For RESYS systems, the heat extraction may include natural ventilation. For plenums, these values are for heat extraction and addition induced by the return air flow. For unconditioned zones, these values should be zero.

2. BASEBOARD ENERGY (millions of Btu) and MAXIMUM BASEBOARD ENERGY (thousands of Btu/hr). When the keyword BASEBOARD-RATIO is used, the zone heating is supplied by baseboards. Monthly heating energy requirements for these baseboards are reported in addition to the peak heating requirement.

3. MAXIMUM ZONE TEMPERATURE (^{o}F) and MINIMUM ZONE TEMPERATURE (^{o}F). The monthly maximum and minimum air temperatures, during system operation (when fans are operating), in this zone are reported for checking space temperature variations. Extreme air temperatures frequently occur at a time when the HVAC system has just been activated. When the fans are not operating for an entire month, the minimum will be shown as 200 ^{o}F and the maximum as 0 ^{o}F. These are initialization values and should not be taken as the temperature to which the zone has floated.

4. HOURS UNDERHEATED and HOURS UNDERCOOLED. If the capacity of the HVAC system is less than the hourly heat extraction or heat addition load for this zone, a load-not-met is recorded as either an underheated or undercooled hour. The number of hours reported as underheated or undercooled may be startups after a night shutdown of the HVAC system.

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80, 10.19.09 SDL RUN 1

REPORT- SS-F ZONE MONTHLY DEMAND SUMMARY FOR SPACE1-1 IN SYST-1

	----DEMANDS-----		--BASEBOARDS---		--TEMPERATURES--		---LOADS NOT MET--	
MONTH	HEAT EXTRACTION LOAD (MBTU)	HEAT ADDITION LOAD (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD ENERGY (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	.47024	-3.278	0.	0.	71.9	55.3	37	0
FEB	.36580	-2.616	0.	0.	71.6	55.3	32	0
MAR	1.16639	-1.187	0.	0.	72.5	55.5	10	0
APR	3.81363	-.150	0.	0.	74.3	67.0	0	9
MAY	5.47289	0.	0.	0.	74.9	70.3	0	18
JUN	6.79777	0.	0.	0.	77.1	71.7	0	85
JUL	9.08298	0.	0.	0.	82.0	72.8	0	214
AUG	8.45185	0.	0.	0.	79.2	72.4	0	194
SEP	6.03911	0.	0.	0.	75.9	70.7	0	39
OCT	4.17455	-.060	0.	0.	72.4	68.0	0	0
NOV	1.35198	-.816	0.	0.	75.9	60.5	5	0
DEC	.23625	-2.552	0.	0.	71.3	55.7	30	0

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-F ZONE MONTHLY DEMAND SUMMARY FOR SPACE2-1 IN SYST-1

	- - - -D E M A N D S- - - - -		- -B A S E B O A R D S- - -		- -T E M P E R A T U R E S- -		- -L O A D S N O T M E T- -	
MONTH	HEAT EXTRACTION LOAD (MBTU)	HEAT ADDITION LOAD (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD ENERGY (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	.10955	-1.487	0.	0.	71.2	55.2	41	0
FEB	.09891	-1.150	0.	0.	70.7	55.3	35	0
MAR	.43162	-.483	0.	0.	72.0	55.4	10	0
APR	1.67672	-.053	0.	0.	75.1	66.5	1	11
MAY	2.43707	0.	0.	0.	75.7	70.4	0	30
JUN	2.87370	0.	0.	0.	78.0	72.0	0	140
JUL	3.82820	0.	0.	0.	83.9	72.9	0	219
AUG	3.53224	0.	0.	0.	80.7	72.6	0	210
SEP	2.59873	0.	0.	0.	77.1	71.0	0	55
OCT	1.72421	-.019	0.	0.	71.9	67.8	0	0
NOV	.45064	-.358	0.	0.	75.6	60.6	4	0
DEC	.04792	-1.126	0.	0.	70.6	55.6	36	0

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-F ZONE MONTHLY DEMAND SUMMARY FOR SPACE3-1 IN SYST-1

	----DEMANDS-----		--BASEBOARDS---		--TEMPERATURES--		--LOADS NOT MET--	
MONTH	HEAT EXTRACTION LOAD (MBTU)	HEAT ADDITION LOAD (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD ENERGY (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	.07683	-3.058	0.	0.	70.6	54.9	48	0
FEB	.05806	-2.317	0.	0.	70.4	55.1	44	0
MAR	.46855	-1.062	0.	0.	71.8	55.3	14	0
APR	2.52395	-.122	0.	0.	75.4	66.1	1	12
MAY	4.13988	0.	0.	0.	76.1	70.4	0	32
JUN	4.87535	0.	0.	0.	78.5	72.2	0	165
JUL	6.47862	0.	0.	0.	84.3	73.2	0	220
AUG	5.96020	0.	0.	0.	80.8	72.5	0	208
SEP	4.17941	0.	0.	0.	77.1	70.9	0	46
OCT	2.52707	-.055	0.	0.	71.9	67.0	0	0
NOV	.55260	-.810	0.	0.	74.8	60.4	8	0
DEC	.04645	-2.227	0.	0.	70.4	55.6	47	0

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-F ZONE MONTHLY DEMAND SUMMARY FOR SPACE4-1 IN SYST-1

	----DEMANDS-----		--BASEBOARDS---		--TEMPERATURES--		--LOADS NOT MET--	
MONTH	HEAT EXTRACTION LOAD (MBTU)	HEAT ADDITION LOAD (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD ENERGY (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	.04722	-1.593	0.	0.	70.7	55.1	44	0
FEB	.03953	-1.210	0.	0.	70.6	55.2	43	0
MAR	.26819	-.564	0.	0.	71.9	55.4	13	0
APR	1.30570	-.072	0.	0.	75.1	66.0	1	11
MAY	2.10535	0.	0.	0.	75.8	70.3	0	24
JUN	2.61989	0.	0.	0.	78.1	71.8	0	119
JUL	3.49085	0.	0.	0.	83.4	72.8	0	218
AUG	3.22684	0.	0.	0.	80.3	72.1	0	201
SEP	2.18042	0.	0.	0.	76.7	70.7	0	30
OCT	1.28432	-.030	0.	0.	71.8	67.1	0	0
NOV	.28903	-.433	0.	0.	75.0	60.4	8	0
DEC	.02430	-1.183	0.	0.	70.4	55.6	42	0

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-F ZONE MONTHLY DEMAND SUMMARY FOR SPACE5-1 IN SYST-1

	----DEMANDS-----		--BASEBOARDS---		--TEMPERATURES--		--LOADS NOT MET--	
MONTH	HEAT EXTRACTION LOAD (MBTU)	HEAT ADDITION LOAD (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD ENERGY (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	.30832	-2.409	0.	0.	71.3	55.4	45	0
FEB	.23176	-1.936	0.	0.	70.9	55.5	41	0
MAR	.84496	-.936	0.	0.	72.0	55.6	15	0
APR	2.98551	-.119	0.	0.	76.5	65.4	1	13
MAY	4.42654	0.	0.	0.	77.2	70.7	0	34
JUN	5.00320	0.	0.	0.	79.7	72.2	0	154
JUL	6.66492	0.	0.	0.	85.4	73.2	0	220
AUG	6.16297	0.	0.	0.	81.9	72.8	0	213
SEP	4.60442	0.	0.	0.	78.4	71.2	0	64
OCT	3.42251	-.043	0.	0.	72.7	66.7	1	0
NOV	1.04831	-.646	0.	0.	75.0	60.8	9	0
DEC	.25753	-1.937	0.	0.	70.9	56.0	44	0

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-F ZONE MONTHLY DEMAND SUMMARY FOR PLENUM-1 IN SYST-1

	- - - -D E M A N D S- - - - -		- -B A S E B O A R D S- - -		- -T E M P E R A T U R E S- -		- -L O A D S N O T M E T- -	
MONTH	HEAT EXTRACTION LOAD (MBTU)	HEAT ADDITION LOAD (MBTU)	BASEBOARD ENERGY (MBTU)	MAXIMUM BASEBOARD ENERGY (KBTU/HR)	MAXIMUM ZONE TEMP (F)	MINIMUM ZONE TEMP (F)	HOURS UNDER HEATED	HOURS UNDER COOLED
JAN	.00005	-5.751	0.	0.	69.6	51.6	0	0
FEB	.00070	-4.587	0.	0.	69.8	53.3	0	0
MAR	.00483	-3.852	0.	0.	71.3	53.7	0	0
APR	.06139	-1.591	0.	0.	75.9	64.0	0	0
MAY	.14592	-.675	0.	0.	76.2	69.3	0	0
JUN	.55474	-.056	0.	0.	78.9	73.0	0	0
JUL	1.71742	-.008	0.	0.	84.8	75.3	0	0
AUG	1.24171	-.015	0.	0.	81.0	74.4	0	0
SEP	.27665	-.331	0.	0.	77.4	69.4	0	0
OCT	0.	-1.530	0.	0.	72.6	63.9	0	0
NOV	.00006	-3.594	0.	0.	74.1	60.3	0	0
DEC	.01396	-4.783	0.	0.	69.0	55.4	0	0

REPORT SS-G - ZONE MONTHLY LOADS SUMMARY

Zone cooling, heating, and electrical requirements are reported in this monthly summary. The user name of the zone (SPACE1-1) is in the title line with the name of the HVAC system (SYST-1) serving the zone. The cooling and heating energy reported is supplied only at the zone level such as reheat coils. Often heating and cooling loads are reported as zero in this report when the central HVAC system provides all the heating and cooling, i.e., a dual duct system.

1. COOLING ENERGY and HEATING ENERGY (millions of Btu). Again, this is monthly energy delivered by coils in this zone during scheduled operation hours.

2. MAXIMUM COOLING LOAD and MAXIMUM HEATING LOAD (thousands of Btu/hr). The peak energy delivered by zone coils for cooling or heating, respectively.

3. TIME OF MAX (DY, HR), DRY-BULB TEMP, and WET-BULB TEMP. The day and hour of the peak zone coil loads are reported; again these times may be for startup loads. The temperatures reported are the outdoor air temperatures at the time of the peak zone coil loads.

4. ELECTRICAL ENERGY and MAXIMUM ELECTRICAL LOAD (kWh). The monthly total and peaks of electrical energy use in this zone, including lights, fans,

REPORT- SS-G ZONE MONTHLY LOADS SUMMARY FOR SPACE1-1 IN SYST-1

	- - - C O O L I N G - - -						- - - H E A T I N G - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.					0.	-4.522	2	9	4F	3F	-40.004	1041.	4.1
FEB	0.					0.	-3.693	25	9	12F	11F	-39.700	910.	4.1
MAR	0.					0.	-1.973	25	9	18F	15F	-39.566	1007.	4.1
APR	0.					0.	-.332	1	9	46F	41F	-38.271	1033.	4.1
MAY	0.					0.	-.009	9	8	43F	39F	-4.383	1041.	4.1
JUN	0.					0.	0.					0.	963.	4.1
JUL	0.					0.	0.					0.	1041.	4.1
AUG	0.					0.	0.					0.	1041.	4.1
SEP	0.					0.	0.					0.	963.	4.1
OCT	0.					0.	-.138	21	8	31F	29F	-39.353	1041.	4.1
NOV	0.					0.	-1.652	29	9	29F	28F	-39.179	963.	4.1
DEC	0.					0.	-3.864	26	9	17F	17F	-39.848	1007.	4.1
TOTAL	0.						-16.183						12052.	
MAX						0.						-40.004		4.1

REPORT- SS-G ZONE MONTHLY LOADS SUMMARY FOR SPACE2-1 IN SYST-1

	- - - C O O L I N G - - -						- - - H E A T I N G - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.					0.	-2.022	2	9	4F	3F	-16.076	450.	1.8
FEB	0.					0.	-1.603	25	9	12F	11F	-16.160	393.	1.8
MAR	0.					0.	-.824	25	9	18F	15F	-16.124	435.	1.8
APR	0.					0.	-.102	8	9	32F	28F	-15.570	446.	1.8
MAY	0.					0.	-.002	9	8	43F	39F	-1.535	450.	1.8
JUN	0.					0.	0.					0.	416.	1.8
JUL	0.					0.	0.					0.	450.	1.8
AUG	0.					0.	0.					0.	450.	1.8
SEP	0.					0.	0.					0.	416.	1.8
OCT	0.					0.	-.037	21	8	31F	29F	-16.045	450.	1.8
NOV	0.					0.	-.734	25	9	27F	25F	-15.751	416.	1.8
DEC	0.					0.	-1.687	26	9	17F	17F	-16.041	435.	1.8
TOTAL	0.						-7.010						5205.	
MAX						0.						-16.160		1.8

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-G ZONE MONTHLY LOADS SUMMARY FOR SPACE3-1 IN SYST-1

	- - - - - - - - C O O L I N G					- - - - - - - -	- - - - - - - - H E A T I N G					- - - - - - - -	- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.					0.	-4.004	2	9	4F	3F	-26.931	1041.	4.1
FEB	0.					0.	-3.136	25	9	12F	11F	-26.732	910.	4.1
MAR	0.					0.	-1.767	25	9	18F	15F	-26.644	1007.	4.1
APR	0.					0.	-.251	8	9	32F	28F	-26.001	1033.	4.1
MAY	0.					0.	-.002	9	8	43F	39F	-2.122	1041.	4.1
JUN	0.					0.	0.					0.	963.	4.1
JUL	0.					0.	0.					0.	1041.	4.1
AUG	0.					0.	0.					0.	1041.	4.1
SEP	0.					0.	0.					0.	963.	4.1
OCT	0.					0.	-.123	21	8	31F	29F	-26.452	1041.	4.1
NOV	0.					0.	-1.499	29	9	29F	28F	-26.168	963.	4.1
DEC	0.					0.	-3.161	26	9	17F	17F	-26.516	1007.	4.1
TOTAL	0.						-13.944						12052.	
MAX						0.						-26.931		4.1

REPORT- SS-G ZONE MONTHLY LOADS SUMMARY FOR SPACE4-1 IN SYST-1

	- - - - - - - - C O O L I N G - - - - - - - -						- - - - - - - - H E A T I N G - - - - - - - -						- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY	HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.					0.	-2.121	2	9	4F	3F	-14.959	450.	1.8
FEB	0.					0.	-1.665	25	9	12F	11F	-14.855	393.	1.8
MAR	0.					0.	-.948	25	9	18F	15F	-14.818	435.	1.8
APR	0.					0.	-.159	8	9	32F	28F	-14.467	446.	1.8
MAY	0.					0.	-.003	9	8	43F	39F	-1.729	450.	1.8
JUN	0.					0.	0.					0.	416.	1.8
JUL	0.					0.	0.					0.	450.	1.8
AUG	0.					0.	0.					0.	450.	1.8
SEP	0.					0.	0.					0.	416.	1.8
OCT	0.					0.	-.074	21	8	31F	29F	-14.718	450.	1.8
NOV	0.					0.	-.826	29	9	29F	28F	-14.558	416.	1.8
DEC	0.					0.	-1.708	26	9	17F	17F	-14.766	435.	1.8
TOTAL	0.						-7.504						5205.	
MAX						0.						-14.959		1.8

EXAMPLE BUILDING 3A, CHICAGO   DOE-2.1   13 MAR 80, 10.19.09   SDL RUN 1

REPORT- SS-G ZONE MONTHLY LOADS SUMMARY FOR   SPACE5-1   IN SYST-1

MONTH	- - - C O O L I N G - - - COOLING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	- - - H E A T I N G - - - HEATING ENERGY (MBTU)	TIME OF MAX DY	TIME OF MAX HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	- - - E L E C - - - ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.					0.	-3.230	2	9	4F	3F	-27.530	1949.	7.7
FEB	0.					0.	-2.653	25	9	12F	11F	-27.338	1703.	7.7
MAR	0.					0.	-1.473	25	9	18F	15F	-27.277	1883.	7.7
APR	0.					0.	-.222	8	9	32F	28F	-26.295	1932.	7.7
MAY	0.					0.	0.					0.	1949.	7.7
JUN	0.					0.	0.					0.	1802.	7.7
JUL	0.					0.	0.					0.	1949.	7.7
AUG	0.					0.	0.					0.	1949.	7.7
SEP	0.					0.	0.					0.	1802.	7.7
OCT	0.					0.	-.082	21	8	31F	29F	-26.754	1949.	7.7
NOV	0.					0.	-1.129	29	10	32F	30F	-26.847	1802.	7.7
DEC	0.					0.	-2.734	26	10	21F	20F	-27.212	1883.	7.7
TOTAL	0.						-11.523						22550.	
MAX						0.						-27.530		7.7

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 SDL RUN 1

REPORT- SS-G ZONE MONTHLY LOADS SUMMARY FOR PLENUM-1 IN SYST-1

	- - - - - - - - C O O L I N G - - - - - - - -					- - - - - - - - H E A T I N G - - - - - - - -					- - - E L E C - - -	
MONTH	COOLING ENERGY (MBTU)	TIME OF MAX DY HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM COOLING LOAD (KBTU/HR)	HEATING ENERGY (MBTU)	TIME OF MAX DY HR	DRY-BULB TEMP	WET-BULB TEMP	MAXIMUM HEATING LOAD (KBTU/HR)	ELEC-TRICAL ENERGY (KWH)	MAXIMUM ELEC LOAD (KW)
JAN	0.				0.	0.				0.	0.	0.
FEB	0.				0.	0.				0.	0.	0.
MAR	0.				0.	0.				0.	0.	0.
APR	0.				0.	0.				0.	0.	0.
MAY	0.				0.	0.				0.	0.	0.
JUN	0.				0.	0.				0.	0.	0.
JUL	0.				0.	0.				0.	0.	0.
AUG	0.				0.	0.				0.	0.	0.
SEP	0.				0.	0.				0.	0.	0.
OCT	0.				0.	0.				0.	0.	0.
NOV	0.				0.	0.				0.	0.	0.
DEC	0.				0.	0.				0.	0.	0.
TOTAL	0.					0.					0.	
MAX					0.					0.		0.

REPORT SS-H - SYSTEM MONTHLY LOADS SUMMARY

In this monthly load summary the name of the HVAC system is given in the title (SYST-1). Found in this report is the fan energy requirement for the HVAC system.

1. Under FAN ELEC is shown the total and maximum hourly electrical consumption of the supply, return, exhaust, and outside fans.

2. Under FUEL HEAT is presented the total oil and gas consumed in Btu equivalents by the system. This will be zero unless the user has made at least one of the heat sources OIL-FURNACE or GAS-FURNACE.

3. For ELEC HEAT the data describe 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.

4. ELEC COOL shows the electrical consumption and hourly maxima for cooling.

REPORT- SS-H SYSTEM MONTHLY LOADS SUMMARY FOR SYST-1

	----FAN ELEC----		--FUEL HEAT----		--ELEC HEAT---		---ELEC COOL---	
MONTH	FAN ELECTRIC ENERGY (KWH)	MAXIMUM FAN ELECTRIC ENERGY (KW)	GAS OIL HEATING ENERGY (MBTU)	MAXIMUM GAS OIL HEATING ENERGY (KBTU/HR)	ELECTRIC HEATING ENERGY (KWH)	MAXIMUM ELECTRIC HEATING ENERGY (KW)	ELECTRIC COOLING ENERGY (KWH)	MAXIMUM ELECTRIC COOLING ENERGY (KW)
JAN	340.	.468	0.	0.	0.	0.	0.	0.
FEB	307.	.457	0.	0.	0.	0.	0.	0.
MAR	343.	.778	0.	0.	0.	0.	0.	0.
APR	206.	2.045	0.	0.	0.	0.	0.	0.
MAY	348.	2.045	0.	0.	0.	0.	0.	0.
JUN	406.	2.045	0.	0.	0.	0.	0.	0.
JUL	449.	2.045	0.	0.	0.	0.	0.	0.
AUG	449.	2.045	0.	0.	0.	0.	0.	0.
SEP	358.	2.045	0.	0.	0.	0.	0.	0.
OCT	206.	1.930	0.	0.	0.	0.	0.	0.
NOV	347.	1.782	0.	0.	0.	0.	0.	0.
DEC	340.	.457	0.	0.	0.	0.	0.	0.
TOTAL	4098.		0.		0.		0.	
MAX		2.045		0.		0.		0.

REPORT SS-I - SYSTEM MONTHLY COOLING LOAD SUMMARY

SS-I is a summary of the monthly cooling energy provided by each HVAC system. The items summarized are sensible cooling, latent cooling, maximum cooling (sensible plus latent) with the corresponding sensible heat ratio, and the day and hour the maximum cooling occurs.

1. SENSIBLE COOLING ENERGY (millions of Btu) is the monthly sum of sensible energy extracted by the HVAC system.

2. LATENT COOLING ENERGY (millions of Btu) is the monthly sum of latent energy extracted by the HVAC system.

   The sum of 1 and 2 should agree with the COOLING ENERGY reported in SS-A.

3. MAX TOTAL COOLING ENERGY (thousands of Btu/hr) is the hourly peak energy (sensible plus latent) extracted by the system during the month.

4. SENSIBLE HEAT RATIO AT MAX is the sensible heat ratio (sensible cooling/total cooling) for the hour that the maximum total cooling occurs.

5. TIME OF MAX DY HR is the day and hour during which the total peak cooling load occurred.

6. TOTAL is the annual totals for sensible cooling energy and latent cooling energy (millions of Btu).

7. MAX is the highest hourly cooling load (thousands of Btu/hr) during the year and the corresponding sensible heat ratio for that hour.

Note: If the RUN-PERIOD interval does not include the entire year, the above definitions apply only during the specified RUN-PERIOD interval(s).

SIMPLE STRUCTURE RUN 3A, CHICAGO   DOE-2.1A   22 DEC 80   15.32.20   SDL RUN 1

REPORT- SS-I SYSTEM MONTHLY COOLING LOAD SUMMARY FOR SYST-1

MONTH	SENSIBLE COOLING ENERGY (MBTU)	LATENT COOLING ENERGY (MBTU)	MAX TOTAL COOLING ENERGY (KBTU/HR)	SENSIBLE HEAT RATIO AT MAX	TIME OF MAX DY	TIME OF MAX HR
JAN	.01941	0.	6.746	1.000	30	16
FEB	.03464	0.	11.962	1.000	28	13
MAR	1.17598	.24525	36.323	.586	3	15
APR	4.95375	.40192	126.401	.481	29	8
MAY	10.84983	1.15515	147.561	.737	21	13
JUN	21.51021	1.51650	168.109	.870	20	16
JUL	32.00380	2.42497	201.825	.597	15	8
AUG	29.89496	2.24354	190.356	.798	19	8
SEP	15.57593	.89939	155.241	.797	11	15
OCT	7.17092	.80704	104.291	.430	29	18
NOV	2.25512	.37413	88.330	.828	1	16
DEC	0.	0.	0.			
TOTAL	125.445	10.068				
MAX			201.825	.597		

REPORT SS-J - SYSTEM PEAK HEATING AND COOLING DAYS

SS-J gives for each HVAC system an hourly profile of the peak heating day and the peak cooling day that occur during the RUN-PERIOD interval(s). The peak cooling day is defined as the day that contains the hour with the maximum (sensible plus latent) cooling energy; the peak cooling day is similarly defined. The items reported for each hour of the peak cooling day are cooling energy, sensible heat ratio, and outdoor dry- and wet-bulb temperatures. For the peak heating day, the items reported are heating energy and outside dry- and wet-bulb temperatures.

1. COOLING and HEATING are the two sections of this system level report. Directly below the headings COOLING and HEATING, the month and day of the peak cooling and heating days are given.

2. HOUR gives the hour of the day, ranging from hour 1 (midnight to 1 am) to hour 24 (11 pm to midnight). Even if DAYLIGHT-SAVINGS = YES, summer hours will not reflect daylight saving time.

3. HOURLY COOLING ENERGY (thousands of Btu) is the total hourly energy, sensible plus latent, extracted by the HVAC system.

4. SENSIBLE HEAT RATIO is the ratio of sensible to total cooling energy for the given hour.

5. DRY-BULB TEMP and WET-BULB TEMP are the outside dry- and wet-bulb temperatures, respectively, for the given hour.

6. HOURLY HEATING ENERGY (thousands of Btu) is the hourly heating energy delivered by the HVAC system. For SYSTEM-TYPE = RESYS, this includes baseboard heating energy.

7. MAX is the highest hourly cooling load and the highest hourly heating load (both in thousands of Btu) during the RUN-PERIOD interval(s), in this case, the year.

REPORT- SS-J SYSTEM PEAK HEATING AND COOLING DAYS FOR SYST-1

	- - - - - C O O L I N G - - - - - JUL 15				- - - H E A T I N G - - - JAN 2		
HOUR	HOURLY COOLING ENERGY (KBTU)	SENSIBLE HEAT RATIO	DRY-BULB TEMP	WET-BULB TEMP	HOURLY HEATING ENERGY (KBTU)	DRY-BULB TEMP	WET-BULB TEMP
1	0.	0.	77F	72F	-65.662	1F	0F
2	0.	0.	77F	72F	-66.260	1F	0F
3	0.	0.	76F	71F	-66.872	1F	0F
4	0.	0.	75F	71F	-66.733	2F	1F
5	0.	0.	73F	70F	-72.498	2F	1F
6	0.	0.	72F	70F	-68.298	2F	1F
7	0.	0.	72F	70F	-72.664	3F	2F
8	201.825	.933	75F	70F	-67.333	4F	3F
9	191.889	.935	76F	69F	-138.464	4F	3F
10	182.781	.935	78F	69F	-134.512	5F	4F
11	181.348	.934	80F	70F	-129.742	6F	5F
12	176.370	.944	81F	70F	-119.621	8F	7F
13	178.112	.928	82F	71F	-111.824	9F	9F
14	176.732	.933	83F	70F	-100.127	11F	11F
15	175.441	.935	81F	69F	-91.372	12F	12F
16	174.493	.933	80F	69F	-85.433	14F	13F
17	172.666	.929	79F	69F	-79.441	15F	14F
18	0.	0.	77F	67F	-74.070	15F	15F
19	0.	0.	76F	67F	0.	17F	16F
20	0.	0.	74F	66F	0.	17F	16F
21	0.	0.	71F	65F	0.	18F	18F
22	0.	0.	69F	64F	0.	17F	17F
23	0.	0.	67F	63F	0.	17F	17F
24	0.	0.	67F	63F	0.	17F	17F
MAX	201.825				-138.464		

HOURLY REPORTS

These optional reports are user-designed. The variables, which are to be displayed, are chosen by the user from the lists in Chapter IV (see REPORT-BLOCK).

1.	MMDDHH	is the month, day, and hour of the simulation period.
2.	SYST-1 TOT HTG COIL BTU	Total energy input (in Btu) each hour to the central heating coil in the SYST-1 system.
3.	SYST-1 TOT ZONE HTG BTU	Total energy input (in Btu) each hour to the zone heating coils served by the SYST-1 system.
4.	SYST-1 RETURN HUMIDITY	The humidity ratio (in lbs H_2O/lb dry air) of the return air to the SYST-1 HVAC unit.
5.	SYST-1 MIX HUMIDITY	The humidity ratio (in lbs H_2O/lb dry air) of the mixed return air and outside ventilation air of the SYST-1 system. The air is mixed prior to passing over any central heating or cooling coils.
6.	SYST-1 HUMIDITY LVG COIL	The humidity ratio (in lbs H_2O/lb dry air) of the air (supply) leaving the SYST-1 cooling coil.
7.	SYST-1 HTG COIL AIR TEMP	The temperature (°F) of the supply air leaving the SYST-1 heating coil - hot deck temperature. (Actually, this variable is not appropriate to the VAVS system that was specified. The program does not check for appropriateness of variables.)
8.	SYST-1 CLG COIL AIR TEMP	The temperature (°F) of the supply air leaving the SYST-1 cooling coil - cold deck temperature.
9.	SYST-1 ENTERING AIR TEMP	The temperature (°F) of the mixed return air and outside ventilation air of the SYST-1 system.
10.	SYST-1 RETURN AIR TEMP	The temperature (°F) of the SYST-1 return air.
11.	SYST-1 TOT SYST CFM	The total SYST-1 system supply air flow rate (in cfm).
12.	SYST-1 RETURN CFM	The total SYST-1 system return air flow rate (in cfm).

MMDDHH	SYST-1 TOT HTG COIL BTU	SYST-1 TOT ZONE HTG BTU	SYST-1 RETURN HUMIDITY	SYST-1 MIX HUMIDITY	SYST-1 HUMIDITY LVG COIL	SYST-1 HTG COIL AIR TEMP	SYST-1 CLG COIL AIR TEMP	SYST-1 ENTERING AIR TEMP	SYST-1 RETURN AIR TEMP	SYST-1 TOT SYST CFM	SYST-1 RETURN CFM
716 1	0.	0.	0.	0.	0.	82.6	82.6	0.	0.	0.	0.
716 2	0.	0.	0.	0.	0.	82.6	82.6	0.	0.	0.	0.
716 3	0.	0.	0.	0.	0.	82.5	82.5	0.	0.	0.	0.
716 4	0.	0.	0.	0.	0.	82.4	82.4	0.	0.	0.	0.
716 5	0.	0.	0.	0.	0.	82.2	82.2	0.	0.	0.	0.
716 6	0.	0.	0.	0.	0.	65.0	65.0	0.	0.	0.	0.
716 7	0.	0.	0.	0.	0.	82.1	82.1	0.	0.	0.	0.
716 8	0.	0.	.0103	.0104	.0102	82.5	57.9	80.1	80.7	6548.	6548.
716 9	0.	0.	.0099	.0100	.0097	81.1	56.7	79.8	80.1	6548.	6548.
71610	0.	0.	.0098	.0098	.0096	80.7	56.4	79.4	79.7	6548.	6548.
71611	0.	0.	.0097	.0098	.0095	80.4	56.1	79.2	79.4	6548.	6548.
71612	0.	0.	.0095	.0096	.0094	80.2	55.9	78.9	79.0	6548.	6548.
71613	0.	0.	.0096	.0097	.0095	79.9	55.9	78.8	78.9	6539.	6539.
71614	0.	0.	.0095	.0096	.0094	79.8	55.7	78.8	78.8	6548.	6548.
71615	0.	0.	.0094	.0096	.0093	79.7	55.4	78.7	78.7	6546.	6546.
71616	0.	0.	.0095	.0096	.0093	79.7	55.5	78.5	78.4	6548.	6548.
71617	0.	0.	.0096	.0096	.0094	79.5	55.7	78.3	78.2	6542.	6542.
71618	0.	0.	0.	0.	0.	76.8	76.8	0.	0.	0.	0.
71619	0.	0.	0.	0.	0.	78.7	78.7	0.	0.	0.	0.
71620	0.	0.	0.	0.	0.	79.5	79.5	0.	0.	0.	0.
71621	0.	0.	0.	0.	0.	80.1	80.1	0.	0.	0.	0.
71622	0.	0.	0.	0.	0.	80.4	80.4	0.	0.	0.	0.
71623	0.	0.	0.	0.	0.	80.6	80.6	0.	0.	0.	0.
71624	0.	0.	0.	0.	0.	80.6	80.6	0.	0.	0.	0.
717 1	0.	0.	0.	0.	0.	80.5	80.5	0.	0.	0.	0.
717 2	0.	0.	0.	0.	0.	80.6	80.6	0.	0.	0.	0.
717 3	0.	0.	0.	0.	0.	80.3	80.3	0.	0.	0.	0.
717 4	0.	0.	0.	0.	0.	80.3	80.3	0.	0.	0.	0.
717 5	0.	0.	0.	0.	0.	80.2	80.2	0.	0.	0.	0.
717 6	0.	0.	0.	0.	0.	80.1	80.1	0.	0.	0.	0.
717 7	0.	0.	0.	0.	0.	80.0	80.0	0.	0.	0.	0.
717 8	0.	0.	.0104	.0103	.0102	80.3	57.9	78.1	78.5	6548.	6548.
717 9	0.	0.	.0097	.0097	.0095	79.0	56.1	77.9	78.1	6548.	6548.
71710	0.	0.	.0095	.0096	.0094	78.9	55.6	77.8	77.7	6548.	6548.
71711	0.	0.	.0092	.0093	.0090	78.7	54.7	77.8	77.5	6548.	6548.
71712	0.	0.	.0090	.0092	.0090	78.8	54.5	77.7	77.3	6548.	6548.
71713	0.	0.	.0091	.0093	.0090	78.6	54.5	77.7	77.2	6544.	6544.
71714	0.	0.	.0091	.0093	.0090	78.7	54.5	77.8	77.1	6541.	6541.
71715	0.	0.	.0091	.0093	.0090	78.7	54.4	77.8	77.1	6533.	6533.
71716	0.	0.	.0091	.0093	.0090	78.7	54.4	77.7	77.0	6548.	6548.
71717	0.	0.	.0092	.0093	.0090	78.7	54.5	77.4	76.8	6548.	6548.
71718	0.	0.	0.	0.	0.	76.2	76.2	0.	0.	0.	0.
71719	0.	0.	0.	0.	0.	78.2	78.2	0.	0.	0.	0.
71720	0.	0.	0.	0.	0.	79.0	79.0	0.	0.	0.	0.
71721	0.	0.	0.	0.	0.	79.6	79.6	0.	0.	0.	0.
71722	0.	0.	0.	0.	0.	79.7	79.7	0.	0.	0.	0.
71723	0.	0.	0.	0.	0.	79.9	79.9	0.	0.	0.	0.
71724	0.	0.	0.	0.	0.	80.0	80.0	0.	0.	0.	0.

D. PLANT OUTPUT REPORT DESCRIPTIONS

To fully explain the following sample output reports from PLANT it is necessary first to display the input data.

Since the VERIFICATION reports for PLANT are basically self-explanatory (especially after having input the data) no attempt is made here to describe these particular reports. They simply echo back to the user the input data, as understood by the PLANT program.

Note: In PLANT report PV-D (cost of utilities and fuels) the entry for uniform cost/unit is not used in the calculation, when the user has entered values for the keyword BLOCKS or the keyword MULTIPLIERS. In these cases it is used as a flag. It has the value 99.0 when the user has entered BLOCKS and -99.0 when the user has entered MULTIPLIERS.

The available SUMMARY reports and an example HOURLY-REPORT are displayed later in this section of the manual.

In report PV-D the ENERGY-SOURCE code-words have been truncated to 8 characters to allow room for the entire report on one page.

PDL PROCESSOR INPUT DATA

13 MAR 80   10.19.09   PDL RUN 1

```
CONVENTIONAL = PLANT-ASSIGNMENT  ..
PLANT-REPORT SUMMARY=(ALL-SUMMARY)
             VERIFICATION=(ALL-VERIFICATION)   ..
 $REPORT SCHEDULING$
 WR1          = WEEK-SCHEDULE  (ALL)  (1,24)  (0.)   ..
 WR2          = WEEK-SCHEDULE  (ALL)  (1,24)  (1.)   ..
 REPRTSCH=SCH   THRU  JUL 15    WR1
                THRU  JUL 17    WR2   $ SUMMER 2 DAYS $
                THRU  DEC 31    WR1   ..

           $ EQUIPMENT DESCRIPTION $

           $ BOILER $

SBOIL1       =PLANT-EQUIPMENT TYPE=HW-BOILER
                              SIZE=0.14
                              MAX-NUMBER-AVAIL=1  $THESE VALUES DEFAULT$
                              INSTALLED-NUMBER=1  $TO 1 IF OMITTED$
                              HOURS-USED=50000   ..

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


           $ RECIPROCATING CHILLER $

CHIL1        =PLANT-EQUIPMENT TYPE=OPEN-REC-CHLR
                              HOURS-USED = 50000
                              SIZE=0.19   ..

           $ COOLING TOWER $

CTOW1        =PLANT-EQUIPMENT  TYPE=COOLING-TWR
                              HOURS-USED = 50000
                              SIZE=0.24   ..

           $ ENERGY COSTS $

           ENERGY-COST        RESOURCE=NATURAL-GAS
                              UNIT=100000
                              UNIFORM-COST=0.22
                              ESCALATION=10   ..

           ENERGY-COST        RESOURCE=ELECTRICITY
                              UNIT=3413
                              UNIFORM-COST=0.045
                              ESCALATION=6   ..

                              PLANT-COSTS
                              PROJECT-LIFE=25   ..

 $ PLANT REPORTS $
  PPLRP = REPORT-BLOCK
  VARIABLE-TYPE = PLANT
  VARIABLE-LIST = (1,2,5,9,10)         ..
```

```
 * 419 *
 * 420 *    RPPLT1 = HOURLY-REPORT       $ SHORT PLANT REPORT $
 * 421 *             REPORT-SCHEDULE = REPRTSCH
 * 422 *             REPORT-BLOCK    = (PPLRP)    ..
 * 423 *  END ..
-CAUTION--------------------------------------------------------------------------------------------NO LOAD-MANAGEMENT MAY CAUSE POOR OPRN
 * 424 *  COMPUTE PLANT   ..
 * 425 *  INPUT ECONOMICS   ..
```

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 PDL RUN 1

REPORT- PV-A EQUIPMENT SIZES

EQUIPMENT	SIZE (MBTU)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU)	NUMBER INSTD	NUMBER AVAIL	SIZE (MBTU)	NUMBER INSTD	NUMBER AVAIL
HW-BOILER	.140	1	1															
OPEN-REC-CHLR	.190	1	1															
COOLING-TWR	.240	1	1															

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 PDL RUN 1

REPORT- PV-B COST REFERENCE DATA (USED TO CALCULATE DEFAULT COSTS)

EQUIPMENT	SIZE (MBTUH)	UNIT COST (K$)	INSTALD COST FACTOR	CONSUM-ABLES ($/HR)	MAINTA-NANCE (HRS/YR)	EQPMT LIFE (HRS)	HOURS ALREADY USED	HRS TO MINOR OVHAUL	MINOR OVHAUL COST ($)	HRS TO MAJOR OVHAUL	MAJOR OVHAUL COST ($)
HW-BOILER	40.000	300.000	1.400	0.	8.0	220000.	0.	10000.	2000.	50000.	25000.
OPEN-REC-CHLR	12.000	100.000	1.200	0.	16.0	100000.	0.	20000.	5000.	50000.	15000.
COOLING-TWR	12.000	60.000	1.300	0.	80.0	100000.	0.	5000.	5000.	50000.	15000.

REPORT- PV-C EQUIPMENT COSTS

EQUIPMENT	SIZE (MBTUH)	UNIT COST (K$)	INSTALD COST FACTOR	CONSUM-ABLES ($/HR)	MAINTA-NANCE (HRS/YR)	EQPMT LIFE (HRS)	HOURS ALREADY USED	HRS TO MINOR OVHAUL	MINOR OVHAUL COST ($)	HRS TO MAJOR OVHAUL	MAJOR OVHAUL COST ($)
HW-BOILER	.140	6.787	1.400	0.	2.6	124977.	50000.	3227.	45.	16136.	566.
OPEN-REC-CHLR	.190	6.219	1.200	0.	7.0	66063.	50000.	8729.	311.	21821.	933.
COOLING-TWR	.240	4.364	1.300	0.	36.6	67624.	50000.	2287.	364.	22865.	1091.

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 10.19.09 PDL RUN 1

REPORT- PV-D COST OF UTILITIES AND FUELS

ENERGY SOURCE	ENERGY /UNIT (BTU)	UNIFRM COST /UNIT ($)	COST ESCAL-ATION RATE	MIN MONTHLY CHARGE ($)	MIN PK LOAD	PK LOAD UNIT COST ($/UNIT)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)
ELECTRIC	3413.	.045	6.000	0.	0.	1.50										
NATURAL-	100000.	.220	10.000	0.	0.	0.										

REPORT- PV-E EQUIPMENT LOAD RATIOS

E Q U I P M E N T	P A R T L O A D R A T I O S MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
HW-BOILER	.2500	1.2000	1.0000	.0220
OPEN-REC-CHLR	.2500	1.0000	1.0000	.2600
COOLING-TWR	0.	0.	0.	0.

REPORT- PV-G EQUIPMENT QUADRATICS

N A M E	COEFF 1	COEFF 2	COEFF 3	COEFF 4	COEFF 5	COEFF 6
STM-BOILER-HIR-F	.082597	.996764	-.079361	0.	0.	0.
HW-BOILER-HIR-FP	.082597	.996764	-.079361	0.	0.	0.
FURNACE-HIR-FPLR	.018610	1.094209	-.112819	0.	0.	0.
DHW-HIR-FPLR	.021826	.977630	.000543	0.	0.	0.
OPEN-CENT-CAP-FT	-1.742040	.029292	-.000067	.048054	-.000291	-.000106
OPEN-REC-CAP-FT	-4.161461	.207050	-.001931	.004723	-.000040	-.000087
HERM-CENT-CAP-FT	-1.742040	.029292	-.000067	.048054	-.000291	-.000106
HERM-REC-CAP-FT	-4.161461	.207050	-.001931	.004723	-.000040	-.000087
OPEN-CENT-EIR-FT	3.117500	-.109236	.001389	.003750	.000150	-.000375
OPEN-REC-EIR-FT	4.720965	-.187504	.002192	.009209	.000098	-.000322
HERM-CENT-EIR-FT	3.117500	-.109236	.001389	.003750	.000150	-.000375
HERM-REC-EIR-FT	4.720965	-.187504	.002192	.009209	.000098	-.000322
OPEN-CENT-EIR-FP	.222903	.313387	.463710	0.	0.	0.
OPEN-REC-EIR-FPL	.088065	1.137742	-.225806	0.	0.	0.
HERM-CENT-EIR-FP	.222903	.313387	.463710	0.	0.	0.
HERM-REC-EIR-FPL	.088065	1.137742	-.225806	0.	0.	0.
DBUN-CAP-FT	-1.742040	.029292	-.000067	.048054	-.000291	-.000106
DBUN-EIR-FT	3.117500	-.109236	.001389	.003750	.000150	-.000375
DBUN-EIR-FPLR	.349032	.263871	.387097	0.	0.	0.
DBUN-CAP-FTRISE	1.000000	-.005650	-.000305	0.	0.	0.
DBUN-EIR-FTRISE	1.000000	.012250	.000175	0.	0.	0.
ABSOR1-CAP-FT	.723412	.079006	-.000897	-.025285	-.000048	.000276
ABSOR2-CAP-FT	-.816039	-.038707	.000450	.071491	-.000636	.000312
FILLER	0.	0.	0.	0.	0.	0.
ABSORS-CAP-FT	0.	0.	0.	0.	0.	0.
ABSORS-CAP-FTS	0.	0.	0.	0.	0.	0.

REPORT- PV-G EQUIPMENT QUADRATICS

(CONTINUED)

N A M E	COEFF 1	COEFF 2	COEFF 3	COEFF 4	COEFF 5	COEFF 6
ABSOR1-HIR-FT	.652273	0.	0.	-.000545	.000055	0.
ABSOR2-HIR-FT	1.658750	0.	0.	-.029000	.000250	0.
FILLER	0.	0.	0.	0.	0.	0.
ABSORS-HIR-FT	0.	0.	0.	0.	0.	0.
ABSORS-HIR-FTS	0.	0.	0.	0.	0.	0.
ABSOR1-HIR-FPLR	.098585	.583850	.560658	-.243093	0.	0.
ABSOR2-HIR-FPLR	.013994	1.240449	-.914883	.660441	0.	0.
FILLER	0.	0.	0.	0.	0.	0.
ABSORS-HIR-FPLR	0.	0.	0.	0.	0.	0.
TWR-RFACT-FRT	1.247458	.902465	.169504	-.050723	.000294	-.002835
TWR-RFACT-FAT	.901306	-.116050	.001904	-.001525	-.000020	.000391
TWR-APP-FRFACT	5.613538	-6.012118	24.025154	.091624	-.000414	-.257926
TWR-FAN-ELEC-FTU	-395.140000	90.990000	-.016000	0.	0.	0.
DIESEL-I/O-FPLR	.097550	.631800	-.416500	0.	0.	0.
DIESEL-LJB-FPLR	.088300	-.137100	.080300	0.	0.	0.
DIESEL-JAC-FPLR	.392200	-.436700	.277960	0.	0.	0.
DIESEL-EXH-FPLR	.314400	-.135300	.097260	0.	0.	0.
DIESEL-TEX-FPLR	720.000000	60.000000	0.	0.	0.	0.
DIESEL-STACK-FU	.019026	.900000	0.	0.	0.	0.
GTURB-I/O-FPLR	7.683000	-13.480000	8.000000	0.	0.	0.
GTURB-I/O-FT	1.882200	-.004330	.000014	0.	0.	0.
GTURB-EXH-FT	.018226	.000029	0.	0.	0.	0.
GTURB-TEX-FPLR	1.000000	.384500	.028150	0.	0.	0.
GTURB-TEX-FT	406.960000	.631700	.000224	0.	0.	0.
GTURB-STACK-FU	.038051	.900000	0.	0.	0.	0.
STURB-I/O-FPLR	1.000000	0.	0.	0.	0.	0.

REPORT- PV-H LIFE CYCLE PARAMETERS

DISCOUNT RATE (PCT)	INFLATION RATES (PCT) LABOR	INFLATION RATES (PCT) MATERIAL	PROJECT LIFE (YEARS)	LABOR COST ($/HR)	SITE COST FACTOR
10.00	0.	0.	25.	25.00	1.000

REPORT PS-A - PLANT ENERGY UTILIZATION SUMMARY

The information in this report is site and source energy use in MBTUs (10^6 Btu). For electrical energy an entry followed by an E is the energy in MWHs (thousands of KWH).

1. MONTH

2. TOTAL HEAT LOAD. These values are identical to those in the HEATING ENERGY column of the SYSTEMS SS-A report except that the heat energy delivered to an absorption chiller, steam turbine, domestic hot water, and circulation losses is included, if one has been assigned to the plant. Also included is the heat input to a storage tank from a boiler. Total heat energy can be described either in terms of the use of that heat or in terms of the source of that heat. Thus total heating energy = load from SYSTEMS + load from PLANT (i.e., absorption chillers + steam turbines + heat dissipated from storage tanks + domestic hot water + heat stored in tanks but not used) + circulation loop losses. Alternatively, total heat energy = boiler output + recovered heat + solar heat + purchased steam + domestic hot water + loads-not-met.

3. TOTAL COOLING LOAD. These are the total of the values shown in the SS-A Report plus the tank and circulation loop losses and represent 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, but no need existed.

7. HEAT INPUT COOLING. This column reports the heat energy used to drive absorption chillers.

8. ELEC INPUT COOLING. This column reports the electric energy used to drive refrigeration units 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. This column reports the electrical energy used in association with supplying heating. This includes the electrical consumption by draft fans, circulation pumps, electric boilers, and hot water storage pumps.

11. FUEL INPUT ELEC. This column reports the fuel used by diesel and gas turbine generators.

12. TOTAL FUEL INPUT. This column reports the sum of users of fossil fuels.

13. TOTAL SITE ENERGY. This column reports the sum of purchased fossil fuel, electricity, chilled water, and steam.

14. TOTAL SOURCE ENERGY. The information in this column is 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 and the results are summed.

EXAMPLE BUILDING 3A, CHICAGO   DOE-2.1   13 MAR 80   10.19.09   PDL RUN 1

REPORT- PS-A PLANT ENERGY UTILIZATION SUMMARY

	SITE ENERGY												SOURCE
	2	3	4	5	6	7	8	9	10	11	12	13	14
MONTH	TOTAL HEAT LOAD	TOTAL COOLING LOAD	TOTAL ELECTR LOAD	RCVRED ENERGY	WASTED RCVRABL ENERGY	HEAT INPUT COOLING	ELEC INPUT COOLING	FUEL INPUT HEATING	ELEC INPUT HEATING	FUEL INPUT ELECT	TOTAL FUEL INPUT	TOTAL SITE ENERGY	TOTAL SOURCE ENERGY
JAN	21.9	0.	19.3	0.	0.	0.	0.	33.4	1.3	0.	33.4	52.7	99.1
			5.7E				0. E		.4E				
FEB	16.7	0.	16.8	0.	0.	0.	0.	26.9	1.1	0.	26.9	43.7	84.1
			4.9E				0. E		.3E				
MAR	8.3	.8	18.5	0.	0.	0.	.5	13.8	.6	0.	13.8	32.3	76.8
			5.4E				.1E		.2E				
APR	1.1	4.2	19.2	0.	0.	0.	1.7	2.1	.1	0.	2.1	21.3	67.4
			5.6E				.5E		.0E				
MAY	.0	10.6	21.8	0.	0.	0.	3.8	.1	.0	0.	.1	21.9	74.4
			6.4E				1.1E		.0E				
JUN	0.	23.3	24.5	0.	0.	0.	7.6	0.	0.	0.	0.	24.5	83.4
			7.2E				2.2E		0. E				
JUL	0.	35.6	29.1	0.	0.	0.	10.8	0.	0.	0.	0.	29.1	99.0
			8.5E				3.2E		0. E				
AUG	0.	33.0	28.5	0.	0.	0.	10.2	0.	0.	0.	0.	28.5	97.0
			8.4E				3.0E		0. E				
SEP	0.	15.7	22.1	0.	0.	0.	5.4	0.	0.	0.	0.	22.1	75.3
			6.5E				1.6E		0. E				
OCT	.5	6.3	20.1	0.	0.	0.	2.5	1.0	.0	0.	1.0	21.1	69.4
			5.9E				.7E		.0E				
NOV	6.2	1.7	18.1	0.	0.	0.	.8	10.6	.5	0.	10.6	28.6	72.0
			5.3E				.2E		.1E				
DEC	15.7	0.	18.4	0.	0.	0.	0.	25.1	1.0	0.	25.1	43.6	87.8
			5.4E				0. E		.3E				
	=======	=======	=======	=======	=======	=======	=======	=======	=======	=======	=======	=======	=======
	70.3	131.1	256.6	0.	0.	0.	43.3	113.0	4.6	0.	113.0	369.6	985.9
			75.2E				12.7E		1.4E				

NOTE-- ALL ENTRIES ARE IN MBTU EXCEPT
ENTRIES FOLLOWED BY E ARE IN MWH (THOUSANDS OF KWH)

REPORT PS-B - MONTHLY PEAKS AND TOTAL ENERGY USE

The information reported treats the electric utility, the diesel, the gas turbine, the boiler, and purchased steam as prime energy users. All other types of plant equipment are considered as auxiliaries, (i.e., storage, heat recovery, pumps, towers, etc.). Therefore, the report shows these types of equipment (whether or not they are part of the plant) for each month, plus the peak energy demand and the day and hour it occurred. Note that the values are at the site. To calculate the peak electrical demand, the user should divide PEAK (MBtuh) by 3413 Btu/kWh.

Up to five of the following user-specified fuels may be printed out in the column headings.

ELECTRICITY
CHILLED-WATER
STEAM
NATURAL-GAS
LPG
FUEL-OIL
DIESEL-OIL
COAL
METHANOL
BIOMASS

EXAMPLE BUILDING 3A, CHICAGO DOE-2.1 13 MAR 80 13.19.09 PDL RUN 1

REPORT- PS-B MONTHLY PEAK AND TOTAL ENERGY USE

MO	UTILITY-	ELECTRICITY	NATURAL-GAS
	TOTAL(MBTU)	19.315	33.426
JAN	PEAK(MBTU)	.072	.195
	DY/HR	31/11	2/ 9
	TOTAL(MBTU)	16.832	26.895
FEB	PEAK(MBTU)	.072	.188
	DY/HR	27/11	4/ 9
	TOTAL(MBTU)	18.500	13.849
MAR	PEAK(MBTU)	.072	.184
	DY/HR	27/11	25/ 9
	TOTAL(MBTU)	19.220	2.066
APR	PEAK(MBTU)	.113	.154
	DY/HR	29/10	1/ 9
	TOTAL(MBTU)	21.836	.082
MAY	PEAK(MBTU)	.119	.028
	DY/HR	21/10	9/ 8
	TOTAL(MBTU)	24.530	0.
JUN	PEAK(MBTU)	.124	0.
	DY/HR	20/14	30/24
	TOTAL(MBTU)	29.117	0.
JUL	PEAK(MBTU)	.131	0.
	DY/HR	8/10	31/24
	TOTAL(MBTU)	28.531	0.
AUG	PEAK(MBTU)	.127	0.
	DY/HR	26/14	31/24
	TOTAL(MBTU)	22.141	0.
SEP	PEAK(MBTU)	.123	0.
	DY/HR	11/14	30/24
	TOTAL(MBTU)	20.119	.985
OCT	PEAK(MBTU)	.106	.158
	DY/HR	31/11	21/ 8
	TOTAL(MBTU)	18.055	10.554
NOV	PEAK(MBTU)	.105	.162
	DY/HR	1/15	25/ 9
	TOTAL(MBTU)	18.429	25.146
DEC	PEAK(MBTU)	.072	.181
	DY/HR	31/11	9/ 9

REPORT- PS-B MONTHLY PEAK AND TOTAL ENERGY USE

--(CONTINUED)--------

UTILITY-	ELECTRICITY	NATURAL-GAS
ONE YEAR	256.624	113.004
USE/PEAK	.131	.195
YEAR COST (K$)	4.0	.2
COST ESCLTN (PCT)	5.0	5.0
TOTAL YEAR USE (MBTU)	369.629	
TOTAL YEAR COST (K$)	4.2	

NOTE -- YEAR COST IS IN CURRENT DOLLARS

REPORT PS-C - EQUIPMENT PART LOAD OPERATION

This report shows the hours spent in each part load ratio range, in increments of 10 per cent. If equipment is oversized, the equipment will never indicate any hours in the 100-110 per cent range.

The TOTAL HOURS entry differs from the total hours in other reports. In this report, TOTAL HOURS refers to the total hours of the day during which one or more units of a given equipment type are operating. This sum is independent of the number of units operating. If three boilers are operating during a given hour, TOTAL HOURS is increased by one rather than three.

ANNUAL LOAD is the useful load handled by the equipment. A FALSE LOAD occurs when, because of OPEN-CENT-UNL-RAT setting (the minimum load that a compression chiller can output without false loading.

ELEC USED is the total electrical energy used by the indicated equipment type. THERMAL USED refers either to the fuel consumed or the heat required for operation, from wherever it arises.

If there had been more than one piece of equipment of the same type, staged for availability, the first line of values for each type is the hours spent in the partial load ratio range for the available capacity. The second line is hours spent for each type in the partial load ratio range for the total capacity. Obviously, when only one piece of equipment is installed, the available capacity and the total capacity are identical.

REPORT- PS-C EQUIPMENT PART LOAD OPERATION

EQUIPMENT	HOURS AT PERCENT PART LOAD RATIO 0 -- 10 -- 20 -- 30 -- 40 -- 50 -- 60 -- 70 -- 80 -- 90 -- 100 - 110+											TOTAL HOURS	ANNUAL LOAD (MBTU)	FALSE LOAD (MBTU)	ELEC USED (MBTU)	THERMAL USED (MBTU)
HW-BOILER	938	350	176	121	99	69	42	45	99	67	31	2037	70.3	0.	3.4	113.0
	938	350	176	121	99	69	42	45	99	67	31					
OPEN-REC-CHLR	131	136	61	36	73	132	223	216	135	68	0	1211	131.1	0.	33.7	0.
	131	136	61	36	73	132	223	216	135	68	0					
COOLING-TWR	124	121	80	28	52	116	199	255	157	65	14	1211	161.5	0.	6.9	0.
	124	121	80	28	52	116	199	255	157	65	14					

HOT LOOP CIRCULATION PUMP ELECTRICAL USE = 1.2 MBTU
COLD LOOP CIRCULATION PUMP ELECTRICAL USE = 2.7 MBTU

NOTES TO TABLE

1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE HOURLY OPERATING CAPACITY

2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS THE HOURLY LOAD DIVIDED BY THE TOTAL INSTALLED CAPACITY

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.

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 DEMAND 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.

The user should be aware that, when PLANT begins its simulation, it assumes that there is no usable energy in the storage tanks. Furthermore, at the end of the simulation there may be significant amounts of RESIDUAL energy remaining. No account of this residual energy is made in other PLANT reports, with the consequence that the total fuel use reported overestimates the heating load met for the run period. The residual energy in the tank is available for the next period of time (beyond the run period) and should properly be subtracted from the reports on site energy used.

Note: A cooling tower can always reject any heat load given to it. If the tower is undersized, the leaving tower water temperature will be hotter, which will degrade chiller performance.

REPORT- PS-D PLANT LOADS SATISFIED

HEATING INPUTS	MBTU SUPPLIED	PCT OF TOTAL LOAD
HW-BOILER	70.3	100.0
LOAD SATISFIED	70.3	100.0
TOTAL LOAD ON PLANT	70.3	

COOLING INPUTS	MBTU SUPPLIED	PCT OF TOTAL LOAD
OPEN-REC-CHLR	131.1	100.0
LOAD SATISFIED	131.1	100.0
TOTAL LOAD ON PLANT	131.1	

ELECTRICAL INPUTS	MBTU SUPPLIED	PCT OF TOTAL LOAD
ELECTRICITY	256.6	100.0
LOAD SATISFIED	256.6	100.0
TOTAL LOAD ON PLANT	256.6	

TOWER ABOVE DESIGN TEMPERATURE OF 85.F 9 HOURS
MAXIMUM TOWER EXIT TEMPERATURE = 87.F

SUMMARY OF LOADS MET

TYPE OF LOAD	TOTAL LOAD (MBTU)	LOAD SATISFIED (MBTU)	TOTAL OVERLOAD (MBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING INPUTS	70.3	70.3	0.	0.	0
COOLING INPUTS	131.1	131.1	.015	.005	12
ELECTRICAL INPUTS	256.6	256.6	0.	0.	0

REPORT PS-G - ELECTRICAL LOADS SCATTER PLOT

In this scatter plot the ordinate, shown in the left most column, is the electrical demand divided into 13 blocks ranging 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. Thus there were 358 days of the year when the electrical demand between midnight and 1:00 a.m. was between 3 and 0 kWh. Similarly there were 122 days in the year when the electrical demand was between 18 and 15 kWh in the 9th hour between 8:00 a.m. and 9:00 a.m.

The right most column is the sum of the entries in each row and shows the relative frequency of the electrical demand throughout the year.

The bottom row is the frequency of the electrical demand for each hour of the average day.

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

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
	39	0	0	0	0	0	0	0	0	4	10	6	0	3	10	6	1	0	0	0	0	0	0	0	0	40
	36	0	0	0	0	0	0	0	3	34	44	42	10	35	51	48	27	27	0	0	0	0	0	0	0	321
	33	0	0	0	0	0	0	0	19	29	25	30	51	41	24	35	52	52	0	0	0	0	0	0	0	358
	30	0	0	0	0	0	0	0	35	8	4	9	24	14	12	10	18	18	5	0	0	0	0	0	0	157
D	27	0	0	0	0	0	0	0	1	12	14	13	13	12	11	12	10	7	3	0	0	0	0	0	0	108
E	24	0	0	0	0	0	0	0	17	8	9	13	11	11	12	12	13	16	5	0	0	0	0	0	0	127
M K	21	0	0	0	0	0	0	0	4	36	147	140	124	22	133	130	131	110	90	0	0	0	0	0	0	1067
A W	18	0	0	0	0	0	0	0	48	122	0	0	20	115	0	0	1	23	23	1	0	0	0	0	0	353
N	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
D	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	127	124	0	0	0	0	0	251
	9	1	1	1	1	0	0	0	0	0	0	2	2	3	2	2	3	3	3	2	3	0	0	0	0	29
	6	6	4	4	3	5	5	4	3	3	4	2	3	2	3	3	2	2	3	134	258	134	9	10	11	617
	3	358	360	360	361	360	360	361	235	109	108	108	107	107	107	107	107	107	106	103	104	231	356	355	354	5331
PERCENT TOTAL DEMAND		.7	.7	.7	.7	.7	.7	.7	4.6	8.0	8.8	8.9	8.4	8.4	8.8	9.0	8.7	8.5	5.4	2.9	1.7	1.1	.7	.7	.7	

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KW	PCT
SYSTEMS LOAD	21.545	56.1
CIRCULATION PUMPS	.650	1.7
OPEN-REC-CHLR	14.428	37.5
COOLING-TWR	1.812	4.7
TOTAL	38.435	

REPORT PS-H - EQUIPMENT USE STATISTICS

This report gives the user an assessment of the appropriateness of the equipment selected.

1) AVG OPER RATIO is the point, on the average, at which the equipment operates on its part load curve.

2) MAX LOAD (MBTU) - MON-DAY-HR gives the maximum demand loading and the time of occurrence. This value should compare favorably with the size of the equipment selected.

3) SIZE (MBTU) is the equipment size selected either automatically by the program or as input by the user.

4) OPER HRS is the total number of equipment-hours the equipment was "on." If more than one unit is involved there is space to report four more units by size and operating hours. If there are two pieces of equipment of the same size, the value for OPER HRS is the sum of the number of hours that each operates.

REPORT- PS-H EQUIPMENT USE STATISTICS

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
HW-BOILER	.246	.159	1	2	9	.140	2037								
OPEN-REC-CHLR	.570	.201	7	15	10	.190	1211								
COOLING-TWR	.556	.244	7	15	10	.240	1211								

REPORT PS-I - EQUIPMENT LIFE CYCLE COSTS

For each piece of equipment the report generates information as follows:

1) Nominal Size in MBtuh

2) Number Installed

3) First Cost of Equipment

4) Annual Cost is the present value of life-cycle cost for maintenance and consumables.

5) Cyclical Costs gives the present value of the life-cycle cost for major and minor overhauls and for equipment replacement.

The user must review Table V.1 to make sure that equipment-cost-related default values are appropriate. Otherwise, the information in this report will be of little value.

The first column of numbers gives the total life-cycle cost for each equipment type. The second column gives the components of this total for all pieces of equipment of that type. The remaining column gives the cost components for each size of equipment. If there is only one size, columns two and three will be identical.

REPORT- PS-I EQUIPMENT LIFE CYCLE COSTS

E Q U I P M E N T T O T A L S

HW-BOILER		1.3		
	NOMINAL SIZE (MBTU)			.140
	NUMBER INSTALLED			1
	FIRST COST (K$)		0.	0.
	ANNUAL COST (K$)		.6	.6
	CYCLICAL COST (K$)		.8	.8
	-----TOTAL----(K$)			1.3
OPEN-REC-CHLR		4.5		
	NOMINAL SIZE (MBTU)			.190
	NUMBER INSTALLED			1
	FIRST COST (K$)		0.	0.
	ANNUAL COST (K$)		1.6	1.6
	CYCLICAL COST (K$)		2.9	2.9
	-----TOTAL----(K$)			4.5
COOLING-TWR		12.0		
	NOMINAL SIZE (MBTU)			.240
	NUMBER INSTALLED			1
	FIRST COST (K$)		0.	0.
	ANNUAL COST (K$)		8.3	8.3
	CYCLICAL COST (K$)		3.7	3.7
	-----TOTAL----(K$)			12.0
EQUIPMENT TOTAL		17.8		

REPORT PS-J - PLANT LIFE-CYCLE COST SUMMARY

The upper portion of this report gives the following quantities:

FIRST COST (INCLUDING INSTALLATION) is the total initial purchase price of all the plant equipment, including the cost of installation.

REPLACEMENTS is the present value of the life-cycle plant replacement costs.

ENERGY is the present value of the life-cycle energy cost.

OPERATIONS is the present value of the life-cycle operations cost.

TOTAL is the sum of the previous four numbers.

The next portion of the report gives the annual energy use, in 10^6 Btu, at the site and at the source.

The final portion gives the present value of the energy and operations cost for each year of the project lifetime.

REPORT- PS-J PLANT LIFE-CYCLE COST SUMMARY

LIFE-CYCLE PLANT COSTS FOR 25.0 YEARS

FIRST COST (INCLUDING INSTALLATION) ($)	REPLACEMENTS ($)	ENERGY ($)	OPERATIONS ($)	TOTAL ($)
0.	3525.	70242.	13460.	87227.

ANNUAL ENERGY USE

AT SITE	369.6	MBTU PER YEAR
AT SOURCE	985.9	MBTU PER YEAR

ANNUAL ENERGY AND PLANT-OPERATIONS COSTS

YEAR	PRESENT VALUE OF ANNUAL ENERGY COST($)	PRESENT VALUE OF ANNUAL OPERATIONS COST($)
1	4104.	1049.
2	3964.	1296.
3	3829.	867.
4	3699.	1075.
5	3573.	745.
6	3452.	863.
7	3336.	617.
8	3224.	1159.
9	3115.	489.
10	3011.	611.
11	2911.	404.
12	2814.	507.
13	2721.	348.
14	2631.	407.
15	2544.	367.
16	2461.	472.
17	2380.	300.
18	2303.	216.
19	2228.	597.
20	2156.	179.
21	2087.	212.
22	2020.	181.
23	1955.	176.
24	1893.	181.
25	1833.	142.
TOTALS($)	70242.	13460.

REPORT BEPS - ESTIMATED BUILDING ENERGY PERFORMANCE

The information in this report has been calculated and formatted to comply with the U.S. Department of Energy's Building Energy Performance Standards. The report makes it possible to review quickly the building performance as a function of site energy used (by type) per unit floor area. The breakdown of usage of up to five different types of energy sources is presented. These energy sources are user-specified through the ENERGY-COST and PLANT-PARAMETERS instructions.

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 includes all equipment 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 instruction and any entries for SOURCE-TYPE = HOT-WATER in the SPACE-CONDITIONS instruction.

Vertical transportation (shown as VERT TRANS) is the summary of energy for elevators and escalators input through the BUILDING-RESOURCE instruction.

Loads that are input through the 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 (i.e., 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.

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 instruction 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.

REPORT- BEPS ESTIMATED BUILDING ENERGY PERFORMANCE

ENERGY TYPE IN SITE MBTU -	ELECTRICITY	NATURAL-GAS
CATEGORY OF USE		
SPACE HEAT	3.42	113.00
SPACE COOL	40.59	0.
HVAC AUX	17.87	0.
DOM HOT WTR	0.	0.
AUX SOLAR	0.	0.
LIGHTS	150.00	0.
VERT TRANS	0.	0.
MISC EQUIP	44.75	0.
TOTAL	256.62	113.00

TOTAL SITE ENERGY	369.63 MBTU	73.9 KBTU/GROSS-SQ-FT	73.9 KBTU/NET-SQ-FT
TOTAL SOURCE ENERGY	985.88 MBTU	197.2 KBTU/GROSS-SQ-FT	197.2 KBTU/NET-SQ-FT

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 19.0
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = .1

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

MBTU = MILLIONS OF BTU

HOURLY REPORTS

These optional reports are user-designed. The variables which are to be displayed are chosen by the user from the lists in this chapter (see REPORT-BLOCK).

1.	MMDDHH	is the month, day, and hours of the simulation period.
2.	PLANT SYS HEAT LOAD	The total heating load (in Btu) that is passed from SYSTEMS to PLANT.
3.	PLANT STANDBY FLAG CLG	A flag indicating that cooling is available in a standby mode.
4.	PLANT TOTAL COOLING	The total PLANT cooling load (in Btu).
5.	PLANT TOTAL ELECTRIC	The total PLANT electrical load (in Btu).

MMDDHH	PLANT SYS HEAT LOAD	PLANT SYS COOL LOAD	PLANT STANDBY FLAG CL	PLANT TOTAL COOLING	PLANT TOTAL ELECTRIC
716 1	0.	0.	0.	0.	2902.
716 2	0.	0.	0.	0.	2902.
716 3	0.	0.	0.	0.	2902.
716 4	0.	0.	0.	0.	2902.
716 5	0.	0.	0.	0.	2902.
716 6	0.	0.	0.	0.	2902.
716 7	0.	0.	0.	0.	2902.
716 8	0.	159147.	0.	163138.	108394.
716 9	0.	165365.	0.	169355.	120375.
71610	0.	165262.	0.	169253.	123331.
71611	0.	165323.	0.	169314.	120785.
71612	0.	163033.	0.	167023.	112981.
71613	0.	163615.	0.	167606.	118131.
71614	0.	166133.	0.	170124.	122010.
71615	0.	168382.	0.	172373.	120745.
71616	0.	166917.	0.	170907.	117421.
71617	0.	162344.	0.	166334.	116584.
71618	0.	0.	0.	0.	35837.
71619	0.	0.	0.	0.	15360.
71620	0.	0.	0.	0.	10581.
71621	0.	0.	0.	0.	2902.
71622	0.	0.	0.	0.	2902.
71623	0.	0.	0.	0.	2902.
71624	0.	0.	0.	0.	2902.
717 1	0.	0.	0.	0.	2902.
717 2	0.	0.	0.	0.	2902.
717 3	0.	0.	0.	0.	2902.
717 4	0.	0.	0.	0.	2902.
717 5	0.	0.	0.	0.	2902.
717 6	0.	0.	0.	0.	2902.
717 7	0.	0.	0.	0.	2902.
717 8	0.	142156.	0.	146146.	104292.
717 9	0.	155781.	0.	159772.	117585.
71710	0.	160133.	0.	164123.	121934.
71711	0.	167174.	0.	171164.	121231.
71712	0.	166483.	0.	170473.	114188.
71713	0.	169355.	0.	173345.	120093.
71714	0.	169855.	0.	173846.	123973.
71715	0.	170651.	0.	174641.	122406.
71716	0.	170376.	0.	174367.	119315.
71717	0.	167692.	0.	171683.	118843.
71718	0.	0.	0.	0.	35837.
71719	0.	0.	0.	0.	15360.
71720	0.	0.	0.	0.	10581.
71721	0.	0.	0.	0.	2902.
71722	0.	0.	0.	0.	2902.
71723	0.	0.	0.	0.	2902.
71724	0.	0.	0.	0.	2902.

E. ECONOMICS OUTPUT REPORT DESCRIPTIONS

To fully explain the following sample output reports from ECONOMICS it is necessary to first display the input data. The first command of the input is, of course, INPUT ECONOMICS ..

The VERIFICATION report for ECONOMICS appears first followed by the available SUMMARY reports.

E D L   P R O C E S S O R   I N P U T   D A T A

13 MAR 80   10.19.09   EDL RUN 1

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   $ ECONOMICS - BASELINE AND NON-PLANT DESCRIPTION $

  ECONOMICS-REPORT      SUMMARY = (ALL-SUMMARY)
                        VERIFICATION = (ALL-VERIFICATION)   ..

  ROOF-INSUL = COMPONENT-COST   UNIT-NAME = *SQFT*
               NUMBER-OF-UNITS = 5000
               FIRST-COST = 0.80
               INSTALL-COST = 0.20   ..

  BASELINE     FIRST-COST = 0.00
               REPLACE-COST = 4462.00
               OPERATIONS-COST = (1090,991,1202,820,1357,678,821,710,
                                  679,696,561,383,464,478,383,333,316,
                                  216,357,329,378,148,214,184,148 )

               ENERGY-COST = (4417,4271,4130,3994,3863,3737,3615,3498,3386,
                              3277,3172,3071,2974,2880,2790,2703,2619,2538,
                              2460,2385,2313,2243,2176,2111,2049)

              ENERGY-USE-SITE = 428.00
              ENERGY-USE-SRC  = 924.60   ..

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

EV-A: LIFE-CYCLE COSTING PARAMETERS
AND BUILDING COMPONENT COST INPUT DATA.

Life-Cycle Costing Parameters

This report section echoes data originally specified by the user in PDL and automatically passed to the ECONOMICS program.

DISCOUNT RATE	is the rate in per cent used in calculating present value.
LABOR INFLATION RATE	is the annual inflation rate (relative to general inflation) of labor cost, in per cent. Installation, maintenance, and overhaul costs are inflated at this rate in calculating present values.
MATERIALS INFLATION RATE	IS THE ANNUAL INFLATION RATE (relative to general inflation) of material costs, in per cent. Capital replacement costs are inflated at this rate in calculating present values.
PROJECT LIFE	is the period, in years, over which the life-cycle cost analysis is performed. This number can range from 1 to 25 years.

Building Component Cost Input Data

This report section echoes building (nonplant) component cost data input with each COMPONENT-COST instruction. The costs here are in current dollars, that is, they correspond to the prices that apply at the start of the analysis period.

COST NAME	is the U-name of the component.
NUMBER OF UNITS	multiplies all costs. Defaults to 1.0 if not specified.
UNIT NAME	is the name assigned to the unit (such as SQFT or CUFT) by the user to identify the size of the unit. This name is arbitrary and optional and is for user convenience only.
LIFE	is the life expectancy of the component, in years. It is used in calculating replacement costs. Defaults to 999 years if not specified.
UNIT FIRST COST	is the purchase price of each unit of the component, in dollars, exclusive of installation.
UNIT INSTALLATION COST	is the installation cost for each unit of the component, in dollars.
UNIT ANNUAL MAINT COST	is the yearly maintenance cost of each unit of the component, in dollars.

UNIT MINOR OVERHAUL COST	is the cost, in dollars, of a minor overhaul for each unit of the component.
MINOR OVERHAUL INTERVAL	is the number of years between minor overhauls.
UNIT MAJOR OVERHAUL COST	is the cost, in dollars, of a major overhaul for each unit of the component.
MAJOR OVERHAUL INTERVAL	is the number of years between major overhauls.

REPORT- EV-A LIFE-CYCLE COSTING PARAMETERS AND BUILDING COMPONENT COST INPUT DATA

LIFE-CYCLE COSTING PARAMETERS

DISCOUNT RATE (PERCENT)	LABOR INFLATION RATE (PERCENT)	MATERIALS INFLATION RATE (PERCENT)	PROJECT LIFE (YRS)
10.0	0.	0.	25.0

BUILDING COMPONENT COST INPUT DATA (CURRENT DOLLARS)

COST NAME	NUMBER OF UNITS	UNIT NAME	LIFE (YRS)	UNIT FIRST COST ($)	UNIT INSTALL -ATION COST ($)	UNIT ANNUAL MAINT COST ($)	UNIT MINOR OVERHAUL COST ($)	MINOR OVERHAUL INTERVAL (YRS)	UNIT MAJOR OVERHAUL COST ($)	MAJOR OVERHAUL INTERVAL (YRS)
ROOF-INSUL	5000.0	SQFT	999.0	.80	.20	0.	0.	999.00	0.	999.00

b. ES-A: ANNUAL ENERGY AND OPERATIONS COSTS AND SAVINGS.

This report gives the present value of energy and operations costs for each year of the project lifetime. Costs are given both for the baseline and for the building being analyzed in the present run. Operations include costs of annual maintenance and major and minor overhauls. For the building being analyzed in this run, operations costs are given separately for plant equipment and for the building (nonplant) components specified using COMPONENT-COST instructions.

ENERGY COST BASELINE	is the present value of the yearly baseline energy cost. These values echo those input using the BASELINE instruction.
ENERGY COST THIS RUN	is the present value of the yearly energy cost for the building being analyzed in this run. These costs are calculated in PLANT and passed to ECONOMICS.
ENERGY COST SAVINGS	is the difference between the above two quantities.
OPRNS COST BASELINE	is the present value of the yearly baseline operations cost.
OPRNS COST--THIS RUN	gives the present value of the yearly operations cost for plant equipment and building components, and for the sum, for the building being analyzed in this run.
OPRNS COST SAVINGS	is the difference between OPRNS COST BASELINE and OPRNS COST--THIS RUN, TOTAL.
TOTAL SAVINGS-ENERGY PLUT OPRNS	is the sum of ENERGY COST SAVINGS and OPRNS COST SAVINGS.

The bottom line of this report (TOTALS) gives the present value of the life-cycle energy and operations costs and savings.

Note: The user must enter baseline cost data in the BASELINE instruction for the "savings" values in this report to be meaningful.

REPORT- ES-A ANNUAL ENERGY AND OPERATIONS COSTS AND SAVINGS

YEAR	ENERGY (K$): ENERGY COST BASELINE	ENERGY (K$): ENERGY COST THIS RUN	ENERGY (K$): ENERGY COST SAVINGS	OPERATIONS (K$): OPRNS COST BASELINE	OPERATIONS (K$): OPRNS COST -- THIS RUN: PLANT	OPERATIONS (K$): OPRNS COST -- THIS RUN: BUILDING	OPERATIONS (K$): OPRNS COST -- THIS RUN: TOTAL	OPERATIONS (K$): OPRNS COST SAVINGS	TOTAL SAVINGS- ENERGY PLUS OPRNS
1	4.42	4.10	.31	1.09	1.05	0.	1.05	.04	.35
2	4.27	3.96	.31	.99	1.30	0.	1.30	-.31	.00
3	4.13	3.83	.30	1.20	.87	0.	.87	.34	.64
4	3.99	3.70	.30	.82	1.08	0.	1.08	-.26	.04
5	3.86	3.57	.29	1.36	.75	0.	.75	.61	.90
6	3.74	3.45	.28	.68	.86	0.	.86	-.19	.10
7	3.62	3.34	.28	.82	.62	0.	.62	.20	.48
8	3.50	3.22	.27	.71	1.16	0.	1.16	-.45	-.17
9	3.39	3.12	.27	.68	.49	0.	.49	.19	.46
10	3.28	3.01	.27	.70	.61	0.	.61	.09	.35
11	3.17	2.91	.26	.56	.40	0.	.40	.16	.42
12	3.07	2.81	.26	.38	.51	0.	.51	-.12	.13
13	2.97	2.72	.25	.46	.35	0.	.35	.12	.37
14	2.88	2.63	.25	.48	.41	0.	.41	.07	.32
15	2.79	2.54	.25	.38	.37	0.	.37	.02	.26
16	2.70	2.46	.24	.33	.47	0.	.47	-.14	.10
17	2.62	2.38	.24	.32	.30	0.	.30	.02	.25
18	2.54	2.30	.24	.22	.22	0.	.22	-.00	.24
19	2.46	2.23	.23	.36	.60	0.	.60	-.24	-.01
20	2.39	2.16	.23	.33	.18	0.	.18	.15	.38
21	2.31	2.09	.23	.38	.21	0.	.21	.17	.39
22	2.24	2.02	.22	.15	.18	0.	.18	-.03	.19
23	2.18	1.96	.22	.21	.18	0.	.18	.04	.26
24	2.11	1.89	.22	.18	.18	0.	.18	.00	.22
25	2.05	1.83	.22	.15	.14	0.	.14	.01	.22
TOTALS(K$)	76.67	70.24	6.43	13.94	13.46	0.	13.46	.48	6.91

ES-B: LIFE-CYCLE BUILDING AND PLANT NON-ENERGY COSTS.

This report summarizes life-cycle costs (other than for energy) for plant equipment and for each building component.

FIRST COST	is the initial purchase price, including installation.
REPLACEMENTS	is the present value of the life-cycle replacement costs.
OPERATIONS	is the present value of the life-cycle cost for annual maintenance and major and minor overhauls.
TOTAL	gives the sum of the previous three quantities.
INVESTMENT	is the sum of the first two quantities, FIRST COST and REPLACEMENTS. Note that the investment does not include operations or energy costs.

REPORT- ES-B LIFE-CYCLE BUILDING AND PLANT NON-ENERGY COSTS

LIFE-CYCLE BUILDING AND PLANT NON-ENERGY COSTS (K$)

COST NAME	FIRST COST (INCLUDING INSTALLATION)	REPLACEMENTS	OPERATIONS	TOTAL	INVESTMENT (FIRST COST PLUS REPLACEMENTS)
ROOF-INSUL	5.00	0.	0.	5.00	5.00
PLANT EQUIPMENT	0.	3.52	13.46	16.98	3.52
TOTALS	5.00	3.52	13.46	21.98	8.52

ES-C: ENERGY SAVINGS, INVESTMENT STATISTICS, AND OVERALL LIFE-CYCLE COSTS.

Energy Savings

This section summarizes the annual energy use in 10^6 Btu at the site and at the source for the baseline and for the present building.

Investment Statistics

INVESTMENT THIS RUN	is the total investment associated with the present building. This number is the same as the total investment in building components and plant equipment given in Report ES-B.

The following quantities are meaningful only if baseline costs and energy use have been specified.

BASELINE REPLACEMENT COSTS	gives the present value of life-cycle replacement costs for the baseline. This quantity is specified by the keyword REPLACE-COST OF THE BASELINE instructions.
INCREMENTAL INVESTMENT	is the INVESTMENT THIS RUN minus the sum of BASELINE REPLACEMENT COSTS and BASELINE FIRST COST.
COST SAVINGS	is the present value of the life-cycle savings in energy and operations costs. This number is also given in Report ES-A.
RATIO OF SAVINGS TO INCREMENTAL INVESTMENT (SIR)	gives dollars saved per dollar invested. It is the ratio of COST SAVINGS and INCREMENTAL INVESTMENT. If this ratio is greater than 1.0, the investment is cost effective.
DISCOUNTED PAYBACK PERIOD	is the number of years it takes for the accumulated cost savings to equal the incremental investment. The shorter the payback period, the more cost effective is the investment.
RATIO OF LIFE-CYCLE ENERGY SAVINGS (AT SITE) TO INCREMENTAL INVESTMENT	gives the life-cycle site energy saved (in units of 10^6 Btu) per incremental investment dollar.
RATIO OF LIFE-CYCLE ENERGY SAVINGS (AT SOURCE) TO INCREMENTAL INVESTMENT	gives the life-cycle source energy saved (in units of 10^6 Btu) per incremental investment dollar.

Overall Life-Cycle Costs

This section summarizes the life-cycle costs and savings for the following categories: first cost (including installation), operations, replacements, energy, and sum of all these.

REPORT- ES-C ENERGY SAVINGS, INVESTMENT STATISTICS, AND OVERALL LIFE-CYCLE COSTS

ENERGY SAVINGS

	ANNUAL ENERGY USE BASELINE (MBTU)	ANNUAL ENERGY USE THIS RUN (MBTU)	ANNUAL ENERGY SAVINGS (MBTU)	ANNUAL ENERGY SAVINGS (PCT)
AT SITE	428.0	369.6	58.4	13.6
AT SOURCE	924.6	985.9	-61.3	-6.6

INVESTMENT STATISTICS

PROJECT LIFE 25.0 YEARS

INVESTMENT THIS RUN (K$)	BASELINE REPLACEMENT COSTS (K$)	INCREMENTAL INVESTMENT (K$)	COST SAVINGS (K$)	RATIO OF SAVINGS TO INCREMENTAL INVESTMENT (SIR)	DISCOUNTED PAYBACK PERIOD (YEARS)	RATIO OF LIFE-CYCLE ENERGY SAVINGS (AT SITE) TO INCREMENTAL INVESTMENT (MBTU/$)	RATIO OF LIFE-CYCLE ENERGY SAVINGS (AT SOURCE) TO INCREMENTAL INVESTMENT (MBTU/$)
8.52	4.46	4.06	6.91	1.70	12.97	.36	-.38

OVERALL LIFE-CYCLE COSTS (K$)

	FIRST COST	OPRNS COST	REPLACEMENTS	ENERGY COST	T O T A L
BASELINE	0.	13.94	4.46	76.67	95.07
THIS RUN	5.00	13.46	3.52	70.24	92.23
SAVINGS(K$)	-5.00	.48	.94	6.43	2.84
(PCT)	0.	3.4	21.0	8.4	3.0

Please remove this section from the newsletter (pages VIII.1 through VIII.22) and use it to replace the original "Weather" section of the DOE-2.1A Reference Manual

DOE-2 Weather Processor

Fred Buhl

LBNL Simulation Research Group

April 1999

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Weather Data in DOE-2.1E

Introduction

The Loads and HVAC simulations in DOE-2 require hourly weather data, which are contained in DOE-2 weather files. These weather files are created from source hourly data by the DOE-2 weather processor program *doewth*. We describe here the weather variables used by DOE-2, the types and formats of source data, the various ways to use *doewth*, and how to process measured weather data or data in nonstandard formats.

Weather Variables

The weather variables used by DOE-2 and present on the weather file are as follows.

Hourly Variables

The DOE-2 weather file contains hourly data for one year (8760 hours). Leap years are ignored; all DOE-2 weather files are 365 days long. The hourly data on the weather files are:

Dry-bulb Temperature (F)
Wet-bulb Temperature (F)
Atmospheric Pressure (inches of Hg times 100)
Wind Speed (knots)
Wind Direction (compass points 0-15, with 0 being north, 1 NNE, etc.)
Cloud Amount (0 to 10, with 0=clear and 10=totally overcast)
Cloud Type (0, 1, or 2) 0 is cirrus or cirrostratus, the least opaque;
1 is stratus or stratus fractus, the most opaque; and
2 is all other cloud types, of medium opacity
Humidity Ratio (lb of water per lb of dry air)
Density of the Air (lb/ft^3)
Specific Enthalpy of the Air (Btu/lb)
Rain Flag (0 means it is not raining; 1 means it is)
Snow Flag (0 means it is not snowing; 1 means it is)

Hourly Solar Variables

There are two types of DOE-2 weather files: those with hourly solar values and those without. In the case of the files without solar data, DOE-2 calculates solar values using the ASHRAE clear sky model and the clearness numbers, cloud amounts, and cloud types from the DOE-2 weather file. The solar DOE-2 weather files contain the following hourly values:

- Total Horizontal Solar Radiation (Btu/hr-ft^2)
- Direct Normal Solar Radiation (Btu/hr-ft^2)

Monthly Variables

- Clearness Number (dimensionless). This is the ASHRAE clearness number; see, for example, p. 27.12, Figure 7, of the 1993 ASHRAE Handbook of Fundamentals.
- Ground Temperature (Rankine)

Header Data

The header record on the weather file contains the file identification, latitude, longitude, and time zone.

Source Data and Formats

Source Data

Source weather data for building energy simulation programs can be broken into two major classes: *historical data* and *typical weather years*. Historical data is just "real" data: usually measured (but sometimes modeled) data from a particular location for a given period of record. Typical years are ersatz years assembled to match the long term data from a particular location using a particular statistical measure.

The primary source for historical weather data is the U.S. National Climatic Data Center (NCDC) [1]. NCDC can provide hourly historical data for thousands of locations around the world. This data may not always be complete; data items or periods of record may be missing. A highly reliable source of historical data for U.S. locations is the Solar and Meteorological Surface Observational Network (SAMSON) data set assembled by the National Renewable Energy Laboratory (NREL)[2]. This contains a 30 year (1961 to 1990) period of record for 239 locations.

There are several sets of typical year data that are widely used in DOE-2 simulations. The TMY2 data set was derived from the SAMSON database by NREL. There are typical years for 239 locations in the US and its territories. NREL also developed the WYEC2 typical year data set for ASHRAE. The selection criteria were different for TMY2 and WYEC2, with TMY2 weighting the solar data more heavily. The California Energy Commission (CEC) has defined 16 climate zones with corresponding typical year data sets (CTZ2) for use in Title 24 energy code compliance. National Resources Canada (NRC) has funded WATSUN Energy Laboratory at the University of Waterloo to create typical weather years for Canada. There are files currently available for 51 locations.

Formats: TMY2, WYEC2, CD144 and TRY

Source data comes in various formats. Typically the files are ASCII, but the data items, units, item location, and record length vary from format to format. NCDC can provide historical data in a variety of formats: TD-3280, TD-9950 and TD-1440 (**CD144**). Of these, the DOE-2 weather processor can only process CD144, usually called TD-1440 by NCDC. Typical years now come in two formats: **TMY2** and **WYEC2**. Note that TMY2 and WYEC2 are names of both typical year data sets and data formats. The DOE-2 weather processor can process files in either TMY2 or WYEC2 format. The NREL TMY2 typical weather year data sets are in TMY2 format. The ASHRAE WYEC2, the Canadian CWEC, and the CEC CTZ2 typical weather year data sets are all in WYEC2 format. One other format worth mentioning is **TRY**. This is the format of an old, typical year data set that did not include solar radiation data. The format can still be useful, however, as a format for measured data. The DOE-2 weather processor can process data in this format and add modeled solar data to the DOE-2 weather file. The format is described below, under "Processing Nonstandard Weather Data."

Solar Data

Source weather data files may or may not contain solar data. All TMY2 and WYEC2 files contain solar data. The weather processor will transfer this data to the DOE-2 weather file and it will be used by the DOE-2 simulation program. Historical weather data files in CD144 format do not contain solar data nor is such data generally available for a specific location and time period. In this case, ersatz solar data must be generated from cloud cover and other data using sky models and regression formulas. This solar data generation can be done either in the weather processor or in the DOE-2 program itself. *When the DOE-2 program detects a DOE-2 weather file containing no solar data it will generate the solar data needed for the simulation.* However, it is more efficient and accurate to have the weather processor generate the solar data. To accomplish this, put CD144S instead of CD144 in line 3 of the weather processor input. For TRY format source data, put TRYSLM instead of TRY. CD144S or TRYSLM tells the weather processor to generate solar data and put it on the DOE-2 weather file for use by the DOE-2 simulation program.

TMY2

The following description is quoted from NREL's website at http://rredc.nrel.gov/solar/ old_data/nsrdb/tmy2/:

> *The TMY2s are data sets of hourly values of solar radiation and meteorological elements for a one-year period. Their intended use is for computer simulations of solar energy conversion systems and building systems to facilitate performance comparisons of different system types, configurations, and locations in the United States and its territories. Because they represent typical rather than extreme conditions, they are not suited for designing systems to meet the worst-case conditions occurring at a location.*
>
> *To distinguish between the old and new TMY data sets, the new TMY data sets are referred to as TMY2s. TMY and TMY2 data sets cannot be used interchangeably because of differences in time (solar versus local), formats, elements, and units. Unless they are revised, computer programs designed for TMY data will not work with TMY2 data.*
>
> *The TMY2 data sets and manual were produced by the National Renewable Energy Laboratory's (NREL's) Analytic Studies Division under the Resource Assessment Program, which is funded and monitored by the U.S. Department of Energy's Office of Solar Energy Conversion.*

[1] National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville, NC 28801-5001, http://www.ncdc.noaa.gov.
[2] National Renewable Energy Laboratory, 1617 Cole Boulevard, Golden, CO ;80401-3393, http://www.nrel.gov.

WYEC2

The following is quoted from the Watsun Simulation Lab website at http://dial.uwaterloo.ca/~watsun/ cwed.htm:

> *Canadian weather for energy calculations (CWEC) files are typical year sets of meteorological data in WYEC2 format; they include such quantities as solar radiation (global, diffuse, direct), dry-bulb, and dew point temperatures, wind speed and direction, atmospheric pressure, etc., on an hourly basis. They were developed by the Watsun Simulation Laboratory under the auspices of the National Research Council of Canada.*

The following description is quoted from the Watsun Simulation Lab website at http://dial.waterloo.ca//~watsun/ cwecovvw.htm:

> *The CWEC files are created by concatenating twelve Typical Meteorological Months selected from a database of, in most cases, 30 years of data. The method is similar to TMY procedure developed in the 1980s by Sandia National Laboratory. The months are chosen by statistically comparing individual with long-term monthly means for daily total global radiation, mean-, minimum- and maximum- dry-bulb temperatures, mean-, minimum- and maximum- dew point temperatures, and mean and maximum wind speeds. The composite index used to select the most 'typical' months uses the following weights (%):*

```
Parameter Dry  Dry  Dry  Dew   Dew   Dew   Wind  Wind  Daily
          Bulb Bulb Bulb Point Point Point Speed Speed Solar
          Max  Min  Mean Max   Min   Mean  Max   Mean  Rad.
          ---- ---- ---- ----- ----- ----- ----- ----- -----
Weight(%) 5    5    30   2.5   2.5   5     5     5     40
```

Additional consideration is given, in the selection process, to the statistics and persistence structures of the daily mean dry-bulb temperature and daily total radiation. A complete description of the procedure used can be found in: D.L. Siurna, L.J. D'Andrea, K.G.T. Hollands, "A Canadian Representative Meteorological Year for Solar System Simulation," Proceedings of the 10th Annual Conference of the Solar Energy Society of Canada (SESCI '84), August 1-6, 1984, Calgary, Alberta, Canada.

In the CWEC files, no missing values will be found in the following WYEC2 fields: extraterrestrial irradiance (101), global horizontal irradiance (102), direct normal irradiance (103), diffuse horizontal irradiance (104), weather (204), station pressure (205), dry-bulb temperature (206), dew point temperature (207), wind direction (208), wind speed (209), total sky cover (210), opaque sky cover (211), snow cover (212). The original long-term data sets (up to 40 years of data) from which the CWEC files were derived can also be obtained directly from Environment Canada.

Weather Processor

The DOE-2 weather processor is a batch or command-line program called *doewth* or *doewth.exe*, depending on the computing environment. The primary function of the weather processor is to read hourly weather data in a variety of formats, extract the data needed by DOE-2, and write a packed binary weather file that is used by the DOE-2 simulation program. In addition to its primary function (called packing) the weather processor can produce hourly listings of raw or packed weather files in a readable format and can produce a summary report of the data on a packed DOE-2 weather file.

Input and Output

The weather processor requires two input files. One, called WEATHR.TMP, is the hourly weather data. This will be either an ASCII (text) file, if raw weather data is being packed, or a binary file, if a packed DOE-2 file is being listed or summarized. The second input file, INPUT.TMP, is a short ASCII file that tells the weather processor what functions it is to perform and supplies any additional information needed to perform the task. This file is described in detail below. Output is on two files. The file OUTPUT. contains any listings, reports, and error messages. The file NEWTH.TMP contains the packed DOE-2 weather file, if one is being created. Copying, renaming, and saving these files will normally be performed by a procedure file specific to the computing environment being used.

Input Description

Here we describe the contents of the input file (INPUT.TMP) needed to perform the three functions:

- create a DOE-2 weather file (packing) (*PACK)*,
- listing a weather file (*LIST)* and
- producing a statistical summary (*STAT).*

PACK

line 1: The word PACK in columns 1-4.

line 2: The station name in columns 1-20. This name will be written on the output file as identification. The entry here is for the user only and is arbitrary.

line 3: The data is entered as shown below. When the format is shown as L, it signifies that the datum must be left justified in the columns indicated. The format R signifies that the datum must be right justified in the columns indicated, and the format D means that the value should be entered with a decimal point (neither right or left justification is required). For those with FORTRAN background: L corresponds to A6, R to I6, and D to F6.1.

Example of how the data is entered (line 3)

Columns	**Format**	**Description**
1-6	L	A code-word specifying the unpacked file type. Options are TMY2, WYEC2, CD144, CD144S[a],TRY, TRYSLM[a], TD9685, and OTHER[b].
7-12	R	Weather station number. This is required.
Note: for TMY2 files, the following inputs on line 3 may be left blank		
13-18	R	The year of the weather data (e.g., 1999). This is required for CD144 and TD9685 files (which can contain several years of weather data). For other files, –999 should be input.
19-24	R	Time zone (as in the SITE-PARAMETERS command)
25-30	D	Latitude (degrees). Positive north of the equator, negative south of the equator.
31-36	D	Longitude (degrees). Positive west of Greenwich, negative east of Greenwich.
37-42	L	A code-word specifying the number of bits per word to be used in packing the output file. The options are 60-BIT or 30-BIT (for 32-bit machines)
43-48	L	A code-word specifying the type of output file. The options are NORMAL and SOLAR. NORMAL produces a DOE-2 weather file with no solar data. SOLAR produces a file containing solar information.
49-54	R	Interpolation interval. The program fills in missing data by linear interpolation between the last and the next value present, if the number of hours of missing data is less than or equal to the interpolation interval. If more hours of data are missing than the interpolation interval, it still does interpolation up to 24 hours and a warning message is issued. If more than 24 hours are missing, the previous value is used. The interpolation interval must be less than 24[c].
55-60	D	This sets the maximum dry-bulb temperature change allowed in one hour. Changes larger than this will cause a warning message to be printed.
61-66	D	Soil thermal diffusivity (ft^2/hr). Used for calculating monthly ground temperatures. A value of 0.010 can be used for dry soil, 0.025 for average soil, and 0.050 for wet soil.
67-72	D	Station altitude (feet), used in CD144 and TD9685.
73-78	R	Location needed only for CD144S and TRYSLM to choose a cloud cover model. See ILOC. Used only for CD144 and TRY formats. Select the location that best represents the data being packaged.

[a] CD144S tells the weather processor to read a file in CD144 format and add ersatz solar data using the ASHRAE clear sky model, SOLMET cloud cover regressions formula, and the Erbs-Klein-Duffie direct/diffuse model. TRYSLM does the same for data in TRY formats.	[b] If OTHER is chosen, the data should either be in the DOE-2 measured weather data format (see Processing Nonstandard Weather Data) or a special OTHER processing subroutine must be written and installed in the weather processor. To accomplish the latter, the you must have the source code and a FORTRAN compiler.	[c] The weather processor makes no evaluation of the data to see that it is internally consistent, except that during interpolation it never allows the wet-bulb temperature to exceed the dry-bulb temperature, or the dew point temperature to exceed the wet-bulb temperature.

ILOC and Station Name			
01 ALBUQUERQUE, NM	08 CHARLESTON, SC	15 GREAT FALLS, MT	21 NEW YORK, NY
02 APALACHICOLA, FL	09 COLUMBIA, MO	16LAKE CHARLES, LA	22 NORTH OMAHA, NE
03 BISMARCK, ND	10 DODGE CITY, KS	17 MADISON, WI	23 PHOENIX, AZ
04 BOSTON, MA	11 EL PASO, TX	18 MEDFORD, OR	24 SANTA MARIA, CA
05 BROWNSVILLE, TX	12 ELY, NV	19 MIAMI, FL	25 SEATTLE-TACOMA,
06 CAPE HATTERAS, NC	13 FORT WORTH, TX	20 NASHVILLE, TN	26 WASHINGTON, DC
07 CARIBOU, ME	14 FRESNO, CA		

line 4: Contains the 12 clearness numbers (one per month) in D format in column intervals 1-6, 7-12, 13-18, etc. (skip for TMY2; unused for WYEC2, so can be just 1.0). See 1993 ASHRAE Fundamentals, p. 27.12.

line 5: Contains the 12 ground temperatures (one per month in F) in D format in column intervals 1-6, 7-12, 13-18, etc. (skip for TMY2). A value of –999 will flag the program to calculate the ground temperature using the method of Kusuda and Achenbach (ASHRAE Trans. 41 (1965) p. 61).

LIST

line 1: The word LIST in columns 1-4.

line 2:

Columns	Format	Description
1-6	L	Input type or file type. Options are PACKED, OTHER, TRY, WYEC2, CD144, TMY2 and TD9685.
7-12	R	Year of weather data (e.g., 1972). Required for CD144 and TD9685 files. Should be –999 if columns 1-6 is TRY, TMY2, WYEC2 or PACKED.
13-18	R	Station number. PACKED can have –999 entered here.
19-24	R	Beginning month of listing (1 to 12 for January to December)
25-30	R	Ending month of listing (1 to 12 for January to December)

STAT

Only one card is necessary for the STAT option with the word STAT in columns 1-4. STAT produces a statistical summary (average monthly temperatures, etc.) of the data on the weather file.

Multiple Options

To exercise several options in the same computer run simply concatenate the input for several functions. The last card in the entire file, whether running one or several options, must have the word END in columns 1-3.

Examples

1. To PACK, LIST for 12 months, and STAT a Mexico City CD144 file.

```
                  1         2         3         4         5         6
         123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890
line 1:  PACK
line 2:  MEXICO CITY 90
line 3:  CD144S 76679  1990     6 19.24 99.0930-BITSOLAR      4    20 .025  7329.    20
line 4:  0.9   0.9   0.9   0.9   0.9   0.9   0.9   0.9   0.9   0.9   0.9   0.9
line 5:  –999.
line 6:  LIST
line 7:  PACKED  –999  –999     1    12
line 8:  STAT
line 9:  END
```

2. To LIST the month of January 1990 from a Mexico City CD144 file.

```
                  1         2         3         4         5         6
         12345678901234567890123456789012345678901234567890123456789012345678901234567890123456
line 1:  LIST
line 2:  CD144   1990 76679     1     1
line 3:  END
```

3. TMY2 input.

```
PACK
```

```
Atlanta GA TMY2
TMY2   13874
STAT
END
```

ASCII Weather Files

Moving Data

This topic involves the transfer of packed weather files from one computer system to another. The weather files used by DOE-2 are packed, binary files and, therefore, they cannot be transferred from computer to computer unless the computer type and operating systems are identical. Frequently, the original raw data used to produce the packed files has been lost or discarded. When a new computer system is installed, or when it is necessary to do runs at another site, a method is needed to preserve and transfer the data contained in the packed files. To do this, we run a small program called WTHFMT, which reads a packed binary weather file and writes out an ASCII file containing the same information. The ASCII file can then be written to floppy disk, along with a program called FMTWTH, which reverses the process (i.e., read the ASCII weather file and output a packed binary DOE-2 compatible file suitable for the new computer system). The disk recipient just has to read the disk, compile FMTWTH and execute it with the ASCII weather file as input. Both WTHFMT and FMTWTH are in FORTRAN and will compile and execute on a Sun workstation and on an IBM-compatible PC. For other systems, the code may need minor changes (to the OPEN statements, for instance).

The ASCII weather file can be examined and edited on a terminal, using the local editor. This means that the technique can be used when you want to make changes to a packed weather file. The format of the ASCII file has been chosen to be easily readable by humans.

With reference to the programs that follow, FMTWTH reads a one-line input file (INPUT.TMP) in addition to the file containing the weather data. INPUT.TMP tells FMTWTH what type of packed binary file to produce. Note that only the first line is used; the subsequent lines are explanatory. The numbers on the first line must be in columns 13 and 31, respectively.

INPUT.TMP for FMTWTH

```
----+----1----+----2----+----3----+----4----+----5----+----6----+----7
WORD SIZE = 2     FILE TYPE = 2
 WORD SIZE = 1 MEANS 60-BIT, 2 MEANS 30-BIT
 FILE TYPE = 1 MEANS OLD, 2 MEANS NORMAL (NO SOLAR DATA),
 3 MEANS THE DATA HAS SOLAR DATA
```

FMTWTH Program Listing

```
PROGRAM FMTWTH
C
C     THIS PROGRAM READS A FORMATTED WEATHER FILE (WEATHER.FMT)
C     AND A FORMATTED INPUT FILE (FMTWTH.INP) AND WRITES A
C     PACKED BINARY DOE2 WEATHER FILE (WEATHER.BIN)
C
      DIMENSION CLN(12),GT(12),MDAYS(12),IDAT(1536),IWDID(5)
C
      DATA MDAYS / 31,28,31,30,31,30,31,31,30,31,30,31 /
C
      OPEN(UNIT=12,FILE='INPUT.DAT')
      OPEN(UNIT=11,FILE='WEATHER.FMT')
      OPEN(UNIT=10,FILE='WEATHER.BIN',FORM='UNFORMATTED')
C
C     IWSZ           WORD SIZE          1 = 60-BIT, 2 = 30-BIT
C     IFTYP          FILE TYPE          1 = OLD, 2 = NORMAL (NO SOLAR),
C                                       3 = THE DATA HAS SOLAR
C     IWDID          LOCATION I.D.
C     IWYR           YEAR
C     WLAT           LATITUDE
C     WLONG          LONGITUDE
C     IWTZN          TIME ZONE NUMBER
C     IWSOL          SOLAR FLAG         FUNCTION OF IWSZ + IFTYP
C     CLN            CLEARNESS NO.
```

```
C     GT              GROUND TEMP.       (DEG R)
C     KMON            MONTH              (1-12)
C     KDAY            DAY OF MONTH
C     KH              HOUR OF DAY
C     WBT             WET-BULB TEMP      (DEG F)
C     DBT             DRY-BULB TEMP      (DEG F)
C     PATM            PRESSURE           (INCHES OF HG)
C     CLDAMT          CLOUD AMOUNT       (0 - 10)
C     ISNOW           SNOW FLAG          (1 = SNOWFALL)
C     IRAIN           RAIN FLAG          (1 = RAINFALL)
C     IWNDDR          WIND DIRECTION     (0 - 15; 0=N, 1=NNE, ETC)
C     HUMRAT          HUMIDITY RATIO     (LB H2O/LB AIR)
C     DENSTY          DENSITY OF AIR     (LB/CU FT)
C     ENTHAL          SPECIFIC ENTHALPY  (BTU/LB)
C     SOLRAD          TOTAL HOR. SOLAR   (BTU/HR-AREA)
C     DIRSOL          DIR. NORMAL SOLAR  (BTU/HR-AREA)
C     ICLDTY          CLOUD TYPE         (0 - 2)
C     WNDSPD          WIND SPEED         KNOTS
C
      REWIND 12
      READ (12,9001) IWSZ,IFTYP
 9001 FORMAT(12X,I1,17X,I1)
      REWIND 11
      READ (11,9002) (IWDID(I),I=1,5),IWYR,WLAT,WLONG,IWTZN,IWSOL
 9002 FORMAT(5A4,I5,2F8.2,2I5)
      IWSOL = IWSZ + (IFTYP-1)*2 - 1
      READ (11,9003) (CLN(I),I=1,12)
      READ (11,9004) (GT(I),I=1,12)
 9003 FORMAT(12F6.2)
 9004 FORMAT(12F6.1)
      DO 1000 IM=1,12
      IDE = MDAYS(IM)
      DO 1000 ID=1,IDE
      IRECXO = IM*2 + (ID-1)/16 - 1
      IDXO = MOD(ID-1,16) + 1
      DO 500 IH=1,24
      READ (11,9005) KMON, KDAY, KH, WBT, DBT, PATM, CLDAMT, ISNOW,
     1               IRAIN, IWNDDR, HUMRAT, DENSTY, ENTHAL, SOLRAD,
     2               DIRSOL, ICLDTY, WNDSPD
 9005 FORMAT(3I2,2F5.0,F6.1,F5.0,2I3,I4,F7.4,F6.3,F6.1,2F7.1,I3,F5.0)
      ISOL = INT(SOLRAD + .5)
      IDN = INT(DIRSOL + .5)
      IWET = INT(WBT+99.5)
      IDRY = INT(DBT+99.5)
      IPRES = INT(PATM*10.-149.5)
      ICLDAM = INT(CLDAMT)
      IWNDSP = INT(WNDSPD+0.5)
      IHUMRT = INT(HUMRAT*10000.+0.5)
      IDENS = INT(DENSTY*1000.-19.5)
      IENTH = INT(ENTHAL*2.0+60.5)
      IP1 = (IDXO-1)*96 + IH*4 - 3
      IDAT(IP1) = IPRES*65536 + IWET*256 + IDRY
      IDAT(IP1+1) = ISOL*1048576 + IDN*1024 +
     1              ICLDAM*64 + ISNOW*32 + IRAIN*16 + IWNDDR
      IDAT(IP1+2) = IHUMRT*128 + IDENS
      IDAT(IP1+3) = IENTH*2048 + ICLDTY*128 + IWNDSP
  500 CONTINUE
      IF ((ID .NE. 16) .AND. (ID .NE. IDE))  GO TO 1000
      WRITE (10) IWDID,IWYR,WLAT,WLONG,IWTZN,IRECXO,IDE,CLN(IM),
     1          GT(IM),IWSOL,IDAT
 1000 CONTINUE
      END
----+----1----+----2----+----3----+----4----+----5----+----6----+----7
```

WTHFMT Program Listing

```
      PROGRAM WTHFMT
C
C     THIS PROGRAM READS A PACKED BINARY DOE-2 WEATHER FILE AND
C     CREATES A FORMATTED WEATHER FILE AS OUTPUT.  THE INPUT
C     FILE IS WEATHER.BIN, THE OUTPUT FILE IS WEATHER.FMT.
C
      DIMENSION CLN(12),GT(12),MDAYS(12),IDAT30(1536),
     _          IWDID(5),IWTH(14)
      DIMENSION XMASK(16,2), CALC(16)
      INTEGER IDUM
C
      DATA MDAYS / 31,28,31,30,31,30,31,31,30,31,30,31 /
      DATA IWDID /5*4H    /
      DATA XMASK / -99., -99., 15., 0., 0., 0., 0., 0., .02, -30., 0.,
     1             .0, .0, .0, .0, 10.,
     2              1., 1., .1, 1., 1., 1., 1., .0001, .001, .5,
     3             1., 1., 1., 1., 0., 0. /
C
      OPEN (UNIT=11,FILE='WEATHER.FMT')
      OPEN (UNIT=10,FILE='WEATHER.BIN',FORM='UNFORMATTED')
      REWIND 10
      DO 100 IM1=1,12
      READ (10) (IWDID(I),I=1,5),IWYR,WLAT,WLONG,IWTZN,LRECX,NUMDAY,
     _          CLN(IM1),GT(IM1),IWSOL
      READ (10) IDUM
  100 CONTINUE
      REWIND 10
      LRECX = 0
      WRITE (11,9001) (IWDID(I),I=1,5),IWYR,WLAT,WLONG,IWTZN,IWSOL
      WRITE (11,9002) (CLN(I),I=1,12)
      WRITE (11,9003) (GT(I),I=1,12)
 9001 FORMAT(5A4,I5,2F8.2,2I5)
 9002 FORMAT(12F6.2)
 9003 FORMAT(12F6.1)
      DO 1000 IM2=1,12
      IDE = MDAYS(IM2)
      DO 1000 ID=1,IDE
      DO 1000 IH=1,24
  105 IRECX = IM2*2 + (ID-1)/16 - 1
      IDX = MOD(ID-1,16) + 1
      IF (IRECX-LRECX) 200,400,300
  200 IDIF = LRECX - IRECX + 1
      DO 220 I=1,IDIF
      BACKSPACE 10
  220 CONTINUE
  300 READ (10) IWDID,IWYR,WLAT,WLONG,IWTZN,LRECX,NUMDAY,CLRNES,
     _          TGRND,IDUM,IDAT30
      GO TO 105
  400 CONTINUE
      IP1 = 96*(IDX-1) + 4*IH - 3
      IWTH(3) = IDAT30(IP1)/65536
      IWTH(1) = MOD(IDAT30(IP1),65536)/256
      IWTH(2) = MOD(IDAT30(IP1),256)
      IWTH(11) = IDAT30(IP1+1)/1048576
      IWTH(12) = MOD(IDAT30(IP1+1),1048576)/1024
      IWTH(4) = MOD(IDAT30(IP1+1),1024)/64
      IWTH(5) = MOD(IDAT30(IP1+1),64)/32
      IWTH(6) = MOD(IDAT30(IP1+1),32)/16
      IWTH(7) = MOD(IDAT30(IP1+1),16)
      IWTH(8) = IDAT30(IP1+2)/128
      IWTH(9) = MOD(IDAT30(IP1+2),128)
      IWTH(10) = IDAT30(IP1+3)/2048
      IWTH(13) = MOD(IDAT30(IP1+3),2048)/128
```

```
      IWTH(14) = MOD(IDAT30(IP1+3),128)
      DO 500 I=1,14
      CALC(I) = FLOAT(IWTH(I))*XMASK(I,2) + XMASK(I,1)
  500 CONTINUE
      ISNOW = INT(CALC(5) + .01)
      IRAIN = INT(CALC(6) + .01)
      IWNDDR = INT(CALC(7) + .01)
      ICLDTY = INT(CALC(13) + .01)
C
C             IM2            MOMTH              (1-12)
C             ID             DAY OF MONTH
C             IH             HOUR OF DAY
C             CALC(1)        WET-BULB TEMP      (DEG F)
C             CALC(2)        DRY-BULB TEMP      (DEG F)
C             CALC(3)        PRESSURE           (INCHES OF HG)
C             CALC(4)        CLOUD AMOUNT       (0 - 10)
C             ISNOW          SNOW FLAG          (1 = SNOWFALL)
C             IRAIN          RAIN FLAG          (1 = RAINFALL)
C             IWNDDR         WIND DIRECTION     (0 - 15; 0=N, 1=NNE, ETC)
C             CALC(8)        HUMIDITY RATIO     (LB H2O/LB AIR)
C             CALC(9)        DENSITY OF AIR     (LB/CU FT)
C             CALC(10)       SPECIFIC ENTHALPY  (BTU/LB)
C             CALC(11)       TOTAL HOR. SOLAR   (BTU/HR-AREA)
C             CALC(12)       DIR. NORMAL SOLAR  (BTU/HR-AREA)
C             ICLDTY         CLOUD TYPE         (0 - 2)
C             CALC(14)       WIND SPEED         KNOTS
C
  900 WRITE (11,9005) IM2, ID, IH, CALC(1), CALC(2), CALC(3), CALC(4),
     1                ISNOW, IRAIN,IWNDDR, CALC(8), CALC(9), CALC(10),
     2                CALC(11), CALC(12), ICLDTY, CALC(14)
 9005 FORMAT(3I2,2F5.0,F6.1,F5.0,2I3,I4,F7.4,F6.3,F6.1,2F7.1,I3,F5.0)
 1000 CONTINUE
      ENDFILE 11
      END
```

Processing Nonstandard Weather Data

The DOE-2 weather processor is capable of processing raw weather data in a variety of formats into a DOE-2 compatible form. Quite frequently, however, users obtain weather data in a format that is unknown to the weather processor. The user then has two alternatives: convert the data into a known format; or process the raw weather data directly by writing code for subroutine OTHER in the DOE-2 weather processor.

Use of the subroutine OTHER

OTHER is a typical weather data processing subroutine in the DOE-2 weather processor. Like the other such routines (TRYDCD, TMYDCD, etc.) it is called once every 24 hours by subroutine PACKER, and its use can be triggered by the weather processor input. Putting OTHER in the first 5 columns of the third line of the PACK input sequence informs the weather packer that subroutine OTHER will be used for reading in and processing the raw data. OTHER is meant to be a user programmable subroutine for processing special weather formats. OTHER already contains code which processes data in the DOE-2 measured weather format. The user can use this format, or replace the code in OTHER with code that will read a different format using the original OTHER code as an example. Basically, the arrays in the common block /RAWDAT/ must be filled for each call to OTHER. The arrays are dimensioned 24, and are all integers. They are

IDRY dry-bulb temperature in °F, rounded to the nearest whole degree.

IWET wet-bulb temperature in °F, rounded to the nearest whole degree.

IDEW dew point temperature in °F, rounded to the nearest whole degree.

IPRESS atmospheric pressure in inches of Hg times 100 (so 29.92 will be 2992, etc.)

IWNDSP wind speed, in knots (!) (nearest whole knot).

ICLAMT cloud amount (sky cover), 0 - 10; 0 = no clouds, 10 = totally overcast.

ISOL, total solar on a horizontal surface and direct normal (beam) solar radiation, both in Btu/ft^2-hr,

IDN nearest whole unit.

IWNDIR wind direction in compass points (0 - 15). 0 is north, 1 is NNE, 15 is NNW.

ICLTY DOE-2 cloud type; takes the values 0, 1, and 2.
0 = most transparent cloud category. It corresponds to TRY types 8 and 9 (cirrus and cirrostratus or cirrocumulus).
1 = most opaque. It corresponds to TRY type 2 (stratus or fractus stratus).
2 = intermediate transparency. It corresponds to all other types of clouds, and is a good default if no cloud type information is available.

ICLTY1 DOE-2 cloud type - UNUSED

IRN, ISN the rain and snow flags, respectively. Set to 1 if raining or snowing, 0 otherwise. IRN and ISN are not currently used in DOE-2, but it is nice to set them anyway. When printed out along with the other weather variables with the LIST option of the weather processor, they can help explain some otherwise odd looking weather or solar data.

Frequently the raw data will include dry-bulb and relative humidity, instead of dry-bulb, wet-bulb, and dew point as required by the weather processor. You should use the procedure given in 1993 ASHRAE Fundamentals, p. 6.14, situation number 3. A slightly different procedure is used in the example OTHER subroutine, below.

In the case of solar data, the weather processor needs total horizontal and direct normal. The data is often in the form of direct and diffuse on a horizontal surface. The cosine of the solar zenith angle (or the sine of the solar altitude) must then be calculated in order to obtain the direct normal from the direct horizontal. This calculation involves knowing the solar declination angle and the equation of time; it is complicated by the fact that the cosine of the zenith angle must usually be averaged over a one hour time bin, since the solar data point is usually the average over one hour of a number of data points taken at less than one-hour intervals. In this case it is best to simply follow the procedure shown in the following example subroutine. As in the example, it is usually necessary to do a limit check on the resulting direct normal, particularly at sunrise and sunset, where the data is frequently bad.

Sometimes only total horizontal solar data is available. A model must then be employed to obtain the direct radiation from the total. We recommend the model of Erbs, Klein, and Duffie (*Solar Energy*, 28, (1982) p. 293. See "*FORTRAN fragment: direct and diffuse solar calculation*," below, or the code included in the weather processor for processing the DOE-2 measured weather data format.

Example of subroutine OTHER

```
      SUBROUTINE OTHER
C
C               INSERT YOUR ROUTINE TO DECODE SPECIAL TAPE FORMAT
C
      COMMON  /LOCALD/   STALAT,STALON,SSTALA,CSTALA,TSTALA,HRSLON
C
      COMMON  /CONST/    DTOR, PIOVR2, PIOVR4, PIOV12, IBLNK
C
      COMMON  /TIMES/    IMNTH,IDAY,IHOUR,IRECXO,IDXO,IDAYL,ITIM
C
      COMMON  /MONTHC/   BEFORE(12),MDAYS(12),MNAMES(12)
      INTEGER            BEFORE
C
      COMMON  /FILES/    INFIL,OUTFIL,INWTH,OUTWTH,SOLWTH,STOUT
      INTEGER            OUTFIL,OUTWTH,SOLWTH,STOUT
C
      COMMON  /GETCRC/   IEOF
      LOGICAL            IEOF
C
      COMMON  /PACKEC/   NTZ,ISTAT,XLAT,XLONG,
     1                   IYR,INTINT,DDBT,IBEGH,NBS,IDOYSH(5),ISSHFT(5),
     2                   ISHFT,ALT,SKYCOV(12),ILOC
C
      COMMON  /PARAMS/   STOPIT,VERS,FIRST,NEWPAK,CALCGT
      LOGICAL            STOPIT,VERS,FIRST,NEWPAK,CALCGT
C
      COMMON  /PCKINT/   KYR,KSTAT,CN(12),TG(12),KTIM,KARD(500),KYRL
C
      COMMON  /RAWDAT/   IDRY(24),IWET(24),IDEW(24),IPRESS(24),
     1                   IWNDSP(24),ICLAMT(24),ISOL(24),IDN(24),
```

```
     2                   IWNDIR(24),ICLTY(24),IRN(24),ISN(24),ICLTY1(24)
      DIMENSION IRAW(24,12)
      EQUIVALENCE        (IDRY(1),IRAW(1,1))
      COMMON /LSTIME/   LSTHRS(24)
C
      COMMON  /REPORC/   IBEGM,IENDM
C
      COMMON  /UNDEF/    IUNDEF,UNDEF
C
C
      DIMENSION DEABC(5)
C              DAY OF YEAR
      IDOY = BEFORE(IMNTH) + IDAY
C              GET SUN PARAMETERS
      CALL SUNPRM(IDOY,DEABC)
C              SOLAR CONSTANT
      SOLCON = 435.2*(1.+0.033*COS(DTOR*360.*FLOAT(IDOY)/365.))
C              LOOP OVER HOURS IN THE DAY
      DO 1000 IH=1,24
C              READ IN WEATHER DATA
      READ (INWTH,9001) IVR,ID,IM,IHR,SKYCVR,IWINDR,WNDSPD,WSVECT,
     1 IWTHR,DEP,PRESMB,TDRY,RELH,IDIRH,IDIFFH,ILLUMH,IRH,IATMRH
 9001 FORMAT(I1,3I2,1X,F4.2,1X,I3,2(1X,F4.1),1X,I2,1X,F4.1,1X,F6.1,
     1 1X,F5.1,1X,F4.2,1X,I4,1X,I4,1X,I7,1X,I4,1X,I4)
C              CONVERT DRY-BULB FROM CENTIGRADE TO FAHRENHEIT
      TDRYF = 1.8*TDRY + 32.
C              CALCULATE WET-BULB AND DEW POINT
C              SATURATED VAPOR PRESSURE
      PS = PPWVMS(TDRYF)
C              PARTIAL PRESSURE
      PW = RELH*PS
C              CONVERT PRESSURE FROM MILLIBARS TO INCHES OF HG
      PRESHG = .02953*PRESMB
C              HUMIDITY RATIO
      HUMRAT = 0.622*PW/(PRESHG-PW)
C              SPECIFIC ENTHALPY
      ENTH = 0.24*TDRYF + (1061.+0.444*TDRYF)*HUMRAT
      TWETF = WBF(ENTH,PRESHG)
      Y = LOG(PW)
      IF (PW .LE. 0.1836) THEN
          TDEWF = 71.98 + 24.873*Y + 0.8927*Y*Y
      ELSE
          TDEWF = 79.047 + 30.579*Y + 1.8893*Y*Y
      END IF
C              CONVERT WINDSPEED FROM M/S TO KNOTS
      WSKNOT = 1.9438*WNDSPD
      SOLHOR = 0.
      SOLDRN = 0.
C              SET UPPER AND LOWER HOUR ANGLE BIN EDGES FOR SOLAR ZENITH
C              ANGLE CALCULATION.  HOUR ANGLE IN UNITS OF HOURS.
      UL = FLOAT(IH) - 12. + FLOAT(NTZ) + DEABC(2) - STALON/PIOV12
      BL = UL -1.
C              SUNRISE AND SUNSET HOUR ANGLES
      SSHA = ACOS(-TAN(STALAT)*TAN(DEABC(1)))/PIOV12
      SRHA = -SSHA
C              SKIP IF SUN DOWN
      IF ((UL .LE. SRHA) .OR. (BL .GE. SSHA)) GO TO 300
C              RESET BIN EDGES AT SUNRISE OR SUNSET
      IF (SRHA .GT. BL)  BL = SRHA
      IF (SSHA .LT. UL)  UL = SSHA
      IF ((UL-BL) .LT. .02)  GO TO 300
C              TOTAL HORIZONTAL SOLAR; CONVERT FROM W/M**2 TO
C              BTU/(FT**2)(HR)
          SOLHOR = .31721*FLOAT(IDIRH+IDIFFH)
C              GET THE AVERAGE OF THE COSINE OF THE SOLAR ZENITH ANGLE
```

```
C              FOR THE 1 HOUR TIME BIN
          A = SIN(DEABC(1))*SIN(STALAT)
          B = COS(DEABC(1))*COS(STALAT)
          COSZIN = A*(UL-BL) + B*(SIN(PIOV12*UL)-SIN(PIOV12*BL))/PIOV12
          COSZAV = COSZIN/(UL-BL)
C              GET DIRECT NORMAL SOLAR
          SOLDRN = .31721*FLOAT(IDIRH)/COSZAV
C              PUT LIMITS ON THE SUNRISE AND SUNSET BEAM RADIATION
          CALL MAXDIR(COSZAV,SOLCON,DIRMAX)
          SOLDRN = AMIN1(SOLDRN,DIRMAX)
  300 CONTINUE
C              FILL THE DATA ARRAYS
      IDRY(IH) = IROUND(TDRYF)
      IWET(IH) = MIN0(IDRY(IH),IROUND(TWETF))
      IDEW(IH) = MIN0(IWET(IH),IROUND(TDEWF))
      IPRESS(IH) = IROUND(100.*PRESHG)
      IWNDSP(IH) = IROUND(WSKNOT)
      IWNDIR(IH) = IROUND(.0444444*FLOAT(IWINDR))
      IF (IWNDIR(IH) .EQ. 16) IWNDIR(IH) = 0
      ICLAMT(IH) = IROUND(10.*SKYCVR)
      ISOL(IH) = IROUND(SOLHOR)
      IDN(IH) = IROUND(SOLDRN)
      ICLTY(IH) = 2
      ICLTY1(IH) = 2
      IRN(IH) = 0
      ISN(IH) = 0
 1000 CONTINUE
      RETURN
      END
```

FORTRAN fragment: direct and diffuse solar calculation

```
C
C              Fortran fragment to calculate direct and diffuse
C              solar radiation from total solar and to get wet-bulb
C              and dew point temperatures from dry-bulb, relative humidity
C              and atmospheric pressure.
C
C     Start with: SOLHOR - total horiz. solar in Btu/hr-area
C                 TDRYF  - dry-bulb temperature in degrees Fahrenheit
C                 PRESHG - atmospheric pressure in inches of mercury
C                 RELHUM - relative humidity in percent
C
C     Define:     DTOR   - degrees to radians = pi/180
C                 PIOV12 - pi/12
C                 IH     - hour of the day (1 - 24)
C                 IDOY   - day of year (1 - 365)
C                 STALAT - weather station latitude in radians
C                 STALAT - station longitude in radians
C                 XLONG  - station longitude in degrees
C                 NTZ    - time zone (PST=8, EST=5, Greenwich=0)
C
C     Externals:  SUNPRM
C                 MAXDIR
C                 PPWVMS
C                 WBF
C                          These are all available from WTHPRC, the DOE-2
C                          weather processor.
C
      DIMENSION DEABC(5)
C
      DIRN = 0.
      DIF = 0.
C              GET SOLAR CONSTANTS.  DEABC(1) IS THE SOLAR
C              DECLINATION ANGLE; DEABC(2) IS THE EQUATION
C              OF TIME.
      CALL SUNPRM(IDOY,DEABC)
```

```
C               GET SOLAR CONSTANT.  THIS FORMULA IS FROM KREIDER
C               AND RABL PAGE 237
C               BECKMAN, PAGE 7.
      SOLCON = 435.2*(1. + 0.033*COS(DTOR*360.*FLOAT(IDOY)/365.))
C               GET HOUR ANGLE AT UPPER AND LOWER HOUR BIN EDGE
C               THIS IS LOCAL TIME!
      UL     = FLOAT(IH) - 12. + FLOAT(NTZ) + DEABC(2) - XLONG/15.
      BL     = UL - 1.
C               SUNRISE AND SUNSET HOUR ANGLES
      SSHA   = ACOS(-TAN(STALAT)*TAN(DEABC(1)))/PIOV12
      SRHA   = -SSHA
C               RESET BIN BOUNDARIES TO ALLOW FOR SUNRISE AND SET
      IF ((UL .LE. SRHA) .OR. (BL .GE. SSHA))  GO TO 1100
      IF (SRHA .GT. BL)  BL = SRHA
      IF (SSHA .LT. UL)  UL = SSHA
      IF ((UL-BL) .LT. 0.02)  GO TO 1100
      IF (SOLHOR .EQ. 0) GO TO 1100
      A      = SIN(DEABC(1))*SIN(STALAT)
      B      = COS(DEABC(1))*COS(STALAT)
C               INTEGRATE SOLAR Z DIREC. COSINE OVER BIN
      COSZIN = A*(UL-BL) + B*(SIN(PIOV12*UL)-SIN(PIOV12*BL))/PIOV12
C               AVERAGE COSINE OF THE SOLAR ZENITH ANGLE FOR THE HOUR
      COSZAV = COSZIN/(UL-BL)
C               EXTRATERRESTRIAL SOLAR HORIZONTAL
      SOLEXH   = SOLCON*COSZIN
C               K sub T IS THE RATIO OF TERRESTRIAL TO EXTRATERRESTRIAL SOLAR
      RKT = AMIN1(SOLHOR/SOLEXH,0.9)
C               GET DIFFUSE COMPONENT FROM ERBS, KLEIN, AND DUFFIE
C               CORRELATION
      IF (RKT .LE. 0.22)  DIF = SOLHOR*(1.-0.09*RKT)
      RKT2   = RKT*RKT
      IF ((RKT .GT. 0.22) .AND. (RKT .LE. 0.8))  DIF = SOLHOR*
     1   (.9511-.1604*RKT+4.388*RKT2-16.638*RKT*RKT2+12.336*RKT2*RKT2)
      IF (RKT .GT. 0.8)  DIF = 0.165*SOLHOR
C               DIRECT HORIZONTAL
      DIRH   = AMAX1(0.,SOLHOR-DIF)
C               DIRECT NORMAL
      DIRN = DIRH/COSZAV
C               CHECK FOR MAXIMUM DIRECT NORMAL
      CALL MAXDIR(COSZAV,SOLCON,DIRMAX)
      DIRN = AMIN1(DIRN,DIRMAX)
 1100 CONTINUE
C               CALCULATE WET-BULB AND DEW POINT.  THE PROCEDURE IS
C               BASICALLY THAT GIVEN ON PAGE 6.16, ASHRAE FUNDAMENTALS
C               1989, SITUATION NO. 3
C
C                SATURATED VAPOR PRESSURE
      PS = PPWVMS(TDRYF)
C                PARTIAL PRESSURE
      PW = .01*RELHUM*PS
C                HUMIDITY RATIO
      HUMRAT = .622*PW/(PRESHG-PW)
C                SPECIFIC ENTHALPY
      ENTH = .24*TDRYF + (1061.+.444*TDRYF)*HUMRAT
C                WET-BULB TEMPERATURE
      TWETF = WBF(ENTH,PRESHG)
C                DEW POINT TEMPERATURE
      Y = LOG(PW)
      IF (PW .LE. .1836) THEN
          TDEWF = 71.98 + 24.873*Y + .8927*Y*Y
      ELSE
          TDEWF = 79.047 + 30.579*Y + 1.8893*Y*Y
      END IF
```

Using Standard Formats for Measured Data

As an alternative to using the OTHER subroutine for measured or nonstandard data, one can convert the measured/nonstandard data into one of the standard formats and then run the DOE-2 weather processor on that format. For weather with no solar data, convert to the TRY format described below under "TRY Format," and then PACK with the weather processor using TRYSLM. Only the following TRY data fields need be filled (all unfilled fields should contain 9's):

hour day month	year station number dry-bulb temperature	wet-bulb temperature dew point temperature wind direction	wind speed station pressure total sky cover	type of lowest cloud layer present weather

For data sets with measured solar data, if global and direct are known, use the TMY2 format, described below under "TMY2 Format." The only hourly fields that need to be filled are:

hour day month	year global horizontal radiation direct normal radiation	opaque sky cover dry-bulb temperature dew point temperature	atmospheric pressure wind direction wind speed	present weather

In the TMY2 header record, all the data items should be filled. For data sets with global horizontal solar data and relative humidity instead of wet-bulb/dew point, use the DOE-2 measured data format described below.

Using the DOE-2 Measured Weather Format

Measured weather data can be put in the DOE-2 measured weather data format. This format uses metric units and contains the most commonly measured weather variables. For instance the format uses relative humidity rather than wet-bulb or dew-point temperature and global horizontal solar rather than direct & diffuse.

Format:

The file must be 8760 records in length, each record being 80 characters long.

Item	**Columns**	**Format**	**Units**
hour	1 - 2	I2	
day	3 - 4	I2	
month	5 - 6	I2	
year	7 -10	I4	
drybulb	11-20	F10.1	Centigrade
relative humidity	21-30	F10.2	a fraction, 0.0 to 1.0
atmos. pressure	31-40	F10.1	millibars
total horiz. rad.	41-50	F10.0	watts/m2
wind speed	51-60	F10.1	m/s
Wind dir.	61-70	F10.0	degrees from north (north=0;east=90)
sky cover	71-80	F10.1	a fraction 0.0 to 1.0

All quantities must be filled. If sky cover is unknown, put in -999.

The raw hourly weather file will look something like this (1 day only):

```
 1 1 11997   20.0    0.6       1003.6     0.         4.5       273.     0.3
 2 1 11997   21.0    0.6       1003.6     0.         4.5       273.     0.3
 3 1 11997   22.0    0.6       1003.6     0.         4.5       273.     0.3
 4 1 11997   23.0    0.6       1003.6     0.         4.5       273.     0.3
 5 1 11997   24.0    0.6       1003.6     0.         4.5       273.     0.3
 6 1 11997   25.0    0.6       1003.6     0.         4.5       273.     0.3
 7 1 11997   26.0    0.6       1003.6     50.        4.5       273.     0.3
 8 1 11997   27.0    0.6       1003.6     200.       4.5       273.     0.3
 9 1 11997   28.0    0.6       1003.6     450.       4.5       273.     0.3
10 1 11997   29.0    0.6       1003.6     600.       4.5       273.     0.3
11 1 11997   29.0    0.6       1003.6     750.       4.5       273.     0.3
12 1 11997   29.0    0.6       1003.6     750.       4.5       273.     0.3
13 1 11997   28.0    0.6       1003.6     750.       4.5       273.     0.3
14 1 11997   27.0    0.6       1003.6     600.       4.5       273.     0.3
15 1 11997   26.0    0.6       1003.6     450.       4.5       273.     0.3
16 1 11997   25.0    0.6       1003.6     200.       4.5       273.     0.3
```

```
17 1 11997   24.0    0.6       1003.6     50.        4.5       273.     0.3
18 1 11997   23.0    0.6       1003.6     20.        4.5       273.     0.3
19 1 11997   23.0    0.6       1003.6     0.         4.5       273.     0.3
20 1 11997   21.0    0.6       1003.6     0.         4.5       273.     0.3
21 1 11997   19.0    0.6       1003.6     0.         4.5       273.     0.3
22 1 11997   18.0    0.6       1003.6     0.         4.5       273.     0.3
23 1 11997   17.0    0.6       1003.6     0.         4.5       273.     0.3
24 1 11997   16.0    0.6       1003.6     0.         4.5       273.     0.3
```

Example Input:

```
PACK
Test MeasWth Format
OTHER   -999  -999     5 40.7  74.2 30-BITSOLAR      4 20.  .025
1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00  1.00
-999.
LIST
PACKED  -999  -999     1    12
STAT
END
```

TRY Format

File Field Number	Columns	Element
001	01 - 05	STATION NUMBER
002	06 - 08	DRY-BULB TEMPERATURE
003	09 - 11	WET-BULB TEMPERATURE
004	12 - 14	DEW POINT TEMPERATURE
005	15 - 17	WIND DIRECTION
006	18 - 20	WIND SPEED
007	21 - 24	STATION PRESSURE
008	25	WEATHER
009	26 - 27	TOTAL SKY COVER
010	28 - 29	AMOUNT OF LOWEST CLOUD LAYER
01l	30	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA
012	31 - 33	HEIGHT OF BASE OF LOWEST LAYER
013	34 - 35	AMOUNT OF SECOND CLOUD LAYER
014	36	TYPE OF CLOUD - SECOND LAYER
015	37 - 39	HEIGHT OF BASE OF SECOND LAYER
016	40 - 41	SUMMATION AMOUNT OF FIRST TWO LAYERS
017	42 - 43	AMOUNT OF THIRD CLOUD LAYER
018	44	TYPE OF CLOUD - THIRD LAYER
019	45 - 47	HEIGHT OF BASE OF THIRD LAYER
020	48 - 49	SUMMATION AMOUNT OF FIRST THREE LAYERS
021	50 - 51	AMOUNT OF FOURTH CLOUD LAYER
022	52	TYPE OF CLOUD - FOURTH LAYER
023	53 - 55	HEIGHT OF BASE OF FOURTH LAYER
024	56 - 59	SOLAR RADIATION[a]
025	60 - 69	BLANK
026	70 - 73	YEAR
027	74 - 75	MONTH
028	76 - 77	DAY
029	78 - 79	HOUR
030	80	BLANK

[a]The DOE-2 weather processor recognizes the following solar data in TRY format:
Columns 57-59 Total horizontal radiation in Btu/ft^2-hr
Columns 61-63 Direct normal radiation in Btu/ft^2-hr

Packing a TRY file with solar data formatted as above and specifying the SOLAR option will result in the solar data being transferred to the DOE-2 packed weather file.

TRY Format (continued)

File Field Number	Columns	Element	Configuration	Code Definitions and Remarks
001	01 - 05	STATION NUMBER	01001 - 98999	Unique number used to identify each station. Usually a WBAN number, but occasionally a WMC or other number system.
002	06 - 08	DRY BULB TEMP	000 to 140	Temperature in whole °F: 000 to 140 = 0° to 14°F -01 to -80 = -l to -80°F 999 = Missing
003	09 - 11	WET BULB TEMP	-01 to -80	
004	12 - 14	DEW POINT TEMP	or 999	
005	15 - 17	WIND DIRECTION	000 - 360 or 999	Direction from which the wind is blowing in whole degrees. 000 = Calm 001-360 = 1° - 360° 999 = Missing
			Note: Prior to 1964, direction was recorded to only 16 intervals (points of the compass). The following scheme was used to convert these values to whole degrees. 000 = Calm 360 = North 023 = North Northeast 045 = Northeast 068 = East Northeast 090 = East 113 = East Southeast 135 = Southeast 158 = South Southeast	180 = South 203 = South Southwest 225 = Southwest 248 = West Southwest 270 = West 293 = West Northwest 315 = Northwest 338 = North Northwest
006	18 - 20	WIND SPEED	000 - 230 or 999	Wind speed in whole knots. 000 = Calm 001-230 = l-230 knots 999 = Missing
007	21 - 24	STATION PRESSURE	1900 - 3999 or 9999	Pressure at station in inches of Hg times 100: 1900-3999 = 19.00 - 39.99 in Hg 9999 = Missing
008	25	WEATHER	0 - 9	Type of weather at the time of observation. 0 = No obstructions 1 = Fog 2 = Haze 3 = Smoke 4 = Haze and smoke 5 = Thunderstorm 6 = Tornado 7 = Liquid precipitation (rain, rain showers, freezing rain, drizzle, freezing drizzle) 8 = Frozen precipitation (snow, snow showers, snow pellets, snow grains, sleet, ice pellets, hail) 9 = Blowing dust, blowing sand, blowing spray, dust Note: Original observations may contain combina-tions of these elements. Whenever this occurred, a priority was assigned for the purpose of indicating weather in this file. (1) - Liquid precipitation - 7 (2) - Frozen precipitation - 8 (3) - Obstructions to vision - l, 2, 3, 4, 9 (4) - Thunderstorm (no precipitation) - 5 (5) - Tornado (no precipitation) - 6

TRY Format (continued)

File Field Number	Columns	Element	Configuration	Code Definitions and Remarks
009	26 - 27	TOTAL SKY COVER	00 - 10	Amount of the sky covered by clouds or obscuring phenomena in tenths.
010	28 - 29	AMT OF LOWEST CLOUD LAYER	or 99	
013	34 - 35	AMT OF SECOND CLOUD LAYER		00-10 = 0-10 tenths
016	40 - 41	SUM OF FIRST TWO LAYERS		99 = Missing
017	42 - 43	AMT OF THIRD CLOUD LAYER		
020	48 - 49	SUM OF FIRST THREE LAYERS		
021	50 - 51	AMT OF FOURTH CLOUD LAYER		
011	30	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA	0 - 9	Generic cloud type or obscuring phenomena: 0 = Clear
014	36	TYPE OF CLOUD - SECOND LAYER		1 = Fog or other obscuring phenomena 2 = Stratus or Fractus Stratus
018	44	TYPE OF CLOUD - THIRD LAYER		3 = Stratocumulus
022	52	TYPE OF CLOUD - FOURTH LAYER		4 = Cumulus or Cumulus Fractus 5 = Cumulonimbus or Mammatus 6 = Altostratus or Nimbostratus 7 = Altocumulus 8 = Cirrus 9 = Cirrostratus or Cirrocumulus 9 = Unknown if the amount of cloud is 99
012	31 - 33	HEIGHT OF BASE OF LOWEST LAYER	000 - 760	Height of base of clouds or obscuring phenomena in hundreds of feet
015	37 - 39	HEIGHT OF BASE OF SECOND LAYER	or 777	000-760 = 0-76,000 feet 777 = Unlimited - clear
019	45 - 47	HEIGHT OF BASE OF THIRD LAYER	or 888	888 = Cirroform clouds of unknown height 999 = Missing
023	53 - 55	HEIGHT OF BASE OF FOURTH LAYER	or 999	
024	56 - 59	SOLAR RADIATION	0000 - 1999 or 9999	Total solar radiation in Langleys to tenths. Values are for the hour ending at time indicated in Field 029. 0000-1999 = 0-199.9 Langleys 9999 = Missing
025	60 - 69	BLANK	Δ Δ Δ Δ Δ Δ	*Blank field--reserved for future use.*
026	70 - 73	YEAR	1900 - 2099	Year
027	74 - 75	MONTH	01 - 12	Month of year: 01 = Jan., 02 = Feb., etc.
028	76 - 77	DAY	01 - 31	Day of month
029	78 - 79	HOUR	00 - 23	Hour of observation in Local Standard Time. 00-23 = 0000-2300 LST
030	80	BLANK	Δ Δ Δ Δ Δ Δ	*Blank field, reserved for future use.*

CD144 Format

STATION NUMBER	YEAR	MO	DAY	HOUR	CEILING HEIGHT	CLOUD COVER BY LAYER 1st	2nd	3rd	4th	VISIBILITY	WEATHER/OBSTRUCTIONS THUNDER-STORMS	RAIN	DRIZZLE	SNOW	SNOW SHOWERS	ICE PRECIP	OBSTR	OBSTR
X X X X X	X X	X X	X X	X X	X X X	X	X	X	X	X X X	X	X	X	X	X	X	X	X

1 TO 31

SEA LEVEL PRESSURE	DEW POINT TEMPERATURE	WIND DIREC-TION	WIND SPEED	STATIC PRESSURE	DRY-BULB TEMPERATURE	WET-BULB TEMPERATURE	RELATIVE HUMIDITY
X X X X	X X X	X X	X X	X X X X	X X X	X X X	X X X

32 TO 55

CLOUDS AND OBSCURING PHENOMENA: TOTAL COVER	LAYER 1 AMOUNT	LAYER 1 TYPE	LAYER 1 HEIGHT	LAYER 2 AMOUNT	LAYER 2 TYPE	LAYER 2 HEIGHT	SUM AMOUNT	LAYER 3 AMOUNT	LAYER 3 TYPE	LAYER 3 HEIGHT	SUM AMOUNT	LAYER 4 AMOUNT	LAYER 4 TYPE	LAYER 4 HEIGHT	OPAQUE	FILLER
X	X	X	X X X	X	X	X X X	X	X	X	X X X	X	X	X	X X X	X	

56 TO 80

Figure 1: Record format for CD144 weather FILEs

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VIII. WEATHER DATA

A. INTRODUCTION

The LOADS, SYSTEMS, and PLANT programs require hourly weather data, which are contained in weather files. Each file contains one year (8760 hours) of weather data for a particular location. In this section, the variables used to describe each of the weather parameters and a list of the weather data in the DOE-2 library are given. The user attaches a weather file using the job control language at his site.

A list of weather stations available in the DOE-2 library is given in Tables VIII.1 and 2, including location data.

If the required weather data are not in the DOE-2 library, the user can create his own weather file using the Weather Processor Programs.

B. WEATHER VARIABLES

The weather variables used by DOE-2 and present on the weather file are:

DRYBULB TEMPERATURE
WETBULB TEMPERATURE
ATMOSPHERIC PRESSURE
WIND SPEED
WIND DIRECTION
CLOUD AMOUNT
CLOUD TYPE
CLEARNESS NUMBER
GROUND TEMPERATURE
HUMIDITY RATIO
DENSITY OF AIR
SPECIFIC ENTHALPY

(For Typical Meteorological Year (TMY) files, CLOUD TYPE is unavailable, but "total horizontal solar" and "total direct normal solar" are available).

This file also contains the latitude, longitude, and time zone of the station, which may be overridden by using the BUILDING-LOCATION instruction described in Chap. III.

C. WEATHER FILES

Three groups of weather files are available in the DOE-2 library. In addition, several types of weather files can be processed by the weather processing programs to produce files for use by DOE-2.

1. TRY

The DOE-2 library has one year of data for each of 60 different US weather stations selected according to the ASHRAE Test Reference Year (TRY) procedure.* Table VIII.1 lists the TRY cities now available and Appendix VIII.D contains weather data summaries for these cities (except St. Louis, Missouri).

A manual for the TRY data, published by the National Climatic Center in Asheville, North Carolina, is reproduced in Appendix VIII.A. Summaries of the TRY data for each city are included in Appendix VIII.E.

The user should exercise caution in applying TRY data. The TRY should be reliable for making comparisons of design or retrofit options. However, as pointed out in the TRY Manual, a TRY is not considered sufficiently typical to yield reliable estimates of average energy requirements over several years.

2. California, CTZ

One year of data for each of 16 climate zones in the State of California is included. These data were assembled by Loren Crow for the California Energy Resources Conservation and Development Commission.

A map showing the boundaries of the California climate zones is given in Fig. VIII.1. Table VIII.2 gives the DOE-2 file name and the major cities for each of the 16 zones.

3. TMY

The DOE-2 library contains weather files for 26 US weather stations in the Typical Meteorological Year (TMY) format. Appendix VIII.B contains a description of the TMY tapes.

4. Others

The DOE-2 weather processing programs (see Appendix VIII.C) can process TRY, TMY, CTZ, CD144, TD1440, and Weather Year for Energy Computation (WYEC) tapes for use by the DOE-2 program. A brief description of these weather tapes is included in the Appendices to this section. Only the TMY, TRY, and CTZ tapes are included in the DOE-2 library.

---

* The TRY tape library is not available for the IBM version of DOE 2.1A. To create a weather tape for DOE-2.1A simulation, the user must get a weather tape from NOAA and process it using the IBM version of the weather processor. Ground temperatures and clearness numbers, available from LBL, must then be added.

TABLE VIII.1

WEATHER DATA

Data for additional cities will be added if it becomes available.

State and City	DOE-2 File Name	Year	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
ALABAMA						
Birmingham	(BIRMING)	1965	33.57	86.85	6	610
ARIZONA						
Phoenix	(PHOENIX)	1951	33.43	112.02	7	1117
CALIFORNIA						
Fresno	(FRESNO)	1951	36.77	119.72	8	326
Los Angeles	(LOSANG)	1973	33.93	118.40	8	99
Sacramento	(SACRAME)	1962	38.52	121.50	8	17
San Diego	(SANDIE)	1974	32.43	117.17	8	19
San Francisco	(SANFRA)	1974	37.62	122.38	8	8
DISTRICT OF COLUMBIA						
Washington DC	(WASHING)	1957	38.85	77.03	5	14
FLORIDA						
Jacksonville	(JACK/FL)	1965	30.50	81.70	5	24
Miami	(MIAMI)	1964	25.80	80.27	5	7
Tampa	(TAMPA)	1953	27.97	82.53	5	19
GEORGIA						
Atlanta	(ATLANTA)	1975	33.65	84.43	5	1005
IDAHO						
Boise	(BOISE)	1966	43.54	116.22	7	2842
ILLINOIS						
Chicago, downtown	(CHICAGO)	1974	41.78	87.75	6	610
INDIANA						
Indianapolis	(INDIANA)	1972	39.93	86.28	5	793

State and City	DOE-2 File Name	Year	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
KANSAS						
Dodge City	(DODGEC)	1971	37.47	99.97	6	2594
KENTUCKY						
Louisville	(LOUISVI)	1972	38.18	85.73	5	979
LOUISIANA						
Lake Charles	(LAKECH)	1966	30.12	93.22	6	14
New Orleans	(NEWORL)	1958	29.98	90.25	6	3
MAINE						
Portland	(PORT/ME)	1965	43.65	70.32	5	61
MASSACHUSETTS						
Boston	(BOSTON)	1969	42.37	71.03	5	15
MICHIGAN						
Detroit	(DETROIT)	1968	42.23	83.33	5	633
MINNESOTA						
Minneapolis	(MINNEAP)	1970	44.88	93.22	6	822
MISSISSIPPI						
Jackson	(JACK/MS)	1964	32.32	90.08	6	330
MISSOURI						
Columbia	(COLUMBI)	1968	38.97	92.32	6	778
Kansas City	(KANSAS)	1968	39.12	94.60	6	742
St. Louis	(STLOUI)	1972	38.45	90.38	6	535
MONTANA						
Great Falls	(GREATF)	1956	47.48	111.37	7	3664
NEBRASKA						
Omaha	(OMAHA)	1966	41.30	95.90	6	978

State and City	DOE-2 File Name	Year	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
NEW MEXICO						
Albuquerque	(ALBUQUE)	1959	35.05	106.62	7	5310
Los Alamos	(LASL)*	1978	35.80	106.3	7	7370
NEW YORK						
Albany	(ALBANY)	1969	42.75	73.80	5	277
Buffalo	(BUFFALO)	1974	42.77	78.73	5	705
New York City	(NEWYOR)	1951	40.77	73.90	5	
NORTH CAROLINA						
Raleigh	(RALEIGH)	1965	35.82	78.78	5	19
NORTH DAKOTA						
Bismarck	(BISMARC)	1970	46.77	100.75	6	
OHIO						
Cincinnati	(CINCINN)	1957	39.07	84.67	5	1647
Cleveland	(CLEVELA)	1969	41.40	81.85	5	777
OKLAHOMA						
Oklahoma City	(OKLAHOM)	1951	35.40	97.60	6	1280
Tulsa	(TULSA)	1973	36.20	95.90	6	650
OREGON						
Medford	(MEDFORD)	1966	42.37	122.87	8	1298
Portland	(PORT/OR)	1960	45.60	122.60	8	21
PENNSYLVANIA						
Philadelphia	(PHILADE)	1969	39.88	75.25	5	7
Pittsburgh	(PITTSBU)	1957	40.50	80.72	5	1137
SOUTH CAROLINA						
Charleston	(CHARLES)	1955	32.90	80.03	5	41
TENNESSEE						
Memphis	(MEMPHIS)	1964	35.05	89.98	6	263
Nashville	(NASHVIL)	1972	36.12	86.68	6	577

*This weather file is not a TRY weather tape.

State and City	DOE-2 File Name	Year	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
TEXAS						
Amarillo	(AMARILL)	1968	35.23	101.70	6	3607
Brownsville	(BROWNSV)	1955	25.90	97.43	6	16
El Paso	(ELPASO)	1967	31.80	106.40	7	3918
Fort Worth	(FORTWO)	1975	32.90	97.03	6	544
Houston	(HOUSTON)	1966	29.65	95.28	6	50
Lubbock	(LUBBOCK)	1955	33.65	101.82	6	3243
San Antonio	(SANANT)	1960	29.53	98.47	6	792
UTAH						
Salt Lake City	(SALTLA)	1948	40.77	111.97	7	4220
VERMONT						
Burlington	(BURLING)	1966	44.47	73.15	5	331
VIRGINIA						
Norfolk	(NORFOLK)	1969	36.90	76.20	5	26
Richmond	(RICHMON)	1969	37.50	77.33	5	162
WASHINGTON						
Seattle	(SEATTLE)	1960	47.45	122.30	8	386
WISCONSIN						
Madison	(MADISON)	1974	43.13	89.33	6	858
WYOMING						
Cheyenne	(CHEYENE)	1974	41.15	104.82	7	6126
KUWAIT						
Kuwait	(KUWAIT)*		29	-48	-3	

*This weather file is not a TRY weather tape.

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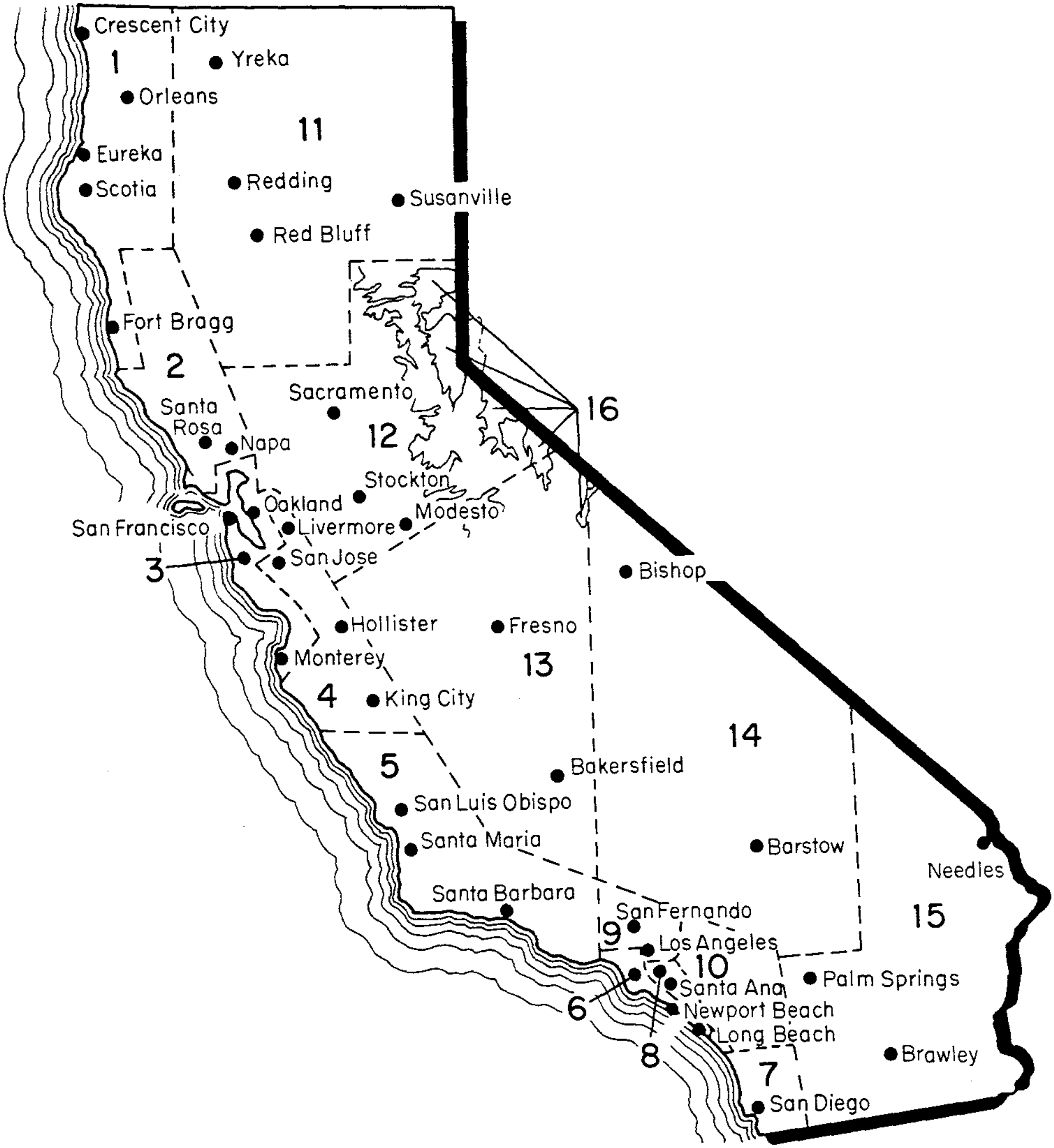


Fig. VIII.1. Map of California climate zones.

TABLE VIII.2

CALIFORNIA CLIMATE ZONE WEATHER FILE INVENTORY

Zone	Representative Cities	DOE-2 Filename
1. North Coast	Crescent City Eureka Fort Bragg Orleans Scotia	CTZ01
2. North Coast Valley	Healdsburg Napa Petaluma Santa Rosa St. Helena Ukiah	CTZ02
3. San Francisco Bay Area	Berkeley Hamilton AFB Oakland Redwood City San Mateo San Rafael San Francisco	CTZ03
4. Upper Coast Range Valley	Hollister King City Livermore Los Gatos Monterey Salinas San Jose Santa Clara Santa Cruz Watsonville	CTZ04
5. Lower Coast Range Valley	Lompoc Ojai Oxnard Paso Robles San Luis Obispo Santa Barbara Santa Paula Santa Maria	CTZ05
6. Los Angeles Beach	Culver City Laguna Beach Los Angeles Airport Newport Beach Santa Monica Torrance	CTZ06

Zone	Representative Cities	DOE-2 Filename
7. San Diego	Chula Vista	CTZ07
	Escondido	
	San Diego	
8. Santa Ana	El Toro	CTZ08
	Long Beach	
	Santa Ana	
	Yorba Linda	
9. Los Angeles City	Burbank	CTZ09
	Los Angeles Civic Center	
	Pasadena	
	San Fernando	
	San Gabriel	
10. San Bernadino	Beaumont	CTZ10
	Corona	
	Redlands	
	Riverside	
	San Bernadino	
	San Jacinto	
	Upland	
11. Northern Zone	Alturas	CTZ11
	Chico	
	Colusa	
	Marysville	
	McCloud	
	Oroville	
	Orland	
	Red Bluff	
	Redding	
	Susanville	
	Willows	
	Yreka	
12. Central Zone	Antioch	CTZ12
	Auburn	
	Davis	
	Lodi	
	Modesto	
	Nevada City	
	Placerville	
	Sacramento	
	Stockton	
	Tahoe City	
	Vacaville	
	Woodland	

Zone	Representative Cities	DOE-2 Filename
13. San Joquin Valley	Bakersfield Coalinga Fresno Los Banos Madera Maricopa Merced Porterville Visalia	CTZ13
14. High Desert	Barstow Bishop Daggett Lake Arrowhead Mt. Wilson Palmdale Sandberg Trona Twentynine Palms Victorville	CTZ14
15. Low Desert	Blythe Brawley Eagle Mtn. El Centro Imperial Indio Iron Mtn. Needles Palm Springs	CTZ15
16. Lake Tahoe	Boca Tahoe City Tahoe Valley airport Truckee (ranger station) (Along the west edge of CTZ 16 - see Fig. VIII.1 - is a 6500 ft. contour. Any area between 6500 ft. and 5600 ft. is part of CTZ 16)	CTZ16

D. SOLAR RADIATION DATA

None of the present TRY or California weather files contain measured solar radiation data. Two options are currently available for calculating the needed hourly values.

In the first option, the LOADS program calculates hourly values of solar radiation for the station in question using the Boeing cloud cover modifier to estimate solar radiation from cloud cover data.

The second option uses the Kimura-Stephenson cloud cover modifier model. This model is available only in the weather processor for TRY tapes. Specifying the TRYKS option to the weather processor will result in a solar packed weather file. The DOE-2 LOADS program will then use these solar values in place of the usual Boeing calculations described in the first option. The Kimura-Stephenson algorithm was developed from a comparison of measured solar data with cloud cover data for a location near Ottawa, Canada. The resulting cloud cover constants, therefore, include the Ottawa clearness numbers. This option should only be used for climates similar to Ottawa.

SOLMET

One year of solar data for each of 35 US weather stations will be included in the weather data library in the future. The SOLMET format and a map showing the location of the solar monitoring weather stations are included as Figs. VIII.2 and VIII.3, respectively. The SOLMET Manual describes how the solar data were prepared and summarizes the methods used to correct existing data and to provide missing data.

E. DESIGN DAY

The user may instruct the program to perform the LOADS and SYSTEMS calculations for a design day. The format for design-day input is given in Chap. III.

F. WEATHER DATA PROCESSING PROGRAMS

DOE-2 contains weather data processing programs that can be used to construct packed binary files of weather data from weather stations that are not in the DOE-2 weather library.

The programs in the weather package are as follows:

a. PACK - This program compresses weather data from TRY (Test Reference Year), TMY, TD1440, CD144, CTZ, and WYEC tapes into a format which is readable by DOE-2.

b. LIST - This program abstracts and prints data from weather files for any user-specified time interval.

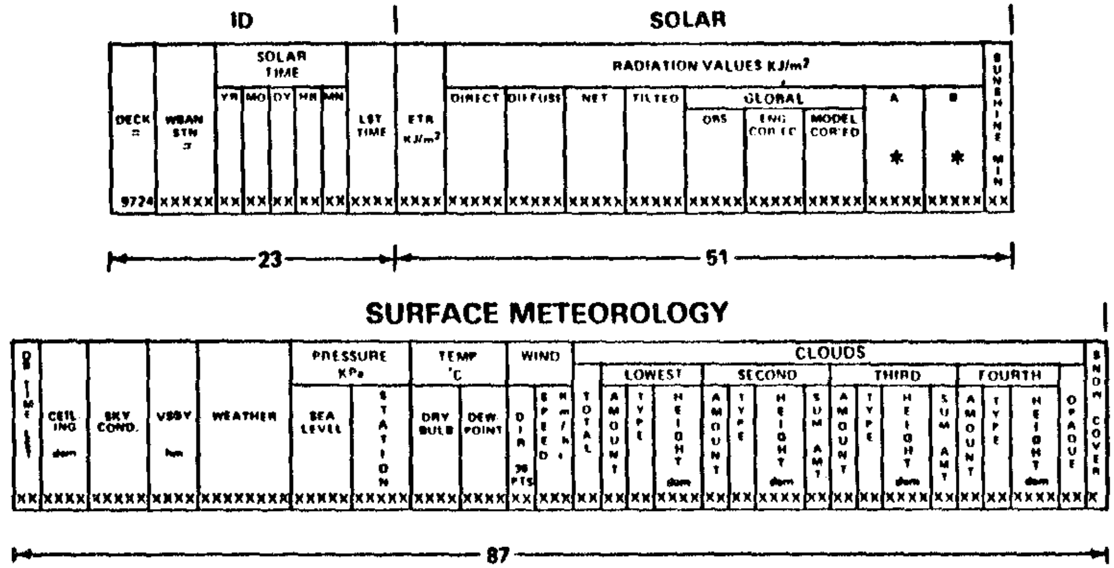
c. EDIT - It is possible with this program to edit, or change, a packed weather file.

d. STAT - This program reads a packed weather file and produces a yearly statistical summary.

See Appendix VIII.C for a discussion of how to use these programs.

Fig. VIII.2.

SOLMET



161 BYTES/RECORD, BLOCKED 24 (3864 BYTES)

14 yrs. per reel at 800 bpi
24 yrs. per reel at 1600 bpi

FORMAT IS FORTRAN COMPATIBLE - NO OVERPUNCHES
- MISSINGS CODED - "9's"

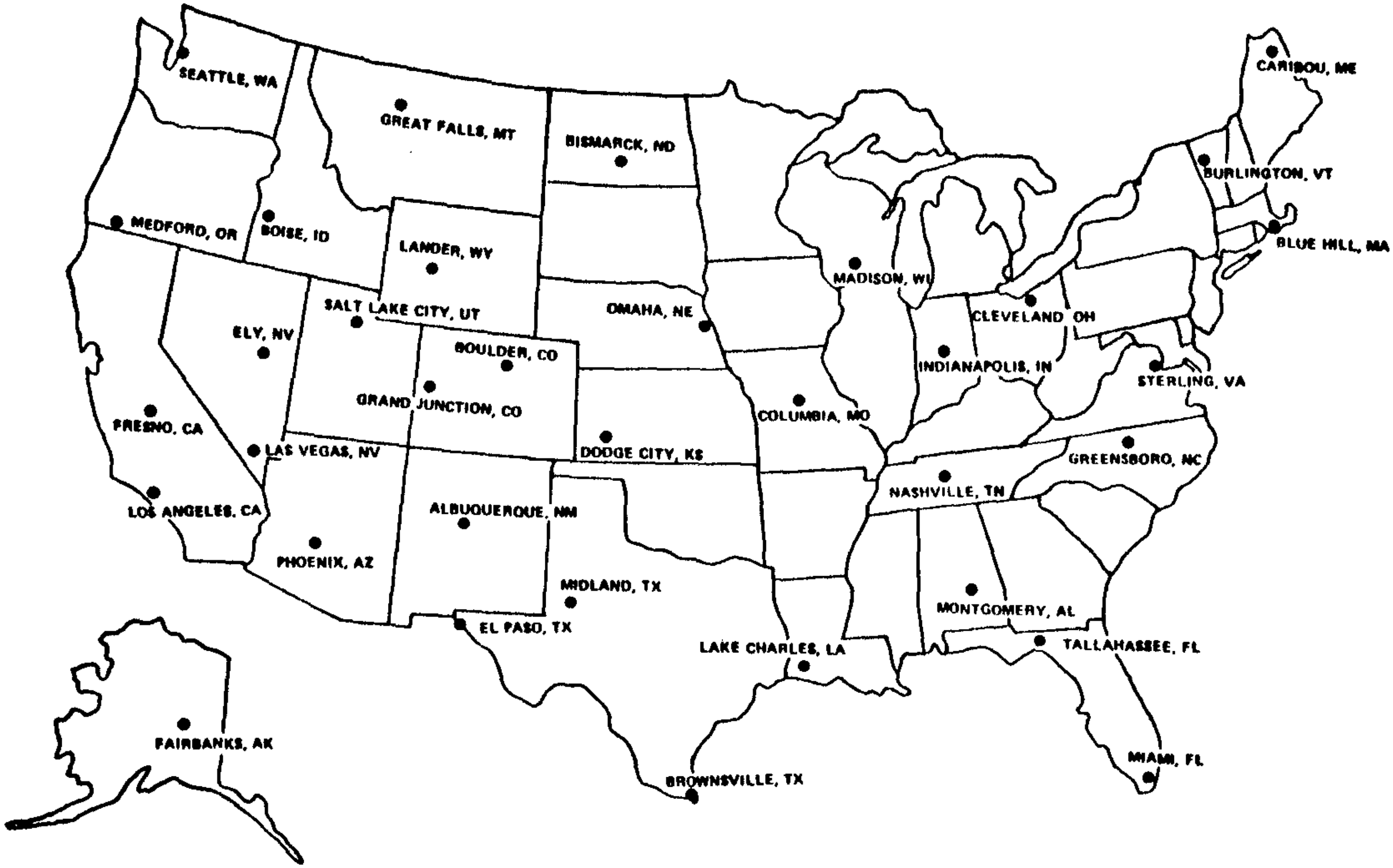
ESTIMATED RADIATION VALUES INDICATED BY ADDING 80,000
ESTIMATION FROM SUNSHINE MODEL INDICATED BY ADDING 60,000
ESTIMATION FROM CLOUD MODEL INDICATED BY ADDING 40,000

* 'A' AND 'B' ARE SUPPLEMENTAL FIELDS FOR ADDITIONAL RADIATION MEASUREMENTS; I.E., ULTRAVIOLET, TILTED, ETC.

LEGEND	
YR	YEAR
MO	MONTH
DY	DAY
HR	HOUR
MN	MINUTE
LST	LOCAL STANDARD TIME
ETR	EXTRATERRESTRIAL RADIATION
KJ/m²	KILOJOULES PER SQUARE METER
OBS	OBSERVED
ENG COR'ED	ENGINEER CORRECTED
MODEL COR'ED	MODEL CORRECTED
MIN	MINUTES
dam	DEKAMETERS (M x 10¹)
hm	HECTOMETERS (M x 10²)
KPa	KILOPASCALS (NEWTONS PER SQUARE METER)
°C	DEGREES CELSIUS
DIR	DIRECTION (TO NEAREST TEN DEGREES)
Km/hr	KILOMETERS PER HOUR
SUM AMT	SUMMARY AMOUNT

FORMAT FOR SOLAR RADIATION/METEOROLOGY DATA

FIGURE 2



NEW NOAA NATIONAL WEATHER SERVICE NETWORK

FIGURE 3

Fig. VIII.3

APPENDIX VIII.A

NOAA TEST REFERENCE YEAR

WEATHER DATA MANUAL

(September 1976)

Available From:

National Climatic Center
Federal Building
Asheville, North Carolina 28801

(704) 254-0961

A. INTRODUCTION

Efficient heating and cooling is largely dependent on building design and on the design of the heating and cooling system. Comparison of heating and air-conditioning systems in a locale requires consideration of the effects of the weather. This weather information must be in great detail.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) established a task group on energy requirements for heating and cooling large structures. Simultaneously, in the interest of energy conservation, the National Bureau of Standards (NBS) and the National Oceanic and Atmospheric Administration (NOAA) were attempting to develop climatological data packaging most useful for building design applications. Joining forces, the three groups established a working group to develop the concept of a Test Reference Year (TRY). TRY would consist of hourly weather data values for a selected reference year to be used by engineers in a given area to compare different heating and air-conditioning systems in the same building or in different buildings.

At the same time, the Federal Energy Administration (FEA)--as a member of the Steering Group on Climatic Conditions and Reference Year of the NATO Committee on Challenges of Modern Society--was also working on the problem. Consolidation of both efforts resulted in the development of a selection process for the TRY, an international format for presentation of the TRY data, and TRY calculations for 60 cities within the United States.

The ASHRAE approved procedure was chosen for selecting a TRY. The principle of selection is to eliminate years in the period of record containing months with extremely high or low mean temperatures until only one year remains. The period of record examined for 59 United States stations is 1948-1975. The 60th station, Portland, Oregon, has a period of record of 1949-1975.

Extreme months are arranged in order of importance for energy comparisons. Hot Julys and cold Januarys are assumed to be the most important. All months are ranked by alternating between the warm half (May to October) and the cold half (November to April) of the year, with the months closest to late July or late January given priority. The resulting order is given in the center column below. If, in addition,, it is assumed that hot summer months or cold winter months are more important than cool summer or mild winter months, then the order of extreme months will be down the first column below from "Hottest July" to "Coolest April" and then down the last column from "Coolest July" to Warmest April".

Hottest	July	Coolest
Coldest	January	Mildest
Hottest	August	Coolest
Coldest	February	Mildest
Hottest	June	Coolest
Coldest	December	Mildest
Hottest	September	Coolest
Coldest	March	Mildest
Warmest	May	Coolest
Coolest	November	Warmest
Warmest	October	Coolest
Coolest	April	Warmest

The first step in the selection process is to mark all 24 extreme months.

Continue marking months starting with next-to-the-hottest July, then next-to-the-coldest January and so on down the first column and then down the second column above until only one year remains without any marked month. If two or more years remain without any marked months, the process is repeated with the third, fourth, etc. hottest or coldest extremes until only one year remains without any marked month. The remaining year is the TRY.

The weather in the test year is a standard for comparison of heating and cooling systems. It is not considered sufficiently typical to yield reliable estimates of average energy requirements over several years.

1. Source

Weather observations, in support of aircraft operations, have been taken at airports since the earliest days of aviation. The rapid growth of the industry during the 1940's made it evident that some mechanical means of summarizing the data must be developed. How was a site to be selected or an airport designed without adequate statistical information on which to base decisions? The first efforts toward this end caused the WBAN No. 1 card to come into being. For archiving purposes, these observations, mostly from military stations, were designated as Card Deck-141. The period of record is generally 1941-1944. A change of format necessitated a new card deck designation (Card Deck-142) to be instituted in 1945. This deck remained in force into 1948. During 1948 additional major changes were made in observing and recording practices. These led to the development of Card Deck-144. Although the usual beginning date of digital information in this form is June 1948, the change-over was made station by station on varying dates. Then too, some stations have had observations back-punched in this format to much earlier dates.

In the early 1960's, the FAA undertook a major airport study. To facilitate the handling of large masses of data necessary for this effort, the Climatological Services of the Weather Bureau, Air Force, and Navy, along with the FAA, devised the tape format. This format was called Tape Data Family-14 (TDF-14) to retain some continuity with the card decks. Within this family of similar observations there are several Tape Decks - each one uniquely identified at the beginning of each physical record on tape.

2. Quality Control and Conversions

All observations have been subjected to some form of quality control. During the earlier years, this was almost entirely a manual effort. As more sophisticated techniques of processing were introduced, the quality control procedures were also improved. Today, the quality control effort is a blend of several computer programs and manual review. Observations are checked for conformance to established observing and coding practices, for internal consistency, for aerial or time oriented consistency, and against defined limits for various meteorological parameters.

The archiving of long term climatological information presents an almost constant dilemma to the archivist, systems analyst, and programmer. Refinements of observational instruments, new techniques, changes in user needs, and other factors combine to keep the incoming data in an almost perpetual state of change. In some instances the changes are of such significance that individual fields in the tape format must be redefined and the ultimate user must adapt this new information to his needs.

At other times, the changes may be of such a nature that they can be incorporated into the existing format by converting units or other measurements. For example, windspeeds were recorded and punched in miles per hour through 1955 and in knots thereafter. All wind speeds on the tape file are in knots, the earlier period having been converted from mph.

Each selected TRY was resubjected to the computer and hand-edit routines, updates being made as necessary.

Some additional conversions were done for the TRY tapes. For the period prior to 1964, wind directions were reported and recorded to 16 points of the compass. These values have been converted to whole degrees. The conversion method used is explained under Tape Field 005. The user is cautioned that for these years wind directions will be biased. Beginning with 1964, wind directions were recorded to whole degrees and these values will appear on the TRY tapes if the selected year occurs during this period.

3. Use of the Manual

This manual was designed so that recourse to additional reference material should be unnecessary. Occasionally, however, the user may wish to obtain copies of original reference manuals or other information. This may be done by writing to the Director, National Climatic Center, Asheville, NC 28801.

Care should be taken to read carefully the general tape notations and coding practices.

B. MANUAL AND TAPE NOTATIONS

1. Format

Each logical record (observation) is 80 bytes long. Archive files are blocked 24 logical records (1920 bytes) per physical tape record. Tapes may be ordered with different blocking factors at no additional cost.

The initial file contains TRY data for 60 stations, 20 stations on each reel of tape. An inventory showing stations and selected years is included in this manual.

The manual presents a graphical representation of the tape format indicating Tape Fields, Tape Positions, and Element Definition followed by detailed information for each field.

2. Manual and Tape

x = any numeric or alphanumeric character
- = an "11" or zone punch
Δ = blank

NOTE: Missing fields are 9 filled.

C. SPECIAL NOTE

Space has been designated for the inclusion of Solar Radiation values. At the present time, this Tape Field will contain 9's.

At the conclusion of the Solar Radiation Rehabilitation Project, it is expected that these data will be added to the TRY tapes. Even at that time, however, only a small percentage of the stations will have the Solar Radiation data available.

D. INVENTORY

WBAN NUMBER	STATION	SELECTED TRY
(Tape 1)		
03927	Fort Worth, TX	1975
03937	Lake Charles, LA	1966
03940	Jackson, MS	1964
12839	Miami, FL	1964
12842	Tampa, FL	1953
12916	New Orleans, LA	1958
12918	Houston, TX	1966
12919	Brownsville, TX	1955
12921	San Antonio, TX	1960
13722	Raleigh, NC	1965
13737	Norfolk, VA	1951
13739	Philadelphia, PA	1969
13740	Richmond, VA	1969
13743	Washington, DC	1957
13874	Atlanta, GA	1975
13876	Birmingham, AL	1965
13880	Charleston, SC	1955
13889	Jacksonville, FL	1965
13893	Memphis, TN	1964
13897	Nashville, TN	1972
(Tape 2)		
13967	Oklahoma City, OK	1951
13968	Tulsa, OK	1973
13983	Columbia, MO	1968
13985	Dodge City, KS	1971
13988	Kansas City, MO	1968
13994	St. Louis, MO	1972
14732	New York, NY	1951
14733	Buffalo, NY	1974
14735	Albany, NY	1969
14739	Boston, MA	1969
14742	Burlington, VT	1966
14764	Portland, ME	1965
14819	Chicago, IL	1974
14820	Cleveland, OH	1969
14837	Madison, WI	1974
14922	Minneapolis, MN	1970
14942	Omaha, NE	1966
23042	Lubbock, TX	1955
23044	El Paso, TX	1967
23047	Amarillo, TX	1968

WBAN NUMBER	STATION	SELECTED TRY
(Tape 3)		
23050	Albuquerque, NM	1959
23174	Los Angeles, CA	1973
23183	Phoenix, AZ	1951
23188	San Diego, CA	1974
23232	Sacramento, CA	1962
23234	San Francisco, CA	1974
24011	Bismarck, ND	1970
24018	Cheyene, WY	1974
24127	Salt Lake City, UT	1948
24131	Boise, ID	1966
24143	Great Falls, MT	1956
24225	Medford, OR	1966
24229	Portland, OR	1960
24233	Seattle-Tacoma, WA	1960
93193	Fresno, CA	1951
93814	Cincinnati, OH	1957
93819	Indianapolis, IN	1972
93821	Louisville, KY	1972
94823	Pittsburgh, PA	1957
94847	Detroit, MI	1968

	STATN NO.	DRY BLB	WET BLB	DEW PT	WIND		STAT PRES	WX	TOT AMT	CLOUDS													
										LAYER 1			LAYER 2				LAYER 3				LAYER 4		
					DIR	SPD				AMT	TYP	HGT	AMT	TYP	HGT	SUM	AMT	TYP	HGT	SUM	AMT	TYP	HGT
	XXXXX	XXX	XXX	XXX	XXX	XXX	XXXX	X	XX	XX	X	XXX	XX	X	XXX	XX	XX	X	XXX	XX	XX	X	XXX
FIELD NUMBER	001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018	019	020	021	022	023

	SLR RAD	BLANK	YEAR	MO	DY	HR	BLNK
	XXXX	XXXXXXXXXX	XXXX	XX	XX	XX	X
FIELD NUMBER	024	025	026	027	028	029	030

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT
001	01 - 05	STATION NUMBER
002	06 - 08	DRY BULB TEMPERATURE
003	09 - 11	WET BULB TEMPERATURE
004	12 - 14	DEW POINT TEMPERATURE
005	15 - 17	WIND DIRECTION
006	18 - 20	WIND SPEED
007	21 - 24	STATION PRESSURE
008	25	WEATHER
009	26 - 27	TOTAL SKY COVER
010	28 - 29	AMOUNT OF LOWEST CLOUD LAYER
011	30	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA
012	31 - 33	HEIGHT OF BASE OF LOWEST LAYER
013	34 - 35	AMOUNT OF SECOND CLOUD LAYER
014	36	TYPE OF CLOUD - SECOND LAYER
015	37 - 39	HEIGHT OF BASE OF SECOND LAYER
016	40 - 41	SUMMATION AMOUNT OF FIRST TWO LAYERS
017	42 - 43	AMOUNT OF THIRD CLOUD LAYER
018	44	TYPE OF CLOUD - THIRD LAYER
019	45 - 47	HEIGHT OF BASE OF THIRD LAYER
020	48 - 49	SUMMATION AMOUNT OF FIRST THREE LAYERS
021	50 - 51	AMOUNT OF FOURTH CLOUD LAYER
022	52	TYPE OF CLOUD - FOURTH LAYER
023	53 - 55	HEIGHT OF BASE OF FOURTH LAYER
024	56 - 59	SOLAR RADIATION
025	60 - 69	BLANK
026	70 - 73	YEAR
027	74 - 75	MONTH
028	76 - 77	DAY
029	78 - 79	HOUR
030	80	BLANK

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
001	01 - 05	STATION NUMBER	01001 - 98999	Unique number used to identify each station. Usually a WBAN number, but occasionally a WMC or other number system.
002 003 004	06 - 08 09 - 11 12 - 14	DRY BULB TEMPERATURE WET BULB TEMPERATURE DEW POINT TEMPERATURE	000 - 140 -01 - -80 999	Specified temperature in whole degrees Fahrenheit. 000-140 = 0° - $+140^{\circ}$F -01--80 = -1° - -80°F 999 = Missing
005	15 - 17	WIND DIRECTION	000 - 360 999	Direction from which the wind is blowing in whole degrees. 000 = Calm 001-360 = 001° - 360° 999 = Missing NOTE: Prior to 1964 direction was recorded to only 16 intervals (points of the compass). The following scheme was used to convert these values to whole degrees. TAPE ORIGINAL CODE 000 = Calm 360 = North 023 = North Northeast 045 = Northeast 068 = East Northeast 090 = East 113 = East Southeast 135 = Southeast 158 = South Southeast 180 = South 203 = South Southwest 225 = Southwest 248 = West Southwest 270 = West 293 = West Northwest 315 = Northwest 338 = North Northwest
006	18 - 20	WIND SPEED	000 - 230 999	Wind speed in whole knots. 000 = Calm 001-230 = 1-230 knots 999 = Missing
007	21 - 24	STATION PRESSURE	1900 - 3999 9999	Pressure at station in inches and hundredths of Hg. 1900-3999 = 19.00 - 39.99 in Hg. 9999 = Missing

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
008	25	WEATHER	0 - 9	Occurrence of weather at the time of observation. 0 = No weather or obstructions to vision. 1 = Fog 2 = Haze 3 = Smoke 4 = Haze and smoke 5 = Thunderstorm 6 = Tornado 7 = Liquid precipitation (rain, rain showers, freezing rain, drizzle, freezing drizzle) 8 = Frozen precipitation (snow, snow showers, snow pellets, snow grains, sleet, ice pellets, hail) 9 = Blowing dust, blowing sand, blowing spray, dust NOTE: Original observations may contain combinations of these elements. Whenever this occurred, a priority was assigned for the purpose of indicating weather in this Tape Deck. (1) - Liquid precip - 7 (2) - Frozen precip - 8 (3) - Obstructions to vision - 1, 2, 3, 4, 9 (4) - Thunderstorm (no precip) - 5 (5) - Tornado (no precip) - 6
009 010 013 016 017 020 021	26 - 27 28 - 29 34 - 35 40 - 41 42 - 43 48 - 49 50 - 51	TOTAL SKY COVER AMOUNT OF LOWEST CLOUD LAYER AMOUNT OF SECOND CLOUD LAYER SUMMATION OF FIRST TWO LAYERS AMOUNT OF THIRD CLOUD LAYER SUMMATION OF FIRST THREE LAYERS AMOUNT OF FOURTH CLOUD LAYER	00 - 10 99	Amount of the celestial dome covered by clouds or obscuring phenomena in tenths. 00-10 = 0-10 tenths 99 = Missing
011 014 018 022	30 36 44 52	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA TYPE OF CLOUD - SECOND LAYER TYPE OF CLOUD - THIRD LAYER TYPE OF CLOUD - FOURTH LAYER	0 - 9	Generic cloud type or obscuring phenomena. 0 = Clear 1 = Fog or other obscuring phenomena 2 = Stratus or Fractus Stratus 3 = Stratocumulus 4 = Cumulus or Cumulus Fractus 5 = Cumulonimbus or Mammatus 6 = Altostratus or Nimbostratus 7 = Altocumulus 8 = Cirrus 9 = Cirrostratus or Cirrocumulus 9 = Unknown if the amount of cloud is 99

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
012 015 019 023	31 - 33 37 - 39 45 - 47 53 - 55	HEIGHT OF BASE OF LOWEST LAYER HEIGHT OF BASE OF SECOND LAYER HEIGHT OF BASE OF THIRD LAYER HEIGHT OF BASE OF FOURTH LAYER	000 - 760 777 888 999	Height of base of clouds or obscuring phenomena in hundreds of feet. 000-760 = 0-76,000 feet 777 = Unlimited - clear 888 = Cirroform clouds of unknown height 999 = Missing
024	56 - 59	SOLAR RADIATION	0000 - 1999 9999	Total solar radiation in Langleys to tenths. Values are for the hour ending at time indicated in Field 029. 0000-1999 = 0-199.9 Langleys 9999 = Missing
025	60 - 69	BLANK	ΔΔΔΔΔΔΔΔΔΔ	Blank field - reserved for future use.
026	70 - 73	YEAR	1948 - 1980	Year
027	74 - 75	MONTH	01 - 12	Month of year 01 = Jan 02 = Feb etc.
028	76 - 77	DAY	01 - 31	Day of month
029	78 - 79	HOUR	00 - 23	Hour of observation in Local Standard Time. 00-23 = 0000-2300 LST
030	80	BLANK	Δ	Blank field - reserved for future use.

APPENDIX VIII.B

TMY WEATHER DATA

INTRODUCTION

Solar radiation and surface meteorological data recorded on an hourly* basis are maintained at the National Climatic Center (NCC), Asheville, North Carolina. These data cover recording periods from January 1953 through December 1975 for 26 data rehabilitation stations, although the recording periods for some stations may differ. The data are available in blocked (compressed) form on magnetic tape (SOLMET) for the entire recording period for the station of interest.

Contractors desiring to use a data base for simulation or system studies for a particular geographic area require a data base that is more tractable than these, and also one that is representative of the area. Sandia National Laboratory has used statistical techniques to develop a method for producing a typical meteorological year (TMY) for each of the 26 rehabilitation stations. This section describes the use of these magnetic tapes.

The TMY tapes comprise specific calendar months selected from the entire recorded span for a given station as the most representative, or typical, for that station and month. For example, a single January is chosen from the 23 Januarys for which data are recorded from 1953 through 1975 on the basis of its being most nearly like the composite of all 23 Januarys. Thus, for a given station, January of 1967 might be selected as the typical meteorological month (TMM) after a statistical comparison with all of the other 22 Januarys. This process is pursued for each of the other calendar months, and the twelve months chosen then constitute the TMY.

Although the data have been rehabilitated by NCC, some recording gaps do occur in the SOLMET tapes. Moreover, there are data gaps because of the change from one-hour to three-hour meteorological data recording in 1965. Consequently, as TMY tapes were being constituted from the SOLMET data, the variables data for barometric pressure, temperature, and wind velocity and direction were scanned on a month by month basis, and missing data were replaced by linear interpolation. Missing data in the leading and trailing positions of each monthly segment are replaced with the earliest/latest legitimate observation.

Also, since the TMM's were selected from different calendar years, discontinuities occurred at the month interfaces for the above continuous variables. Hence, after the monthly segments were rearranged in calendar order, the discontinuities at the month interfaces were ameliorated by cubic spline smoothing covering the six-hourly points on either side of the interface.

*Hourly readings for meteorological data are available through 1964; readings are on a three-hourly basis subsequently.

The record length of the TMY format is 132 characters. Fields actually used by the DOE-2.1 weather processor are marked with asterisks.

Column	Contents
* 1-5	WBAN station number.
* 6-15	Solar time at end of hourly solar observation.
	* 6-7 Year of observation (00-99 = 1900-1999)
	* 8-9 Month of observation (01-12)
	* 10-11 Day (01-31)
	* 12-15 End of the hour of observation 0001-2400 (hours and minutes).
* 16-19	Local standard time in hours and minutes corresponding to the solar time given above.
* 20-23	Extraterrestrial radiation kJ/m^2 based on solar constant = 1377 J/m^2s.
* 24-28	Direct normal radiation kJ/m^2. Column 24 is a model flag; columns 25-28 contain the data.
29-33	Diffuse radiation kJ/m^2.
34-38	Net radiation.
39-43	Tilt radiation.
44-48	Observed radiation kJ/m^2.
49-53	Engineering corrected radiation.
* 54-58	Standard year corrected radiation in kJ/m^2. This is used by DOE-2 as the total horizontal radiation. Column 54 is a model flag; columns 55-58 contain the data.
59-68	Additional radiation data.
69-70	Minutes of sunshine for local standard hour most closely matching the solar hour.
* 71-72	Time of surface observation (hour) 00-23. This is the local standard hour of the TD 1440 observation closest to the mid-point of the hour for which solar data was taken.
73-76	Ceiling height in meters times ten.

Column	Contents
77-81	Sky condition.
82-85	Visibility in hundreds of meters (tenths of kilometers).
86-93	Weather flags—used to set the rain and snow flags for the weather file. These flags are never used by the program. See SOLMET manual Vol. I, page 4 for a description of this field.
94-98	Atmospheric pressure reduced to sea level in tenths of millibars (08000 to 10999).
* 99-103	Station atmospheric pressure in tenths of millibars.
* 104-107	Dry-bulb temperature in tenths of °C (-700 - 0600).
* 108-111	Dew point temperature in tenths of °C.
* 112-114	Wind direction in degrees.
* 115-118	Wind speed in tenths of m/s (0000-1500).
* 119-120	Total sky cover (tenths) (00-10).
* 121-122	Total opaque sky cover (tenths).
123	Snow cover flag; 0 = none, 1 = some.
124-132	Blank.

STATION NUMBER	STATION NAME
03927	Fort Worth, TX
03937	Lake Charles, LA
03945	Columbia, MO
12832	Apalachicola, FL
12839	Miami, FL
12919	Brownsville, TX
13880	Charleston, SC
13897	Nashville, TN
13985	Dodge City, KS
14607	Caribou, ME
14837	Madison, WI
23044	El Paso, TX
23050	Albuquerque, NM
23154	Ely, NV
23183	Phoenix, AZ
23273	Santa Maria, CA
24011	Bismarck, ND
24143	Great Falls, MT
24225	Medford, OR
24233	Seattle-Tacoma, WA
93193	Fresno, CA
93729	Cape Hatteras, NC
93734	Sterling, VA
94701	Boston, MA
94728	New York, CN Park
94918	Omaha, NE

Typical Meteorological Months Comprising
Typical Meteorological Year for 26 Stations

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Madison	65	60	72	64	53	57	73	63	58	74	65	54
Bismarck	60	71	57	54	57	75	69	55	57	68	67	67
Albuquerque	58	53	65	66	64	69	57	54	67	65	59	54
Apalachicola	60	60	64	63	67	63	58	55	66	55	59	65
Seattle	75	71	62	72	61	59	62	70	62	66	68	56
Boston	66	53	61	60	62	65	53	56	62	57	61	61
Brownsville	64	61	56	65	71	64	61	66	68	53	68	75
Caribou	59	70	70	69	71	53	74	53	72	73	74	60
Lake Charles	67	72	56	74	64	59	70	55	64	72	67	65
Cape Hatteras	65	55	56	69	54	69	68	71	64	66	74	66
New York	58	59	59	74	74	61	60	72	58	56	71	67
Charleston	60	60	75	59	73	61	53	67	60	65	71	75
Columbia	65	55	54	70	58	64	62	63	67	74	71	64
Dodge City	60	73	54	62	55	63	61	60	66	54	71	67
El Paso	74	67	75	74	54	61	71	61	71	67	71	56
Fort Worth	72	61	62	66	66	59	65	55	57	68	71	62
Great Falls	68	65	71	63	70	59	54	62	73	71	71	65
Fresno	64	75	68	53	68	62	54	73	68	66	74	68
Miami	62	74	67	59	64	53	57	63	57	65	61	68
Nashville	54	59	64	74	63	68	75	73	58	69	66	66
Phoenix	68	75	63	57	68	56	74	72	72	68	59	66
Santa Maria	63	59	57	57	56	64	53	62	61	62	53	62
Wash., DC	65	70	67	67	56	75	73	65	73	73	73	61
Omaha	72	59	59	63	58	72	61	60	66	68	74	62
Ely	74	71	71	71	56	75	58	73	66	66	63	65
Medford	66	62	53	69	64	59	69	63	62	60	62	61

APPENDIX VIII.C

WEATHER DATA PROCESSING PACKAGE

The following pages contain a general description of the weather data processing routines.

DOE-2 Weather Processor

The weather data available from TRY (Test Reference Year), 1440, TMY (Typical Meteorological Year), WYEC (Weather Year for Energy Computation), CD144 or CTZ tapes are not useable by the DOE-2 program until they have been packed, i.e., compressed into a format readable by the DOE-2 program. It is the purpose of the DOE-2 Weather Processor to accomplish this task. In addition to this task the Weather Processor is capable of fulfilling other tasks.

1. It can read either a weather tape or a packed weather file and produce an hour by hour listing of the data.

2. It can read a packed file and replace user-selected variables, i.e., it can edit a packed file.

3. It can read a packed file and produce a yearly statistical summary.

These four functions will be abbreviated here with the code-words: PACK, LIST, EDIT, and STAT.

The input deck for the Weather Processor has the following form:

job card

control
cards

End-of-Record Card

user-supplied
data deck

End-of-File

The job card must be formatted according to the rules of the computer service being used and will not be described here. The control cards will also be site dependent and will also vary according to which of the above functions is desired by the user.

Before describing the user-supplied input deck, one other point must be stressed. Depending upon the computer system being used, the user must arrange for the unpacked weather file to be placed in the system--either as a tape file or in some other permanent file storage device. The user will have to supply, to the control cards, the file name and other parameters required by the computer system to identify the unpacked weather file. Similarly, the output of the packing and editing functions must also be given a location for storage. Either a tape number and ownership or the disk file name must be supplied by the user, to the control cards, so that (1) the program knows where to put the output and (2) the user can retrieve the packed data when running DOE-2.

In the previous discussion it is assumed that the user has taken care of these operational details and only the user-specified data deck will be described. The following section will describe, as an example, the control card structure for the Lawrence Berkeley Laboratory computer system.

Data Deck Structure

The data input to the DOE-2 Weather Processor is a set of cards arranged in a precise order, depending upon the function to be performed by the Weather Processor. Several different functions can be performed in order by the same computer run, but the same function cannot be duplicated in the same run. Thus it is possible to PACK, LIST, and STAT on the same run or, similarly, to EDIT, LIST, and STAT. The data deck for each of the functions follows a different format and will be described separately below.

1. PACK

Card 1: The word PACK in columns 1-4.

Card 2: The station name in columns 1-20. This name will be written on the output file as identification. The entry here is for the user only and is arbitrary.

Card 3: The data on this card is entered as shown below. When the format is shown as L, it signifies that the datum must be left justified in the columns indicated. The format R signifies that the data must be right justified in the columns indicated, and the format D means that the value should be entered with a decimal point (neither right or left justification is required). For those with FORTRAN background: L corresponds to A6, R to I6, and D to F6.1.

Columns	Format	Description
1-6	L	A code-word specifying the unpacked tape type. Options are TRY, TRYKS, 1440, 1440-3, CD144, CD1443, CTZ, TMY, WYEC, and OTHER.*
7-12	R	Weather station number. This is required for TRY, TMY, and WYEC input. For 1440, 1440-3, CD144, CD1443, or CTZ input, the entry of -999 flags this field as unused.
13-18	R	The year of the weather data (e.g., 1972). This is required for 1440, CD144, CD1443, or CTZ tapes (which contain several years of weather data). For TRY and TMY tapes, -999 should be input.

* If OTHER is chosen, the user must first have written a subroutine with the name OTHER to be placed in the code. This subroutine will interpret the format on the unpacked tape to the Weather Processor. The user must have access to the source code of the Weather Processor to see how to do this.

Columns	Format	Description
19-24	R	Time zone (as in the BUILDING-LOCATION instruction)
25-30	D	Latitude
31-36	D	Longitude
37-42	L	A code-word specifying the number of bits per word to be used in packing the output file. The options are 60-BIT (for CDC computers) or 30-BIT (for 32 bit machines).
43-48	L	A code-word specifying the type of output file. The options are OLD, NORMAL, and SOLAR. OLD produces a DOE-1 compatible file. NORMAL produces a DOE-2 file (not readable by DOE-1). SOLAR will be used to write a file containing additional solar information.
49-54	R	Interpolation interval. The program fills in missing data by linear interpolation between the last and the next value present, if the number of hours of missing data is less than or equal to the interpolation interval. If more hours of data are missing than the interpolation interval, it still does interpolation up to 24 hours and a warning message is issued. If more than 24 hours are missing the previous value is used. The interpolation interval must be less than 24*.
55-60	D	This sets the maximum dry-bulb temperature change allowed in one hour. Changes larger than this will cause a warning message to be printed.

Card 4: Contains the 12 clearness numbers (one per month) in D format in column intervals 1-6, 7-12, 13-18, etc.

Card 5: Contains the 12 ground temperatures (one per month in °F) in D format in column intervals 1-6, 7-12, 13-18, etc.

2. LIST

Card 1: The word LIST in columns 1-4.

* The Weather Processor makes no evaluation of the data to see that it is internally consistent, except that during interpolation it never allows the wet-bulb temperature to exceed the dry-bulb temperature, or the dew point temperature to exceed the wet-bulb temperature.

Card 2:

Columns	Format	Description
1–6	L	Input type or file type. Options are PACKED, OTHER, TRY, TRYKS, 1440, 1440-3, CD144, CD1443, CTZ, WYEC, and TMY.
7–12	R	Year of weather data (e.g., 1972). Required for CD144, CD1443, CTZ, 1440-3, and 1440 tapes. TRY, TMY, WYEC, and PACKED should have -999.
13–18	R	Station number. Required for WYEC, TRY, and TMY. 1440, 1440-3, CD144, CD1443, CTZ, and PACKED can have -999 entered here.
19–24	R	Beginning month of listing (1-12 for January - December).
25–30	R	Ending month of listing (1-12 for January - December).

The next three fields must be supplied only when listing an unpacked TMY or WYEC tape.

Columns	Format	Description
31–36	R	Time zone (4 = Atlantic, 5 = Eastern, 6 = Central, 7 = Mountain, 8 = Pacific, 9 = Yukon, 10 = Hawaii)
37–42	D	D station latitude (°N)
43–48	D	D Station longitude (°W) (Latitude and longitude should be given to tenths of a degree).

Note that for 1440, 1440-3, CD144, CD1443 and TRY tapes, the station number or weather year for the first file listed will be printed in the heading for the second file. This offset will continue for subsequent file listings.

3. EDIT

The user is permitted to change up to 336 hours (which corresponds to two weeks) of data in one run. In addition, the user may change the clearness numbers and the ground temperatures. The latter requires three data cards, while the former requires two data cards for each hour being changed. If the user desires to change the clearness numbers and the ground temperatures these data cards must precede the set of pairs of data cards for the hourly changes.

Card 1: The word EDIT in columns 1-4.

Card 2:

Columns	Format	Description
1–6	L	A code-word specifying the word size on the packed output file. Options are 60-BIT or 30-BIT.

7-12	L	A code-word specifying the output file type. Options are OLD, NORMAL, and SOLAR as described in columns 43-48 of PACK. It must be the same as on the packed input file.

Card 3: Assuming that clearness numbers and ground temperatures are being changed, should be blank or a 0 in column 6.

Card 4: Should have the same format as Card 5 in PACK for the new ground temperatures*.

Card 5: Should have the same format as Card 4 in PACK for the new clearness numbers*.

If clearness numbers and ground temperatures are being changed, then n = 6, 8, 10, 12, etc., for successive hourly data being changed. If clearness numbers and ground temperatures are not being changed then n = 3, 5, 7, 9, etc.

Card n:

Columns	Format	Description
1-6	R	Month of change (1-12)
7-12	R	Day of change (1-31)
13-18	R	Hour of change (1-24)

Card n+1:

Columns	Format	Description	
1-6	D	New wet-bulb temperature	(°F)
7-12	D	New dry-bulb temperature	(°F)
13-18	D	New dew-point temperature	(°F)
19-24	D	New pressure	(inches of Hg)
25-30	D	New wind speed	(knots)
31-36	D	New cloud amount	(0-10)
37-42	R	New cloud type	(0,1,2)
43-48	R	New wind direction	(0-15)
49-54	D	New total horizontal solar	($Btu/hr-ft^2$)
55-60	D	New direct normal solar	($Btu/hr-ft^2$)

If any field has -999. (in D format) or -999 (in R format), the old value remains unchanged. All fields must be filled either with a new value or an indication that the old value is to be unchanged.

Note that if dry-bulb temperature is changed, the user should also correct the dew-point temperature so that calculated humidity will be correct.

Card last: The EDIT option must close with a card with -999 in column 3-6.

4. STAT

Only one card is necessary for the STAT option with the word STAT in columns 1-4.

*Note that the clearness numbers and ground temperatures are reversed for the EDIT option only.

5. Multiple Options

To exercise several options in the same computer run it is merely necessary to place the appropriate decks one behind the other, without any end-of-record cards between them. The last card in the entire deck--whether running one or several options must have the word END in columns 1-3.

6. Examples

Example 1: To PACK, LIST for 12 months, and STAT a Sacramento TRY tape.

```
                   1         2         3         4         5         6
          123456789012345678901234567890123456789012345678901234567890

Card 1:   PACK

Card 2:   TRY SACRAMENTO
                                         30-BIT
Card 3:   TRY    23232  -999      8 38.5 121.5/60-BITNORMAL      4 20.

Card 4:   1.06   1.05   1.03   1.01 0.99  0.97   0.99  0.98  1.00 1.00

                                                             1.04  1.05

Card 5:   57.    55.     56.  60.  65.    70.    70.    74.  76.  72.

                                                             66.    61.

                   1         2         3         4         5         6
          123456789012345678901234567890123456789012345678901234567890

Card 6:   LIST

Card 7:   PACKED  -999  -999    1    12

Card 8:   STAT

Card 9:   END
```

Example 2: To EDIT for August 15 from 12:00 noon through 7:00 p.m. the wet-bulb temperature, dew-point temperature, wind speed, and wind direction and LIST for the month of August a packed OAKLAND tape.

```
                   1         2         3         4         5         6
          123456789012345678901234567890123456789012345678901234567890

Card 1:   EDIT

Card 2:   60-BITNORMAL

Card 3:        8     15     12

Card 4:      76. -999.   69. -999.  0.  -999.    -999      0  -999  -999

Card 5:        8     15     13

Card 6:      79. -999.   73. -999.  0.  -999.    -999      0  -999  -999

   .
   .
   .
Card 19:  -999

Card 20:  LIST

Card 21:  PACKED  -999  -999     8     8

Card 22:  END
```

Example 3: To LIST the month of January 1973 from a CHICAGO 1440 tape.

```
                   1         2         3         4         5         6
          123456789012345678901234567890123456789012345678901234567890

Card 1:   LIST

Card 2:     1440  1973  -999     1     1

Card 3:   END
```

7. General Comments

One of the major problems of weather tapes is the amount of missing data. As mentioned before while discussing the interpolation interval, the DOE-2 Weather Processor attempts to supply values for the missing data according to a linear interpolation process. This makes sense when the number of consecutive missing values is relatively small. The purpose of the interpolation interval is to allow the user to specify what "relatively small" means. The next question is how should the user evaluate "relative smallness." It is suggested that, before attempting to create a packed file, the user LIST a month of the unpacked tape to obtain an idea of how much data is missing. This will be indicated by the value -999 or -999. in the data columns of the print-out.

1440 and CD144 tapes come in two varieties: tapes with measurements every hour and those with measurements every third hour. Listing the tape is the best way of discovering which kind of tape the user is dealing with. If the tape turns out to have data every third hour, the user should use the code-word 1440-3 or CD1443 in the PACK input. This will speed up the packing and cut down the number of warning messages.

After the tape has been listed, the appropriate interpolation warning interval may be chosen. For 1440-3 and CD1443 tapes not many consecutive values need to be missing before the number of hours of missing data becomes large. An interpolation warning interval of 9 is recommended for these tapes. Other tapes, such as TRY, WYEC and TMY, have little missing data and an interpolation warning interval of 4 can be used.

Once the file is packed, it should again be listed (or as in Example 1, listed along with the packing). The user should examine the days that were flagged with warning messages to see whether it is desirable to replace some of the hourly values using the EDIT option. The EDIT option cannot be used in the same run as PACK. Both EDIT and STAT can be used only with packed files, whereas PACK can only be used with unpacked files. The EDIT feature cannot be used to change file types; that is, to change an OLD file to a NORMAL file.

When changing dry-bulb temperatures through the EDIT option, the user should also make changes in the dew-point temperatures, so that the humidity ratio will be recalculated appropriately.

APPENDIX VIII.D

MISCELLANEOUS WEATHER TAPES

The weather tapes described here can be processed by the weather processing programs to produce weather files for use with DOE-2. With the exception of the CTZ tapes, these tapes are not available in the DOE-2 library.

A. AIRWAYS SURFACE OBSERVATIONS, TD1440

1. General

Observations (physical records) are placed on tape in groups (logical records) of six. Thus, the 24 observations for each day are contained in four logical record groups. Space is always retained on the tape for 24 observations per day with missing observations being coded blank.

Beginning January 1, 1965, a new program was initiated for most Weather Bureau stations reducing the number of hourly observations being punched from 24 to 8 per day. These 3-hourly observations are punched in local standard time, the hours selected to coincide with the standard international synoptic times of 0000GMT, 0300GMT, 0600GMT, etc. Available taped LST observations will, therefore, vary depending upon the time zone at a given station. A few Weather Bureau stations that are specially processed and most Air Force and Navy stations continue to be available on a 24 observation/day basis.

These unpacked tapes are available from the National Climatic Center.

2. Format

Each record within the record group consists of 80 character positions, including those for hour, and the position for record mark at the end of each record. Six such records, plus the record-group identification fields of 15 character positions, make up the record group, 495 characters in length. The fields within the first observation of the record group are referred to as fields 101 through 135, those of the second observation as 201 through 235, etc., up to the sixth and last observation, where the fields are numbered 601 through 635.

The format of the identification field and the first observation of the record group are shown in Fig VIII.4.

B. CD144 WEATHER TAPES

1. General

Weather data is collected in CD144 weather tape format. These tapes are then processed by the National Climatic Center (NCC) into the TD1440 format. If the user wishes to use the CD144 tapes for years earlier than the NCC, or new CD144 tapes that have not yet been converted, the CD144 weather processor option should be chosen.

2. Format

The format of the CD144 records is shown in Fig. VIII.5. Each hourly observation is stored in one 80-character record. Therefore, for stations that take hourly observations, there are 8760 records per year (code-word CD144), and for those that take data every 3 hours, there are 2920 records per year (code-word CD1443).

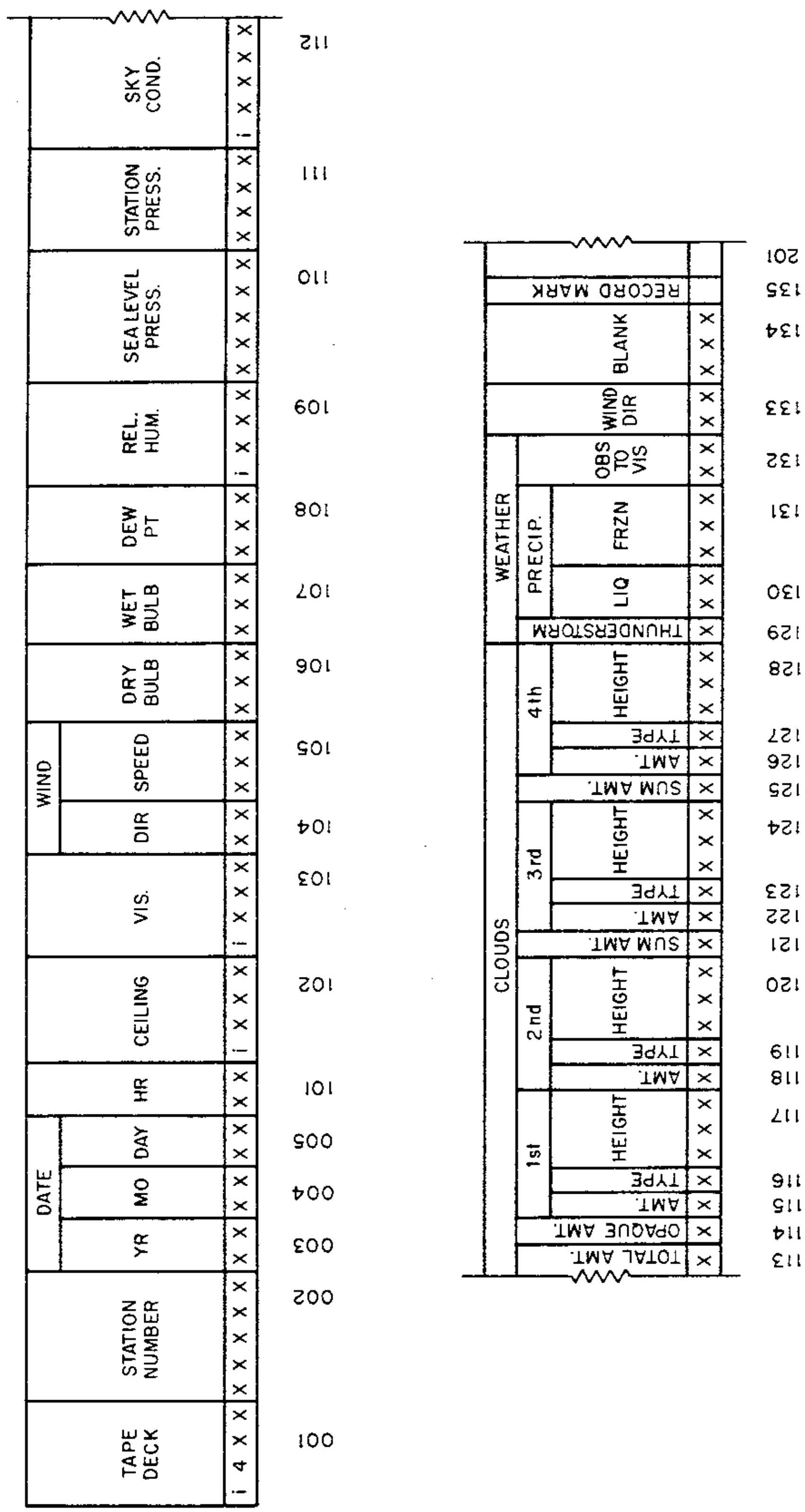


Fig. VIII.4. Format for TD1440 weather tapes.

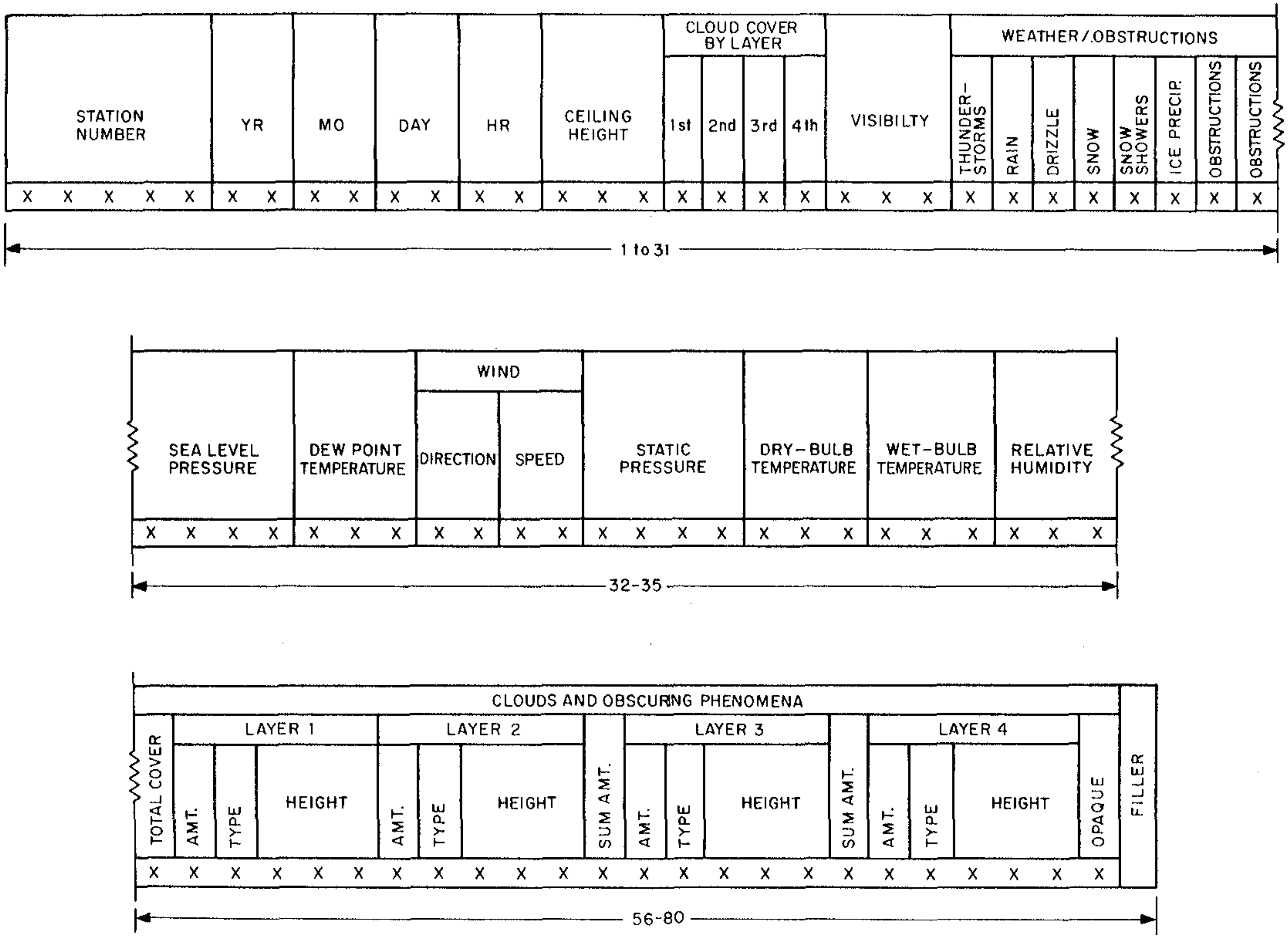


Fig. VIII.5. Record format for CD144 weather tapes.

C. CTZ WEATHER TAPES

1. General

The CTZ weather tapes were developed for the California Energy Resources Conservation and Development Commission (CERCDC). They represent "typical" weather for the 16 California climate zones. These unpacked tapes can be obtained from CERCDC or LBNL. Packed CTZ tapes are included in the DOE-2 library.

2. Format

With the exception of the first seven columns, the format of the CTZ tape format is identical to the CD144 format (see Fig. VIII.5). The station number and year are replaced by 2 blanks and a 5 digit zone number.

D. WYEC WEATHER TAPES

1. General

The Weather Year for Energy Computation (WYEC) weather tapes represent "typical" weather. The WYEC data was taken from rehabilitated SOLMET data and contains measured solar data similar to the TMY tapes. WYEC tapes are available for some places not included in the TMY tapes and vice versa. The WYEC unpacked files are available from ASHRAE.

APPENDIX VIII.E

WEATHER DATA SUMMARIES FOR TRY CITIES

These weather data summaries were obtained from TRY weather data tapes using the STAT option of the DOE-2 Weather Processor Program.

LATITUDE = 42.75 LONGITUDE = 73.80 TIME ZONE = 5

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
AVG. TEMP. (F) (DRYBULB)	21.3	25.0	31.1	48.3	56.4	66.3	69.6	70.2	61.0	49.1	39.7	22.6	46.8
AVG. TEMP. (F) (WETBULB)	20.1	23.5	27.8	42.5	50.3	61.0	64.0	64.1	56.1	43.8	37.1	21.5	42.7
AVG. DAILY MAX. TEMP.	29.2	31.9	39.2	59.9	68.1	76.9	79.4	82.0	72.9	60.8	45.7	28.9	56.4
AVG. DAILY MIN. TEMP.	13.0	17.5	23.1	36.0	44.4	54.8	59.4	59.0	51.2	37.0	33.1	15.2	37.0
HEATING DEG. DAYS (BASE 65)	1353.8	1118.7	1051.5	518.4	304.0	100.3	49.5	56.6	196.5	506.6	759.4	1313.0	7328.4
(BASE 60)	1198.8	978.7	896.5	386.0	194.5	43.4	21.5	24.5	120.3	373.9	609.4	1158.0	6005.6
(BASE 55)	1043.8	838.7	742.1	268.9	112.3	16.3	6.8	9.3	65.8	259.9	460.3	1003.0	4827.0
COOLING DEG. DAYS (BASE 70)	0.	0.	0.	7.8	15.0	69.4	93.6	121.7	32.1	3.3	0.	0.	342.8
(BASE 75)	0.	0.	0.	2.8	4.5	30.4	35.6	57.6	12.3	.3	0.	0.	143.5
(BASE 80)	0.	0.	0.	.5	1.5	11.3	11.7	19.1	3.9	0.	0.	0.	47.9
MAXIMUM TEMP.	41	43	60	83	87	91	92	91	88	79	60	54	92
MINIMUM TEMP.	-7	1	6	14	29	42	44	43	36	17	11	-19	-19
NO. DAYS MAX. 90.AND ABOVE	0	0	0	0	0	2	2	1	0	0	0	0	5
NO. DAYS MAX. 32 AND BELOW	20	15	5	0	0	0	0	0	0	0	2	23	65
NO. DAYS MIN. 32 AND BELOW	29	28	27	12	5	0	0	0	0	8	14	28	151
NO. DAYS MIN. 0 AND BELOW	5	0	0	0	0	0	0	0	0	0	0	3	8
AVG. WIND SPEED (MPH)	9.6	10.4	11.6	10.4	9.0	7.8	6.7	5.7	5.4	6.6	8.1	9.7	8.4
AVG. WIND SPEED (DAY)	11.7	11.4	13.0	11.0	10.2	8.6	7.5	6.9	7.0	8.2	8.8	10.3	9.4
AVG. WIND SPEED (NIGHT)	8.4	9.7	10.2	9.6	7.1	6.4	5.5	4.1	3.6	5.2	7.5	9.3	7.4
AVG. TEMP. (DAY)	23.2	27.2	33.9	51.9	59.8	69.3	72.7	74.6	65.4	53.7	41.8	25.0	52.8
AVG. TEMP. (NIGHT)	20.2	23.5	28.5	43.9	51.2	61.2	64.6	64.4	56.1	44.9	38.1	21.2	40.6
AVG. SKY COVER (DAY)	7.3	7.1	7.3	6.6	6.8	6.7	7.9	5.8	7.2	6.5	8.5	7.6	7.1
AVG. REL. HUM. AT 4AM	91.3	90.6	78.9	80.8	84.5	91.6	90.7	90.8	86.8	77.6	82.9	93.6	86.6
10AM	88.7	84.9	71.2	65.0	65.3	72.8	75.6	71.7	76.8	67.8	81.3	90.7	75.9
4PM	71.3	70.0	55.0	50.5	50.5	61.7	61.1	53.7	56.3	50.4	70.4	76.9	60.6
10PM	85.6	84.9	71.5	67.5	72.7	80.7	79.5	80.5	80.9	71.6	82.8	87.0	78.7

IX. INDEX OF BDL COMMANDS, KEYWORDS, AND CODE-WORDS

A. LDL IX.1

B. SDL IX.9

C. PDL IX.18

D. CBSDL IX.28

E. EDL IX.39

A. LDL

Command Word	Abbreviation	Page
ABORT	none	(see Chap. II)
BUILDING-LOCATION	B-L	III.51
BUILDING-RESOURCE	B-R	III.107
BUILDING-SHADE	B-S	III.56
COMPUTE	none	(see Chap. II)
CONSTRUCTION	CONS	III.65
DAY-SCHEDULE	D-SCH	(see Chap. II)
DESIGN-DAY	D-D	III.110
DIAGNOSTIC	LIST	(see Chap. II)
DOOR	none	III.105
END	none	(see Chap. II)
EXTERIOR-WALL	E-W	III.90
GLASS-TYPE	G-T	III.71
HOURLY-REPORT	H-R	III.117
INPUT	none	(See Chap. II)
INTERIOR-WALL	I-W	III.96
LAYERS	LA	III.63
LIBRARY-INPUT	none	(See sec. III.B.1)
LOADS-REPORT	L-R	III.115
MATERIAL	MAT	III.61
PARAMETER	DEFINE	(see Chap. II)
PARAMETRIC-INPUT	PAR-INPUT	(see Chap. II)
REPORT-BLOCK	R-B	III.121
ROOF	none	III.90
RUN-PERIOD	none	III.49
SAVE-FILES	none	(see Chap. II)
SCHEDULE	SCH	(see Chap. II)
SET-DEFAULT	SET	(see Chap. II)
SPACE	S	III.87
SPACE-CONDITIONS	S-C	III.78
STOP	none	(see Chap. II)
TITLE	none	(see Chap. II)
UNDERGROUND-FLOOR	U-F	III.99

UNDERGROUND-WALL	U-W	III.99
WEEK-SCHEDULE	W-SCH	(see Chap. II)
WINDOW	WI	III.101

Keywords	Abbreviation	Associated Command Words
ABSORPTANCE	ABS	CONSTRUCTION
AIR-CHANGES/HR	A-C	SPACE, SPACE-CONDITIONS
ALTITUDE	ALT	BUILDING-LOCATION
AREA	A	SPACE, INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR
AXIS-ASSIGN	A-A	HOURLY-REPORT
AXIS-MAX	A-MAX	HOURLY-REPORT
AXIS-MIN	A-MIN	HOURLY-REPORT
AXIS-TITLES	A-T	HOURLY-REPORT
AZIMUTH	AZ	BUILDING-LOCATION, BUILDING-SHADE, SPACE, EXTERIOR-WALL, ROOF
CLEARNESS	CL	DESIGN-DAY
CLEARNESS-NUMBER	C-N	BUILDING-LOCATION
CLOUD-AMOUNT	C-A	DESIGN-DAY
CLOUD-TYPE	C-T	DESIGN-DAY
CONDUCTIVITY	COND	MATERIAL
CONDUCT-SCHEDULE	C-SCH	WINDOW
CONSTRUCTION	CONS	EXTERIOR-WALL, INTERIOR-WALL, ROOF, UNDERGROUND-WALL, UNDERGROUND-FLOOR, DOOR
COOL-PEAK-PERIOD	C-P-P	BUILDING-LOCATION
DAYLIGHT-SAVINGS	D-S	BUILDING-LOCATION
DENSITY	DENS	MATERIAL
DEPTH	D	SPACE
DEWPT-HI	DP-H	DESIGN-DAY
DEWPT-LO	DP-L	DESIGN-DAY
DHOUR-HI	DH-H	DESIGN-DAY
DHOUR-LO	DH-L	DESIGN-DAY

Keywords	Abbreviation	Associated Command Words
DIVIDE	–	HOURLY-REPORT
DRYBULB-HI	DB-H	DESIGN-DAY
DRYBULB-LO	DB-L	DESIGN-DAY
ELEC-KW	E-KW	BUILDING-RESOURCE
ELEC-SCHEDULE	E-SCH	BUILDING-RESOURCE
EQUIP-LATENT	E-L	SPACE, SPACE-CONDITIONS
EQUIPMENT-KW	E-KW	SPACE, SPACE-CONDITIONS
EQUIPMENT-W/SQFT	E-W	SPACE, SPACE-CONDITIONS
EQUIP-SCHEDULE	E-SCH	SPACE, SPACE-CONDITIONS
EQUIP-SENSIBLE	E-S	SPACE, SPACE-CONDITIONS
FLOOR-WEIGHT	F-W	SPACE, SPACE-CONDITIONS
FURNITURE-TYPE	F-TYPE	SPACE, SPACE-CONDITIONS under LIBRARY-INPUT
FURN-FRACTION	F-F	SPACE, SPACE-CONDITIONS under LIBRARY-INPUT
FURN-WEIGHT	F-WGT	SPACE, SPACE-CONDITIONS under LIBRARY-INPUT
GAS-SCHEDULE	G-SCH	BUILDING-RESOURCE
GAS-THERMS	G-T	BUILDING-RESOURCE
GLASS-CONDUCTANCE	G-C	GLASS-TYPE
GLASS-TYPE	G-T	WINDOW
GLASS-TYPE-CODE	G-T-C	GLASS-TYPE
GND-FORM-FACTOR	G-F-F	EXTERIOR-WALL, WINDOW, ROOF, DOOR
GND-REFLECTANCE	G-R	EXTERIOR-WALL, ROOF
GROSS-AREA	G-A	BUILDING-LOCATION
GROUND-T	G-T	BUILDING-LOCATION, DESIGN-DAY
HEAT-PEAK-PERIOD	H-P-P	BUILDING-LOCATION
HEIGHT	H	BUILDING-SHADE, SPACE, DOOR, EXTERIOR-WALL, WINDOW, ROOF (INTERIOR-WALL, UNDERGROUND-WALL UNDERGROUND-FLOOR under LIBRARY-INPUT)
HOLIDAY	HOL	BUILDING-LOCATION
HOT-WATER	H-W	BUILDING-RESOURCE
HOUR-HI	H-H	DESIGN-DAY

Keywords	Abbreviation	Associated Command Words
HOUR-LO	H-L	DESIGN-DAY
HW-SCHEDULE	HW-SCH	BUILDING-RESOURCE
INF-CFM/SQFT	I-CFM	SPACE, SPACE-CONDITIONS
INF-COEF	I-C	EXTERIOR-WALL, WINDOW, ROOF, DOOR
INF-METHOD	I-M	SPACE, SPACE-CONDITIONS
INF-SCHEDULE	I-SCH	SPACE, SPACE-CONDITIONS
INSIDE-FILM-RES	I-F-R	LAYERS
LATITUDE	LAT	BUILDING-LOCATION
LAYERS	LA	CONSTRUCTION
LIGHTING-KW	L-KW	SPACE, SPACE-CONDITIONS
LIGHTING-SCHEDULE	L-SCH	SPACE, SPACE-CONDITIONS
LIGHTING-TYPE	L-T	SPACE, SPACE-CONDITIONS
LIGHTING-W/SQFT	L-W	SPACE, SPACE-CONDITIONS
LIGHT-TO-SPACE	L-T-S	SPACE, SPACE-CONDITIONS
LIKE	none	MATERIAL, LAYERS, CONSTRUCTION, GLASS-TYPE, SPACE, BUILDING-SHADE, SPACE-CONDITIONS, EXTERIOR WALL, ROOF, INTERIOR-WALL, UNDERGROUND-FLOOR, DOOR, UNDERGROUND-WALL, WINDOW, DESIGN-DAY
LOCATION	LOC	EXTERIOR-WALL, ROOF (INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR under LIBRARY-INPUT)
LONGITUDE	LON	BUILDING-LOCATION
MATERIAL	MAT	LAYERS
MULTIPLIER	M	SPACE, EXTERIOR-WALL, ROOF INTERIOR-WALL, UNDERGROUND-WALL, WINDOW, DOOR, UNDERGROUND-FLOOR
NEUTRAL-ZONE-HT	N-Z-H	SPACE, SPACE-CONDITIONS
NEXT-TO	N-T	INTERIOR-WALL
NUMBER-OF-PEOPLE	N-O-P	SPACE, SPACE-CONDITIONS
OPTION	O	HOURLY-REPORT

Keywords	Abbreviation	Associated Command Words
PANES	P	GLASS-TYPE
PEOPLE-HEAT-GAIN	P-H-G	SPACE, SPACE-CONDITIONS
PEOPLE-HG-LAT	P-H-L	SPACE, SPACE-CONDITIONS
PEOPLE-HG-SENS	P-H-S	SPACE, SPACE-CONDITIONS
PEOPLE-SCHEDULE	P-SCH	SPACE, SPACE-CONDITIONS
REPORT-BLOCK	R-B	HOURLY-REPORT
REPORT-SCHEDULE	R-SCH	HOURLY-REPORT
RESISTANCE	RES	MATERIAL
RES-INF-COEF	R-I-C	SPACE, SPACE-CONDITIONS
ROUGHNESS	RO	CONSTRUCTION
SETBACK	SETB	WINDOW, DOOR
SHADING-COEF	S-C	GLASS-TYPE
SHADING-DIVISION	S-D	EXTERIOR-WALL, WINDOW, ROOF, DOOR
SHADING-SCHEDULE	S-SCH	WINDOW
SHAPE	none	SPACE
SKY-FORM-FACTOR	S-F-F	EXTERIOR-WALL, WINDOW, ROOF, DOOR
SOLAR-FRACTION	S-F	EXTERIOR-WALL, ROOF, DOOR, INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR under LIBRARY-INPUT
SOURCE-BTU/HR	S-B	SPACE, SPACE-CONDITIONS
SOURCE-LATENT	S-L	SPACE, SPACE-CONDITIONS
SOURCE-SCHEDULE	S-SCH	SPACE, SPACE-CONDITIONS
SOURCE-SENSIBLE	S-S	SPACE, SPACE-CONDITIONS
SOURCE-TYPE	S-T	SPACE, SPACE-CONDITIONS
SPACE-CONDITIONS	S-C	SPACE
SPECIFIC-HEAT	S-H	MATERIAL
SUMMARY	S	LOADS-REPORT
TASK-LIGHTING-KW	T-L-KW	SPACE, SPACE-CONDITIONS
TASK-LIGHT-SCH	T-L-SCH	SPACE, SPACE-CONDITIONS
TASK-LT-W/SQFT	T-L-W	SPACE, SPACE-CONDITIONS
TEMPERATURE	T	SPACE, SPACE-CONDITIONS
THICKNESS	TH	MATERIAL, LAYERS
TILT	none	BUILDING-SHADE, EXTERIOR-WALL, ROOF (INTERIOR-WALL, UNDER-GROUND-WALL, UNDERGROUND-FLOOR, with LIBRARY-INPUT)
TIME-ZONE	T-Z	BUILDING-LOCATION

Keywords	Abbreviation	Associated Command Words
TRANSMITTANCE	TR	BUILDING-SHADE
U-EFFECTIVE		UNDERGROUND-WALL, UNDERGROUND-FLOOR
U-VALUE	U	CONSTRUCTION
VARIABLE-LIST	V-L	REPORT-BLOCK
VARIABLE-TYPE	V-T	REPORT-BLOCK
VERIFICATION	V	LOADS-REPORT
VERT-TRANS-KW	V-T-KW	BUILDING-RESOURCE
VERT-TRANS-SCH	V-T-SCH	BUILDING-RESOURCE
VOLUME	V	SPACE
WEIGHTING-FACTOR	W-F	SPACE, SPACE-CONDITIONS
WIDTH	W	BUILDING-SHADE, SPACE, ROOF EXTERIOR-WALL, WINDOW, DOOR (INTERIOR-WALL, UNDERGROUND-WALL, UNDERGROUND-FLOOR under LIBRARY-INPUT
WIND-DIR	W-D	DESIGN-DAY
WIND-SPEED	W-S	DESIGN-DAY
X	none	BUILDING-SHADE, ROOF, SPACE, DOOR, EXTERIOR-WALL, WINDOW
Y	none	BUILDING-SHADE, ROOF, SPACE, DOOR, EXTERIOR-WALL, WINDOW
Z	none	BUILDING-SHADE, ROOF, SPACE, EXTERIOR-WALL
ZONE-TYPE	Z-TYPE	SPACE, SPACE-CONDITIONS

Code-Words	Associated Keywords
AIR-CHANGE	INF-METHOD
ALL-SUMMARY	SUMMARY
ALL-VERIFICATION	VERIFICATION
APR	RUN-PERIOD, SCHEDULE (commands)
AUG	RUN-PERIOD, SCHEDULE (commands)
BACK	LOCATION
BOTTOM	LOCATION
BOX	SHAPE
BUILDING	VARIABLE-TYPE
CONDITIONED	ZONE-TYPE
Constructions Library Code-words,	CONSTRUCTION (see Chap. X)
CRACK	INF-METHOD
DEC	RUN-PERIOD, SCHEDULE (commands)
ELECTRIC	SOURCE-TYPE
FEB	RUN-PERIOD, SCHEDULE (commands)
FRONT	LOCATION
GAS	SOURCE-TYPE
GLOBAL	VARIABLE-TYPE
HEAVY	FURNITURE-TYPE
HOT-WATER	SOURCE-TYPE
INCAND	LIGHTING-TYPE
JAN	RUN-PERIOD, SCHEDULE (commands)
JUL	RUN-PERIOD, SCHEDULE (commands)
JUN	RUN-PERIOD, SCHEDULE (commands)
LEFT	LOCATION
LIGHT	FURNITURE-TYPE
LS-A	SUMMARY
LS-B	SUMMARY
LS-C	SUMMARY
LS-D	SUMMARY
LV-A	VERIFICATION
LV-B	VERIFICATION
LV-C	VERIFICATION

Code-Words	Associated Keywords
LV-D	VERIFICATION
LV-E	VERIFICATION
LV-F	VERIFICATION
LV-G	VERIFICATION
LV-H	VERIFICATION
LV-I	VERIFICATION
LV-J	VERIFICATION
LV-K	VERIFICATION
Materials Library Code-words, MATERIAL (see Chap. X)	
MAR	RUN-PERIOD, SCHEDULE (commands)
MAY	RUN-PERIOD, SCHEDULE (commands)
NO	DAYLIGHT-SAVINGS, HOLIDAY
NONE	INF-METHOD
NOV	RUN-PERIOD, SCHEDULE (commands)
OCT	RUN-PERIOD, SCHEDULE (commands)
PLENUM	ZONE-TYPE
PLOT	OPTION
PRINT	OPTION
PROCESS	SOURCE-TYPE
REC-FLUOR-NV	LIGHTING-TYPE
REC-FLUOR-RSV	LIGHTING-TYPE
REC-FLUOR-RV	LIGHTING-TYPE
RESIDENTIAL	INF-METHOD
RIGHT	LOCATION
SEP	RUN-PERIOD, SCHEDULE (commands)
SUS-FLUOR	LIGHTING-TYPE
TOP	LOCATION
UNCONDITIONED	ZONE-TYPE
YES	DAYLIGHT-SAVINGS, HOLIDAY

B. SDL

Command Word	Abbreviation	Page
ABORT	-	(see Chap. II)
COMPUTE	-	(see Chap. II)
CURVE-FIT	C-F	IV.14
DAY-RESET-SCH	D-R-SCH	IV.10
DAY-SCHEDULE	D-SCH	(see Chap. II)
DIAGNOSTIC	LIST	(see Chap. II)
END	-	(see Chap. II)
HOURLY-REPORT	H-R	IV.107
INPUT	-	(see Chap. II)
PARAMETER	DEFINE	(see Chap. II)
PLANT-ASSIGNMENT	P-A	IV.101
REPORT-BLOCK	R-B	IV.109
RESET-SCHEDULE	R-SCH	IV.10
SAVE-FILES	-	(see Chap. II)
SCHEDULE	SCH	(see Chap. II)
SET-DEFAULT	SET	(see Chap. II)
STOP	-	(see Chap. II)
SYSTEM	SYST	IV.92
SYSTEMS-REPORT	S-R	IV.103
SYSTEM-AIR	S-A	IV.47
SYSTEM-CONTROL	S-C	IV.37
SYSTEM-EQUIPMENT	S-EQ	IV.68
SYSTEM-FANS	S-FANS	IV.54
SYSTEM-FLUID	S-FLU	IV.65
SYSTEM-TERMINAL	S-T	IV.63
TITLE	-	(see Chap. II)
WEEK-SCHEDULE	W-SCH	(see Chap. II)
ZONE	Z	IV.32
ZONE-AIR	Z-A	IV.22
ZONE-CONTROL	Z-C	IV.27

Keyword	Abbreviation	Associated Command Words
AIR-CHANGES/HR	A-C/HR	ZONE-AIR, ZONE
ASSIGNED-CFM	A-CFM	ZONE-AIR, ZONE
AXIS-ASSIGN	A-A	HOURLY-REPORT
AXIS-MAX	A-MAX	HOURLY-REPORT
AXIS-MIN	A-MIN	HOURLY-REPORT
AXIS-TITLES	A-T	HOURLY-REPORT
BASEBOARD-CTRL	B-C	ZONE-CONTROL, ZONE
BASEBOARD-RATING	B-R	ZONE
BASEBOARD-SCH	B-SCH	SYSTEM-CONTROL, SYSTEM
BASEBOARD-SOURCE	BASEB-S	SYSTEM
CFM/SQFT	-	ZONE-AIR, ZONE
COEFFICIENTS	COEF	CURVE-FIT
COIL-BF	C-BF	SYSTEM-EQUIPMENT, SYSTEM
COIL-BF-FCFM	C-BF-FC	SYSTEM-EQUIPMENT, SYSTEM
COIL-BF-FT	C-BF-FT	SYSTEM-EQUIPMENT, SYSTEM
COMPRESSOR-TYPE	C-TYPE	SYSTEM-EQUIPMENT, SYSTEM
COOLING-CAPACITY	C-CAP	SYSTEM-EQUIPMENT, SYSTEM, ZONE
COOLING-EIR	C-EIR	SYSTEM-EQUIPMENT, SYSTEM
COOLING-SCHEDULE	C-SCH	SYSTEM-CONTROL, SYSTEM
COOL-CAP-FT	C-C-FT	SYSTEM-EQUIPMENT, SYSTEM
COOL-CONTROL	C-C	SYSTEM-CONTROL, SYSTEM
COOL-CTRL-RANGE	C-C-R	SYSTEM-EQUIPMENT, SYSTEM
COOL-EIR-FPLR	C-E-FP	SYSTEM-EQUIPMENT, SYSTEM
COOL-EIR-FT	C-E-FT	SYSTEM-EQUIPMENT, SYSTEM
COOL-FT-MIN	C-FT-MIN	SYSTEM-EQUIPMENT, SYSTEM
COOL-RESET-SCH	C-R-SCH	SYSTEM-CONTROL, SYSTEM
COOL-SET-SCH	C-S-SCH	SYSTEM-CONTROL, SYSTEM
COOL-SET-T	C-S-T	SYSTEM-CONTROL, SYSTEM
COOL-SH-CAP	C-S-C	SYSTEM-EQUIPMENT, SYSTEM, ZONE
COOL-SH-FT	C-S-FT	SYSTEM-EQUIPMENT, SYSTEM
COOL-TEMP-SCH	C-T-SCH	ZONE-CONTROL, ZONE
CRANKCASE-HEAT	C-H	SYSTEM-EQUIPMENT, SYSTEM
CRANKCASE-MAX-T	C-M-T	SYSTEM-EQUIPMENT, SYSTEM
DATA	DATA	CURVE-FIT

Keyword	Abbreviation	Associated Command Words
DEFROST-DEGRADE	D-D	SYSTEM-EQUIPMENT, SYSTEM
DEFROST-T	D-T	SYSTEM-EQUIPMENT, SYSTEM
DESIGN-COOL-T	D-C-T	ZONE-CONTROL, ZONE
DESIGN-HEAT-T	D-H-T	ZONE-CONTROL, ZONE
DIVIDE	-	HOURLY-REPORT
DUCT-AIR-LOSS	D-A-L	SYSTEM-AIR, SYSTEM
DUCT-DELTA-T	D-D-T	SYSTEM-AIR, SYSTEM
ECONO-LIMIT-T	E-L-T	SYSTEM-CONTROL, SYSTEM
ELEC-HEAT-CAP	E-H-C	SYSTEM-EQUIPMENT, SYSTEM
EXHAUST-CFM	E-CFM	ZONE-AIR, ZONE
EXHAUST-EFF	E-E	ZONE-AIR, ZONE
EXHAUST-KW	E-KW	ZONE-AIR, ZONE
EXHAUST-STATIC	E-S	ZONE-AIR, ZONE
FAN-CONTROL	F-C	SYSTEM-FANS, SYSTEM
FAN-EIR-FPLR	F-E-FPLR	SYSTEM-FANS, SYSTEM
FAN-PLACEMENT	F-P	SYSTEM-FANS, SYSTEM
FAN-SCHEDULE	F-SCH	SYSTEM-FANS, SYSTEM
FLUID-HEAT-CAP	F-H-C	SYSTEM-FLUID, SYSTEM
FURNACE-AUX	F-A	SYSTEM-EQUIPMENT, SYSTEM
FURNACE-HIR	F-HIR	SYSTEM-EQUIPMENT, SYSTEM
FURNACE-HIR-FPLR	F-H-FP	SYSTEM-EQUIPMENT, SYSTEM
FURNACE-OFF-LOSS	F-O-L	SYSTEM-EQUIPMENT, SYSTEM
HCOIL-WIPE-FCFM	H-W-FC	SYSTEM-EQUIPMENT, SYSTEM
HEATING-CAPACITY	H-CAP	SYSTEM-EQUIPMENT, SYSTEM, ZONE
HEATING-EIR	H-EIR	SYSTEM-EQUIPMENT, SYSTEM
HEATING-SCHEDULE	H-SCH	SYSTEM-CONTROL, SYSTEM
HEAT-CAP-FT	H-C-FT	SYSTEM-EQUIPMENT, SYSTEM
HEAT-CONTROL	H-C	SYSTEM-CONTROL, SYSTEM
HEAT-EIR-FPLR	H-E-FP	SYSTEM-EQUIPMENT, SYSTEM
HEAT-EIR-FT	H-E-FT	SYSTEM-EQUIPMENT, SYSTEM
HEAT-RESET-SCH	H-R-SCH	SYSTEM-CONTROL, SYSTEM
HEAT-SET-SCH	H-S-SCH	SYSTEM-CONTROL, SYSTEM
HEAT-SET-T	H-S-T	SYSTEM-CONTROL, SYSTEM
HEAT-SOURCE	HEAT-S	SYSTEM

Keyword	Abbreviation	Associated Command Words
HEAT-TEMP-SCH	H-T-SCH	ZONE-CONTROL, ZONE
INDUCTION-RATIO	I-R	SYSTEM-TERMINAL, SYSTEM
INDUC-MODE-SCH	I-M-SCH	SYSTEM-FLUID, SYSTEM
LIKE	-	DAY-RESET-SCH, ZONE-AIR, ZONE-CONTROL, ZONE, SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, SYSTEM-TERMINAL, SYSTEM-FLUID, SYSTEM-EQUIPMENT SYSTEM, HOURLY-REPORT, REPORT-BLOCK
LOW-SPEED-RATIOS	L-S-R	SYSTEM-FANS, SYSTEM
MAX-COOL-RATE	M-C-R	ZONE
MAX-COND-RCVRY	M-C-R	SYSTEM-EQUIPMENT, SYSTEM
MAX-ELEC-T	M-E-T	SYSTEM-EQUIPMENT, SYSTEM
MAX-FAN-RATIO	MAX-F-R	SYSTEM-FANS, SYSTEM
MAX-FLUID-T	MAX-F-T	SYSTEM-FLUID, SYSTEM
MAX-HEAT-RATE	M-H-R	ZONE
MAX-HUMIDITY	MAX-H	SYSTEM-CONTROL, SYSTEM
MAX-OA-FRACTION	M-O-F	SYSTEM-AIR, SYSTEM
MAX-SUPPLY-T	MAX-S-T	SYSTEM-CONTROL, SYSTEM
MIN-AIR-SCH	M-A-SCH	SYSTEM-AIR, SYSTEM
MIN-CFM-RATIO	M-C-R	SYSTEM-TERMINAL, SYSTEM, ZONE
MIN-FAN-RATIO	MIN-F-R	SYSTEM-FANS, SYSTEM
MIN-FLUID-T	MIN-F-T	SYSTEM-FLUID, SYSTEM
MIN-HGB-RATIO	M-H-R	SYSTEM-EQUIPMENT, SYSTEM
MIN-HP-T	M-H-T	SYSTEM-EQUIPMENT, SYSTEM
MIN-HUMIDITY	MIN-H	SYSTEM-CONTROL, SYSTEM
MIN-OUTSIDE-AIR	M-O-A	SYSTEM-AIR, SYSTEM
MIN-SUPPLY-T	MIN-S-T	SYSTEM-CONTROL, SYSTEM
MIN-UNLOAD-RATIO	M-U-R	SYSTEM-EQUIPMENT, SYSTEM
MOTOR-PLACEMENT	M-P	SYSTEM-FANS, SYSTEM
MULTIPLIER	M	ZONE
NATURAL-VENT-AC	N-V-A	SYSTEM-AIR, SYSTEM
NATURAL-VENT-SCH	N-V-SCH	SYSTEM-AIR, SYSTEM
NIGHT-CYCLE-CTRL	N-C-C	SYSTEM-FANS, SYSTEM
OA-CFM/PER	O-CFM/P	ZONE-AIR, ZONE
OA-CHANGES	O-C	ZONE-AIR, ZONE

Keyword	Abbreviation	Associated Command Words
OA-CONTROL	O-CTRL	SYSTEM-AIR, SYSTEM
OPTION	O	HOURLY-REPORT
OUTSIDE-AIR-CFM	O-A-CFM	ZONE-AIR, ZONE
OUTSIDE-FAN-KW	O-F-KW	SYSTEM-EQUIPMENT, SYSTEM
OUTSIDE-FAN-MODE	O-F-M	SYSTEM-EQUIPMENT, SYSTEM
OUTSIDE-FAN-T	O-F-T	SYSTEM-EQUIPMENT, SYSTEM
OUTSIDE-HI	O-H	DAY-RESET-SCH
OUTSIDE-LO	O-L	DAY-RESET-SCH
PANEL-LOSS-RATIO	P-L-R	ZONE
PLENUM-NAMES	P-N	SYSTEM
PREHEAT-SOURCE	PREHEAT	SYSTEM
PREHEAT-T	P-T	SYSTEM-CONTROL, SYSTEM
RATED-CCAP-FCFM	R-CC-FC	SYSTEM-EQUIPMENT, SYSTEM
RATED-CEIR-FCFM	R-CE-FC	SYSTEM-EQUIPMENT, SYSTEM
RATED-CFM	R-C	SYSTEM-AIR, SYSTEM
RATED-CFM	R-CFM	ZONE-AIR, ZONE
RATED-HCAP-FCFM	R-HC-FC	SYSTEM-EQUIPMENT, SYSTEM
RATED-HEIR-FCFM	R-HE-FC	SYSTEM-EQUIPMENT, SYSTEM
RATED-SH-FCFM	R-S-FC	SYSTEM-EQUIPMENT, SYSTEM
RECOVERY-EFF	REC-E	SYSTEM-AIR, SYSTEM
REHEAT-DELTA-T	R-D-T	SYSTEM-TERMINAL, SYSTEM
REPORT-BLOCK	R-B	HOURLY-REPORT
REPORT-SCHEDULE	R-SCH	HOURLY-REPORT
RETURN-AIR-PATH	R-A-P	SYSTEM
RETURN-CFM	R-CFM	SYSTEM-AIR, SYSTEM
RETURN-DELTA-T	RET-D-T	SYSTEM-FANS, SYSTEM
RETURN-EFF	R-E	SYSTEM-FANS, SYSTEM
RETURN-KW	R-KW	SYSTEM-FANS, SYSTEM
RETURN-STATIC	R-S	SYSTEM-FANS, SYSTEM
SIZING-OPTION*	S-O	SYSTEM
SIZING-OPTION*	S-O	ZONE
SIZING-RATIO	S-R	SYSTEM
SUMMARY	S	SYSTEMS-REPORT

*These are two different keywords with different meanings.

Keyword	Abbreviation	Associated Command Words
SUPPLY-CFM	S-CFM	SYSTEM-AIR, SYSTEM
SUPPLY-DELTA-T	S-D-T	SYSTEM-FANS, SYSTEM
SUPPLY-EFF	S-E	SYSTEM-FANS, SYSTEM
SUPPLY-HI	S-H	DAY-RESET-SCH
SUPPLY-KW	S-KW	SYSTEM-FANS, SYSTEM
SUPPLY-LO	S-L	DAY-RESET-SCH
SUPPLY-MECH-EFF	S-M-E	SYSTEM-FANS, SYSTEM
SUPPLY-STATIC	S-S	SYSTEM-FANS, SYSTEM
SYSTEM-AIR	S-A	SYSTEM
SYSTEM-CONTROL	S-C	SYSTEM
SYSTEM-EQUIPMENT	S-EQ	SYSTEM
SYSTEM-FANS	S-FANS	SYSTEM
SYSTEM-FLUID	S-FLU	SYSTEM
SYSTEM-NAMES	S-N	PLANT-ASSIGNMENT
SYSTEM-TERMINAL	S-T	SYSTEM
SYSTEM-TYPE	S-TYPE	SYSTEM
THERMOSTAT-TYPE	T-TYPE	ZONE-CONTROL, ZONE
THROTTLING-RANGE	T-R	ZONE-CONTROL, ZONE
TYPE	TYPE	CURVE-FIT
VARIABLE-LIST	V-L	REPORT-BLOCK
VARIABLE-TYPE	V-T	REPORT-BLOCK
VENT-TEMP-SCH	V-T-SCH	SYSTEM-AIR, SYSTEM
VERIFICATION	V	SYSTEMS-REPORT
ZONE-AIR	Z-A	ZONE
ZONE-CONTROL	Z-C	ZONE
ZONE-HEAT-SOURCE	Z-H-S	SYSTEM
ZONE-NAMES	Z-N	SYSTEM
ZONE-TYPE	Z-TYPE	ZONE

Code-Word	Associated Keyword
ALL-SUMMARY	SUMMARY
BI-LINEAR	TYPE
BI-QUADRATIC	TYPE
BLOW-THROUGH	FAN-PLACEMENT
CBVAV	SYSTEM-TYPE
COINCIDENT	SIZING-OPTION
COLDEST	HEAT-CONTROL
CONDITIONED	ZONE-TYPE
CONSTANT	COOL-CONTROL, HEAT-CONTROL
CONSTANT-VOLUME	FAN-CONTROL
CONTINUOUS	OUTSIDE-FAN-MODE
CUBIC	TYPE
CYCLE-ON-ANY	NIGHT-CYCLE-CTRL
CYCLE-ON-FIRST	NIGHT-CYCLE-CTRL
CYCLING	FAN-CONTROL
DDS	SYSTEM-TYPE
DIRECT	RETURN-AIR-PATH
DISCHARGE	FAN-CONTROL
DRAW-THROUGH	FAN-PLACEMENT
DUAL-SPEED	COMPRESSOR-TYPE
DUCT	RETURN-AIR-PATH
ELECTRIC	BASEBOARD-SOURCE, HEAT-SOURCE, PREHEAT-SOURCE, ZONE-HEAT-SOURCE
ENTHALPY	OA-CONTROL
FAN-EIR-FPLR	FAN-CONTROL
FIXED	OA-CONTROL
FPFC	SYSTEM-TYPE
FPH	SYSTEM-TYPE
FPIU	SYSTEM-TYPE
GAS-FURNACE	BASEBOARD-SOURCE, HEAT-SOURCE, PREHEAT-SOURCE, ZONE-HEAT-SOURCE
GLOBAL	VARIABLE-TYPE
HEAT-PUMP	HEAT-SOURCE
HOT-WATER	BASEBOARD-SOURCE, HEAT-SOURCE, PREHEAT-SOURCE, ZONE-HEAT-SOURCE
HOT-WATER/SOLAR	HEAT-SOURCE, PREHEAT-SOURCE, ZONE-HEAT-SOURCE

Code-Word	Associated Keyword
HP	SYSTEM-TYPE
HVSYS	SYSTEM-TYPE
INLET	FAN-CONTROL
INTERMITTENT	OUTSIDE-FAN-MODE
IN-AIRFLOW	MOTOR-PLACEMENT
LINEAR	TYPE
MZS	SYSTEM-TYPE
NON-COINCIDENT	SIZING-OPTION
OIL-FURNACE	BASEBOARD-SOURCE, HEAT-SOURCE, PREHEAT-SOURCE, ZONE-HEAT-SOURCE
OUTDOOR-RESET	BASEBOARD-CTRL
OUTSIDE-AIRFLOW	MOTOR-PLACEMENT
PLANT-ASSIGNMENT	VARIABLE-TYPE
PLENUM	ZONE-TYPE
PLENUM-ZONES	RETURN-AIR-PATH
PLOT	OPTION
PMZS	SYSTEM-TYPE
PRINT	OPTION
PROPORTIONAL	THERMOSTAT-TYPE
PSZ	SYSTEM-TYPE
PTAC	SYSTEM-TYPE
PVAVS	SYSTEM-TYPE
QUADRATIC	TYPE
REPORT-ONLY	VERIFICATION
RESET	COOL-CONTROL, HEAT-CONTROL
RESYS	SYSTEM-TYPE
REVERSE-ACTION	THERMOSTAT-TYPE
RHFS	SYSTEM-TYPE
SCHEDULED	COOL-CONTROL, HEAT-CONTROL
SINGLE-SPEED	COMPRESSOR-TYPE
SPEED	FAN-CONTROL
SS-A	SUMMARY
SS-B	SUMMARY
SS-C	SUMMARY

Code-Word	Associated Keyword
SS-D	SUMMARY
SS-E	SUMMARY
SS-F	SUMMARY
SS-G	SUMMARY
SS-H	SUMMARY
SS-I	SUMMARY
SS-J	SUMMARY
STAY-OFF	NIGHT-CYCLE-CTRL
SUM	SYSTEM-TYPE
SV-A	VERIFICATION
SYSTEM	VARIABLE-TYPE
SZCI	SYSTEM-TYPE
SZRH	SYSTEM-TYPE
TEMP	OA-CONTROL
THERMOSTATIC	BASEBOARD-CTRL
TPFC	SYSTEM-TYPE
TPIU	SYSTEM-TYPE
TWO-POSITION	THERMOSTAT-TYPE
TWO-SPEED	FAN-CONTROL
UHT	SYSTEM-TYPE
UNCONDITIONED	ZONE-TYPE
UVT	SYSTEM-TYPE
VAVS	SYSTEM-TYPE
WARMEST	COOL-CONTROL
ZONE	VARIABLE-TYPE

C. PDL

Command Word	Abbreviation	Page
ABORT	none	(see Chap. II)
COMPUTE	none	(see Chap. II)
CURVE-FIT	C-F	(see Chap. IV)
DAY-ASSIGN-SCH	D-A-SCH	V.90
DAY-SCHEDULE	D-SCH	(see Chap. II)
DIAGNOSTIC	LIST	(see Chap. II)
END	none	(see Chap. II)
ENERGY-COST	E-C	V.77
ENERGY-STORAGE	E-S	V.67
EQUIPMENT-QUAD	E-Q	V.35
HEAT-RECOVERY	HEAT-R	V.61
HOURLY-REPORT	H-R	V.94
INPUT	none	(see Chap. II)
LOAD-ASSIGNMENT	L-A	V.49
LOAD-MANAGEMENT	L-M	V.55
PARAMETER	DEFINE	(see Chap. II)
PARAMETRIC-INPUT	PAR-INPUT	(see Chap. II)
PART-LOAD-RATIO	P-L-R	V.16
PLANT-ASSIGNMENT	P-A	V.91
PLANT-COSTS	P-C	V.84
PLANT-EQUIPMENT	P-E	V.8
PLANT-PARAMETERS	P-P	V.20
PLANT-REPORT	P-R	V.92
REFERENCE-COSTS	R-C	V.87
REPORT-BLOCK	R-B	V.96
SAVE-FILES	none	(see Chap. II)
SCHEDULE	SCH	(see Chap. II)
SET-DEFAULT	SET	(see Chap. II)
SOLAR-EQUIPMENT	S-E	V.105
STOP	none	(see Chap. II)
TITLE	none	(see Chap. II)
WEEK-SCHEDULE	W-SCH	(see Chap. II)

Keyword	Abbreviation	Associated Command Words
ABSORS-CAP-FT	none	EQUIPMENT-QUAD
ABSORS-CAP-FTS	none	EQUIPMENT-QUAD
ABSORS-HIR	none	PLANT-PARAMETERS
ABSORS-HIR-FPLR	none	EQUIPMENT-QUAD
ABSORS-HIR-FT	none	EQUIPMENT-QUAD
ABSORS-HIR-FTS	none	EQUIPMENT-QUAD
ABSOR-TO-TWR-WTR	none	PLANT-PARAMETERS
ABSOR1-CAP-FT	none	EQUIPMENT-QUAD
ABSOR1-HIR	none	PLANT-PARAMETERS
ABSOR1-HIR-FPLR	none	EQUIPMENT-QUAD
ABSOR1-HIR-FT	none	EQUIPMENT-QUAD
ABSOR2-CAP-FT	none	EQUIPMENT-QUAD
ABSOR2-HIR	none	PLANT-PARAMETERS
ABSOR2-HIR-FPLR	none	EQUIPMENT-QUAD
ABSOR2-HIR-FT	none	EQUIPMENT-QUAD
ASSIGN-SCHEDULE	A-SCH	LOAD-MANAGEMENT
AXIS-ASSIGN	A-A	HOURLY-REPORT
AXIS-MAX	A-MAX	HOURLY-REPORT
AXIS-MIN	A-MIN	HOURLY-REPORT
AXIS-TITLES	A-T	HOURLY-REPORT
BLOCK	B	ENERGY-COST
BOILER-BLOW-RAT	none	PLANT-PARAMETERS
BOILER-CONTROL	none	PLANT-PARAMETERS
BOILER-FUEL	none	PLANT-PARAMETERS
CCIRC-DESIGN-T-DROP	none	PLANT-PARAMETERS
CCIRC-HEAD	none	PLANT-PARAMETERS
CCIRC-IMPELLER-EFF	none	PLANT-PARAMETERS
CCIRC-LOSS	none	PLANT-PARAMETERS
CCIRC-MOTOR-EFF	none	PLANT-PARAMETERS
CHILLER-CONTROL	none	PLANT-PARAMETERS
CHILL-WTR-T	none	PLANT-PARAMETERS
CHILL-WTR-THROTTLE	none	PLANT-PARAMETERS
COEFFICIENTS	COEF	CURVE-FIT
COMP-TO-TWR-WTR	none	PLANT-PARAMETERS

Keyword	Abbreviation	Associated Command Words
CONSUMABLES	C	PLANT-EQUIPMENT
CONSUMABLES-REF	C-R	REFERENCE-COSTS
COOL-MULTIPLIER	C-M	LOAD-MANAGEMENT
COOL-STORE-RATE	C-ST-R	ENERGY-STORAGE
COOL-STORE-SCH	C-ST-SCH	ENERGY-STORAGE
COOL-SUPPLY-RATE	C-SU-R	ENERGY-STORAGE
COST	C	ENERGY-COST
CTANK-BASE-T	C-B-T	ENERGY-STORAGE
CTANK-ENV-T	C-E-T	ENERGY-STORAGE
CTANK-FREEZ-T	C-F-T	ENERGY-STORAGE
CTANK-LOSS-COEF	C-L-C	ENERGY-STORAGE
CTANK-T-RANGE	C-T-R	ENERGY-STORAGE
DATA	none	CURVE-FIT
DBUN-CAP-COR-REC	none	PLANT-PARAMETERS
DBUN-CAP-FT	none	EQUIPMENT-QUAD
DBUN-CAP-FTRISE	none	EQUIPMENT-QUAD
DBUN-COND-T-ENT	none	PLANT-PARAMETERS
DBUN-COND-T-REC	none	PLANT-PARAMETERS
DBUN-EIR-COR-REC	none	PLANT-PARAMETERS
DBUN-EIR-FPLR	none	EQUIPMENT-QUAD
DBUN-EIR-FT	none	EQUIPMENT-QUAD
DBUN-EIR-FTRISE	none	EQUIPMENT-QUAD
DBUN-HT-REC-RAT	none	PLANT-PARAMETERS
DBUN-TO-TWR-WTR	none	PLANT-PARAMETERS
DBUN-UNL-RAT-DES	none	PLANT-PARAMETERS
DBUN-UNL-RAT-REC	none	PLANT-PARAMETERS
DC-CHILL-WTR-T	none	PLANT-PARAMETERS
DC-MAX-T	none	PLANT-PARAMETERS
DEMAND-1 through DEMAND-5	D-1--D-5	HEAT-RECOVERY
DHW-HIR	none	PLANT-PARAMETERS
DHW-HEATER-FUEL	none	PLANT-PARAMETERS
DHW-HIR-FPLR	none	EQUIPMENT-QUAD
DIESEL-EXH-FPLR	none	EQUIPMENT-QUAD
DIESEL-FUEL	none	PLANT-PARAMETERS
DIESEL-I/O-FPLR	none	EQUIPMENT-QUAD

Keyword	Abbreviation	Associated Command Words
DIESEL-JAC-FPLR	none	EQUIPMENT-QUAD
DIESEL-LUB-FPLR	none	EQUIPMENT-QUAD
DIESEL-STACK-FU	none	EQUIPMENT-QUAD
DIESEL-TEX-FPLR	none	EQUIPMENT-QUAD
DIRECT-COOL-KW	none	PLANT-PARAMETERS
DIRECT-COOL-MODE	none	PLANT-PARAMETERS
DIRECT-COOL-SCH	none	PLANT-PARAMETERS
DISCOUNT-RATE	D-R	PLANT-COSTS
DIVIDE	none	HOURLY-REPORT
ELEC-DHW-LOSS	none	PLANT-PARAMETERS
ELEC-INPUT-RATIO	E-I-R	PART-LOAD-RATIO
ELEC-MULTIPLIER	E-M	LOAD-MANAGEMENT
EQUIPMENT-LIFE	E-L	PLANT-EQUIPMENT
ESCALATION	E	ENERGY-COST
E-HW-BOILER-LOSS	none	PLANT-PARAMETERS
E-STM-BOILER-LOSS	none	PLANT-PARAMETERS
FIRST-COST	F-C	PLANT-EQUIPMENT
FIRST-COST-REF	F-C-R	REFERENCE-COSTS
FURNACE-AUX	none	PLANT-PARAMETERS
FURNACE-HIR	none	PLANT-PARAMETERS
FURNACE-HIR-FPLR	none	EQUIPMENT-QUAD
FURNACE-FUEL	none	PLANT-PARAMETERS
GTURB-EXH-FT	none	EQUIPMENT-QUAD
GTURB-FUEL	none	PLANT-PARAMETERS
GTURB-I/O-FPLR	none	EQUIPMENT-QUAD
GTURB-I/O-FT	none	EQUIPMENT-QUAD
GTURB-STACK-FU	none	EQUIPMENT-QUAD
GTURB-TEX-FPLR	none	EQUIPMENT-QUAD
GTURB-TEX-FT	none	EQUIPMENT-QUAD
HCIRC-DESIGN-T-DROP	none	PLANT-PARAMETERS
HCIRC-HEAD	none	PLANT-PARAMETERS
HCIRC-IMPELLER-EFF	none	PLANT-PARAMETERS
HCIRC-LOSS	none	PLANT-PARAMETERS
HCIRC-MOTOR-EFF	none	PLANT-PARAMETERS
HEAT-MULTIPLIER	H-M	LOAD-MANAGEMENT

Keyword	Abbreviation	Associated Command Words
HEAT-STORE-RATE	H-ST-R	ENERGY-STORAGE
HEAT-STORE-SCH	H-ST-SCH	ENERGY-STORAGE
HEAT-SUPPLY-RATE	H-SU-R	ENERGY-STORAGE
HERM-CENT-CAP-FT	none	EQUIPMENT-QUAD
HERM-CENT-COND-PWR	none	PLANT-PARAMETERS
HERM-CENT-COND-TYPE	none	PLANT-PARAMETERS
HERM-CENT-EIR-FPLR	none	EQUIPMENT-QUAD
HERM-CENT-EIR-FT	none	EQUIPMENT-QUAD
HERM-CENT-UNL-RAT	none	PLANT-PARAMETERS
HERM-REC-CAP-FT	none	EQUIPMENT-QUAD
HERM-REC-COND-PWR	none	PLANT-PARAMETERS
HERM-REC-COND-TYPE	none	PLANT-PARAMETERS
HERM-REC-EIR-FPLR	none	EQUIPMENT-QUAD
HERM-REC-EIR-FT	none	EQUIPMENT-QUAD
HERM-REC-UNL-RAT	none	PLANT-PARAMETERS
HOURS-USED	H-U	PLANT-EQUIPMENT
HTANK-BASE-T	H-B-T	ENERGY-STORAGE
HTANK-ENV-T	H-E-T	ENERGY-STORAGE
HTANK-FREEZ-T	H-F-T	ENERGY-STORAGE
HTANK-LOSS-COEF	H-L-C	ENERGY-STORAGE
HTANK-T-RANGE	H-T-R	ENERGY-STORAGE
HW-BOILER-HIR	none	PLANT-PARAMETERS
HW-BOILER-HIR-FPLR	none	EQUIPMENT-QUAD
INSTALLATION	I	PLANT-EQUIPMENT
INSTALLATION-REF	I-R	REFERENCE-COSTS
INSTALLED-NUMBER	I-N	PLANT-EQUIPMENT
LABOR	L	PLANT-COSTS
LABOR-INFLTN	L-I	PLANT-COSTS
LIFE-REF	L-R	REFERENCE-COSTS
LIKE	none	HOURLY-REPORT
LOAD-ASSIGNMENT	L-A	LOAD-MANAGEMENT
LOAD-RANGE	L-R	LOAD-ASSIGNMENT
MAINTENANCE	M	PLANT-EQUIPMENT
MAINTENANCE-REF	M-R	REFERENCE-COSTS
MAKEUP-WTR-T	none	PLANT-PARAMETERS

Keyword	Abbreviation	Associated Command Words
MAJOR-OVHL-COST	MAJ-O-C	PLANT-EQUIPMENT
MAJOR-OVHL-INT	MAJ-O-I	PLANT-EQUIPMENT
MAJ-OVHL-CST-REF	MAJ-O-C	REFERENCE-COSTS
MAJ-OVHL-INT-REF	MAJ-O-I	REFERENCE COSTS
MATERIALS-INFLTN	M-I	PLANT-COSTS
MAX-DIESEL-EXH	none	PLANT-PARAMETERS
MAX-GTURB-EXH	none	PLANT-PARAMETERS
MAX-NUMBER-AVAIL	M-N-A	PLANT-EQUIPMENT
MAX-RATIO	MAX-R	PART-LOAD-RATIO
MINOR-OVHL-COST	MIN-O-C	PLANT-EQUIPMENT
MINOR-OVHL-INT	MIN-O-I	PLANT-EQUIPMENT
MIN-COND-AIR-T	none	PLANT-PARAMETERS
MIN-MONTHLY-CHG	M-M-C	ENERGY-COST
MIN-OVHL-CST-REF	MIN-O-C	REFERENCE-COSTS
MIN-OVHL-INT-REF	MIN-O-I	REFERENCE-COSTS
MIN-PEAK-LOAD	M-P-L	ENERGY-COST
MIN-RATIO	MIN-R	PART-LOAD-RATIO
MIN-SOL-COOL-T	none	PLANT-PARAMETERS
MIN-SOL-HEAT-T	none	PLANT-PARAMETERS
MIN-SOL-PROCESS-T	none	PLANT-PARAMETERS
MIN-TWR-WTR-T	none	PLANT-PARAMETERS
MULTIPLIER	M	ENERGY-COST
NUMBER	N	LOAD-ASSIGNMENT
OPEN-CENT-CAP-FT	none	EQUIPMENT-QUAD
OPEN-CENT-COND-PWR	none	PLANT-PARAMETERS
OPEN-CENT-COND-TYPE	none	PLANT-PARAMETERS
OPEN-CENT-EIR-FPLR	none	EQUIPMENT-QUAD
OPEN-CENT-EIR-FT	none	EQUIPMENT-QUAD
OPEN-CENT-MOTOR-EFF	none	PLANT-PARAMETERS
OPEN-CENT-UNL-RAT	none	PLANT-PARAMETERS
OPEN-REC-CAP-FT	none	EQUIPMENT-QUAD
OPEN-REC-COND-PWR	none	PLANT-PARAMETERS
OPEN-REC-COND-TYPE	none	PLANT-PARAMETERS
OPEN-REC-EIR-FPLR	none	EQUIPMENT-QUAD
OPEN-REC-EIR-FT	none	EQUIPMENT-QUAD

Keyword	Abbreviation	Associated Command Words
OPEN-REC-MOTOR-EFF	none	PLANT-PARAMETERS
OPEN-REC-UNL-RAT	none	PLANT-PARAMETERS
OPERATING-RATIO	O-R	PART-LOAD-RATIO
OPERATION-MODE	O-M	LOAD-ASSIGNMENT
OPTION	O	HOURLY-REPORT
PEAK-LOAD-CHG	P-L-C	ENERGY-COST
PLANT-EQUIPMENT	P-E	LOAD-ASSIGNMENT
PRED-LOAD-RANGE	P-L-R	LOAD-MANAGEMENT
PROJECT-LIFE	P-L	PLANT-COSTS
RECVR-HEAT/BLOW	none	PLANT-PARAMETERS
REPORT-BLOCK	R-B	HOURLY-REPORT
REPORT-SCHEDULE	R-SCH	HOURLY-REPORT
RESOURCE	R	ENERGY-COST
RFACT-CFM-EXPONENT	none	PLANT-PARAMETERS
SITE-FACTOR	S-F	PLANT-COSTS
SIZE	SIZE	PLANT-EQUIPMENT
SIZE-REF	S-R	REFERENCE-COSTS
SOURCE-SITE-EFF	S-S-E	ENERGY-COST
STM-BOILER-HIR	none	PLANT-PARAMETERS
STM-BOILER-HIR-FPLR	none	EQUIPMENT-QUAD
STM-PRES	none	PLANT-PARAMETERS
STM-SATURATION-T	none	PLANT-PARAMETERS
STURB-EXH-PRES	none	PLANT-PARAMETERS
STURB-I/O-FPLR	none	EQUIPMENT-QUAD
STURB-PRES	none	PLANT-PARAMETERS
STURB-SPEED	none	PLANT-PARAMETERS
STURB-T	none	PLANT-PARAMETERS
STURB-WTR-RETURN	none	PLANT-PARAMETERS
SUMMARY	S	PLANT-REPORT
SUPPLY-1 through SUPPLY-5	S-1--S-5	HEAT-RECOVERY
TC-CHLR-CAP-FT	none	EQUIPMENT-QUAD
TWR-APP-FRFACT	none	EQUIPMENT-QUAD
TWR-CELL-MAX-GPM	none	PLANT-PARAMETERS
TWR-DESIGN-WETBULB	none	PLANT-PARAMETERS

Keyword	Abbreviation	Associated Command Words
TWR-FAN-CONTROL	none	PLANT-PARAMETERS
TWR-FAN-ELEC-FTU	none	EQUIPMENT-QUAD
TWR-FAN-LOW-CFM	none	PLANT-PARAMETERS
TWR-FAN-LOW-ELEC	none	PLANT-PARAMETERS
TWR-FAN-OFF-CFM	none	PLANT-PARAMETERS
TWR-IMPELLER-EFF	none	PLANT-PARAMETERS
TWR-MOTOR-EFF	none	PLANT-PARAMETERS
TWR-PUMP-HEAD	none	PLANT-PRAMETERS
TWR-RFACT-FAT	none	EQUIPMENT-QUAD
TWR-RFACT-FRT	none	EQUIPMENT-QUAD
TWR-TEMP-CONTROL	none	PLANT-PARAMETERS
TWR-WTR-SET-POINT	none	PLANT-PARAMETERS
TWR-WTR-THROTTLE	none	PLANT-PARAMETERS
TYPE	TYPE	PLANT-EQUIPMENT, PART-LOAD-RATIO, LOAD-ASSIGNMENT, REFERENCE-COSTS, CURVE-FIT
UNIFORM-COST	U-C	ENERGY-COST
UNIT	U	ENERGY-COST
VARIABLE-LIST	V-L	REPORT-BLOCK
VARIABLE-TYPE	V-T	REPORT-BLOCK
VERIFICATION	V	PLANT-REPORT

Code-Words	Associated Keywords
ABSORS-CHLR	TYPE, VARIABLE-TYPE
ABSOR1-CHLR	TYPE, DEMAND-n, VARIABLE-TYPE
ABSOR2-CHLR	TYPE, DEMAND-n, VARIABLE-TYPE
AIR	OPEN-CENT-COND-TYPE, OPEN-REC-COND-TYPE HERM-CENT-COND-TYPE, HERM-REC-COND-TYPE
ALL-SUMMARY	SUMMARY
ALL-VERIFICATION	VERIFICATION
BEPS	SUMMARY
BIOMASS	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, FURNACE-FUEL, DHW-HEATER-FUEL
BI-LINEAR	TYPE (in CURVE-FIT)
BI-QUADRATIC	TYPE (in CURVE-FIT)
CERAMIC-TWR	TYPE, VARIABLE-TYPE

Code-Words	Associated Keywords
CHILLED-WATER	RESOURCE
COAL	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, FURNACE-FUEL, DHW-HEATER-FUEL
COOLING	TYPE (in LOAD-ASSIGNMENT)
COOLING-TWR	TYPE, VARIABLE-TYPE
CTANK-STORAGE	TYPE, VARIABLE-TYPE
CUBIC	TYPE (in CURVE-FIT)
DBUN-CHLR	TYPE, SUPPLY-n, VARIABLE-TYPE
DEMAND-ONLY	BOILER-CONTROL, CHILLER-CONTROL
DHW-HEATER	TYPE, VARIABLE-TYPE
DIESEL-GEN	TYPE, SUPPLY-n, VARIABLE-TYPE
DIESEL-JACKET	SUPPLY-n
DIESEL-OIL	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, FURNACE-FUEL, DHW-HEATER-FUEL
ELECTRICAL	TYPE (in LOAD-ASSIGNMENT)
ELECTRICITY	RESOURCE
ELEC-DHW-HEATER	TYPE, VARIABLE-TYPE
ELEC-HW-BOILER	TYPE, VARIABLE-TYPE
ELEC-STM-BOILER	TYPE, VARIABLE-TYPE
FIXED	TWR-TEMP-CONTROL
FLOAT	TWR-TEMP-CONTROL
FUEL-OIL	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, FURNACE-FUEL, DHW-HEATER-FUEL
FURNACE	TYPE, VARIABLE-TYPE
GLOBAL	VARIABLE-TYPE
GTURB-GEN	TYPE, SUPPLY-n, VARIABLE-TYPE
HEATING	TYPE (in LOAD-ASSIGNMENT)
HEAT-RECOVERY	VARIABLE-TYPE
HERM-CENT-CHLR	TYPE, VARIABLE-TYPE
HERM-REC-CHLR	TYPE, VARIABLE-TYPE
HTANK-STORAGE	TYPE, SUPPLY-n, DEMAND-n, VARIABLE-TYPE
HW-BOILER	TYPE, VARIABLE-TYPE
LEFTOVERS	TYPE, SUPPLY-n
LINEAR	TYPE (in CURVE-FIT)
LPG	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, FURNACE-FUEL, DHW-HEATER-FUEL

Code-Words	Associated Keywords
METHANOL	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, FURNACE-FUEL, DHW-HEATER-FUEL
NATURAL-GAS	RESOURCE, BOILER-FUEL, DIESEL-FUEL, GTURB-FUEL, DHW-HEATER-FUEL, FURNACE-FUEL
ONE-SPEED	TWR-FAN-CONTROL
OPEN-CENT-CHLR	TYPE, VARIABLE-TYPE
OPEN-REC-CHLR	TYPE, VARIABLE-TYPE
PLANT	VARIABLE-TYPE
PLOT	OPTION
PRINT	OPTION
PROCESS-HEAT	TYPE, DEMAND-n
PS-A	SUMMARY
PS-B	SUMMARY
PS-C	SUMMARY
PS-D	SUMMARY
PS-G	SUMMARY
PS-H	SUMMARY
PS-I	SUMMARY
PS-J	SUMMARY
PV-A	VERIFICATION
PV-B	VERIFICATION
PV-C	VERIFICATION
PV-D	VERIFICATION
PV-E	VERIFICATION
PV-G	VERIFICATION
PV-H	VERIFICATION
QUADRATIC	TYPE (in CURVE-FIT)
RUN-ALL	OPERATION-MODE
RUN-NEEDED	OPERATION-MODE
SOLAR-COOLING	TYPE
SOLAR-HEATING	TYPE
SOL-COOLING	SUPPLY-n
SOL-PROCESS-HEAT	SUPPLY-n
SOL-SPACE-HEAT	SUPPLY-n
SPACE-HEAT	TYPE, DEMAND-n

Code-Words	Associated Keywords
STEAM	RESOURCE
STANDBY	BOILER-CONTROL, CHILLER-CONTROL
STM-BOILER	TYPE, VARIABLE-TYPE
STRAINER-CYCLE	DIRECT-COOL-MODE
STURB-GEN	TYPE, SUPPLY-n, DEMAND-n, VARIABLE-TYPE
THERMO-CYCLE	DIRECT-COOL-MODE
TOWER	OPEN-CENT-COND-TYPE, OPEN-REC-COND-TYPE, HERM-CENT-COND-TYPE, HERM-REC-COND-TYPE
TWO-SPEED	TWR-FAN-CONTROL

Keyword	Associated Command Word	Associated TYPE
BED-LOSS-COEF	COMPONENT	CASH-SUBSYS-1
BED-SP-HT	COMPONENT	CASH-SUBSYS-1
BED-WIDTH	COMPONENT	CASH-SUBSYS-1
CAP	COMPONENT	COL-EC-1, COL-EC-AIR-1, DUCT-LOSSES-1, PIPE-LOSSES-1
CMPR-EFF	COMPONENT	RFA-SUBSYS-1
COIL-T-MIN	COMPONENT	CLSH-CNTRL-1, CLSH-SUBSYS-1
COL-AREA	COMPONENT	CLSH-SUBSYS-1
COL-BOIL-T	COMPONENT	CLSH-SUBSYS-1
COL-CAP	COMPONENT	CASH-SUBSYS-1, CLSH-SUBSYS-1
COL-DEN	COMPONENT	CLSH-SUBSYS-1
COL-EXCH-TYPE	COMPONENT	CLSH-SUBSYS-1
COL-EXCH-UA	COMPONENT	CLSH-SUBSYS-1
COL-FLOW	COMPONENT	CLSH-SUBSYS-1
COL-INIT-T	COMPONENT	CASH-SUBSYS-1, CLSH-SUBSYS-1
COL-SP-HT	COMPONENT	CLSH-SUBSYS-1
COND	COMPONENT	ROCK-BED-1
COP	COMPONENT	RFA-SUBSYS-1
DECIMAL-PLACES	COMPONENT	REPORT-1
DEN	COMPONENT	FAN-1, PUMP-1
DEN-AIR	COMPONENT	CASH-AUX-1, CASH-SUBSYS-1, COL-EC-AIR-1, RFA-SUBSYS-1
DEN-COLD	COMPONENT	COL-EC-1
DEN-FLD	COMPONENT	CLSH-CNTRL-1, TANK-1
DEN-HOT	COMPONENT	COL-EC-1
DEN-LIQ	COMPONENT	RFA-SUBSYS-1
DEPTH	COMPONENT	ROCK-BED-1
DESC	COMPONENT	PRINTER-PLOT-1
DIVIDE	COMPONENT	PRINTER-PLOT-1, REPORT-1
DOUBLE-SPACE	COMPONENT	REPORT-1
DT-MIN	COMPONENT	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1

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Command Word	Abbreviation	Page
ABORT	none	(see Chap. II)
COMPONENT	none	V.111
CONNECT	none	V.112
DAY-SCHEDULE	D-SCH	(see Chap. II)
DIAGNOSTIC	LIST	(see Chap. II)
END	none	(see Chap. II)
ITERATIONS	none	V.113
PARAMETER	DEFINE	V.114
SCHEDULE	SCH	V.114
SYSTEM	none	V.115
TITLE	none	(see Chap. II)
TRACE	none	V.116
WEEK-SCHEDULE	W-SCH	(see Chap. II)

Keyword	Associated Command Word	Associated TYPE
ABSORPTANCE	COMPONENT	COL-HWB-4
ACCEPTANCE	COMPONENT	INSOL-1
ANGLE-COEF	COMPONENT	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1
AREA	COMPONENT	CASH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4
AUX-MODE	COMPONENT	CLSH-SUBSYS-1
AXIS	COMPONENT	INSOL-1
AXIS-ASSIGN	COMPONENT	PRINTER-PLOT-1
AXIS-MAX	COMPONENT	PRINTER-PLOT-1
AXIS-MIN	COMPONENT	PRINTER-PLOT-1
AXIS-TITLES	COMPONENT	PRINTER-PLOT-1
AZIMUTH	COMPONENT	INSOL-1
BED-COND	COMPONENT	CASH-SUBSYS-1
BED-DEN	COMPONENT	CASH-SUBSYS-1
BED-DEPTH	COMPONENT	CASH-SUBSYS-1
BED-ENV-T	COMPONENT	CASH-SUBSYS-1
BED-HEIGHT	COMPONENT	CASH-SUBSYS-1
BED-INIT-T	COMPONENT	CASH-SUBSYS-1

Keyword	Associated Command Word	Associated TYPE
OUT-1 through OUT-12	COMPONENT	PRINTER-PLOT-1, REPORT-1
PARAS-KW	COMPONENT	RFA-SUBSYS-1
PLOT-SCH	COMPONENT	PRINTER-PLOT-1
PLOT-TITLE	COMPONENT	PRINTER-PLOT-1
PUMP-KW	COMPONENT	CLSH-SUBSYS-1, COL-EC-1, PUMP-1, RFA-SUBSYS-1
Q-AUX-CAP	COMPONENT	RFA-SUBSYS-1
Q-REJ	COMPONENT	RFA-SUBSYS-1
REPORT-SCH	COMPONENT	REPORT-1
REPORT-TITLE	COMPONENT	REPORT-1
SCH-1 through SCH-10	COMPONENT	SCHEDULE-1
SP-HT	COMPONENT	RELIEF-1
SP-HT-AIR	COMPONENT	CASH-CNTRL-1, CASH-SUBSYS-1, CLSH-CNTRL-1, CLSH-SUBSYS-1, COL-EC-AIR-1, RFA-SUBSYS-1, ROCK-BED-1
SP-HT-BED	COMPONENT	ROCK-BED-1
SP-HT-COLD	COMPONENT	COL-EC-1, EXCHANGER-1
SP-HT-FLD	COMPONENT	CLSH-CNTRL-1, COL-HWB-4, DUCT-LOSSES-1, PIPE-LOSSES-1, TANK-1
SP-HT-HOT	COMPONENT	COL-EC-1, EXCHANGER-1
SP-HT-LIQ	COMPONENT	RFA-SUBSYS-1
T	COMPONENT	RFA-SUBSYS-1
TANK-DEN	COMPONENT	CLSH-SUBSYS-1
TANK-ENV-T	COMPONENT	CLSH-SUBSYS-1
TANK-FLOW	COMPONENT	CLSH-SUBSYS-1
TANK-HT/DIA	COMPONENT	CLSH-SUBSYS-1, TANK-1
TANK-INIT-T	COMPONENT	CLSH-SUBSYS-1
TANK-LOSS-COEF	COMPONENT	CLSH-SUBSYS-1
TANK-SP-HT	COMPONENT	CLSH-SUBSYS-1
TANK-VOL	COMPONENT	CLSH-SUBSYS-1
TILT	COMPONENT	COL-HWB-4, INSOL-1
TILT-SCH	COMPONENT	INSOL-1
TITLE-25	COMPONENT	REPORT-1
TYPE	SYSTEM, COMPONENT	---
T-BOIL	COMPONENT	COL-EC-1, COL-HWB-4, RELIEF-1

Keyword	Associated Command Word	Associated TYPE
EFF-COEF	COMPONENT	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1
EFF-DEN-BED	COMPONENT	ROCK-BED-1
EFF-EXCH	COMPONENT	RFA-SUBSYS-1
EMITTANCE	COMPONENT	COL-HWB-4
EXCH-TYPE	COMPONENT	CLSH-CNTRL-1, COL-EC-1, EXCHANGER-1
EXCH-UA	COMPONENT	CLSH-CNTRL-1, COL-EC-1, EXCHANGER-1
FAN-KW	COMPONENT	CASH-SUBSYS-1, COL-EC-AIR-1, FAN-1 RFA-SUBSYS-1
FLOW	COMPONENT	CLSH-CNTRL-1, FAN-1, PUMP-1
FLOW-AIR	COMPONENT	COL-EC-AIR-1, RFA-SUBSYS-1
FLOW-COL	COMPONENT	CASH-SUBSYS-1
FLOW-COLD	COMPONENT	COL-EC-1
FLOW-HOT	COMPONENT	COL-EC-1
FLOW-LIQ	COMPONENT	RFA-SUBSYS-1
FLUID-TEMP	COMPONENT	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1
FREQUENCY	COMPONENT	PRINTER-PLOT-1, REPORT-1
F-PRIME	COMPONENT	COL-HWB-4
GLAZINGS	COMPONENT	COL-HWB-4
GROUND-REFL	COMPONENT	INSOL-1
HEADINGS	COMPONENT	REPORT-1
HEIGHT	COMPONENT	ROCK-BED-1
HP-TYPE	COMPONENT	RFA-SUBSYS-1
K-L-PROD	COMPONENT	COL-HWB-4
LENGTH	COMPONENT	DUCT-LOSSES-1, PIPE-LOSSES-1
LOAD-EXCH-TYPE	COMPONENT	CLSH-SUBSYS-1
LOAD-EXCH-UA	COMPONENT	CLSH-SUBSYS-1
LOAD-FLOW	COMPONENT	CLSH-SUBSYS-1
LOSS-COEF	COMPONENT	DUCT-LOSSES-1, PIPE-LOSSES-1, ROCK-BED-1, TANK-1
LOSS-COEF-B-E	COMPONENT	COL-HWB-4
MAX-DIF	COMPONENT	DIF-CNTRL-1
MAX-V	COMPONENT	DIF-CNTRL-1
MIN-DIF	COMPONENT	DIF-CNTRL-1
MODE	COMPONENT	CLSH-CNTRL-1
NODES	COMPONENT	ROCK-BED-1

Code-Word	Associated Keyword
LIQ-SOURCE	HP-TYPE
MONTHLY	FREQUENCY
NO	DOUBLE-SPACE, TITLE-25
N-S	AXIS
PARALLEL	AUX-MODE, MODE
PARALLEL-FLOW	EXCH-TYPE, AUX-EXCH-TYPE, LOAD-EXCH-TYPE, COL-EXCH-TYPE
PIPE-LOSSES-1	TYPE (in COMPONENT)
PLANT-1	TYPE (in COMPONENT)
PLANT-2	TYPE (in COMPONENT)
PRINTER-PLOT-1	TYPE (in COMPONENT)
PUMP-1	TYPE (in COMPONENT)
RASH	TYPE (in SYSTEM)
RELIEF-1	TYPE (in COMPONENT)
REPORT-1	TYPE (in COMPONENT)
REPORT-2	TYPE (in COMPONENT)
RFA-SUBSYS-1	TYPE (in COMPONENT)
RLSH	TYPE (in SYSTEM)
ROCK-BED-1	TYPE (in COMPONENT)
SCHEDULE-1	TYPE (in COMPONENT)
SERIES	AUX-MODE, MODE
TANK-1	TYPE (in COMPONENT)
TEE-1	TYPE (in COMPONENT)
USER	TYPE (in SYSTEM)
YES	DOUBLE-SPACE, TITLE-25

Input or Output Name	Input to Component TYPE (from the CONNECT instruction)	Output from Component TYPE
CAP-RATE-C		COL-EC-1, COL-EC-AIR-1
CAP-RATE-H		COL-EC-1, COL-EC-AIR-1,
CAP-RATE-MIN		COL-EC-1, COL-EC-AIR-1,
CAP-TANK	PLANT-2	CLSH-SUBSYS-1, TANK-1
CLOUD-AMT	INSOL-1	DOE-WEATH-1
CLOUD-TYPE	INSOL-1	DOE-WEATH-1
COP		RFA-SUBSYS-1

Keyword	Associated Command Word	Associated TYPE
T-INIT	COMPONENT	COL-EC-1, COL-EC-AIR-1, ROCK-BED-1, TANK-1, DUCT-LOSSES-1, PIPE-LOSSES-1
T-OUT-MAX	COMPONENT	COL-EC-1, COL-EC-AIR-1
T-SUP-MIN	COMPONENT	RFA-SUBSYS-1
VARIABLES	COMPONENT	PRINTER-PLOT-1, REPORT-1
VOL	COMPONENT	TANK-1
WIDTH	COMPONENT	ROCK-BED-1

Code-Word	Associated Keyword
AIR-SOURCE	HP-TYPE
AVERAGE	FLUID-TEMP
CASH	TYPE (in SYSTEM)
CASH-CNTRL-1	TYPE (in COMPONENT)
CASH-SUBSYS-1	TYPE (in COMPONENT)
CLSH	TYPE (in SYSTEM)
CLSH-CNTRL-1	TYPE (in COMPONENT)
CLSH-SUBSYS-1	TYPE (in COMPONENT)
COL-EC-1	TYPE (in COMPONENT)
COL-EC-AIR-1	TYPE (in COMPONENT)
COL-HWB-4	TYPE (in COMPONENT)
CONSTANT-EFF	EXCH-TYPE, AUX-EXCH-TYPE, LOAD-EXCH-TYPE, COL-EXCH-TYPE
COUNTER-FLOW	EXCH-TYPE, AUX-EXCH-TYPE, LOAD-EXCH-TYPE, COL-EXCH-TYPE
CROSS-FLOW	EXCH-TYPE, AUX-EXCH-TYPE, LOAD-EXCH-TYPE, COL-EXCH-TYPE
DAILY	FREQUENCY
DIF-CNTRL-1	TYPE (in COMPONENT)
DOE-WEATH-1	TYPE (in COMPONENT)
DUCT-LOSSES-1	TYPE (in COMPONENT)
EXCHANGER-1	TYPE (in COMPONENT)
E-W	AXIS
FAN-1	TYPE (in COMPONENT)
FLOW-DIVERTER-1	TYPE (in COMPONENT)
HOURLY	FREQUENCY
INLET	FLUID-TEMP
INSOL-1	TYPE (in COMPONENT)

Input or Output Name	Input to Component TYPE	Output from Component TYPE
	(from the CONNECT instruction)	
IN-1 through IN-6	PRINTER-PLOT-1, REPORT-1, REPORT-2	
IN-7 through IN-20	PRINTER-PLOT-1 REPORT-1	
LOSS-COEF		COL-HWB-4
OUT-1 through OUT-10		SCHEDULE-1
Q-ABS		RFA-SUBSYS-1
Q-AUX		CASH-CNTRL-1, CASH-SUBSYS-1, CLSH-CNTRL-1, CLSH-SUBSYS-1, RFA-SUBSYS-1
Q-BOIL		RELIEF-1
Q-COL		CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4
Q-DIR		RFA-SUBSYS-1
Q-DUMP		CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1
Q-FREE		RFA-SUBSYS-1
Q-HC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
Q-IN		ROCK-BED-1, TANK-1
Q-INC		CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4
Q-LOAD	CASH-CNTRL-1, CASH-SUBSYS-1, RFA-SUBSYS-1	CLSH-CNTRL-1, CLSH-SUBSYS-1
Q-LOAD-MOD		CASH-CNTRL-1, CASH-SUBSYS-1
Q-LOSS		CASH-SUBSYS-1, CLSH-SUBSYS-1, DUCT-LOSSES-1, PIPE-LOSSES-1, ROCK-BED-1, TANK-1
Q-NET-ZERO		CASH-SUBSYS-1, CLSH-SUBSYS-1, ROCK-BED-1, TANK-1
Q-NON-AUX		RFA-SUBSYS-1
Q-OUT		ROCK-BED-1, TANK-1
Q-OVER		CASH-CNTRL-1
Q-PLANT	CLSH-SUBSYS-1, TANK-1	PLANT-1
Q-PHC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
Q-PRE		RFA-SUBSYS-1
Q-REDUC		RFA-SUBSYS-1

Input or Output Name	Input to Component TYPE	Output from Component TYPE
	(from the CONNECT instruction)	
COS-INC	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4	INSOL-1
EFFECTIVENESS		EXCHANGER-1
ELEC		CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, FAN-1, PLANT-2, PUMP-1, RFA-SUBSYS-1
ELEC-FAN		RFA-SUBSYS-1
ELEC-HP		RFA-SUBSYS-1
ELEC-PUMP		RFA-SUBSYS-1
EXCH-EFF		COL-EC-1
FLOW	COL-HWB-4, DUCT-LOSSES-1, PIPE-LOSSES-1, RELIEF-1	CASH-CNTRL-1, FAN-1, PUMP-1
FLOW-AIR		RFA-SUBSYS-1
FLOW-COLD	EXCHANGER-1	
FLOW-HC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
FLOW-HOT	EXCHANGER-1	
FLOW-IN	FLOW-DIVERTER-1	
FLOW-IN-BOT	ROCK-BED-1, TANK-1	
FLOW-IN-TOP	ROCK-BED-1, TANK-1	
FLOW-LIQ-OUT		CLSH-CNTRL-1, RFA-SUBSYS-1
FLOW-LOAD	CASH-CNTRL-1, CASH-SUBSYS-1	CLSH-SUBSYS-1,
FLOW-MIXED		TEE-1
FLOW-OUT		COL-EC-1, COL-EC-AIR-1
FLOW-OUT-1		FLOW-DIVERTER-1
FLOW-OUT-2		FLOW-DIVERTER-2
FLOW-PHC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
FLOW-ZHC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
FLOW-1	TEE-1	
FLOW-2	TEE-1	
F-AUX		RFA-SUBSYS-1
F-DIR		RFA-SUBSYS-1
F-FAN		RFA-SUBSYS-1
F-FP		RFA-SUBSYS-1

Input or Output Name	Input to Component TYPE	Output from Component TYPE
	(from the CONNECT instruction)	
T-IN	CASH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4, DUCT-LOSSES-1, PIPE-LOSSES-1, RELIEF-1	
T-IN-BOT	ROCK-BED-1, TANK-1	
T-IN-COLD	EXCHANGER-1	
T-IN-HC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
T-IN-HOT	EXCHANGER-1	
T-IN-PHC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
T-IN-ZHC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
T-IN-TOP	ROCK-BED-1, TANK-1	
T-LIQ-IN	CLSH-CNTRL-1 RFA-SUBSYS-1	
T-LIQ-OUT		CLSH-CNTRL-1, RFA-SUBSYS-1
T-LOAD		CLSH-SUBSYS-1
T-LOAD-SUP		CASH-SUBSYS-1
T-MIXED		TEE-1
T-OUT		COL-EC-1, COL-EC-AIR-1, COL-HWB-4, DUCT-LOSSES-1, PIPE-LOSSES-1, RELIEF-1
T-OUT-BOT		ROCK-BED-1
T-OUT-COLD		EXCHANGER-1
T-OUT-HOT		EXCHANGER-1
T-OUT-TOP		ROCK-BED-1
T-RET	CASH-CNTRL-1	CASH-CNTRL-1
T-SOL	CASH-CNTRL-1	
T-SPACE	RFA-SUBSYS-1	
T-STOR	COL-EC-1, COL-EC-AIR-1	
T-STOR-AVG		ROCK-BED-1
T-TANK	PLANT-2	CLSH-SUBSYS-1, TANK-1
T-TANK-NEW		CLSH-SUBSYS-1
T-TANK-OLD		CLSH-SUBSYS-1
T-TANK-1		TANK-1
T-TANK-2		TANK-1

Input or Output Name	Input to Component TYPE	Output from Component TYPE
	(from the CONNECT instruction)	
Q-REJ		RFA-SUBSYS-1
Q-SOL	PLANT-2	CASH-CNTRL-1, CASH-SUBSYS-1, CLSH-CNTRL-1, CLSH-SUBSYS-1, RFA-SUBSYS-1
Q-TRANS		EXCHANGER-1
Q-WORK		RFA-SUBSYS-1
Q-ZHC	CLSH-CNTRL-1, CLSH-SUBSYS-1	PLANT-1
RAD-HOR-DIF		INSOL-1
RAD-HOR-TOT	INSOL-1	DOE-WEATH-1, INSOL-1
RAD-NORM-DIR	INSOL-1	INSOL-1
RAD-TILT-DIF	CASH-SUBSYS-1, CLSH-SUBSYS-1 COL-EC-1, COL-EC-AIR-1, COL-HWB-4	INSOL-1
RAD-TILT-DIR	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4	INSOL-1
RAD-TILT-TOT	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-HWB-4, COL-EC-1, COL-EC-AIR-1	INSOL-1
SIGNAL	FAN-1, PUMP-1, FLOW-DIVIDER-1	DIF-CNTRL-1
TRANS-ABS-PROD		COL-HWB-4
T-AIR-IN	RFA-SUBSYS-1	
T-AMB	CASH-SUBSYS-1, CLSH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, COL-HWB-4, RFA-SUBSYS-1	DOE-WEATH-1
T-AVG		CASH-SUBSYS-1
T-BOT-NODE		ROCK-BED-1
T-COL		CLSH-SUBSYS-1
T-COL-IN		CASH-SUBSYS-1
T-COL-NEW		CASH-SUBSYS-1, CLSH-SUBSYS-1
T-COL-OLD		CASH-SUBSYS-1, CLSH-SUBSYS-1
T-COL-OUT		CASH-SUBSYS-1, COL-EC-1
T-ENV	DUCT-LOSSES-1, PIPE-LOSSES-1, ROCK-BED-1, TANK-1	

E. EDL

Command Word	Abbreviation	Page
ABORT	none	(see Chap. II)
BASELINE	none	VI.9
COMPONENT-COST	C-C	VI.6
COMPUTE	none	(see Chap. II)
DIAGNOSTIC	LIST	(see Chap. II)
ECONOMICS-REPORT	E-R	VI.12
END	none	(see Chap. II)
INPUT	none	(see Chap. II)
PARAMETER	DEFINE	(see Chap. II)
PARAMETRIC-INPUT	PAR-INPUT	(see Chap. II)
SET-DEFAULT	SET	(see Chap. II)
STOP	none	(see Chap. II)
TITLE	none	(see Chap. II)

Keyword	Abbreviation	Associated Command Word
ANNUAL-COST	A-C	COMPONENT-COST
COMPONENT-LIFE	C-L	COMPONENT-COST
ENERGY-COST	E-C	BASELINE
ENERGY-USE-SITE	E-U-SITE	BASELINE
ENERGY-USE-SRC	E-U-SRC	BASELINE
FIRST-COST	F-C	BASELINE, COMPONENT-COST
INSTALL-COST	I-C	COMPONENT-COST
MAJ-OVHL-COST	MAJ-O-C	COMPONENT-COST
MAJ-OVHL-INT	MAJ-O-I	COMPONENT-COST
MIN-OVHL-COST	MIN-O-C	COMPONENT-COST
MIN-OVHL-INT	MIN-O-I	COMPONENT-COST
NUMBER-OF-UNITS	N-O-U	COMPONENT-COST
OPERATIONS-COST	O-C	BASELINE
REPLACE-COST	R-C	BASELINE
SUMMARY	S	ECONOMICS-REPORT
UNIT-NAME	U-N	COMPONENT-COST
VERIFICATION	V	ECONOMICS-REPORT

Input or Output Name	Input to Component TYPE (from the CONNECT instruction)	Output from Component TYPE
T-1 and T-2	TEE-1	CASH-SUBSYS-1, COL-EC-1, COL-EC-AIR-1, ROCK-BED-1, DUCT-LOSSES-1, PIPE-LOSSES-1
T-3 through T-5		CASH-SUBSYS-1, ROCK-BED-1
T-6 through T-10		ROCK-BED-1
UA		TANK-1
V-HI	DIF-CNTRL-1	
V-LO	DIF-CNTRL-1	
WIND-SPEED	COL-HWB-4	DOE-WEATH-1

Code-Word	Associated Keyword
ALL-SUMMARY	SUMMARY
ALL-VERIFICATION	VERIFICATION
ES-A	SUMMARY
ES-B	SUMMARY
ES-C	SUMMARY
EV-A	VERIFICATION

X. LIBRARY DATA

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3. Thermal Properties of Air Films and Air Spaces X.B.11
4. Notes X.B.12

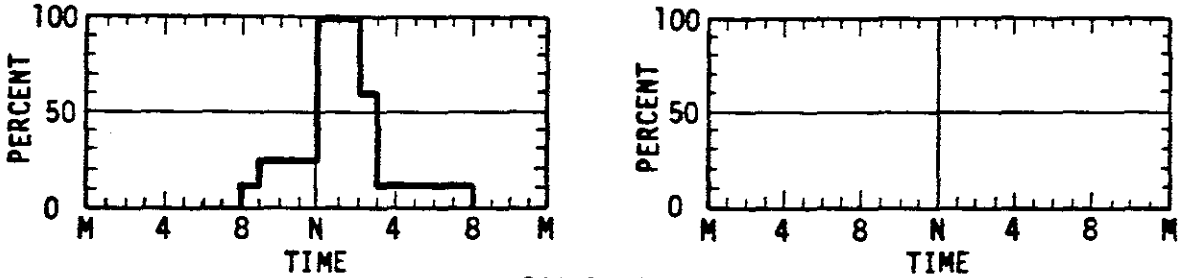
X. LIBRARY DATA

A. SCHEDULES LIBRARY

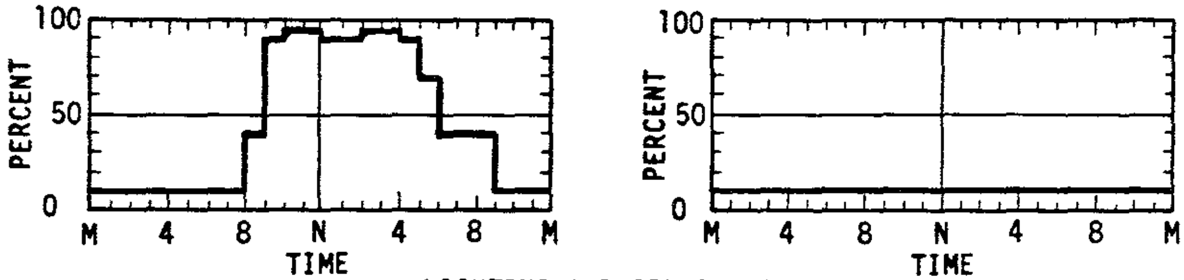
Graphic examples of typical schedules are included in this section to aid the user. The user must enter his own schedules into the program with the DAY-SCHEDULE, WEEK-SCHEDULE, and SCHEDULE instructions (see Chap. II). A set of blank schedule graphs is also included at the end of this section.

BANKS

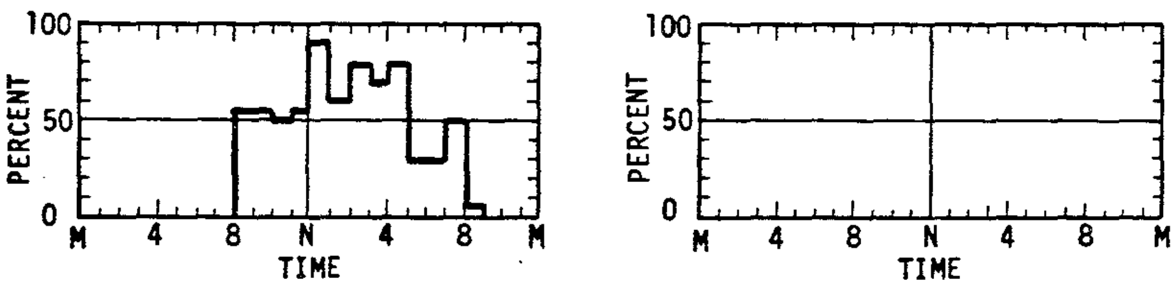
WEEKDAYS | WEEKENDS & HOLIDAYS



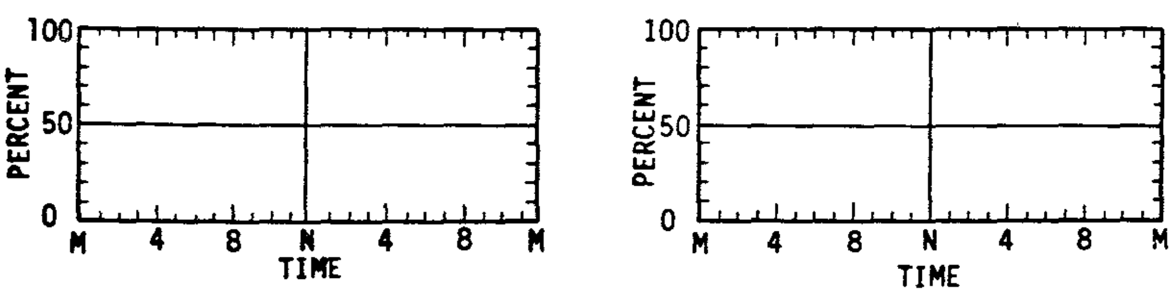
OCCUPANCY



LIGHTING & RECEPTACLES

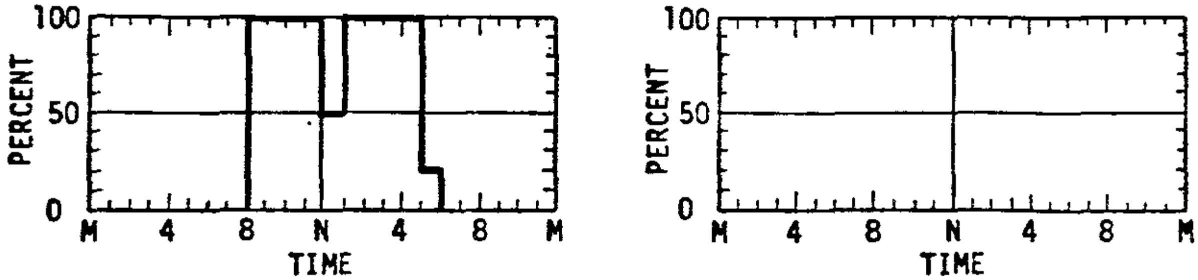


HOT WATER



BANK OFFICES

WEEKDAYS | WEEKENDS & HOLIDAYS



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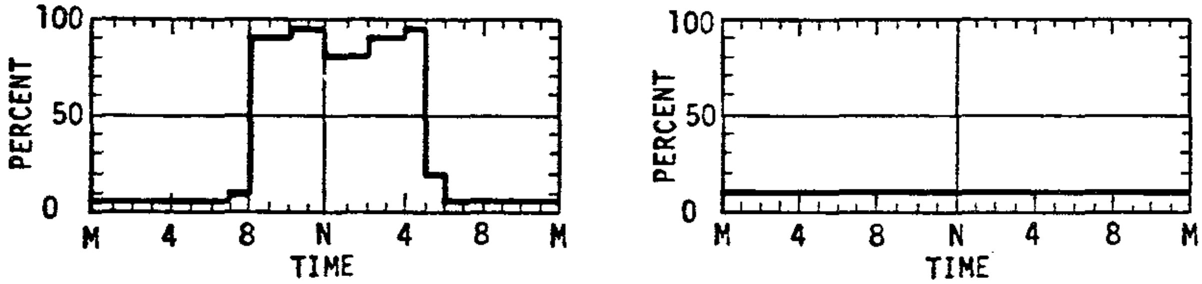

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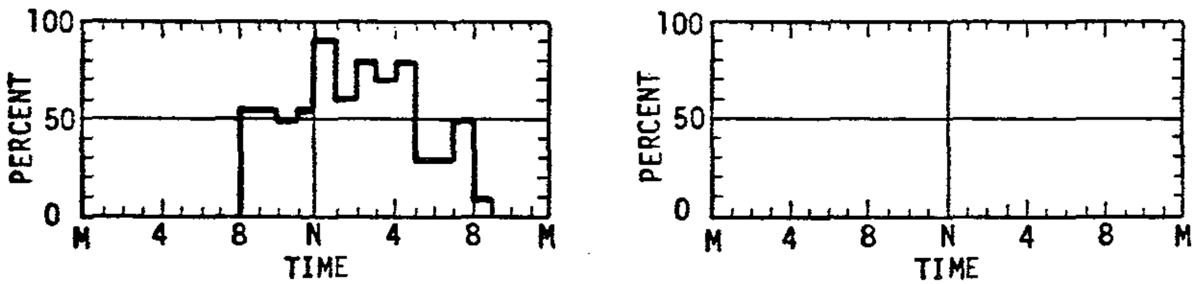
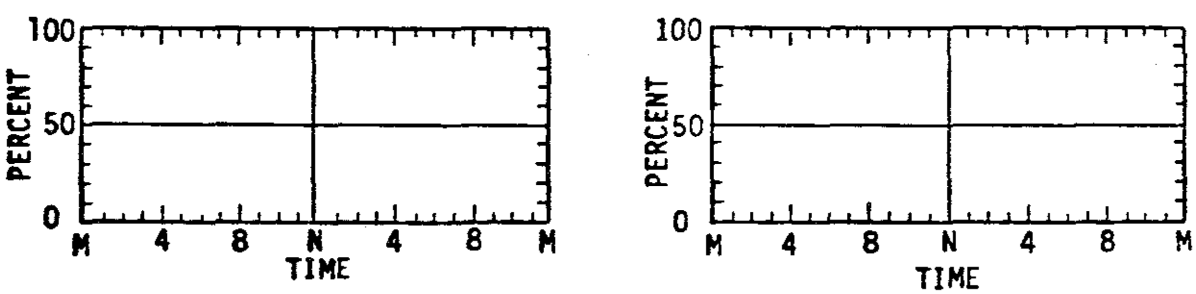
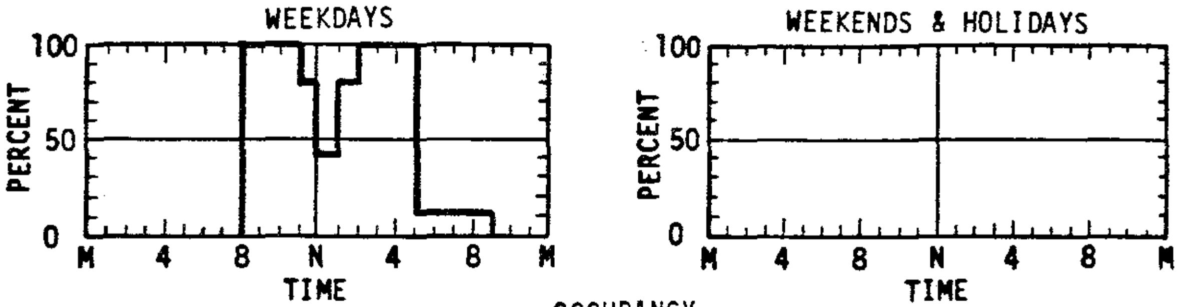


HOT WATER



SMALL OFFICE BUILDING



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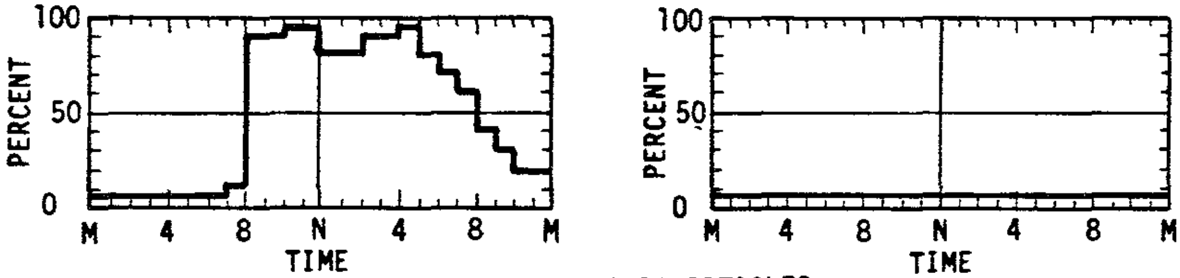
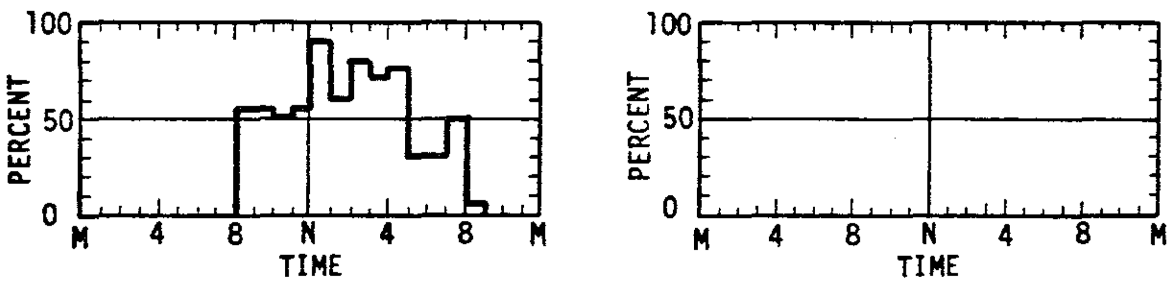
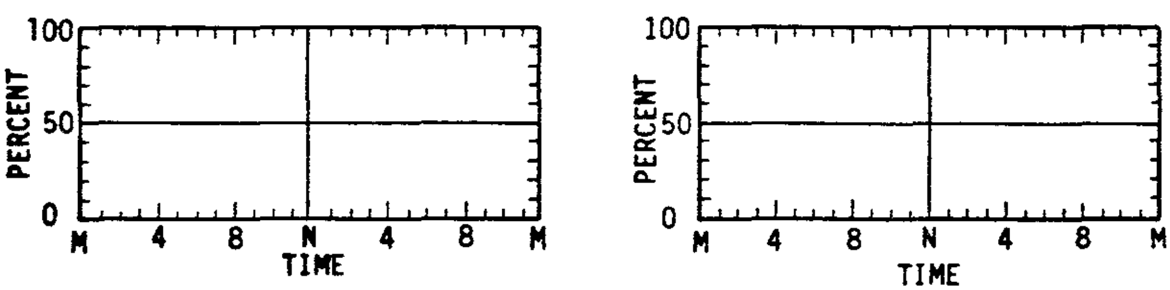


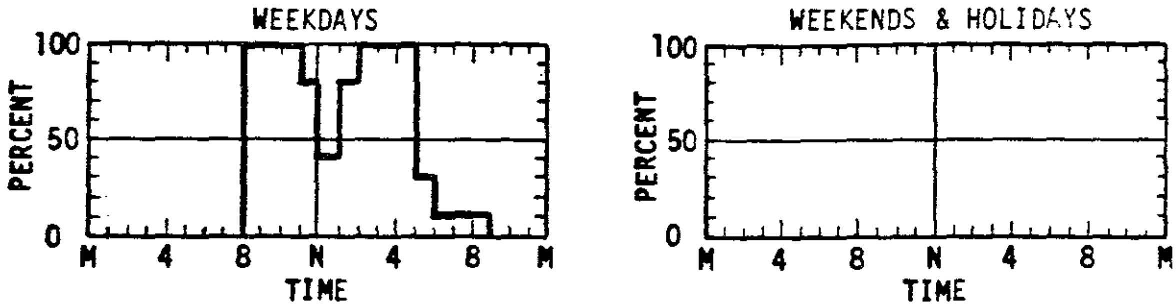
LIGHTING & RECEPTACLES



HOT WATER



OFFICES



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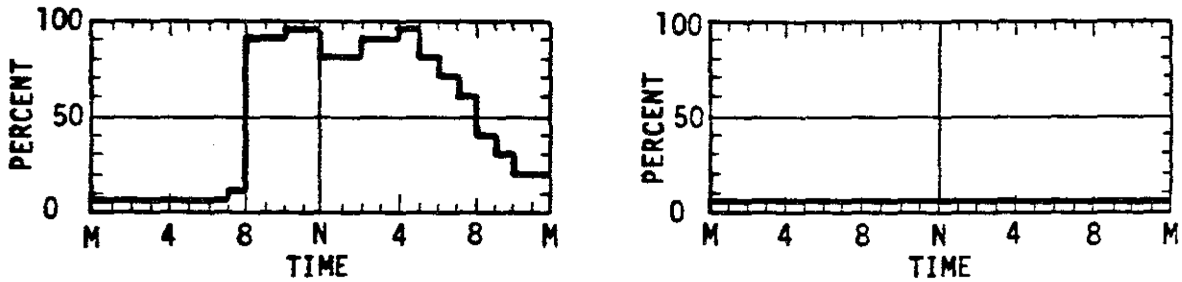
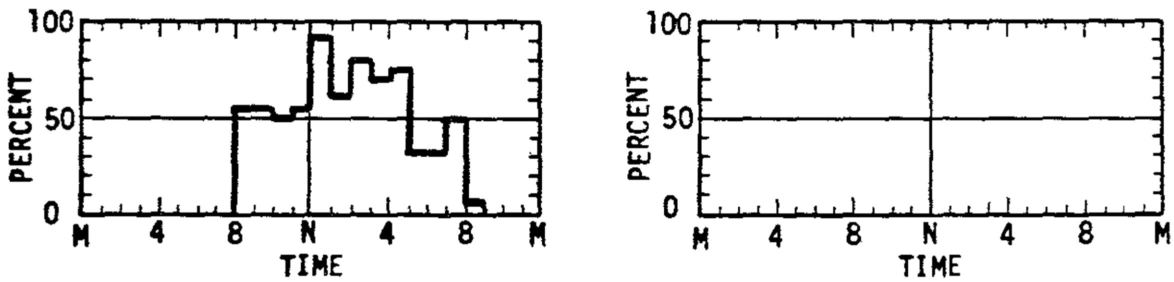
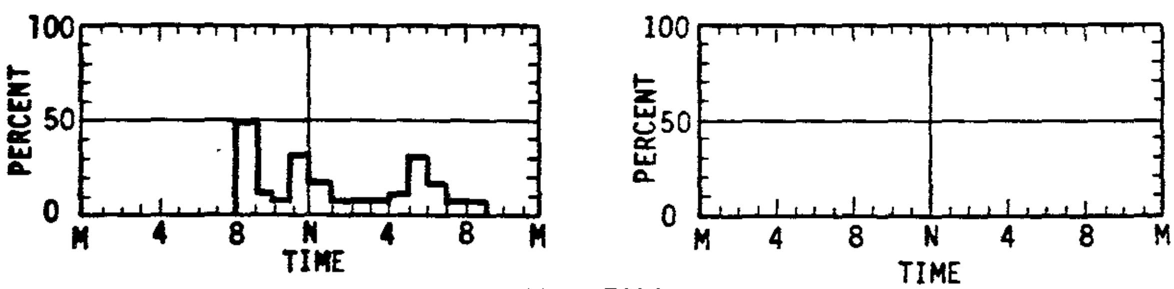


LIGHTING AND RECEPTACLES

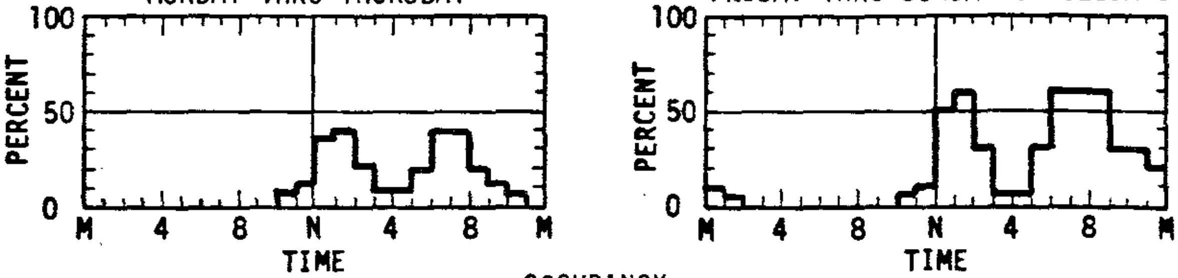


HOT WATER, HOT AND COLD WATER PUMPS



ELEVATORS

MONDAY THRU THURSDAY | FRIDAY THRU SUNDAY & HOLIDAYS



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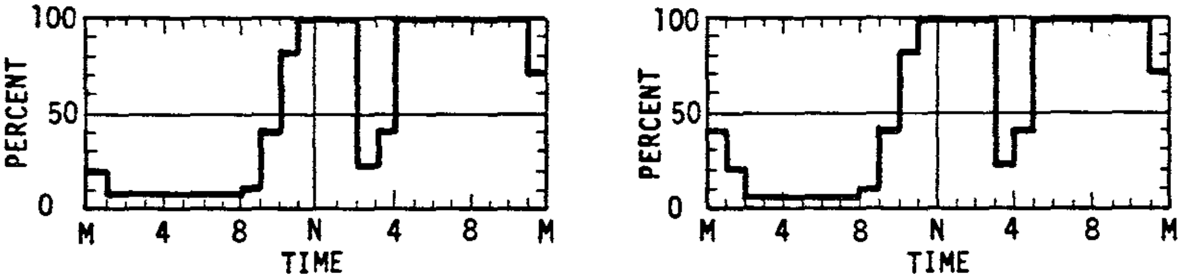

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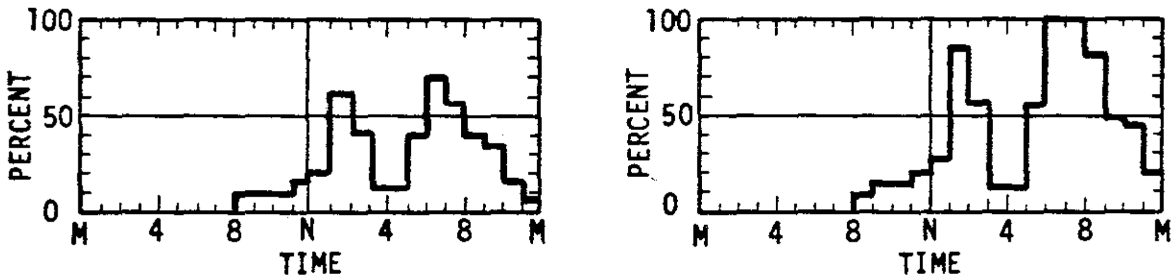
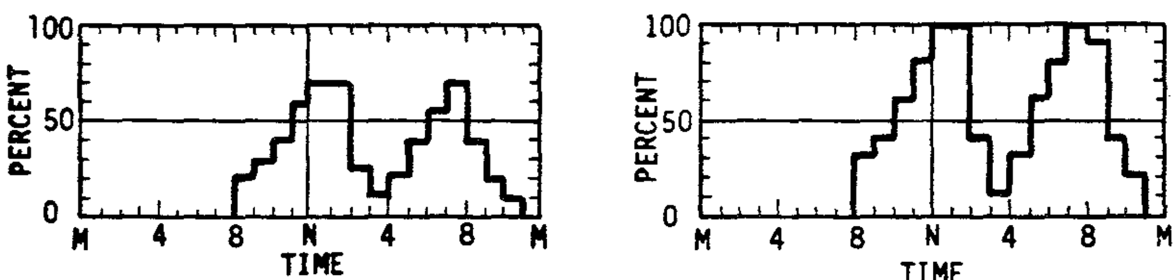
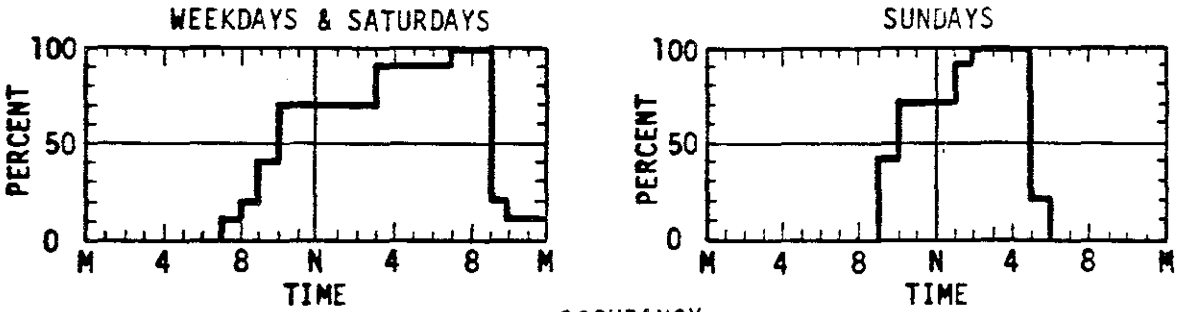


HOT WATER



KITCHEN PROCESS

SMALL RETAIL STORE



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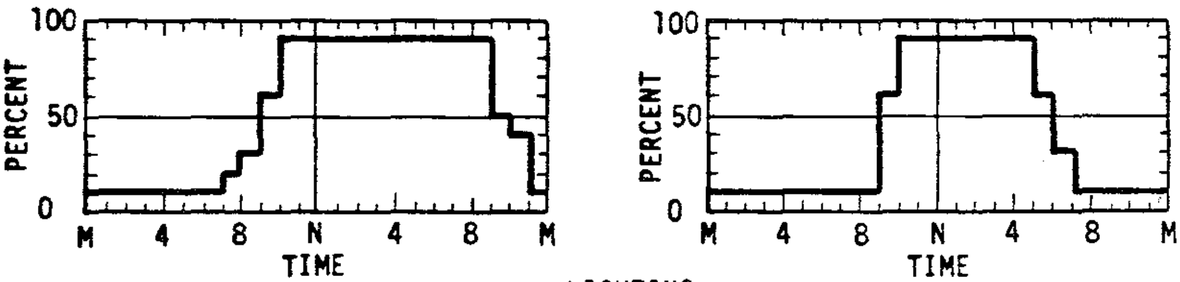

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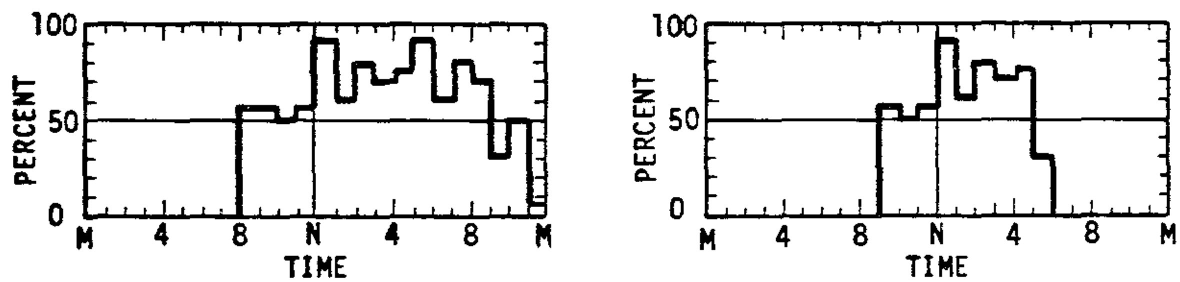
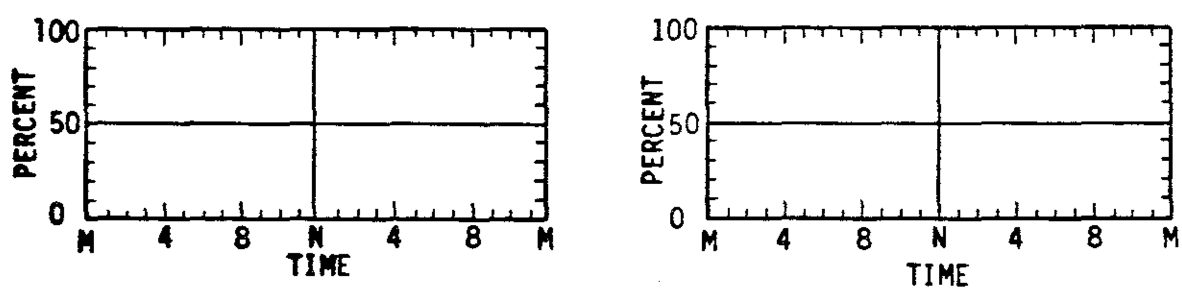
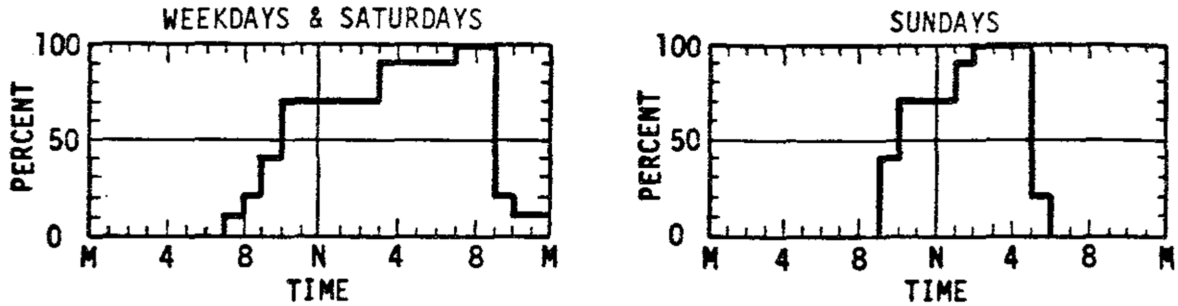


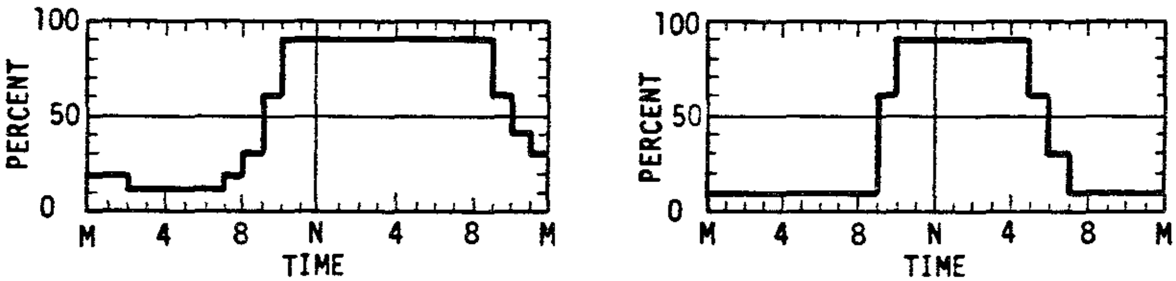
HOT WATER



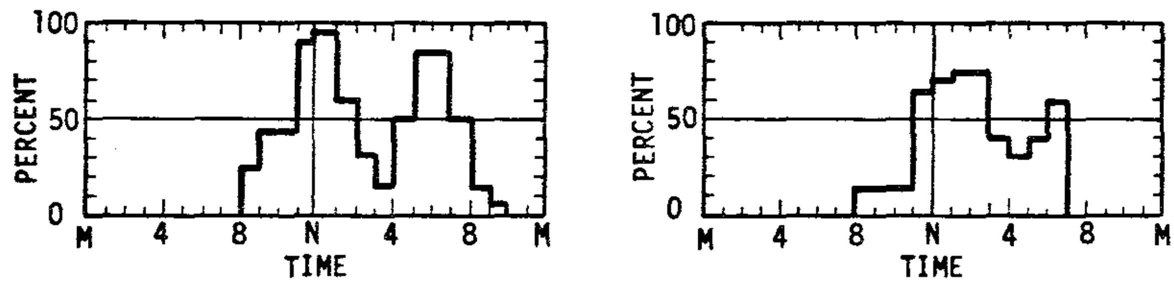
LARGE RETAIL STORE



OCCUPANCY



LIGHTING AND RECEPTACLE



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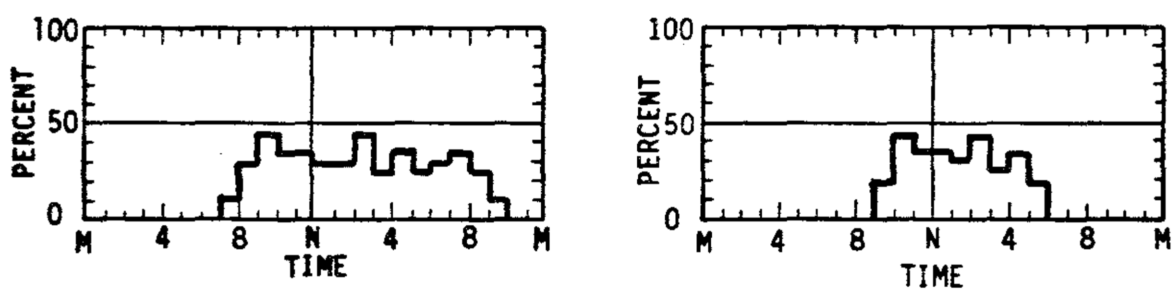
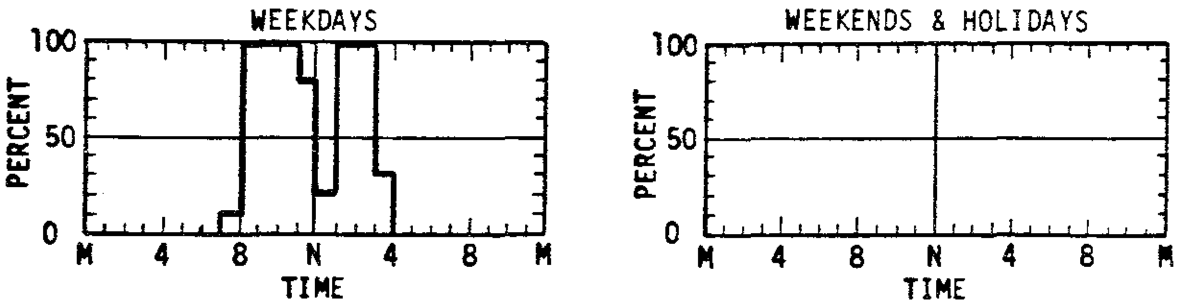


ESCALATOR & ELEVATOR

SCHOOL/CLASSROOM

REGULAR SCHOOL



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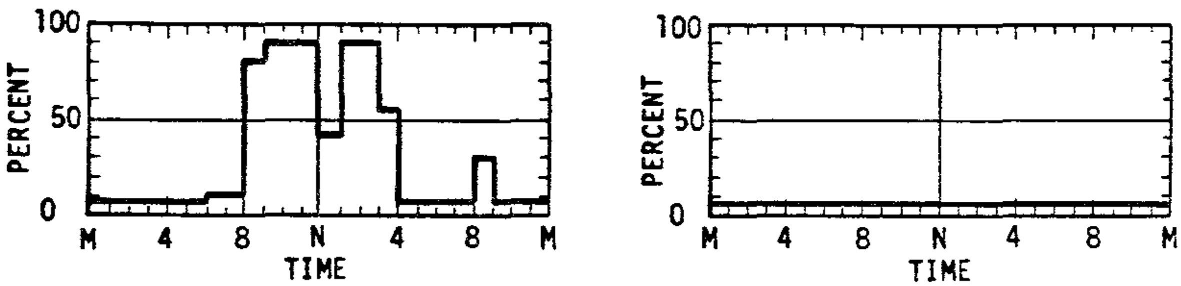
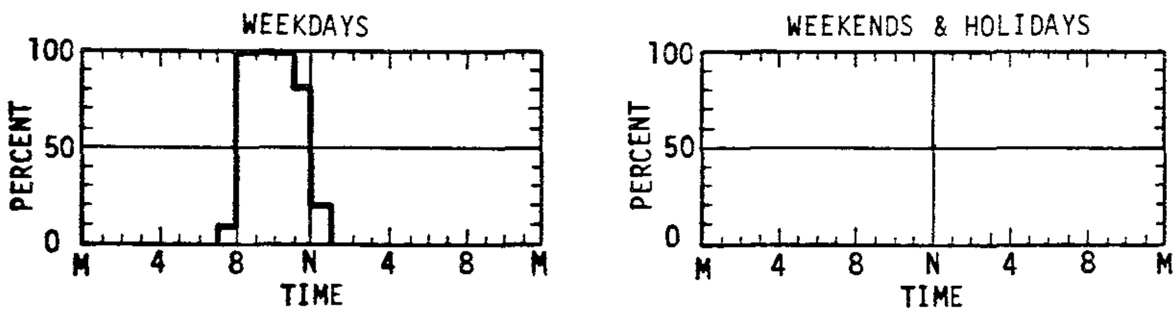


LIGHTING & RECEPTACLE

SUMMER SCHOOL



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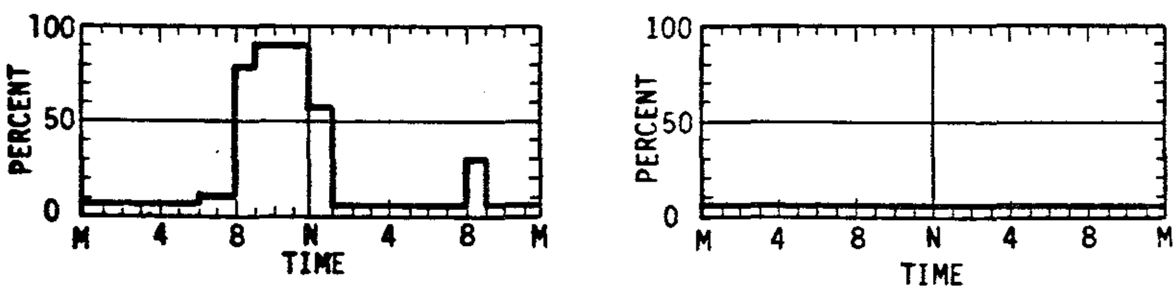

LIGHTING AND RECEPTACLES

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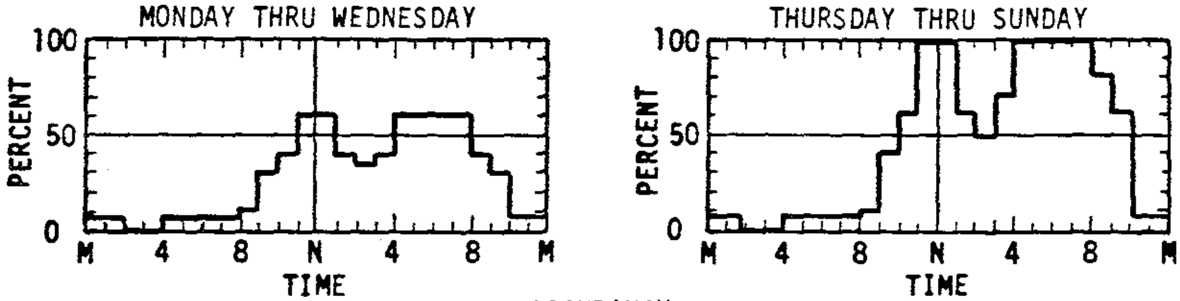

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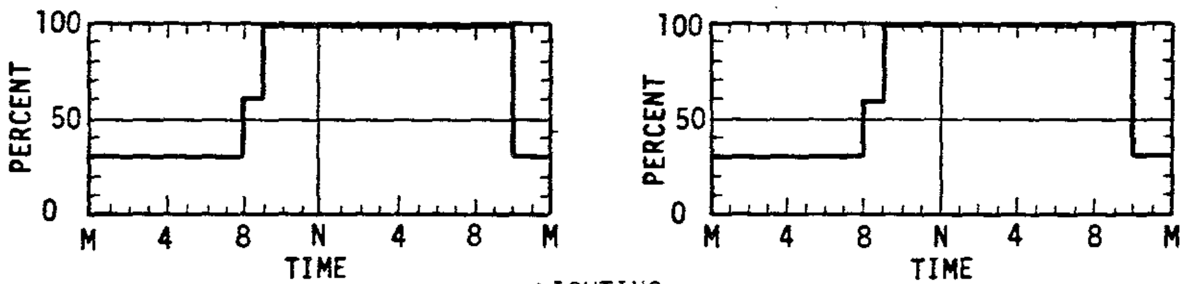

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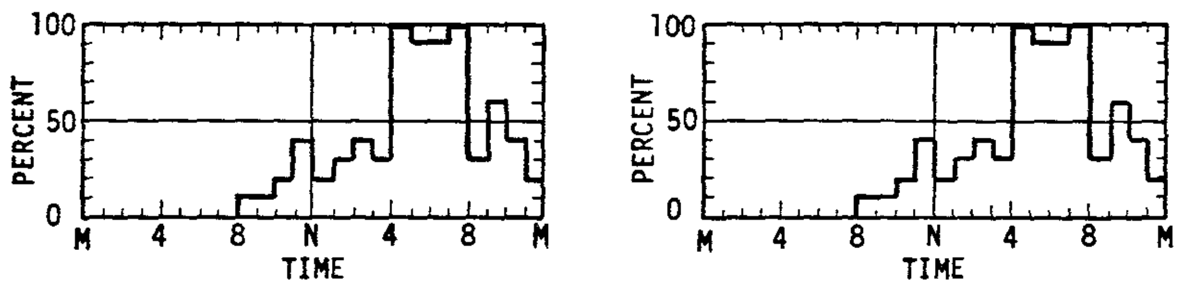

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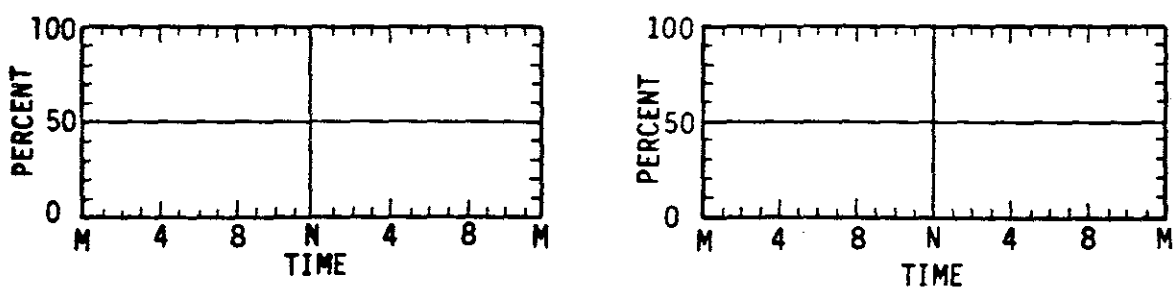

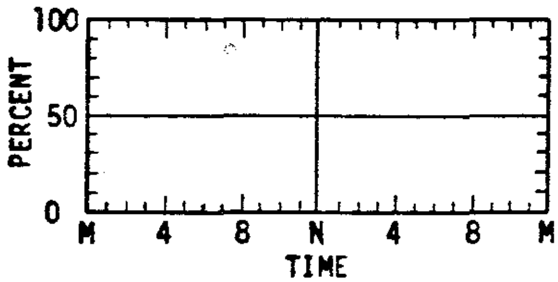
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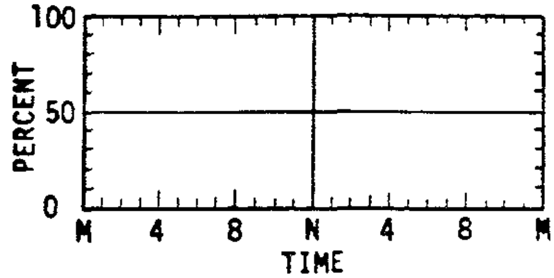
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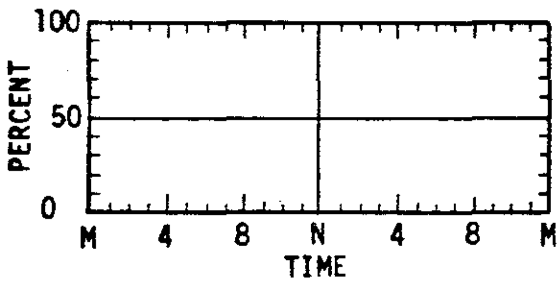
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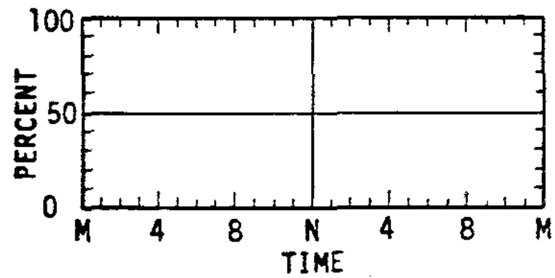
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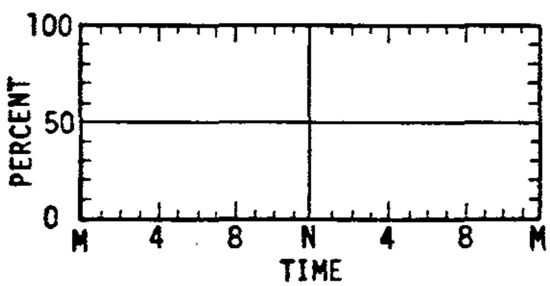
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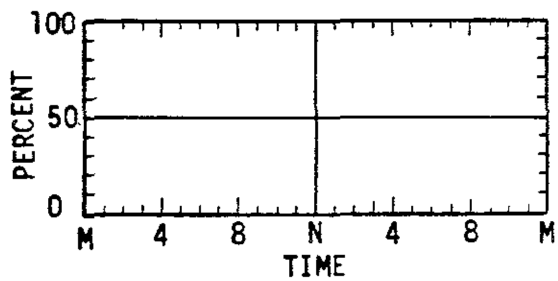
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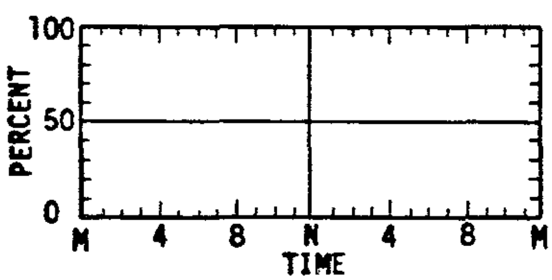
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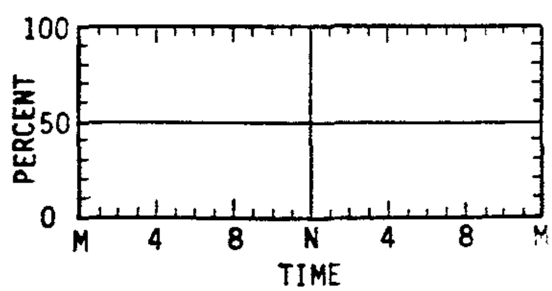
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B. MATERIALS LIBRARY

This section contains tables showing the thermal properties of building materials, insulating materials, and air films and air spaces, with associated DOE-2 code-words. These materials are machine-addressable by DOE-2 through the LAYERS command in LOADS (Chap. III).

1. Thermal Properties of Building Materials

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°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				0.3	0.05
	Brick					
BK01	4 inch Common	0.3333	0.4167	120.0	0.2	0.80
BK02	8 inch "	0.6667	0.4167	120.0	0.2	1.60
BK03	12 inch "	1.0000	0.4167	120.0	0.2	2.40
BK04	3 inch Face	0.2500	0.7576	130.0	0.22	0.33
BK05	4 inch "	0.3333	0.7576	130.0	0.22	0.44
BR01	Built-up Roofing, 3/8 inch	0.0313	0.0939	70.0	0.35	0.33
	Building Paper					
BP01	Permeable Felt					0.06
BP02	2-Layers Seal					0.12
BP03	Plastic Film Seal					0.01

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°F / Btu
	Carpet					
CP01	With Fibrous Pad				0.34	2.08
CP02	With Rubber Pad				0.34	1.23
	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

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°F / Btu
	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
	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		0.71
CB02	Concrete Filled	0.3333	0.7575	140.0		0.44
CB03	Perlite Filled	0.3333	0.3001	103.0		1.11
CB04	Partially filled concrete(1)	0.3333	0.5844	114.0		0.57
CB05	Concrete and Perlite(2)	0.3333	0.4772	115.0		0.70
	Concrete Block, 6 inch Heavy Weight					
CB06	Hollow	0.5000	0.5555	85.0		0.90
CB07	Concrete Filled	0.5000	0.7575	140.0		0.66
CB08	Perlite Filled	0.5000	0.2222	88.0		2.25
CB09	Partially filled concrete(1)	0.5000	0.6119	104.0		0.82
CB10	Concrete and Perlite(2)	0.5000	0.4238	104.0		1.18
	Concrete Block, 8 inch Heavy Weight					
CB11	Hollow	0.6667	0.6060	69.0		1.10
CB12	Concrete Filled	0.6667	0.7575	140.0		.88
CB13	Perlite Filled	0.6667	0.2272	70.0		2.93
CB14	Partially filled concrete(1)	0.6667	0.6746	93.0		0.99
CB15	Concrete and Perlite(2)	0.6667	0.4160	93.0		1.60

See NOTES at the end of this Section.

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°F / Btu
	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)	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(1)	0.3333	0.3306	89.0	0.2	1.01
CB25	Concrete and Perlite(2)	0.3333	0.2493	90.0	0.2	1.34
	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(1)	0.5000	0.3686	83.0	0.2	1.36
CB30	Concrete and Perlite(2)	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(1)	0.6667	0.4348	76.0	0.2	1.53
CB35	Concrete and Perlite(2)	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)	1.0000	0.4919	79.0	0.2	2.03

See NOTES at the end of this Section.

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°F / Btu
	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(1)	0.3333	0.2808	78.0	0.2	1.19
CB45	Concrete and Perlite(2)	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(1)	0.5000	0.3189	73.0	0.2	1.57
CB50	Concrete and Perlite(2)	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(1)	0.6667	0.3846	68.0	0.2	1.73
CB55	Concrete and Perlite(2)	0.6667	0.2095	69.0	0.2	3.18
	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)	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

See NOTES at the end of this Section.

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^\circ F}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^\circ F}$	$\frac{Hr \cdot Ft^2 \cdot {}^\circ F}{Btu}$
	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
	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

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°F / Btu
	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	0.3	0.87
WS02	For Roof					0.94

2. Thermal Properties of Insulating Materials

Thermal Properties of Insulating Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°F / Btu
	Mineral Wool/Fiber					
IN01	Batt, R-7(3)	0.1882	0.0250	.60	0.2	7.53
IN02	Batt, R-11	0.2957	0.0250	.60	0.2	11.83
IN03	Batt, R-19	0.5108	0.0250	.60	0.2	20.43
IN04	Batt, R-24	0.6969	0.0250	.60	0.2	27.88
IN05	Batt, R-30	0.8065	0.0250	.60	0.2	32.26
IN11	Fill, 3.5 inch, R-11	0.2917	0.0270	.60	0.2	10.80
IN12	Fill, 5.5 inch, R-19	0.4583	0.0270	.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

See NOTES at the end of this Section.

Thermal Properties of Insulating Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft²·°F	Lb / Ft³	Btu / Lb·°F	Hr·Ft²·°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

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3. Thermal Properties of Air Films and Air Spaces

Thermal Properties of Air Films and Air Spaces

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^\circ F}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^\circ F}$	$\frac{Hr \cdot Ft^2 \cdot {}^\circ F}{Btu}$
	Air Layer, 3/4 inch or less					
AL11	Vertical Walls					0.90
AL12	Slope 45 degrees					0.84
AL13	Horizontal Roofs					0.82
	Air Layer, 3/4 inch to 4 inch					
AL21	Vertical Walls					0.89
AL22	Slope 45 degrees					0.87
AL23	Horizontal Roofs					0.87
	Air Layer, 4 inch or more					
AL31	Vertical Walls					0.92
AL32	Slope 45 degrees					0.89
AL33	Horizontal Roofs					0.92

4. Notes

NOTES

TO

Tables of Materials and Air Spaces

NOTE 1 One filled and reinforced concrete core every 24 inches of wall length.

NOTE 2 One filled and reinforced concrete core every 24 inches of wall length with the remaining cores filled with perlite insulation.

NOTE 3 Nominal thickness is 2 inches to 2-3/4 inches. Resistance value is based on a thickness of 2.26 inches.

NOTE 4 The air space resistance value represents a compromise between actual summer and winter values. There is no mechanism in the current program for varying air space resistance as a function of temperature.

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