ANL/ENG-77-03

MASTER

CAL-ERDA
USERS MANUA[redacted]

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Argonne, Illinois

LB
Lawrence Berkeley Laboratory

Argonne National Laboratory

LAS
Los Alamos Scientific Laboratory

In Cooperation with
Consultants Computation Bureau
and Supported by the
State of California, Energy Resources Conservation and Development Commission
and the United States Energy Research and Development Administration

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* In Preparation

ABSTRACT

A new set of computer programs is described which are capable of rapid and detailed analysis of energy consumption in buildings. A new user-oriented input language, named the Building Design Language (BDL), has been written to allow simplified manipulation of the many variables used to describe a building and its operation. The new computer programs presented in this manual include:

1. a Building Design Language program to analyze the input instructions, execute computer system control commands, 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 (design) loads and hourly space loads due to ambient weather conditions and the internal occupancy, lighting, and equipment within the building, as well as variations in the size, location, orientation, construction, walls, roofs, floors, fenestrations, attachments (awnings, balconies) and shape of a building;

3. a Heating, Ventilating, and Air-Conditioning (HVAC) SYSTEMS program capable of modeling the operation of 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 and humidity control schedules;

4. a PLANT equipment program which models the operation of boilers, chillers, electrical generation equipment (e.g., diesel engines or turbines), heat storage apparatus (e.g., chilled or heated water) and solar heating and/or cooling systems;

5. an ECONOMICS analysis program which calculates life cycle costs;

6. a REPORT program which produces tables of user-selected variables and arranges them according to user-selected formats; and

7. an EXECUTIVE processor to create computer system control commands.

A library of weather data has been prepared which includes temperature, 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 (8,760 hours/year). A library of typical schedule data has also been prepared which allows hourly, daily, weekly, monthly, seasonal, and yearly specifications of the operation of a building. These schedules are used to specify desired temperature variations, occupancy patterns, lighting schedules and equipment operation schedules. Another library contains data on the properties of walls, roofs, and floors. A user is allowed to enter data and/or select and assemble library data for each specific job. Finally, a series of examples are included to illustrate the use of this new set of computer programs.

ACKNOWLEDGMENTS

The set of Cal-ERDA computer programs described by this Users 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.

The following organizations and individuals have made many significant contributions to produce this new set of public domain computer programs for the analysis of energy consumption in buildings.

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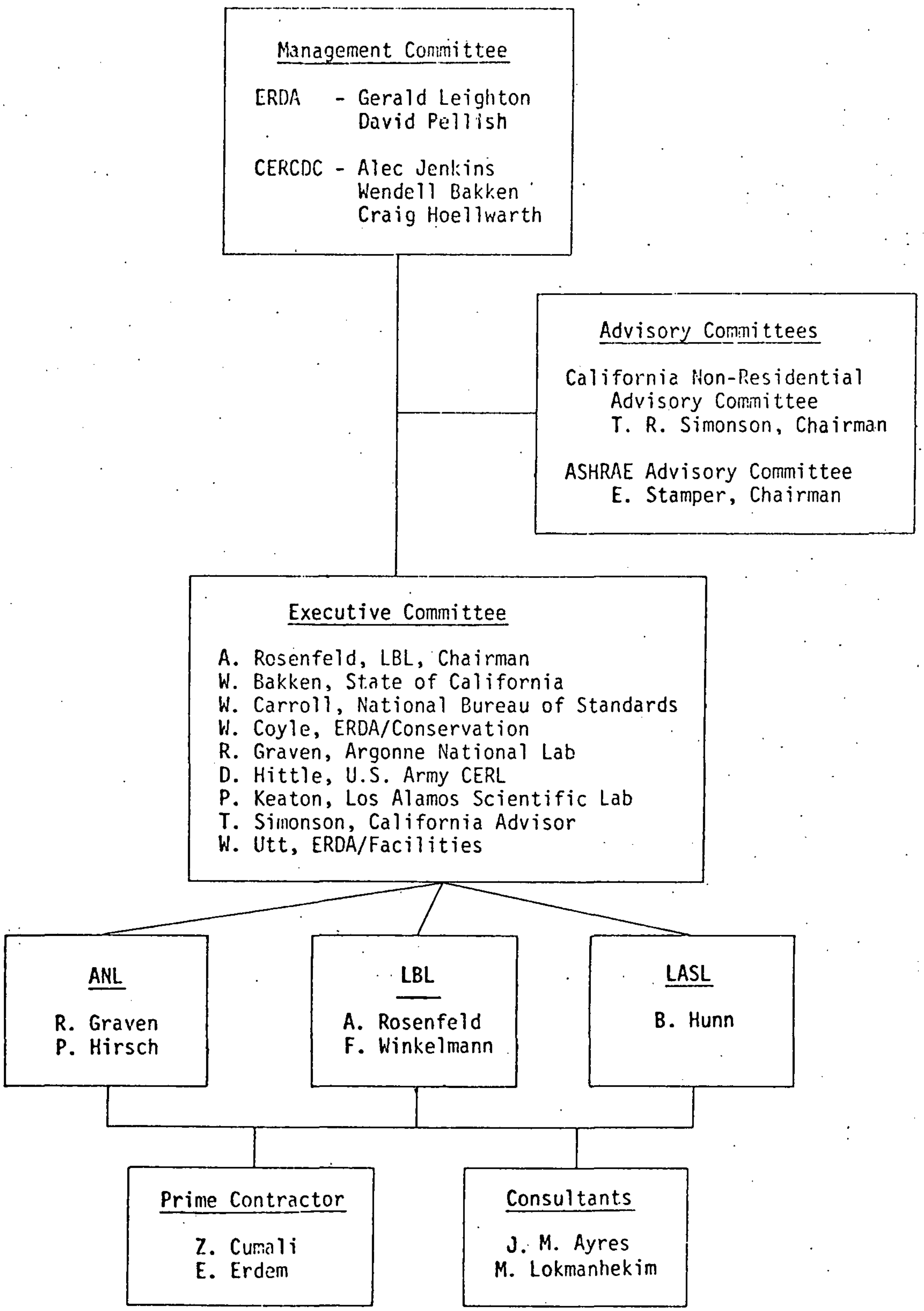

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PREFACE

The energy required to operate buildings accounts for about one-third of the total energy consumed in the United States. The efficient use of energy in each building will contribute to the reduction of energy consumption at local, national, and international levels. Saving energy in buildings involves new public policies, new building codes, and innovations in the design of buildings and communities. It requires 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 the last few years, the designers of buildings have had no comprehensive tools for the dynamic calculation of heating and cooling loads, for the simulation of heating and cooling distribution systems for modeling the operation of the equipment supplying the required energy, and for 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 due to the weather outside and human activity inside is practical only with the aid on an electronic computer. Each of the previous computer programs which addressed this problem has limitations, has been difficult to use, and has often been inflexible; some are expensive to run, and many are limited in scope and generality. Furthermore, differences in algorithms and assumptions cause different programs to give widely differing results.

As a result of this situation, there was growing recognition of the need for an easy-to-use, fast-running, well-documented, widely available computer program for the analysis of energy usage in residential and commercial buildings. In addition, the Energy Resources Conservation and Development Commission (ERCDC) of the State of California (Cal) needed a program that could be used by building code officials and by building designers, because of its responsibility for establishing and enforcing 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 them in many different energy conservation efforts at all of the ERDA facilities.

To satisfy these needs, the Argonne National Laboratory held a meeting to create a joint national laboratory collaboration to develop a tool for design, research and code compliance. The Lawrence Berkeley Laboratory was selected to be the lead laboratory, with Dr. Arthur H. Rosenfeld as the project director. The objective was to form a joint project for development of computer programs which emphasized ease of input and inexpensive calculations. The State of California (Cal) and the Energy Research and Development Administration (ERDA) provided the necessary support for this Cal-ERDA project.

The programs described herein are based on the dedicated and continuing work of many people to develop public-domain computer programs. The pioneer public programs upon which we have built are the Post Office, NECAP, NBSLD, and TRNSYS programs, which are listed in the references.

NOTICE

This report was prepared as a progress report of work sponsored by the United States Government and the State of California. Neither the United States, nor the State of California, nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, nor their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately-owned rights.

The Cal-ERDA computer programs are intended to aid in the analysis of energy consumption in buildings. They are not intended to be the sole source of information for the design of buildings. The judgment and experience of the engineer remain invaluable; and no responsibility is assumed by the Cal-ERDA staff for errors resulting from use of these programs.

By acceptance of this report, the recipient acknowledges the U. S. Government's and the State of California's right to retain a nonexclusive, royalty-free license in and to any copyright covering this report. No portion of this report or the Cal-ERDA computer programs may be reproduced in any manner without written permission in advance from the authors.

The equations and methodology used by the Cal-ERDA LOADS computer program evolved from algorithms published by The American Society of Heating, Refrigeration, and Air Conditioning Engineers, Inc., cited in Chap. I, Ref. 1 of this manual; however, this edition of the Users Manual does not reflect ASHRAE review comments. New features continue to be added and defects corrected.

ASHRAE POLICY STATEMENT ON THE USE OF THE NAME ASHRAE IN CONNECTION WITH COMPUTER PROGRAMS

Numerous computer programs have been developed and are being marketed with the statement that they are in accordance with the ASHRAE Handbook of Fundamentals and/or are based on ASHRAE calculation procedures.

The Society does not endorse and is not responsible for any computer programs which may or may not use information published in the ASHRAE Handbook of Fundamentals or other ASHRAE publications.

Persons using the name ASHRAE in connection with any computer programs or persons considering the use of computer programs which imply that ASHRAE has endorsed them are hereby cautioned that ASHRAE does not make any such endorsement.

AVAILABILITY

To obtain a copy of the Cal-ERDA computer programs and documentation, one should write to:

Cal-ERDA
Argonne Code Center, Building 221
Argonne National Laboratory
Argonne, Illinois 60439

Tel: (312) 739-7711, ext. 4366
or FTS 388-4366

and ask for the ordering information for the Cal-ERDA computer programs. Loose leaf copies of the documentation, suitable for updating, are supplied as part of the Cal-ERDA Program Package.

The Cal-ERDA programs are installed and operating at Lawrence Berkeley Laboratory (LBL) on a CDC 6600/7600. ERDA (DOE) users may access it through the LBL remote users network. Use of the Cal-ERDA computer programs at LBL is restricted to analysis of State of California and United States Government buildings only. These users may contact:

Mr. H. C. Mitchell
Cal-ERDA Users Office
Lawrence Berkeley Laboratory
Berkeley, California 94720

Tel: (415) 843-2740 Ext. 5628
Or FTS 451-5628

Another version of the Cal-ERDA computer programs is being implemented on the IBM 370/195 at Argonne National Laboratory. Source and Job Control Language (JCL) card decks and listings for this version are expected to be available early in 1978

A third version of the Cal-ERDA programs is available at the Los Alamos Scientific Laboratory, in Los Alamos, New Mexico, for in-house use by LASL personnel.

These programs are also available at the State of California Energy Commission. To obtain information, California users may contact:

Mr. Ken Laca
Office of Computer Services
Energy Resources Conservation and Development Commission
1111 Howe Avenue
Sacramento, California 95825

Tel: (916) 322-3548
or FTS 552-3548

If a private sector user desires to practice using the Cal-ERDA programs, it is strongly suggested that he first attempt to use them at one of the computer service bureaus.

The following computer service companies have expressed an interest in this project and may offer these programs for private use. To obtain current status of their efforts, one should contact:

Cybernet User Services	Attn:	Mr. Barry Rossum, HQW 056 Control Data Corporation P. O. Box 0 Minneapolis, Minnesota 55440 Tel: (612) 853-6782

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

UofC-AUA-USERDA

ARGONNE CODE CENTER

Telephone 312-739-7711 Ext. 4366 FTS 388-4366

October, 1977

I am enclosing for your information, material describing the Argonne Code Center and its operation.

The Argonne Code Center sheet describes the conditions under which organizations participate in our program. The Center's information and distribution services are limited to registered installations. Organizations qualify as ACC registered installations in two ways, either as waiver-list installations or as subscription-fee installations.

Installations sponsored by agencies funding the Center program, those designated by other government agencies or computer software information centers with whom exchange arrangements exist, or others recognized as contributors to the Center program, are waiver-list establishments and receive Center services free-of-charge.

Establishments not eligible for inclusion on the waiver list may subscribe to the Center program to obtain ACC information and distribution services; such organizations are subscription-fee installations and pay the cost of services requested.

An Installation Registration Form enclosed with the information sheet may be used to register your organization for the Center program. These enclosures are intended to be self-explanatory; however, if you have any questions please call us at Area 312, 739-7711, ext. 4366. Our Federal TeleCommunications System number is 388-4366.

Sincerely yours,

Margaret Butler

Margaret Butler (Mrs.)
Argonne Code Center

MB/hma
Enclosures: ACC Information Sheet
ACC IR Form

AMD-92 (1-76)

ARGONNE CODE CENTER

The Center is responsible for operating a computer software and data exchange and information center under U. S. Energy Research and Development Administration and Nuclear Regulatory Commission funding. Our ERDA program includes maintaining communication and exchange arrangements with other U. S. and foreign computer program information centers, and coordinating proposed acquisition of non-Government software by USERDA-offices and -contractors.

The "registered installation" is an integral part of the Argonne Code Center operation. Each registered installation, (e.g. ERDA-laboratory, university, NRC-contractor, or industrial establishment), designates an individual to serve as liaison between that installation and the Center. These installation representatives (IRs) function as a source of information to the Code Center concerning programs or requests originating at their installation and as a source of information to personnel at their establishment concerning the Code Center operation, procedures, and the Center library.

REGISTERED INSTALLATIONS:

Installations qualify as registered installations in either of two ways: If they meet the Center's waiver-list requirements, they are registered as waiver-list installations; if not they may choose to register as subscription-fee installations. Waiver-list installations are:

1. Installations covered by direct funding of the Center program, e.g. ERDA field offices and contractors covered by ERDA funding, NRC offices and contractors covered by NRC funding, etc.

2. Installations designated by other government agencies or computer software information centers with whom bilateral or reciprocal arrangements have been executed, or exchange arrangements have been completed.

3. Identifiable installations or individuals who are recognized as providing material important to the functioning of the Center, or contributing to the contents of its program or data package collection.

Establishments not eligible for inclusion on the waiver-list, may subscribe to the Center program to obtain information and distribution services, and such establishments, upon payment of an annual subscription charge, are considered to be registered installations in the same sense as those on the waiver list. The initial registration fee per installation is set at one hundred and seventy dollars ($170.00) with an annual renewal fee of fifty-five dollars ($55.00). This subscription fee covers the cost to the Center of establishing and maintaining installation records and the cost of publications and information services provided to registered installations.

Registration procedures are initiated by completing the Center's Installation Registration Form, copy attached. Those establishments not eligible for inclusion on the waiver list and wishing to subscribe to the Center program will then receive from the Laboratory an agreement form together with instructions for its completion and payment of the first-time subscription fee of $170.00. Advance payment of the subscription fee is necessary; no invoice will be issued. Upon registration the designated IR will receive the ACC Installation Representative Guide describing procedures for submitting and ordering packages, together with his installation's copy of the Center's current Compilation of Program Abstracts, ANL-7411, and a supply of the Code Center forms contained in the IR Guide. On a continuing basis, the subscription charge provides the IR with copies of ANL-7411 supplements at time of publication; the relevant ACC Notes prepared to notify package recipients of corrections, additional material, and replacement revisions to Center packages; forms for ordering and submitting packages, and the assistance of the Center staff in attempting to locate programs or data not in the library and in implementing library packages.

PACKAGE FEES:

All registered installations will be entitled to request computer program and data packages from the Center. One copy of any package which the registered installation is authorized to receive (i.e. limited distribution conditions are met and release forms completed) will be available. Requests from subscription-fee installations will be handled in the same manner as those received from waiver-list installations with the following exceptions. Subscription-fee installations will be required to pay an established fee for each package requested to cover costs of processing and mailing. Since no package fee is levied on waiver-list installations they are required to supply the magnetic tapes used for package transmittal. In the case of subscription-fee installations, tapes are purchased by the Code Center and supplied as part of the package price. Individual package fees have been established for each package in the Code Center collection and a price list prepared. The average package fee amounts to approximately $75.00. Advance payment of package charges is required whenever packages are requested; no invoice will be issued.

INSTALLATIONS OUTSIDE THE U.S.:

Registered installations outside the United States are asked to establish an account with the Laboratory for Code Center use. This account, when established, is used to pay subscription charges, package fees, and mailing costs. An amount of $300.00 is sufficient to open such an account and the organization is notified when the account has been depeleted so that additional funding can be provided.

If you are interested in becoming a registered installation, please complete the enclosed Installation Registration form and return it to:

Argonne Code Center
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439.

Upon receipt of the registration form, organizations which qualify as waiver-list installations will be established as registered installations and appropriate Code Center materials will be mailed to them. Subscription-fee installatio will be mailed the agreement letter which includes instructions for becoming a registered installation.

ARGONNE CODE CENTER

Installation Registration Form

The establishment listed below would like to participate in the Argonne Code Center program as a registered installation.

NAME OF INSTALLATION: ____________________

Suggested 4-character Installation Identification ___ ___ ___ ___

Serving as our representative for liaison with the Center will be:

REPRESENTATIVE NAME: ____________________

MAILING ADDRESS: ____________________

____

____

____

____

TELEPHONE: ____________________ FTS: ____________________

Registration should be as:

☐ Waiver-list Installation by virtue of:

___ ERDA-office or Contractor

Contract # __________

___ NRC-office or Contractor

Contract # __________

___ Exchange Agreement (other government agency or information center)

___ Contributor to Center

☐ Subscription-fee Installation

All subscription-fee installation forms should be signed below by an individual authorized to sign for the registered establishment.

Signed: ____________________

Title: ____________________

(please complete both sides of form)

COMPUTER FACILITIES INFORMATION:

Number of Main Processors ________

Specify computer manufacturer and model of each:

Special-purpose computer facilities or equipment available:

Package material transmitted on magnetic tape will be most useful to our installation, if recorded:

☐ 7-track

☐ BCD ☐ ______

____ 556 ____ 800 bpi

☐ 9-track

☐ EBCDIC ☐ ______

____ 800 ____ 1600 ____ 6250 bpi

Blocking of card records can be accommodated with the following limitations:

____

____

____

ARGONNE CODE CENTER

PROGRAM PACKAGE REQUEST

Program: Cal-ERDA 1.3

Machine: CDC ______________________

IBM ______________________

____

A. MANUAL(S) ONLY

Users Manual, loose leaf: __________ each at $40.00 * = __________

soft bound: __________ each at $25.00 = __________

Program Manual, loose leaf: __________ each at $40.00 * = __________

soft bound: __________ each at $25.00 = __________

B. ANL CODE CENTER SUBSCRIPTION

First year $ 170.00
OR
Annual renewal $ 55.00 = __________

C. PROGRAM PACKAGE FOR ANL CODE CENTER SUBSCRIBERS [1.]

__________ each at $ 275.00 ** = __________

D. PROGRAM PACKAGE FOR NON SUBSCRIBERS [2.]

__________ each at $ 325.00 ** = __________

TOTAL = __________

* Cost of loose leaf manual includes up-dating service for current fiscal year (ie. through September)

** These prices are estimates as of November 15, 1977. Please telephone the Argonne Code Center at (312) 739-7711, Ext. 4366 for current prices.

1. Program package includes: magnetic tape copy of programs, weather library (TRY year data for 60 cities), construction library and sample problems, one loose leaf Users Manual, and one loose leaf Program Manual. CDC version expected to be available January 1. 1978. IBM version availability extimated for first quarter 1978.

2. Program Package for non-subscribers does not include up-date service.

FROM :

NAME : ______________________________

ADDRESS : ______________________________

____

____

TELEPHONE : ______________________________

FTS : ______________________________

REGISTRATION :

Waiver-list Contract Number ______________________________

Subscription-fee installation identification ______________________________

If a blank tape is enclosed give the reel identification ______________________________

Make Check Payable To :
Argonne National Laboratory
DO NOT SEND CASH

MAIL TO :

Cal - ERDA
Argonne Code Center
Argonne National Laboratory
9700 S. Cass Avenue
Argonne, Illinois 60439

Cal-ERDA 1.3

October 1977

STATUS

This document is the first edition of the Users Manual. It reflects the status of the programs as of October, 1977. The Program Manual is not yet complete. However it is being printed as a DRAFT in the interest of providing as much information as is presently available.

Cal-ERDA 1.3 is the first version of these Programs to be released for general use through The Argonne Code Center. Cal-ERDA 1.0 was released to The State of California in July, 1977. Current plans are to periodically issue up-dates of the Program and its documentation. Updated versions will be designated Cal-ERDA 1.4 etc.

An asterisk * and the footnote * In Preparation are used in this text to refer to a feature of these programs which was not available in version Cal-ERDA 1.3, as of October, 1977. Each of these features may be in one of the following stages of completion:

design

development

debugging
or
documentation

Note: The functions of the *EXECUTIVE Program and the command word *WEATHER-STATION are currently being performed by commands in the control deck. Other command words and keywords marked with an asterisk "*In Preparation" are not operational.

I. INTRODUCTION

I. INTRODUCTION

The Users Manual describes the Cal-ERDA computer programs which are used to calculate building energy LOADS, to simulate heating, ventilating and air conditioning SYSTEMS operation, to determine PLANT operation, and to compute ECONOMICS parameters. Each of the major programs used for these computations is described in more detail in Chapters III, IV, V, and VI, respectively. This manual provides the background information needed to understand how to use the Cal-ERDA programs and which calculations are being performed. The Program Manual provides a detailed discussion of each program, including listings, comments, and algorithms.

This manual is also a reference book which contains library data and summaries of the Building Design Language (BDL) instructions. It is intended to be used by an engineer or architect who has some experience in programming. However, it is recognized that many potential users do not have adequate programming experience; hence, several examples and additional descriptive text are included to guide those users in the proper use of these computer programs.

This manual is organized as a loose-leaf notebook in order to encourage and simplify removal of obsolete pages and insertion of new pages.

An introduction to the Building Design Language (BDL) is given in the next chapter. It allows an architect/engineer to study various design options, including detailed computations of the thermal performance of building envelopes, the selection and operation of ventilation systems, the hourly performance of heating and cooling equipment, and to study the results of variations in the economic constraints. BDL also controls data retrieval from a large set of libraries containing information on building components, materials, and operation schedules.

Chapters III, IV, V, and VI describe respectively the LOADS, SYSTEMS, PLANT and ECONOMICS (LSPE) simulation programs. The use of BDL to provide the specific information required by each of these programs is described in each chapter. Examples are included to illustrate the use of each BDL input instruction.

Chapter VII describes the standard pre-programmed report formats. A user may select one or more of the standard output report formats to print and/or plot the results. Within the standard report format, a user may define his own titles and headings.

Chapter VIII identifies five computer programs useful for examination and preparation of weather data for the Cal-ERDA weather library. However, the ordinary use of the Cal-ERDA LSPE programs does not require the use of these five programs. They are provided for detailed analysis of weather data and were used to prepare the Cal-ERDA weather input files. Test Reference Year (TRY) data for 60 cities are presently available in the Cal-ERDA weather library. Solar radiation data (SOLMET data) and more weather station data will be entered as they become available.

Introduction

Chapter IX outlines the task of the computer system control program. The EXECUTIVE program provides the necessary job control card sequences to prepare the various Cal-ERDA programs for input, calculations, and output and is entirely dependent on the operating system presently installed at each computer center.

Chapter X provides examples of complete runs for several types of buildings to illustrate the possibilities for energy conservation and the versatility of the Building Design Language.

Chapter XI summarizes the library data used by the Cal-ERDA computer programs. The weather data are outlined, and the occupancy, lighting, and internal heat generating equipment schedules* are presented. Graphical representations of these schedules for daily (24-hour sequence), weekly (8-day sequence including holidays), and yearly data groups (365-day sequence) for typical cases are presented. Any of these generalized schedules may be applied to any SCHEDULE instruction. A table of the thermal properties of various materials, and the code names used by the program, is given. Construction details, including the layer-by-layer composition, are given for walls* and roofs* and are used by the program to calculate the time history of heat flow.

The remainder of this first chapter contains a brief discussion of the documentation of the Cal-ERDA programs, followed by an outline of the major computer programs, a review of the Program Manual, and a list of acronyms and abbreviations. Finally, there is a selected list of references upon which the Cal-ERDA programs are based.

A. Documentation

1. Users Manual

The Users Manual provides the information and instructions required to use the Cal-ERDA set of computer programs. It contains a brief description of each program and an introduction to the Building Design Language (BDL) and a summary of the library data used to perform the desired calculations. It also contains examples that illustrate the use of the Cal-ERDA computer programs.

2. Program Manual

The Program Manual provides a user with the necessary information to understand in detail the Cal-ERDA set of computer programs. It contains a summary of the equations and algorithms used to perform the calculations, as well as flow charts to describe how each program operates. The relationship of the Cal-ERDA algorithms to ASHRAE algorithms is also given and traced to the ASHRAE documentation. The operation, structure, and logical sequence of calculations are described in a step-by-step manner for each of the major computational programs. An outline of the Program Manual appears in Section C of this chapter.

* In Preparation

3. Magnetic Tape

Card image copies of the source code for the Cal-ERDA programs on magnetic tape are also available. This form provides all the necessary programs and library data to allow a convenient implementation on other machines. It is the recommended form for transferring these programs to other machines. The standard form is on nine track tapes, at 800 bits per inch; for CDC machines, a binary code is used, and for IBM machines, the EBCDIC code is used. However, other densities can be ordered from the Argonne Code Center.

4. Listings

A listing of the FORTRAN statements for each program gives the specific instructions used to perform the calculations. In addition, listings of the weather analysis programs and the response factor program are also available. Users should request listings in microfiche form since that form is easily sent through the mail in an envelope. A paper copy (print-out) listing all the Cal-ERDA computer programs and the library data is about eight inches thick and should only be requested by persons wishing to implement these codes on their own machines.

5. Cards

Punched card copies of the Cal-ERDA computer programs may also be requested. However, the reader should recognize that a punched card copy of these programs consists of about ten boxes of cards. It is a time-consuming and expensive job to reproduce, interpret, package, and ship the programs in card image form.

B. Summary of Cal-ERDA Computer Programs

This set of computer programs allows architects and engineers to compute the energy consumption in buildings. The programs simulate hour-by-hour performance of a building for each of the 8760 hours in a year. One primary advance of the Cal-ERDA programs over all other previous building energy-analysis computer programs is that a new computer input language, called the Building Design Language, has been written. It is the first input language for analysis of building energy consumption which allows a user to instruct a computer using familiar English language terminology. The Cal-ERDA programs can easily be implemented in many other languages (e.g., Turkish or French) by simply providing the appropriate vocabulary entries.

Building Design Language, or BDL, has been developed to aid architects and engineers in the difficult and time-consuming task of designing energy-efficient buildings which have a low life-cycle cost. The energy consumption of a building is determined by the shape of a space; the thermodynamic 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 the temperature and humidity controls. It is also determined by the operation of 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. BDL greatly expands the versatility, and hence the usefulness, of computer-aided analysis of a building's energy consumption.

Another important contribution of these Cal-ERDA computer programs is that they provide architects and engineers with a tool that can perform the complicated analysis of energy consumption without the burden of having to instruct the program correctly in every minor detail. A set of default values (numbers to use for the value of a variable if the user does not assign one) are included to reduce the amount of input a user must supply in order to run the programs. Boundary values, or limits for the maximum and minimum expected values, are also built in to warn the user that a particular entry is beyond the normally expected range. The value entered by the user is then used in the calculations, and the results are printed.

Another feature of BDL is that it allows a user to select and use a variety of keywords. Keywords are used to identify variables and assign a value in the form "keyword = value." Examples of keywords are FLOOR-AREA and TEMPERATURE, and their use is explained in the chapters where they appear. Abbreviations for each keyword are also allowed.

Figure I-1 illustrates the Cal-ERDA computer programs used to analyze energy consumption in buildings. A user controls the programs by using BDL instructions. The instructions are decoded using the BDL processor program and commands are forwarded to any of the other appropriate programs. BDL commands are used to instruct the computational programs (LOADS, SYSTEMS, PLANT and ECONOMICS) to save the values of various calculations for later use, such as for inclusion in a printout of the results.

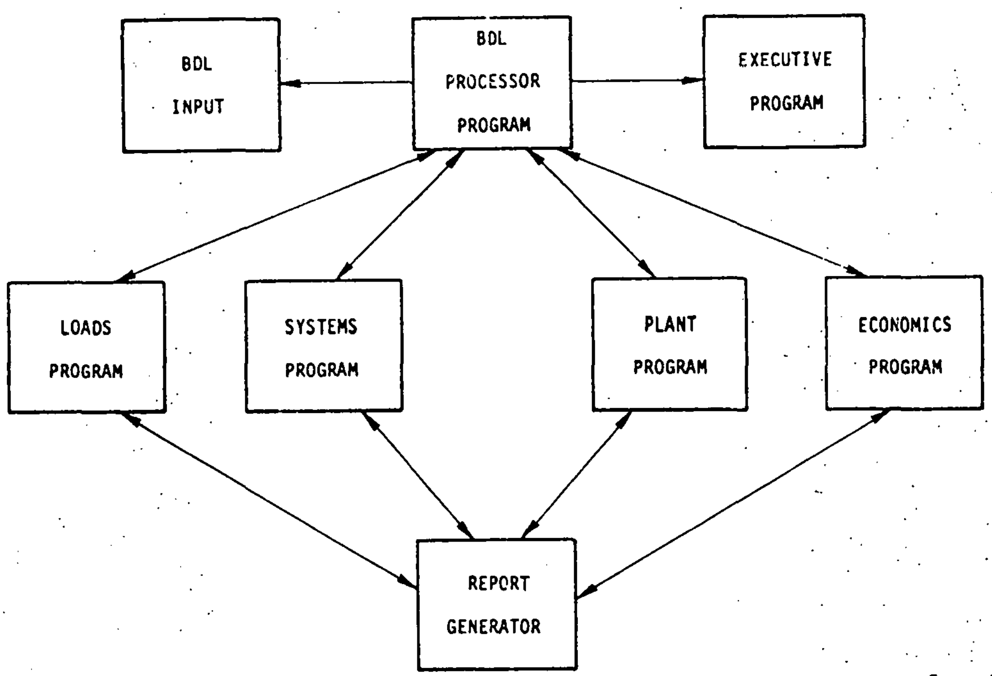

Figure I-1

1. EXECUTIVE Program

The EXECUTIVE* program performs the necessary bookkeeping functions to assure that the operation of the programs is properly executed. It connects the independent programs, provides the necessary computer memory space (storage), and creates a set of control cards in the proper sequence to control the operation of the programs. This program is unique to each site, since it is dependent upon the current operating system at each installation (see a Site Manual for a description of the site-specific user input procedure).

2. BDL Processor

The BDL processor checks each BDL instruction for proper form, syntax, and content. The input text (BDL) is read sequentially, and each instruction is examined to determine if any reserved BDL commands or keywords have been used and if any values (numbers) have been assigned to specific variables. The BDL processor contains all these decoding routines, and it checks for values which are beyond the expected range for input variables. If no values are specified, the BDL processor inserts an assumed value, called a default value, which will appear in the listing of input data. The BDL processor also prepares the data input files for use by the LOADS, SYSTEMS, PLANT, or ECONOMICS (LSPE) programs.

The BDL processor collects whatever data the user desires from the various permanent libraries (e.g., data from the weather files) and from various user-defined libraries (e.g., a user-entered schedule for simulating the hour-by-hour use of lighting). It then creates a new job input file, which contains the sequence of instructions and data used to perform the energy consumption calculations.

The final task of the BDL processor is to assemble the results of calculations performed by the LSPE programs. The results of each program are sent to an output printer according to instructions given by the user. It is important to recognize that each of the LSPE programs depends on the results of some or all of the previous programs and that many variations and combinations are allowed. Each of the LSPE programs can be run repeatedly to study the effect of design variations in the building's shape, its HVAC system, its plant equipment, or the cost parameters. This is a very useful feature for a creative and sophisticated user. A superior design of an energy-efficient building based on information generated by proper manipulation of the LSPE programs can result in greatly reduced energy consumption and significantly lower life cycle cost.

* In Preparation

3. LOADS Program

The LOADS program calculates the heating and cooling loads primarily using the algorithms described in Reference 1 of this chapter. It is assumed that the reader is familiar with the contents of the "Procedure for Determining Heating and Cooling Loads for Computerizing Energy Calculations, Algorithms for Building Heat Transfer Subroutines" available from the American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. (ASHRAE).

A major contribution that the Cal-ERDA set of computer programs provides is a reorganization and reprogramming of the ASHRAE algorithms. A considerable increase in speed over previous programs has been achieved by careful programming. A brief description of the Cal-ERDA LOADS program is presented in Chapter III, and a detailed description of it is given in the Program Manual.

The LOADS program calculates the amount of heat entering and leaving a building for each hour of a year (i.e., for 8760 hours). The heat gains and losses through walls, roofs, floors, windows, and doors are each calculated separately. Heat transfer by conduction and radiation through the building skin is computed considering the effects of the thermal mass, placement of insulation, sun angle, cloud cover, and building location, orientation, and architectural features. Infiltration loads are calculated based on the difference between the inside and outside conditions and on an assumed leak rate (crack method), or by using 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 based on a fixed TEMPERATURE for each space as specified by the user. The response factor technique is used to generate the sequence of numbers which describe the transient thermal characteristics of the building envelope.

The LOADS program calculates thermal "loads" based on hourly weather data but artificial <u>(fixed) space temperatures</u>. Thus the output of LOADS may have little bearing on the actual thermal requirements of a building. It is instead a baseline profile of the thermal performance for exterior surfaces of a space, given a fixed internal temperature for the space.

The SYSTEMS program then <u>recalculates</u> the LOADS output to produce actual thermal loads based on an hourly variable internal temperature. It also considers thermostat schedules, HVAC performance characteristics, ventilation requirements, etc. and simulates the HVAC distribution systems required to satisfy these thermal loads.

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 most engineers will be more interested in the predicted thermal demands on the physical plant (chillers and heaters). This is done by running both the LOADS and SYSTEMS programs.

4. SYSTEMS Program

The SYSTEMS program contains algorithms for simulating performance of the HVAC secondary equipment used by the air distribution system to control the temperature and humidity within the building. Many of the equations used to develop the SYSTEMS simulation procedure are given in References 2 and 3. These algorithms have been organized and coded to allow a user to select one of the preprogrammed space conditioning systems described in Chapter IV. In order to use the SYSTEMS program, the user chooses one of these preprogrammed systems and provides the necessary input data for the simulation calculations. If a user wishes to study a system that has not been preprogrammed, he may do so by adding his own subroutines to model a particular system.

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 that the Heating, Ventilating, and Air Conditioning (HVAC) distribution system must supply to maintain the desired conditions. The SYSTEMS program calculates thermal loads based on variable TEMPERATURE conditions for each zone as specified by the user.

5. PLANT Program

The PLANT program contains the necessary equations 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) is modeled based on operating conditions and part-load performance characteristics. A user selects the type of plant equipment he decides to model (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 by a user if he decides not to use the preprogrammed values given for these variables. A user may also specify the sequence of equipment operation 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 PLANT program uses this user input information and hourly results from the LOADS and SYSTEMS programs to calculate the electrical and thermal energy consumption of the building.

6. ECONOMICS Program

The ECONOMICS program computes the life-cycle cost of operating the building. The usual inputs required are the interest rate, labor inflation rate, materials inflation rate, energy inflation rate, project life, cost of labor ($/hr) and site cost factors. Equipment costs can be assigned by generic class or by specific size. The present cost of electricity, natural gas, oil, and coal may also be entered by a user, as well as various cost escalation factors. These user-specified input data are combined with the results of the LOADS, SYSTEMS, and PLANT programs to run the ECONOMICS analysis program. A present-value is calculated for each item (e.g., electricity or equipment) and summed to compute the life-cycle cost. Results of the ECONOMICS program calculations are sent to an output file to be printed.

7. REPORT Program

A REPORT*program is used to collect information from the standard 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 (e.g., a research user) wishes to examine a particular variable which is not available in a standard output report, he may select the variable and print it using the report generator program. Various graphs can also be plotted using this and computer system library programs. Many additional output features will be added in response to user requests.

8. WEATHER Programs

Manipulation of weather data is a separate activity, independent of the LSPE programs. The ordinary use of the LSPE programs to calculate the energy consumption of a building does not require use of the WEATHER analysis programs. A typical user activity will be to select the desired data (e.g., TRY city) for a particular weather station by specifying an access code to inform the LSPE programs which weather data to use from the library.

The WEATHER analysis programs may be used independently to examine and prepare weather data for use by the Cal-ERDA programs. A table of weather stations for which data are presently available in the Cal-ERDA library is given in Chapter VIII. The weather data used for the standard hourly simulations are the Test Reference Year (TRY) data compiled and distributed by the National Oceanic and Atmospheric Administration (NOAA). Each meteorological variable may be changed, printed, or plotted as desired by the user, by using these programs.

9. LIBRARY Programs

The LIBRARY programs are used to add, delete or change data in the library. The library contains the following groups of data: weather, materials, construction* schedules* and building shapes* The weather section of the library contains Test Reference Year (TRY) data for the locations listed in Chapter VIII. It also contains* weather data for the national laboratory sites, solar radiation data (SOLMET), and data for various California climate regions. As additional weather data become available, they will be added to the library.

The materials section of the library contains data on the thermal properties of materials. These data are used in the calculation of heat transfer through space boundaries. Different materials may be laminated (mathematically) to model a wall layer-by-layer.

The construction section of the library contains data used to simulate the thermal performance of walls* roofs* and floors* Each of the ASHRAE constructions listed in Reference 5 and each of the typical

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California constructions listed in Reference 6 are given a short, unique alphanumeric code for rapid reference by the user.

The user can select and use the data for a building surface by simply specifying the library name* For example, the library item named WA01-1 contains the layer-by-layer data used in the simulation of the heat transfer through a wall having layer-by-layer composition the same as those described in Chapter XI under the library name WA01-1. The data used by the program are the composite response factors for the selected wall.

The schedule section includes graphs of various schedules which may be applied to calculate the hour-by-hour heat input to a space due to lighting, equipment, or occupants. If none of the pre-programmed schedules*apply to the problem being studied, a user may define as many new schedules as necessary. Various changes to the schedule data may also be performed by a user as he customizes the data to suit his particular needs.

In summary, the library consists of permanent data (preprogrammed) and private, user-defined data. The permanent library data are available to all Cal-ERDA users, while private data files may be created by each user for individual use only.

Some examples, as well as a set of blank input forms to guide the reader on the use of the Cal-ERDA programs, have been included. More detailed, complex, and comprehensive examples, which demonstrate the many features of BDL, can be prepared for workshops where verbal instructions and operational experience are available.

Figure I-2 is a diagram of the interconnected Cal-ERDA computer programs and data files. These programs, plus the WEATHER, Response Factor, and GRAPHICS programs, are described in the Program Manual.

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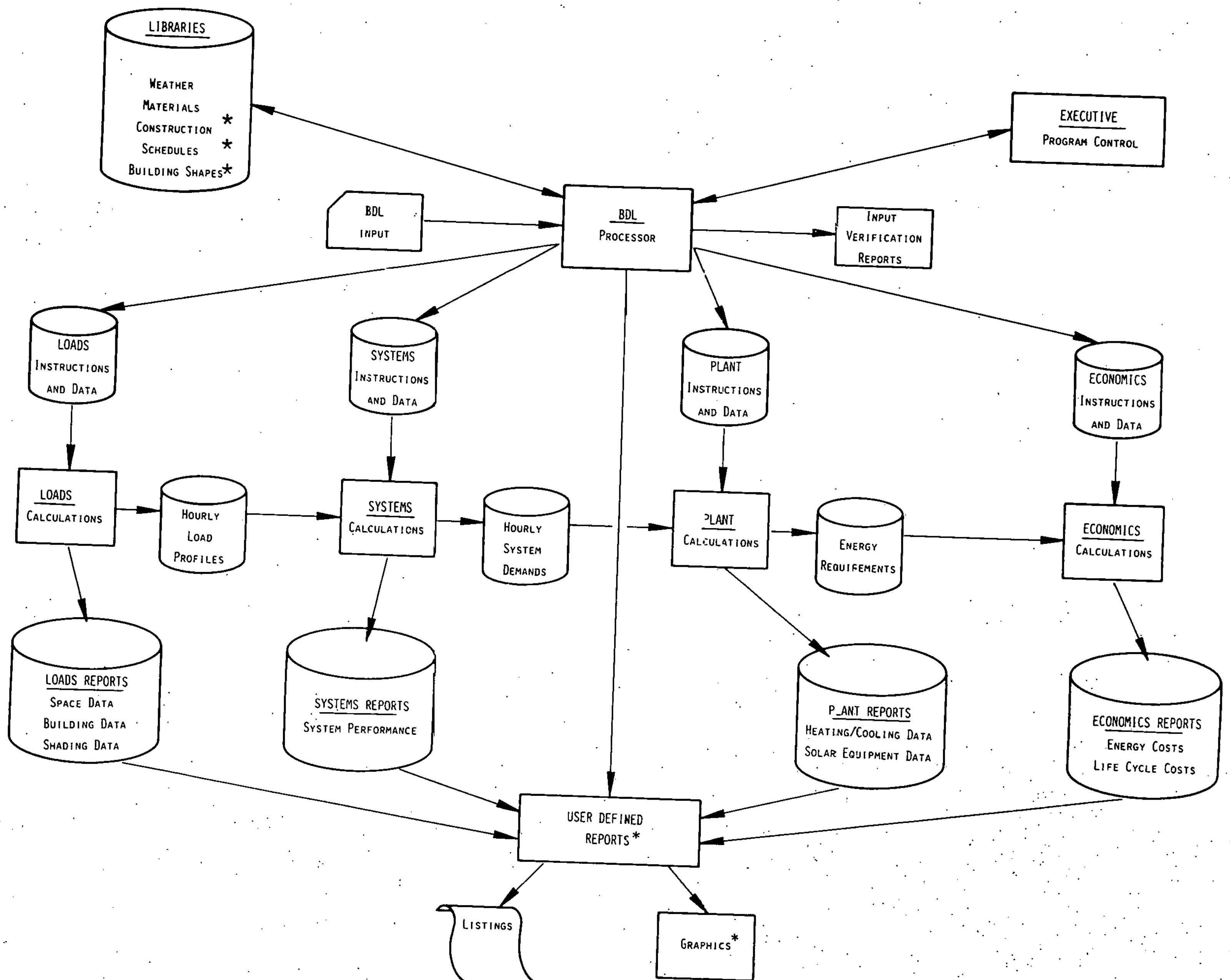

Figure 1.1

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C. Program Manual Outline

The content of the Program Manual is presented to summarize the additional documentation available.

CONTENTS OF PROGRAM MANUAL

* II. BDL PROCESSOR

A. Buildings Design Language (BDL)

B. BDL Hierarchy

C. The Building

D. Response Factors

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2. Response Factors/Weighting Factors Concept

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4. CALOTH
5. CCM
6. DAYCLC
7. DESFOU
8. DST
9. EXTPRP
10. FILLN
11. FILM
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13. HOLDAY
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17. Function MONLEN
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    b. RPT2
    c. RPT3
    d. RPT2H
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21. RMRSS
22. SETBAC
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24. SUNI
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4. System #4 - Single Zone Fan System with Subzone Induction Boxes
5. System #5 - Unit Heater
6. System #6 - Unit Ventilator
7. System #7 - Floor Panel Heating System
8. System #8 - Two-pipe Fan Coil System
9. System #9 - Four-pipe Fan Coil System
10. System #10 - Two-pipe Induction Unit Fan System
11. System #11 - Four-pipe Induction Unit Fan System
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13. System #13 - Constant Volume Reheat Fan System
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   b. ABSREF
   c. BOILER
   d. COMREF
   e. DBUNDLE
   f. DESVAR
   g. DFLTASG
   h. DIESEL
   i. EFFIC
   j. ENSTOR
   k. Function ENTHAL
   l. Function ENTHROP
   m. GASTUR
   n. HEATREC
   o. KARDRD
   p. LDIST
   q. LSEARC
   r. OPCOOL
   s. OPDBUN
   t. OPELEC
   u. REPORT
   v. Function RFACT
   w. RTPRNT
   x. R1PRNT
   y. R3PRNT
   z. Function SATUR
   aa. SOCOOL
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   ff. STMUSE
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D. Acronyms and Abbreviations

ANL	Argonne National Laboratory
ASHRAE	American Society of Heating, Refrigeration, and Air Conditioning Engineers
BDL	Building Design Language
BNL	Brookhaven National Laboratory
CERL	Construction Engineering Research Laboratories of the Army Corps of Engineers
ERCDC	Energy Resources Conservation and Development Commission, State of California
ERDA	Energy Research and Development Administration
HVAC	Heating, Ventilating, and Air Conditioning
LASL	Los Alamos Scientific Laboratory
LLL	Lawrence Livermore Laboratory
NBSLD	National Bureau of Standards Loads Determination Program
NECAP	NASA Energy Cost Analysis Program
NOAA	National Oceanic and Atmospheric Administration
ORNL	Oak Ridge National Laboratory
SOLMET	Solar Meteorological Observations
TRY	Test Reference Year

E. References

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II. BUILDING DESIGN LANGUAGE

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* In Preparation

II. BUILDING DESIGN LANGUAGE

A. Introduction

The Building Design Language (BDL) can assist in the difficult and time-consuming task of analyzing the thermal performance of a building. It is the first computer language capable of instructing a computer to manipulate mathematical models of building spaces (e.g., rooms, zones, wings), components (e.g., walls, doors, roofs), materials (e.g., brick, wood, concrete), HVAC equipment (e.g., fans, coils, humidifiers), plant equipment (e.g., boilers, chillers, solar collectors) and economic parameters (e.g., interest rates, inflation rates, initial costs). This is the first version of the BDL computer language, and it includes many new instructions and data manipulation features. It also permits a user to explore many new design concepts and predict the performance of a building.

It provides the user with a very powerful tool, useful to extract previously unavailable information and to perform a wide range of new evaluations. In this chapter, the fundamentals of BDL are introduced. In Chapter III, BDL instructions for input of space, component, and materials data are given in order to calculate the building loads. Chapters IV, V, and VI contain the BDL instructions for the SYSTEMS, PLANT, and ECONOMICS programs, respectively.

BDL consists of two parts: (1) the BDL language used to describe the problem and (2) a computer program, the BDL processor, to translate the sequence of language instructions into a sequence of machine operations. The BDL language consists of an alphabet, words, syntax, and spelling rules, grammatical restrictions, sentences, subjects, verbs, objects, numbers, punctuation, and equations. Each feature of the language will be explained in the following sections. The BDL processor consists of the machine instructions needed to interpret the sequence of BDL instructions, or "sentences," in order to perform the desired calculations. The processor contains the decoding routines for the BDL program control instructions, for the computational program instructions, as well as error, diagnostic, and report subroutines.

BDL is a problem-oriented language for the user of the Cal-ERDA set of computer programs. It facilitates the description of a thermal model for use in building energy analysis by the LOADS, SYSTEMS, PLANT, and ECONOMICS programs, which are the major computational blocks. BDL allows the user to select weather data and to describe the geometry of a building; its HVAC systems; schedules for occupancy, equipment, and lighting; central plant equipment; and economic parameters for the calculation of life cycle costs.

BDL also controls which reports are to be printed and which data values are to be varied for parametric runs. Furthermore, it simplifies control of program execution and management of the various memory files required by the Cal-ERDA programs for any particular run.

BDL allows the user to select data from a library of elements frequently used in the thermal models. In this way, the input is greatly simplified. A user can take advantage of repetition and commonality through a facility for description and definition of the data. BDL also allows, as an alternative, the use of input forms, to aid in the rapid collection and input of data. BDL permits a user to specify the position or location of various elements in relation to a previously located element the user finds most convenient, usually the closest element. BDL converts these relative locations into a common system of coordinates. These and other BDL features, such as default values and abbreviated command words, further increase the versatility and computational power available to the user.

A default value is a pre-programmed number used by the computational programs if the user does not specify a value for a variable (i.e., an assumed value). The default value used for each variable is given in the chapter where the variable is introduced.

The user should keep the level of input detail consistent with the purposes of analysis. The simpler the model, the more efficient and less expensive it will be to run, and the easier it will be to make effective use of the results. BDL permits an energy analysis to be calculated based on a minimum set of input data. The default values used in the computations are printed as part of the output reports.

Each BDL instruction can result in a substantial number of calculations, data manipulations and cost. Hence it is important that a new user carefully prepare the first attempts at using BDL. It is strongly suggested that the user gain experience with simple examples first, before attempting to analyze large complex buildings.

Each BDL instruction serves as a command for the computer to perform some operation(s). Instructions are processed individually, in the order in which they are read. Hence the user must recognize that the order in which the input instructions are given determines the sequence of calculations. Care must be taken not to ask for computations before specifying all the necessary input data. To do so will result in errors.

The sequence of ordering instructions and the BDL naming feature can be used to reduce the amount of input a user must supply. The hierarchy feature (explained in Section H) is also useful for reducing the amount of input effort required and, hence, the potential for mistakes.

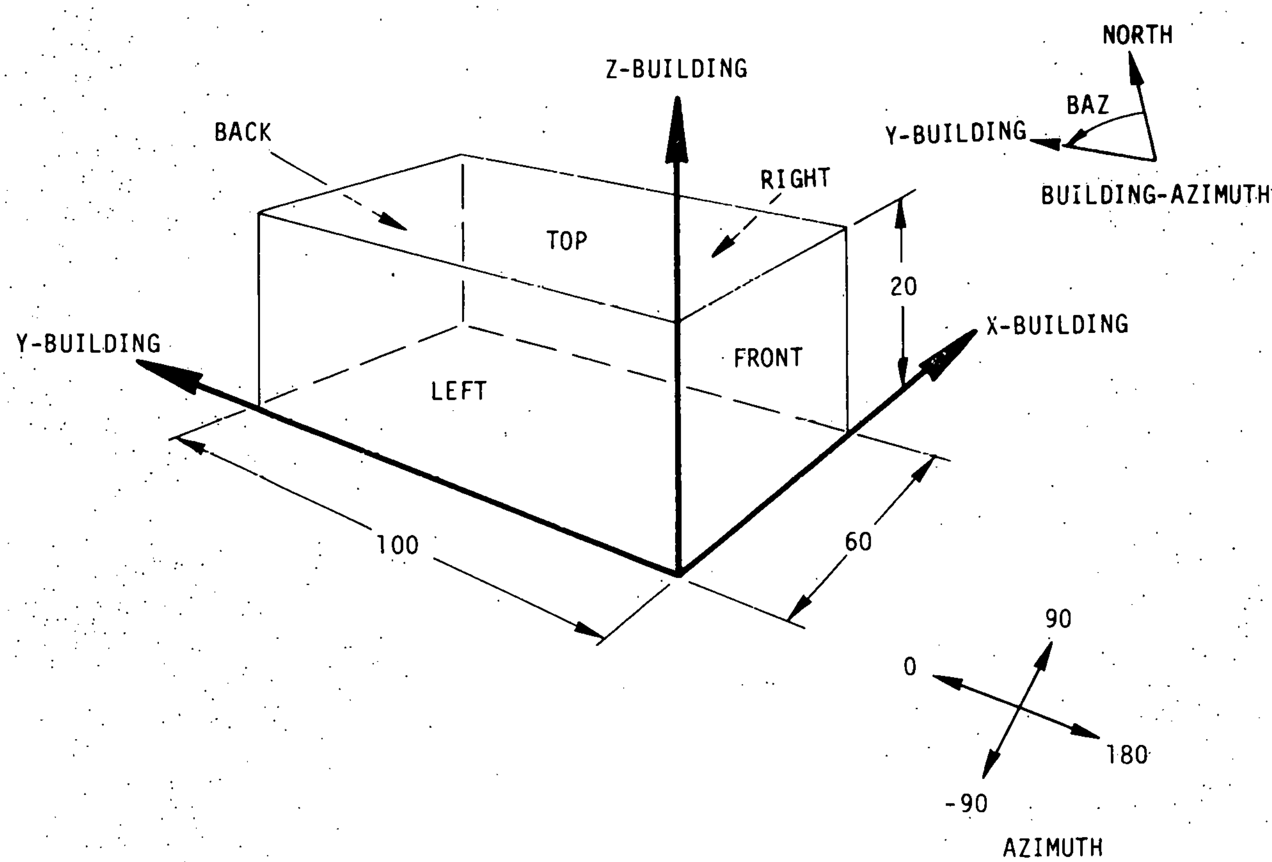
The design of an energy efficient building with proper evaluation of the possible geometrical variations, architectural features, equipment characteristics, financial variables, and energy requirements is a complex task. The use of BDL will greatly extend a designer's ability to create new designs and to perform comparative evaluations of various design options.

BDL has been designed to allow the user as much freedom as possible when specifying the input instructions. Each instruction uses familiar English language terms, such as SCHEDULE, LATITUDE, WIDTH, ROOF, etc., to describe the required data. Abbreviations of each term are also allowed to reduce the amount of keypunching or typing required. However, the user is cautioned that although the full keyword takes a little longer to enter, it is often more self-explanatory and easier to remember. In particular, when reading BDL instructions prepared by others, or when attempting to explain one's own instructions it is usually easier to have the full BDL words.

The format of the instructions presented in the examples has been prepared to illustrate good programming practice. When attempting to locate mistakes or check the instruction against actual conditions, it is very helpful to have, and maintain, a uniform input format. Within the limitations of the program sequence structure, the hierarchy structure, and the language syntax the user will specify BDL words which will direct the computational and computer system control programs. A consistent and visually organized instruction format can aid the user in locating errors; alternatively, the task is more difficult if the user has not used an organized format.

A simplified sketch of the building should be used and labeled with the same names as used in the BDL instructions.

A simple example will introduce these and other useful BDL features. The conventions, characters, elements, and syntax of the BDL language are described in this chapter. A series of BDL instructions which apply to all the computational programs are also described in this chapter.



Example of a One Space Building

Figure II - 1

An example of the BDL instructions used to describe the simple building, shown in Figure II-1, compute the heating and cooling loads due to ambient weather conditions for a period of one year, and print the results is as follows:

```
Name          Command                Data List                                  Terminator

          /*  INPUT                  LOADS                */
              TITLE                  EXAMPLE BUILDING                              ..
              TITLE                  BOB GRAVEN                                    ..
          /*  WEATHER-STATION        CHICAGO              */
              RUN-PERIOD             JAN 1 1974 THRU DEC 31 1974                   ..
              LOADS-REPORT           L02                                           ..
              BUILDING-LOCATION      LATITUDE = 42.0  LONGITUDE = 88.0
                                     TIME-ZONE = 6    BAZ = -45                    ..

                      /*  CONSTRUCTION DATA  */

WA01-2  = LAYERS                     M1 = WS01        M2 = BP01
                                     M3 = PW03        M4 = IN02
                                     M5 = GP01        M6 = AL01    IFR=0.68..
RB01-1  = LAYERS                     M1 = RG01        M2 = BR01
                                     M3 = IN72        M4 = WD01
                                     M5 = AL03        IFR= .76                     ..
WALL-1  = CONSTRUCTION               WALL-TYPE = WA01-2                            ..
ROOF-1  = CONSTRUCTION               ROOF-TYPE = RB01-1                            ..
FLOOR-1 = CONSTRUCTION               U = 0.45                                      ..
          SET-DEFAULT                CONSTRUCTION = WALL-1
                                     HEIGHT = 20                                   ..
                     /* SPACE DATA */
ROOM-1  = SPACE                                                                    ..
                                                                                   ..
FRONT   = EXTERIOR-WALL              WIDTH = 60       AZIMUTH = 180                ..
RIGHT   = EXTERIOR-WALL              WIDTH = 100      AZIMUTH =  90                ..
BACK    = EXTERIOR-WALL              WIDTH = 60       AZIMUTH =   0                ..
LEFT    = EXTERIOR-WALL              WIDTH = 100      AZIMUTH = -90                ..
TOP     = ROOF                       LENGTH = 60      WIDTH   = 100
                                     CONSTRUCTION = ROOF-1
                                     AZIMUTH = 180    TILT    = 0                  ..
BOTTOM  = UNDERGROUND-FLOOR          AREA = 6000
                                     CONSTRUCTION = FLOOR-1                        ..
          END  ..
       /* COMPUTE                    LOADS  */
       /* STOP                              */
```

BDL does not require the user to organize the input instruction in a columnar format. However, an experienced user will recognize the advantage of having the input instructions in a format that is presentable for reports, easily understood by others, and organized for easy debugging. For punched card input it is recommended that columns 1 through 19 be reserved for the name field, columns 20 through 36 be reserved for the command name, columns 37 through 77 be used for the data list and columns 78 and 79 be used for the terminator.

B. BDL Language Conventions

The BDL language is oriented to normal engineering practice and is quite flexible. Each communication to the BDL processor program is given through a statement called an instruction. Each BDL instruction either supplies some data to the program or instructs it to perform some calculations on data already specified, or both.

1. Data Preparation

The instructions and associated data that describe a problem to the BDL processor must be in a machine readable form. The present version requires that the user provide BDL instructions punched onto computer cards. The user probably will not be concerned with the keypunching but will only need to print the instructions in readable form onto paper. The paper (frequently a BDL coding form, although this is not necessary) is then usually given to a keypunch operator, together with instructions on how to keypunch the information.

2. Lists

Quite often it is useful to speak of a list of elements or identifiers as a group. The detailed descriptions of the various types of BDL statements will frequently contain reference to a data list. A list in BDL is a set of different integers or alphanumeric identifiers, separated by blank spaces, commas, or equal signs (e.g., WIDTH = 18, HEIGHT = 36).

3. Rules

a. Each instruction must contain a BDL command word or its abbreviation and end with a terminator (double period).
b. All data elements are separated from other data elements by a blank space, a comma, or an equal sign. A number of spaces together are treated as a single blank space.
c. A comment is to be preceded by the characters /* and followed by the characters */.
d. Comments may be inserted between instructions or within instructions, but not embedded within keywords, command words, symbols, or values.
* e. Special Rule: An equals sign = must be entered between any user-defined name entered in the Name field and any BDL command word entered in the command field. For example,

u-name = command -word

* This special rule applies to Cal-ERDA 1.3, October 1977. All other equals signs are optional.

C. BDL Character Set

Letters	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
Digits	0 1 2 3 4 5 6 7 8 9
Separators	blank , comma = equal sign Any of the above separators may be used to separate words and/or numbers.
Terminator	.. A double period preceded by one or more blanks is used to terminate all BDL instructions.
Comments	/* beginning of a comment field */ end of a comment field /* EXAMPLE OF COMMENT FIELD DELIMITORS */
† Mathematical Operators	+ addition - subtraction * multiplication / division ** exponentiation ( ) quantification

† The Mathematical Operators have been reserved for a future version which will allow the user to perform mathematical operations.

D. Language Elements

1. Alphabet

The alphabet consists of the 26 upper case English letters; the decimal digits 0 through 9; and symbols previously given in Section C.

2. Words

Words are defined as a sequence of alphanumeric characters (letters and numbers) and punctuation without any blank characters. Blanks are used to distinguish between words. Command words, keywords, and code-words are reserved and have special meanings. Optional abbreviations of keywords instruct the BDL processor to perform the same operations, and are also included in the keyword list.

Rule: No separators (i.e., blank, comma, or equal sign) are allowed between the characters which form a BDL word.

Example: SPACE-CONDITIONS is a pre-programmed BDL command word; SPACE CONDITIONS is not.

3. Sentences

A BDL sentence is equivalent to a BDL instruction. The familiar sequence subject, verb, object, and period ~~is replaced~~ by the following sequence: name, command word, data list, and terminator. The meaning of each of these terms is described in the next section. One instruction may exceed one card length (i.e., 80 characters).

Example: ROOM-102 = SPACE FLOOR-AREA = 150.0 ..

4. Paragraph

A collection of instructions (sentences) which describe one concept is similar to a paragraph. For example, a sequence of instructions may be used to describe the geometry and materials for the boundaries of a space or room.

5. Chapter

A sequence of paragraphs which describe a complete task or job is analogous to a chapter. The set of instructions which describes all the input for one of the computational programs is an example of a chapter.

E. BDL Syntax

Each BDL instruction which results in data manipulations or calculations must have the following syntax (order of fields):

Name	Command	Data List	Terminator

The entry of a BDL command word and the terminator characters (double period ..) are mandatory to form a BDL instruction. If a proper command word and a terminator do not appear, no calculations or data manipulations will occur, and an error message will result. All BDL command words are listed in Table II-1. The meaning and use of each command word are described in the chapter where the command is used (e.g., LOADS, SYSTEMS). The definition, rules, and examples for the BDL program control commands are given in this chapter.

1. Symbol

A symbol is defined as a sequence of up to 16 unique characters but may not contain a separator, terminator, or comment delimiter. Symbols may be inserted by the user as u-names or variable names. The following rules apply to any symbol inserted by the user.

Rules:

1. All symbols should begin with a letter. Digits and punctuation marks are not valid first characters.
2. Blanks are not allowed within a BDL symbol.
3. The first 16 or less characters must form a unique BDL word.
4. Letters, hyphens, and digits are allowed within a BDL word, but separators, a terminator, and functional operators are not.
5. Separators terminate a word.

2. Numbers

A number may be any valid integer or floating point number expressed in I or F format. The rules for the expression of a number are the same as the FORTRAN rules for a number as implemented on each specific machine. Several examples of the I or integer form are 1 20 and 300. Several examples of the F or floating point form are 1.0 20. and 300.0. All numbers are to be expressed in base ten (i.e., decimal digits). Base eight, binary, or other numbers are not allowed as valid BDL numbers.

3. Name

A name is a unique user-defined BDL word. It is used by the BDL processor to identify a unique BDL instruction. A user should insert in the name field whatever word most appropriately describes the data which follows it. If the user does not enter a valid user-given name in the name field, then the BDL processor creates its own internal "names" and uses them for data manipulations. However, these internal names and data are not available to a user.

The name field is designated by u-name to remind the user that a new user-given name is required, and by u-named to indicate that a previously defined name (u-name) is being referred to. Entries may be allowed or disallowed in the name field depending on the instruction. The LOADS, PLANT, and ECONOMICS programs employ user-defined names in each instruction for data referencing; however, the BDL program control instructions normally do not allow entries in the name field, as noted in Table II-1. Any instructions which are expected to be used repeatedly, as in the hierarchical description of walls attached to spaces, must be named.

The user should adopt a convention for assigning u-names to instructions which will aid both the user and others in understanding what is being specified. It is suggested that the user specify u-names as a series of letters, followed by a hyphen sign, followed by numbers, with no intervening blanks. This is similar to identifying surfaces, spaces, etc. with a subscripted variable name. The examples which follow illustrate good practice. It is recommended that the user only assign u-names to those which will be referred to later in the program, and to those commands which require user names.

Rules:

1. All user-given names must be unique.
2. No BDL command words or keywords may be given as user-defined names.
3. No comment delimitors may be used in a name. (I.e., no user comments may be embedded in a BDL name, nor may the sequence /* or */.)
4. No parentheses may be used in a name field.
5. All the rules of a BDL symbol apply to a BDL name.

Valid Examples:

LOADS Program	SYSTEMS Program
ROOM-10	SYSTEMS-4C
WING-A	FAN-3
WALL-4	REHEAT

PLANT Program	ECONOMICS Program
BOILER-B3	INTEREST-8.5
CHILLER.C2	FUEL-SCHD-4
ANL-COLLECTOR	JEAN

Invalid Examples:

Name	Reason
A(2)	has a parenthesis
1X	starts with a number
C,D	no embedded separators
C D	two valid names, not one
A..B	contains a terminator
C/*	contains a comment delimitor
C*/	contains a comment delimitor

† Special Rule: An equals sign "=" must be entered between any user-defined name entered in the Name field and any BDL command word entered in the command field. For example,

u-name = command word

† This special rule applies to Cal-ERDA 1.3, October 1977. All other equal signs are optional.

4. Command word

A command word is a unique user-selected BDL word, taken from the choices given in Table II-1. It is used to describe the data, operations, or calculations that the user desires to perform. A user should insert in the command field the one word which best describes the function he wishes to perform. The sequence of instructions given by the user determines the sequence by which the programs assign values to keywords, select library data, perform calculations, print reports, etc.

Most BDL command words identify a category or group of information which follow in the data list. For example, the "TITLE" command word is used to place user identification information on the printed results. The use of each BDL command word is described in the following chapters as the instruction is introduced.

Rules:

1. The full command word or its abbreviation must be used
2. No misspellings are allowed.
3. All the rules of a symbol apply to a command word (e.g., no blanks).

<u>Valid Examples:</u>

TITLE
RUN-PERIOD
SET-DEFAULT
SPACE

<u>Invalid Examples:</u>

Command	Reason
TITLB	misspelled
RUN	incomplete
X	x is not a BDL command word; it is a keyword

Table II-1

BDL Command Words

U-name	Command	Abbr	Comments
* not allowed	INPUT		mandatory before the data for LOADS, SYSTEMS, PLANT, or ECONOMICS programs may be specified
not allowed	TITLE		optional
not allowed	RUN-PERIOD		required for LOADS program
not allowed	DEFINE		optional
not allowed	SET-DEFAULT		optional
* not allowed	SET-MINIMUM		optional
* not allowed	SET-MAXIMUM		optional
not allowed	DIAGNOSTIC		optional
* not allowed	ABORT		optional
* not allowed	SPACING		optional
required	DAY-SCHEDULE	DS	optional
required	WEEK-SCHEDULE	WS	optional
required	SCHEDULE	SCH	optional
not allowed	END		mandatory at end of input instructions for each computational program.
* not allowed	COMPUTE		mandatory to perform computations
* not allowed	STOP		mandatory as last instruction

* In preparation - Not available in Cal-ERDA 1.3

Table II-1

LOADS Program

U-name	Command	Abbr
* not allowed	WEATHER-STATION	
not allowed	BUILDING-LOCATION	BL
optional	BUILDING-SHADE	BS
required	SPACE	S
required	SPACE-CONDITIONS	SC
recommended	EXTERIOR-WALL	EW
optional	INTERIOR-WALL	IW
optional	UNDERGROUND-WALL	UW
optional	FLOOR	FL
optional	UNDERGROUND-FLOOR	UF
optional	ROOF	
recommended	WINDOW	WI
recommended	GLASS-TYPE	GT
* optional	DOOR	
* optional	FIN	
* optional	OVERHANG	OV
required	CONSTRUCTION	CONS
required	LAYERS	LA
required	MATERIAL	MAT
* not allowed	DESIGN-DAY	
* required	VERTEX	V
optional	LOADS-REPORT	

* In preparation

Table II-1

SYSTEMS Program

U-name	Command	Abbr
mandatory	PLANT-ASSIGNMENT	P-A
mandatory	SYSTEM	SYST
mandatory	SYSTEM-CONTROL	S-C
mandatory	SYSTEM-AIR	S-A
mandatory	SYSTEM-FANS	S-FAN
mandatory	SYSTEM-TERMINAL	S-T
mandatory	SYSTEM-FLUID	S-FLU
mandatory	RESET-SCHEDULE	R-C
mandatory	ZONE	
mandatory	ZONE-AIR	Z-A
mandatory	ZONE-CONTROL	Z-C
not allowed	SYSTEMS-REPORT	S-R

Table II-1

PLANT Program

U-name	Command	Abbr
mandatory	PLANT-EQUIPMENT	PE
optional	PART-LOAD-RATIO	PLR
optional	PERFORMANCE	PC
optional	EQUIPMENT-ASSIGNMENT	EA
optional	PLANT-CONSTANTS	PP
optional	SOLAR-EQUIPMENT	SE

ECONOMICS Program

U-name	Command	Abbr
† optional	EQUIPMENT-COST	
† optional	ENERGY-COST	
† optional	LIFE-CYCLE COSTS	
† optional	PLANT-RATES	
optional	COMPONENT-COST	
optional	COMPONENT-RATES	
optional	BASELINE	

† Presently in the PLANT Program

5. Data List

A data list is a sequence of assignment statements used to define a list of variables and assign, respectively, a list of values to each variable. If no data are entered in the data list field, the BDL processor assigns a default value or indicates an error. The data list variables are usually keywords having default values, maximum and minimum allowed values, and preassigned units. Each keyword is described in the chapter where it is introduced.

BDL also contains an assignment capability to provide the user with a means for assigning previously named (u-named) data to a command. The BDL word "LIKE" permits a user to rapidly duplicate previously entered data.

a. Label

A label is a unique user-defined word used by the BDL processor to refer to a set of data or a sequence of instructions that have been previously named. The user must have first assigned a name (u-name) in the name field of a previous instruction, before it can be used as a label. The unique user entries in this field are referred to as u-named in the description of each instruction. A label is a sequence of alphanumeric characters and may be considered as a user-defined variable name.

Rules:

1. The characters used as a label must have been previously defined in a name field.
2. Each label must obey the rules for a symbol.

Example:

```
ROOM-102 = SPACE   LIKE ROOM-101 ..
```

In the above example, the user-given name ROOM-102 (i.e., the subject) is used to identify or name this instruction. The BDL command word SPACE informs the BDL processor that the data list elements which follow should be attached to a SPACE named ROOM-102. The keyword LIKE instructs the program to copy and assign all the data associated with its label, ROOM-101, to the newly defined named ROOM-102. The double period .. instructs the BDL processor that the instruction has been terminated.

b. Value

The value of a variable is the number used in the calculations It may be a fixed or floating point number. This number should be written with a decimal point for the most efficient use of the LSPE programs. If no value is specified for a keyword, its default value will be used.

Default values greatly reduce the required user entries, however the user is required to enter keywords and their variables when the desired value is different from the default value. This reminds the user to think about the meaning of the variable and its value. A value must be expressed as a base 10 (decimal) number. In FORTRAN, blanks are ignored; however, BDL differs from FORTRAN in that blanks are used to terminate a number or a word; they are not ignored.

Rules:

1. The value may be fixed or floating point base 10 numbers in I or F FORTRAN format.
2. If no value is specified, a default value will be used.
3. A zero may be specified as 0 or 0. or 0.0. The sequence blank-period-blank is not recognized as a number, nor is the sequence blank-period-zero.
4. No blanks are allowed within a number. (I.e., for a negative number, -xxx is permissible, but - xxx is not.)
5. + signs are optional.

Valid Examples:

1 2.0 -90

Invalid Examples:

- 2.70 blank between the minus sign and the digits

c. Keyword

A keyword is a pre-programmed BDL word used to identify a specific variable within the LOADS, SYSTEMS, PLANT or ECONOMICS (LSPE) programs. It must be selected from the list of keywords given with each instruction. The primary function of a keyword is to provide the user with a means for identifying a specific variable. A keyword followed by its value forms a two-word sequence in the data list of the form

keyword = value

For example, the sequence TEMPERATURE = 70.0 is used to identify the keyword "TEMPERATURE" and assign its value "70.0". An equal sign between the keyword and its value is optional, as is the use of the abbreviation TEMP. Hence an equivalent sequence is

TEMP 70.

Some BDL keywords (e.g., CONSTRUCTION, LAYERS, MATERIAL, SPACE-CONDITIONS) also function as command words. These command keywords must be followed by a u-name to identify the instruction which contains all the data the user desires to specify. A keyword used in this manner can greatly reduce the user's input task, and they may be thought of as "sub-command" or reference command words. In other words, a keyword may also be identical to a command word, in which case all the values for the keywords in the referenced instruction are referred to by entering the keyword followed by the u-name for the instruction.

Rules:

1. Keywords or their abbreviations must be selected from the keyword data list given for each instruction.
2. No misspellings are allowed.
3. No blank characters are allowed within a keyword.
4. All the rules of a BDL symbol also apply to a BDL keyword.
5. * Keyword names are optional. If the user lists the values he wishes to assign to the keywords in the same sequence as the keywords appear in the instruction data list, then the keywords do not have to be entered, just the values.
6. A label (or BDL word) entered by the user following a keyword must have been previously defined in a name field by the user or defined as pre-programmed library code-word.
7. An equal sign (=) between a keyword and a label, or between a keyword and its value, is optional.
8. For the LOADS program a reference keyword, or a keyword which refers to a command, may only specify a pre-defined u-name or library name.

Valid Examples:

```
HEIGHT         H
WIDTH          W
TEMPERATURE    TEMP
```

Example 1: BUILDING-LOCATION LATITUDE = 42.0, LONGITUDE = 88.0 ..

The keyword LATITUDE is set equal to 42.0 degrees, and the keyword LONGITUDE is set equal to 88.0.

Example 2: BL BAZ = 180 ..

In this example, the command word is the abbreviation "BL." The BUILDING-AZIMUTH keyword, BAZ, was set to 180.0. The remainder of the keywords have been allowed to take on default values and are not specified.

Invalid Examples:

```
HIGH       not a keyword
WIDE       not a keyword
```

* In Preparation

d. Code-words

Some BDL keywords and some BDL command words must be followed by a BDL code-word. Code-words are used to identify which of several alternatives are allowed to be specified by the user. Each of the command words, or keywords, which must be followed by a BDL code-word is described as the words are introduced.

Rules:

1. Code-words must be selected from the code-word data list given for each instruction.
2. No misspellings are allowed.
3. No blank characters are allowed within a code-word.
4. All the rules of a BDL symbol also apply to a BDL code-word.

Examples:

Command Word	Code-word
* INPUT	LOADS
* COMPUTE	ECONOMICS

Keyword	Code-word
* WALL-TYPE	WC01-1
* ROOF-TYPE	RB01-1

6. Terminator

A terminator is a sequence of characters used to indicate that all the information the user wishes to associate with the given u-name and command has been given. A terminator is required at the end of each BDL instruction. The only allowed instruction terminator is two sequential periods with no spaces or blanks between the periods (i.e., ..).

Example:

```
  END ..
* COMPUTE LOADS ..
*   STOP ..
```

Rule: Any two sequential periods preceded by one or more blank characters are treated as a terminator.

Note: Terminators should be inserted in columns 78 and 79 so that the default values for the unused keywords will be listed immediately following the instruction where they are used.

* In Preparation

F. BDL Instructions

1. Program Initialization Instructions

a. TITLE

The TITLE instruction is used to write titles on the output reports. It has the following form:

Name	Command	Data List	Terminator
	TITLE	title text	..

Name	No entry is allowed in the name field of the TITLE instruction. Any data in this field will cause an error.
TITLE	TITLE is a BDL command word used to identify the characters which follow as title text. Up to five TITLE instructions may be specified.
title text	Title text is a sequence of up to 40 alphanumeric characters to be printed in the title heading. Any and all characters are allowed in this field, except the terminator (..). Each title field is limited to 40 characters. A blank character must be between the command word TITLE and the first character of the title text. The first 80 characters are printed on the output reports on the first line and the next 120 characters are printed on the next line.

Examples:

```
TITLE   MEDICAL BUILDING ..
TITLE   USERS NAME ..
TITLE   FEB. 12 1977 ..
```

b. RUN-PERIOD

The RUN-PERIOD instruction identifies initial and final calendar dates which specify the simulation time period.

Name	Command	Initial Date		Final Date	Terminator
	RUN-PERIOD	month day year	THRU	month day year	..

Name — No entry is allowed in the name field of the RUN-PERIOD instruction. Any data in this field will cause an error.

RUN-PERIOD — RUN-PERIOD is a BDL command word used to identify the data which follow as the initial and final calendar dates of the desired run period.

Initial Date — The first date of the simulation analysis is given in the following order: Month Day Year. The first hour analyzed is the hour from midnight to 1:00 a.m. of the date selected, using the weather data recorded at 1:00 a.m. The BDL code-words to specify the names of the months are given below. The day and year are specified as numbers with a separator (e.g., blank or comma) on each side.

Final Date — The last date of the simulation analysis is given in the following order: Month Day Year. The last hour analyzed is the hour from 11:00 p.m. to midnight of the date selected using the weather data recorded at the last hour (i.e., midnight).

Code-words — The code-words for the months are as follows:

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

The maximum number of days specified for each month may not exceed the number of days within that month.

JAN = 31	MAY = 31	SEP = 30
FEB = 29	JUN = 30	OCT = 31
MAR = 31	JUL = 31	NOV = 30
APR = 30	AUG = 31	DEC = 31

The length of the RUN-PERIOD for a leap year is computed using 366 days (8784 hours) of weather data; for ordinary years, it is computed using 365 days (8760 hours).

Example 1:

```
RUN-PERIOD     JAN 1 1976 THRU DEC 31 1976 ..
```

This instruction would run the LOADS program for one year.

Example 2:

If the user desires to run the LSPE programs for December, January, and February to study the winter heating peak, and for June, July, and August to study the summer cooling peak, the BDL input instruction would be as follows:

```
RUN-PERIOD   JAN 1 1976   THRU   FEB 28 1976 ..
RUN-PERIOD   JUN 1 1976   THRU   AUG 31 1976 ..
RUN-PERIOD   DEC 1 1976   THRU   DEC 31 1976 ..
```

Since only one year of weather data is presently available for each location, as described in Chapter VIII, that one year (a Test Reference Year, or TRY) of data is used.

If no RUN-PERIOD instruction is entered by the user, an error will cause the program to stop, and no computations will occur.

Rules:

1. A RUN-PERIOD instruction must be entered by the user for successful operation of the LOADS program.
2. The sequence of RUN-PERIOD dates must be given as increasing calendar dates in chronological order.
3. Up to 12 RUN-PERIOD instructions and their associated schedule periods are allowed.
4. A minimum RUN-PERIOD of one day may be specified.
5. A RUN-PERIOD instruction cannot exceed one year. (I.e., DEC 31 is the last day that can be specified for a RUN-PERIOD.)
6. Multiple date limits are not allowed within one RUN-PERIOD instruction.

A second form of the RUN-PERIOD instruction is as follows:

Command	Initial Date	Length	Terminator
RUN-PERIOD	Month day year	FOR n DAYS	..

where n is an integer between 1 and 31 representing the number of days (including the first and last days) that the user decides to run the simulation programs. The total number n specified must not be larger than the remaining days of the month.

Example:

```
RUN-PERIOD     JAN 1 1976     FOR 31 DAYS ..
RUN-PERIOD     JUN 10 1976    FOR 20 DAYS ..
RUN-PERIOD     DEC 25 1976    FOR 7 DAYS ..
```

* A third form of the RUN-PERIOD instruction is as follows:

Command	Year	Terminator
RUN-PERIOD	YEAR	..

The above form will instruct the LSPE programs to calculate hourly numbers for each hourly variable.

* In Preparation

2. Assignment Instructions

a. DEFINE

The DEFINE instruction provides a user with the ability to define any user-specified word as a variable and assign a value to it.

Name	Command	Data List	Terminator
	DEFINE	Variable = Value	..

Name — No entry is allowed in the name field of the DEFINE instruction. Any data in this field will cause an error.

DEFINE — DEFINE is a BDL command word used to define a BDL variable name and its value in the form:

variable = value

Example 1: Variable Definition

One common use of this instruction is to define a variable name (e.g., W1) and assign a value (e.g., 4.0) to it. The variable W1 can then be used throughout the program in place of the number 4.0 by inserting the following instruction

```
DEFINE W1 = 4.0 ..
```

before using the variable W1 in a value field. If the above instruction is specified, then the user must not use the symbol W1 in the Name field. The only allowed use would be to assign W1 as the value for a keyword.

A user may desire to study the effect on energy consumption of a change in window width from four feet to six feet. To accomplish this task, the above DEFINE instruction would be followed by the instruction

```
WINDOW    GLASS-WIDTH = W1 ..
```

whenever the user specifies a window. Use of the BDL sequence GLASS-WIDTH = W1 instructs the program to compute the window width by using the value of the variable W1. The user would run the program twice, first using the above DEFINE W1=4.0 .. instruction, and second using the following instruction:

```
DEFINE W1 = 6.0 ..
```

The DEFINE instruction, combined with the assignment of keyword values as variable names, allows the user to rapidly examine the effects of many architectural and engineering design alternatives simply by changing one value.

Example 2: Command Word Definition

Another feature of BDL using the DEFINE instruction is the ability to completely redefine any of the command words (except the END command word) and/or any of their abbreviations. The user may DEFINE a new command word by specifying a new variable name and selecting a BDL command word as a value. The sequence is:

DEFINE user variable = BDL command word ..

Hence, if the user prefers to use some other term, for example, ROOM instead of SPACE, he may redefine the command word "SPACE" using:

DEFINE ROOM = SPACE ..

Note that this also allows multilingual versions. A user may insert the French language words by specifying its vocabulary. For example, the French word for window is fenetre. Hence, to create a version of the program in which the user may specify the French word for window, one need only insert the BDL instruction

DEFINE FENETRE = WINDOW ..

Alternatively, if the user redefines the abbreviations in a second language, a dual language (e.g., English and French) will exist. Three or more simultaneous languages and simultaneous abbreviations may also be implemented if desired. The input words may be user-defined; however, the reports are presently printed using English words. Reports in alternative languages may be inserted by foreign users by replacing the English words within the program by their foreign equivalents.

Example 3: Keyword Definition

The user may also redefine any of the BDL keywords using the DEFINE instruction

DEFINE variable = BDL keyword ..

As an example, to insert an additional abbreviation for the keyword LIGHTING-SCHEDULE, the user may specify

DEFINE LIGHT-SCH = LIGHTING-SCHEDULE ..

<u>Rules:</u>

1. All newly defined variable names must be entirely unique; no other use is allowed for a variable name. (I.e., a variable name may not be specified as a u-name.)
2. The END statement cannot be redefined.
3. Newly defined variable names must obey the rules for a BDL symbol.
4. Code-words may not be redefined by the user.
5. The equals sign is optional.

b. SET-DEFAULT

The SET-DEFAULT instruction provides a user with the ability to assign (or SET) a new default value to a keyword for a particular sequence of instructions.

Name	Command	Data List	Terminator
	SET-DEFAULT	Keyword = Value	..

Name — No u-name is allowed in the name field of the SET-DEFAULT instruction. Any data in this field will cause an error.

SET-DEFAULT — SET-DEFAULT is a BDL command word used to identify the data which follow as a list of BDL keywords followed by a numerical value to be assigned to each word.

Data List — The data list is a sequence of "keyword = value" assignment statements. Any BDL keyword may be specified as a variable name. Values may be integers or floating point numbers. Alphanumeric characters (symbols) must be in the value field for those keywords which expect a symbolic value.

Examples:

If the user specifies

```
SET-DEFAULT    WIDTH = 6.0
              HEIGHT = 4.0 ..
```

then the default value of the WIDTH variable is set to 6.0 (feet), and the default value of the HEIGHT variable is set to 4.0 (feet).

* c. SET-MINIMUM

The SET-MINIMUM instruction provides a user with the ability to assign (or SET) a new minimum value to a keyword for a particular sequence of instructions.

Name	Command	Data List	Terminator
	SET-MINIMUM	Keyword = Value	..

Name — No u-name is allowed in the name field of the SET-MINIMUM instruction. Any data in this field will cause an error.

* SET-MINIMUM — SET-MINIMUM is a BDL command word used to identify the data which follow as a list of BDL keywords followed by a numerical value to be assigned to each word.

Data List — The data list is a sequence of "keyword = value" assignment statements. Any BDL keyword may be specified as a variable name. Values may be integers or floating point numbers. Alphanumeric characters (symbols) must be in the value field for those keywords which expect a symbolic value.

Example:

If the user specifies

```
SET-MINIMUM   WIDTH = 1.0
             HEIGHT = 1.0 ..
```

then the minimum value of the WIDTH keyword is set to 1.0 (feet), and the minimum value of the HEIGHT keyword is set to 1.0 (feet).

* In Preparation

* d. SET-MAXIMUM

The SET-MAXIMUM instruction provides a user with the ability to assign (or SET) a new maximum value to a keyword for a particular sequence of instructions.

Name	Command	Data List	Terminator
	SET-MAXIMUM	Keyword = Value	..

Name — No u-name is allowed in the name field of the SET-MAXIMUM instruction. Any data in this field will cause an error.

* SET-MAXIMUM — SET-MAXIMUM is a BDL command word used to identify the data which follow as a list of BDL keywords followed by a numerical value to be assigned to each word.

Data List — The data list is a sequence of "keyword = value" assignment statements. Any BDL keyword may be specified as a variable name. Values may be integers or floating point numbers. Alphanumeric characters (symbols) must be in the value field for

Example:

If the user specifies

```
SET-MAXIMUM    WIDTH = 100.0
              HEIGHT =  10.0 ..
```

then the maximum value of the WIDTH variable is set to 100.0 (feet), and the maximum value of the HEIGHT variable is set to 10.0 (feet).

* In preparation

3. Message Instructions

a. <u>DIAGNOSTIC</u>

The DIAGNOSTIC instruction allows a user to select one of three pre-programmed levels for diagnostic and informative messages.

Name	Command	Code-word	Terminator
	DIAGNOSTIC	ERROR WARNING COMMENT	..

Name	No u-name is allowed in the name field of the DIAGNOSTIC instruction. Any data in this field will cause an error.

DIAGNOSTIC — DIAGNOSTIC is a BDL command word used to identify which of three message levels the user desires. This command word must precede one of the following BDL code-words: ERROR, WARNING, or COMMENT. If the user specifies

DIAGNOSTIC = ERROR ..

only input errors are printed; all other messages are suppressed. If the user specifies

DIAGNOSTIC= WARNING ..

both WARNING (possible mistake, data out-of-range) and ERROR diagnostic messages are printed. If the user specifies

DIAGNOSTIC= COMMENT ..

all COMMENT (e.g., undefined variable and default values) WARNING, and ERROR diagnostic messages are printed. This is the most informative level and allows the user to rapidly check the input instruction to determine if correct and complete data have been specified.

The default value for the DIAGNOSTIC command is the ERROR level. The equals sign is optional.

* b. ABORT

The ABORT instruction allows a user to select one of three pre-programmed levels to cause computations to stop.

Name	Command	Data List	Terminator
	ABORT	Code-word	..

Name — No u-name is allowed in the name field of this instruction.

* ABORT — After the BDL command word ABORT, the user must enter one of the following BDL code-words: ERROR, WARNING or CAUTION If the user specifies

ABORT = ERROR ..

the LOADS program will not perform any computations if an ERROR message is detected. If the user specifies

ABORT = WARNING ..

the LOADS program will not perform any computations if either an ERROR or a WARNING message is detected. If the user specifies

ABORT = CAUTION ..

no computations will be performed if any ERROR, WARNING, or CAUTION messages are detected. The default value for the ABORT command is the WARNING level. The equals sign (=) is optional.

* In Preparation

* c. SPACING

The SPACING instruction specifies whether the user desires the output to be single or double spaced.

Name	Command	Code-word	Terminator
	SPACING	SINGLE DOUBLE	..

Name — No u-name entry is allowed.

* SPACING — After the BDL command word SPACING, the user must enter one of the following BDL code-words: SINGLE or DOUBLE. If the user specifies

SPACING = SINGLE ..

the BDL processor will print a listing of the input instructions single spaced, for economy of paper. If the user specifies

SPACING = DOUBLE ..

the BDL processor will print a listing of the input instructions double spaced. This allows the user to insert correction on the print-out sheets and enhances the readability of listing pages which have been reduced for printing on notebook-size paper. The default value for the SPACING keyword is SINGLE. The equals sign is optional.

* In Preparation

4. Schedule Instructions

a. DAY-SCHEDULE

The DAY-SCHEDULE instruction is used to insert new user-specified 24-hour schedules or to modify previously named schedules.

Name	Command	Keyword	Value	Terminator
u-name	DAY-SCHEDULE	LIKE	u-named	..
	DS	SCALE	n	
		OFFSET	n	
		(hour)	n	
		(hour hour)	n	
		(hour hour)	n	

Name — The name field must contain a user-designated name which must not be identical to any of the previously defined library names or any other previously named instruction.

DAY-SCHEDULE — DAY-SCHEDULE is a BDL command word used to define a sequence of 24 numbers as hourly schedule values. All 24 numbers must be specified, either by using the LIKE keyword to specify a previously defined DAY-SCHEDULE u-name, or by entering hourly value.

LIKE — LIKE is a BDL variable used to identify 24 hourly values in a previously named (u-named) DAY-SCHEDULE instruction. Use of this keyword does not include the SCALE or OFFSET values as modifiers; just the 24 DAY-SCHEDULE values are duplicated. If the user desires to duplicate previously entered SCALE and OFFSET modifiers, they must be re-entered after using the LIKE keyword.

SCALE — SCALE is a BDL keyword used to assign a number (n) by which each of the 24 hourly DAY-SCHEDULE values are multiplied.

OFFSET — OFFSET is a BDL keyword used to assign a number (n) which is added to each of the 24 hourly day schedule values.

hour — The word hour is to be replaced by a number between 1 and 24 used to represent the one hour time period for which the user desires to specify a schedule value. The hour numbers must be entered in increasing values (i.e., from 1 to 24). A set of parentheses must enclose the hour number and must be selected from the following table.

The symbol n indicates that a sequence of numbers, or a list, may be entered.

BDL Hour Numbers

hour	TIME PERIOD	hour	TIME PERIOD
1	12M - 1AM	13	12N - 1PM
2	1AM - 2AM	14	1PM - 2PM
3	2AM - 3AM	15	2PM - 3PM
4	3AM - 4AM	16	3PM - 4PM
5	4AM - 5AM	17	4PM - 5PM
6	5AM - 6AM	18	5PM - 6PM
7	6AM - 7AM	19	6PM - 7PM
8	7AM - 8AM	20	7PM - 8PM
9	8AM - 9AM	21	8PM - 9PM
10	9AM - 10AM	22	9PM - 10PM
11	10AM - 11AM	23	10PM - 11PM
12	11AM - 12noon	24	11PM - 12midnight

Example 1: The following instruction would select an occupancy schedule named OCC-4 from the schedule library, define a new schedule named OFFICE-2, and change the value of the schedule for one hour (8) to the value 0.5.

```
OFFICE-2 = DAY-SCHEDULE LIKE OCC-4 (8) 0.5 ..
```

Example 2: The following instruction creates a new DAY-SCHEDULE named SCHD-2:

```
SCHD-2 =DAY-SCHEDULE  ( 1 8 ) 0.1
                      ( 9 17) 0.9
                      (18 21) 0.8 0.7 0.6 0.5
                      (22 24) 0.2             ..
```

b. WEEK-SCHEDULE

The WEEK-SCHEDULE instruction is used to identify a sequence of DAY-SCHEDULE instructions as a group.

Name	Command	Keyword	Value	Terminator
u-named	WEEK-SCHEDULE	LIKE	day-schedule u-named	..
	WS	(day)	day-schedule u-named	
		(day-1 day-2)	day-schedule u-named	

Name — The name field must contain a user-designated name which must not be identical to any previously defined library names or any other previously named instruction.

WEEK-SCHEDULE — WEEK-SCHEDULE is a BDL command word used to define a sequence of DAY-SCHEDULE instructions as a single block (e.g., a week).

LIKE — LIKE is a BDL keyword used to duplicate the data associated with a previously named (u-named) WEEK-SCHEDULE instruction.

(day) — The word "day" is to be replaced by a BDL code-word for a day of the week to which a user desires to assign a DAY-SCHEDULE u-name. A set of parentheses must enclose the day code-word, and it must be selected from the following table.

BDL Keywords for Days

Days	Code-word	Comment
Sunday	SUN	1st day of WEEK-SCHEDULE
Monday	MON	2nd
Tuesday	TUE	3rd
Wednesday	WED	4th
Thursday	THU	5th
Friday	FRI	6th
Saturday	SAT	7th
holiday	HOL	8th
week-day	WD	
week-end	WE	
week-end + holiday	WEH	
all	ALL	

(day-1 day-2)

The second day "day-2" must be specified as later in the week than the first day "day-1". Both day-1 and day-2 must be one of the days of the week between SUN and HOL inclusive, but not WD, WE, WEH, or ALL.

A separator (blank, comma, or equals sign) must be between day-1 and day-2.

HOL

The BDL code-word HOL assigns a DAY-SCHEDULE to the following dates.

Default Values for HOL dates

JAN 1	
JAN 2	if a Monday
FEB 21	if a Friday
FEB 22	
FEB 23	if a Monday
MAY 29	if a Friday
MAY 30	
MAY 31	if a Monday
JUL 3	if a Friday
JUL 4	
JUL 5	if a Monday
First Monday in September	
Last Thursday in November	
DEC 24	if a Friday
DEC 25	
DEC 26	if a Monday
DEC 31	if a Friday

Example 1:

Assume that DAY-SCHEDULE instructions named OFFICE-2 and SCHD-2 have been previously defined in the input instruction sequence. Hence, the following instruction defines a weekly schedule named WEEK-1, having the day schedules named SCHD-2 for Sunday, Saturday, and Holiday; and the day schedule named OFFICE-1 for Monday through Friday.

```
WEEK-1 = WEEK-SCHEDULE (SUN)      SCHD-2
                       (MON FRI)  OFFICE-1
                       (SAT HOL)  SCHD-2     ..
```

c. <u>SCHEDULE</u>

The SCHEDULE instruction is used to assign WEEK-SCHEDULE data to a sequence of dates.

Name	Command	Data List	Terminator
u-name	SCHEDULE SCH	THRU month date week-schedule u-named	..

Name — The name field must contain a user-designated name which must not be identical to any previously defined library name or to any other previously named instruction.

SCHEDULE — SCHEDULE is a BDL command word used to define a sequence of WEEK-SCHEDULE instructions as a yearly schedule.

THRU — The keyword THRU is used to identify the data which follows as the sequence (month, date, u-named week-schedule). The first day is assumed to be JANUARY 1st, and all succeeding dates must be entered in chronological calendar order. FEBRUARY is assumed to have 28 days.

month — The word month is to be replaced by a BDL code-word for a month of the year selected from the following table.

BDL Code-words for Months

Month	Code-word
January	JAN
February	FEB
March	MAR
April	APR
May	MAY
June	JUN
July	JUL
August	AUG
September	SEP
October	OCT
November	NOV
December	DEC

Example: Assume that WEEK-SCHEDULE instructions named SCHOOL-WEEK and VACATION have been previously defined in the input instruction sequence. Hence the following instruction defines a yearly schedule named SCHOOL-YEAR having the schedule block SCHOOL-WEEK when school is in session, and the schedule block named VACATION for Easter week, summer, and Christmas vacations.

```
SCHOOL-YEAR=SCHEDULE THRU MAR 23, SCHOOL-WEEK
                     THRU APR  2, VACATION
                     THRU JUN 15, SCHOOL-WEEK
                     THRU SEP  5, VACATION
                     THRU DEC 20, SCHOOL-WEEK
                     THRU DEC 31, VACATION ..
```

The holiday schedules will be automatically superimposed using the default values for the HOLIDAY dates, unless they are deactivated by the user.

5. Program Control Instructions

* a. INPUT

The INPUT instruction informs the BDL processor that the next instructions apply to one of the computational programs.

Name	Command	Code-word	Terminator
	* INPUT	LOADS SYSTEMS PLANT ECONOMICS	..

Name	No entries are allowed in the name field. Any data in this field will cause an error.
* INPUT	INPUT is a BDL command word which informs the BDL processor that the user desires to insert instructions for one of the computational programs. This instruction is used to identify the beginning of data files for the LOADS, SYSTEMS, PLANT, and ECONOMICS programs. The required sequence of INPUT instructions is described in Section G, "Instruction Sequence."
Example:	Before any BDL instructions for the LOADS program are inserted, an * INPUT LOADS .. instruction must appear. An END .. instruction must be the last of the BDL instructions which describe the LOADS data.

* In Preparation

* b. COMPUTE

The COMPUTE instruction informs the BDL processor to request the desired computations.

Name	Command	Code-word	Terminator
	* COMPUTE	LOADS SYSTEMS PLANT ECONOMICS	..

Name — No entries are allowed in the name field. Any data in this field will cause an error.

* COMPUTE — COMPUTE is a BDL command word used to request computations. The command word COMPUTE must be followed by one of the BDL code-words named for a computational program. A computation of the building loads using the COMPUTE LOADS .. instruction must precede any use of the COMPUTE SYSTEMS .. instruction, since the result of the buildings loads computation is used in the HVAC system computations. Similarly, a COMPUTE SYSTEMS .. instruction must precede a COMPUTE PLANT .. instruction, since the result of the system computation is used in the plant computations.

The ECONOMICS program requires input data from the LOADS, SYSTEMS, and PLANT programs. Hence a COMPUTE ECONOMICS .. instruction must have been preceded by a computation of the LOADS, SYSTEMS, and PLANT programs. However, the requirement of prior computations need not be repeated each time a SYSTEMS, PLANT, or ECONOMICS program is run, if the user has saved the result of previous computations in machine-readable form (e.g., written on output file).

Examples:

* COMPUTE LOADS ..

*COMPUTE SYSTEMS ..

* In Preparation

c. END

The END .. instruction informs the BDL processor that a sequence of input instructions for one of the computational programs is finished. One END .. instruction must follow each INPUT instruction set as illustrated in Section G, "Instruction Sequence."

Example: END ..

* d. STOP

One STOP .. instruction must be inserted as the last instruction the user specifies.

Example: STOP ..

* In Preparation

G. Instruction Sequence

The BDL instructions used to describe a building should be arranged according to the following sequence for a complete run of all the programs.

```
  User job statement        These are unique for each site.
  Job control statements

* INPUT LOADS ..
  DIAGNOSTIC
  TITLE
  DEFINE
  RUN-PERIOD

  DAY-SCHEDULE
  WEEK-SCHEDULE
  SCHEDULE

  BDL instructions for the LOADS program
  END ..
* COMPUTE LOADS ..

* INPUT SYSTEMS ..
  BDL instructions for the SYSTEMS program
  END ..
* COMPUTE SYSTEMS ..

* INPUT PLANT ..
  BDL instructions for the PLANT program
  END ..
* COMPUTE PLANT ..

* INPUT ECONOMICS ..
  BDL instructions for the ECONOMICS program
  END ..
* COMPUTE ECONOMICS  ..

* STOP ..
```

Rules: In general, the instructions for each of the computational programs (LSPE) may be arranged in any order the user desires. The exceptions are:

1. In the LOADS, PLANT, and ECONOMICS programs, u-names must not appear in a value field until after they have been used in a name field, this restriction does not apply to the SYSTEMS program.

2. The sequence of instructions determines which SPACE an EXTERIOR-WALL, INTERIOR-WALL, UNDERGROUND-WALL, FLOOR, FLOOR-ON-SOIL, or ROOF are assigned to when the hierarchy feature is used.

* In Preparation

H. Data Hierarchy

1. Geometrical Data

The LOADS program contains the following instruction hierarchy:

LEVEL	INSTRUCTION	CATEGORY
0.	BUILDING-LOCATION	building
1.	BUILDING-SHADE	adjacent shading
2.	SPACE	space
3.	EXTERIOR-WALL INTERIOR-WALL UNDERGROUND-WALL FLOOR UNDERGROUND-FLOOR ROOF	surfaces
4.	WINDOW *DOOR *OVERHANG	fenestrations attached shading
5.	*FIN	attached shading

* In preparation

The BUILDING-LOCATION instruction position keywords (e.g., X-BUILDING, Y-BUILDING, Z-BUILDING) and orientation keywords (e.g., AZIMUTH, TILT) are associated with the level 0 instruction. Only one building may be studied at a time. Once a BUILDING-LOCATION instruction is specified, various BUILDING-SHADE instructions may be inserted. All BUILDING-SHADE instructions must precede any SPACE instructions.

The SPACE instruction is the only level 2 instruction. It is the cornerstone upon which all the level 3 and 4 instructions depend. The user should first conceptually divide the building into various spaces by selecting areas that have unique thermal characteristics. Chapter X on Examples illustrates several possibilities for selecting spaces. Once a u-name and SPACE instruction are specified, any of the level 3 instructions which immediately follow it are assumed to belong to that SPACE.

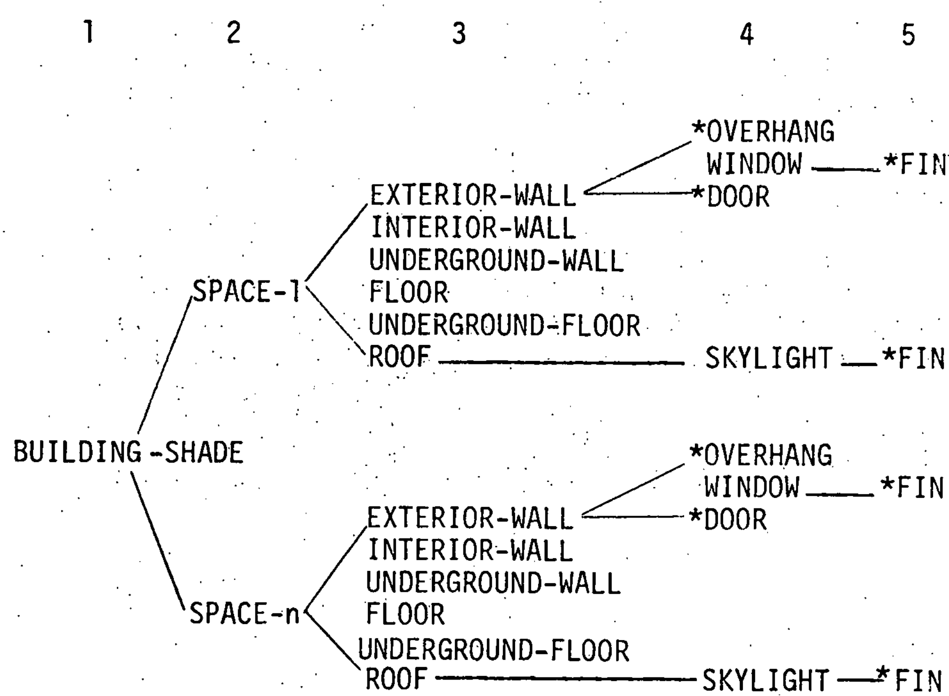
Level 3 instructions may or may not be specified for each SPACE. If a level 3 instruction is specified, a mathematical model of the thermal properties for that surface is generated. Hence the user should fully account for all the surfaces of a SPACE. If only partial studies are desired, the user may create partial models, but a mental note must be made that incomplete data have been specified. BDL cannot check that the user has read in all the necessary information for the correct analysis of a building or a space. The user is cautioned not to specify common interior walls twice for two adjacent spaces. Several examples illustrate this problem in the INTERIOR-WALL instruction.

Level 4 instructions (WINDOW, DOOR, OVERHANG) are assumed to belong to the EXTERIOR-WALL or ROOF instruction which they immediately follow. Level 4 instructions may not be attached to the INTERIOR-WALL, UNDERGROUND-WALL, FLOOR, or UNDERGROUND-FLOOR instruction.

The level 5 instruction (FIN) may be attached to the level 4 instructions WINDOW or DOOR, but not to OVERHANG. A FIN may also be attached to the EXTERIOR-WALL or ROOF instructions of level 3.. The FIN instruction is used to compute the amount of incident solar radiation (insolation) a WINDOW, DOOR, EXTERIOR-WALL, or ROOF will receive. To reduce air-conditioning loads, it is expected that architectural FIN's will be specified.

Figure II-2 illustrates the geometrical data hierarchy.

Geometrical Data Level



* In preparation

Figure II-2

2. Thermal Property Data

A data reference feature is available in the LOADS program through which thermal property data are assigned to the building surfaces. Each of the surface instructions (e.g., EXTERIOR-WALL, INTERIOR-WALL, UNDERGROUND-WALL, FLOOR, FLOOR-ON-SOIL, DOOR, and ROOF) includes the CONSTRUCTION keyword, which refers to the name (u-name or library name) of a previously entered CONSTRUCTION instruction.

The CONSTRUCTION instruction includes LAYERS, WALL-TYPE, ROOF-TYPE, FLOOR-TYPE*,U-VALUE, ABSORPTANCE, ROUGHNESS, and WALL-INFILTRATION keywords. If the LAYERS keyword is specified and assigned a value (a previously defined u-name), then the LAYERS instruction is used to specify the materials of the wall, roof, or floor layer-by-layer. If the LAYERS, WALL-TYPE, ROOF-TYPE, or FLOOR-TYPE*keywords in the CONSTRUCTION instruction are not specified, then the other keywords, U-VALUE through WALL-INFILTRATION, provide the thermal property data.

The LAYERS instruction describes the sequence of materials starting with the exterior surface of a space boundary. The outside film coefficient is not specified since the LOADS program computes it based on the square of the wind velocity for each hour. The sequence of keywords (MATERIAL-1, THICKNESS-1, MATERIAL-2, etc.) determines the sequence in which the thermal properties of materials will be mathematically assembled.

The MATERIAL instruction provides values for the THICKNESS (which may have been overwritten by THICKNESS-n of the LAYERS instruction) DENSITY, SPECIFIC-HEAT, CONDUCTIVITY, and RESISTANCE keywords. The appropriate values, from either the materials library or the user specifications, are sent to the response factor subroutine which computes the response factors used in the heat flow calculations.

* In Preparation

1. BDL Instruction Summary

The following sequence is a summary of BDL input instructions which is ready for the user to fill in the blanks.

/* INPUT ________________ */ — Select code-word LOADS, SYSTEMS, PLANT, or ECONOMICS

TITLE ________________ .. — 40 character maximum

TITLE ________________ .. — 40 character maximum

TITLE ________________ .. — 40 character maximum

TITLE ________________ .. — 40 character maximum

TITLE ________________ .. — 40 character maximum

RUN-PERIOD ____ ____ ____ THRU ____ ____ ____ ..
(month day year) (month day year)

DEFINE ________ = ________
________ = ________ ..
(variable) (value)

SET-DEFAULT ________ = ________
________ = ________ ..
(keyword) (value)

________ DAY-SCHEDULE LIKE ________ ..
(u-name) (day-schedule u-named)

________ WEEK-SCHEDULE LIKE ________ ..
(u-name) (week-schedule u-named)

________ SCHEDULE THRU ____ ____ ________ ..
(u-name) (month date week-schedule u-named)

III. LOADS PROGRAM

* In preparation

III. LOADS PROGRAM

A. Introduction

The accurate determination of energy requirements for a building has always been difficult, not just because the thermodynamics can be complex, but also because the task requires a huge amount of computation. The correct prediction of heating and cooling loads is important because the maximum loads are used to determine the size and, hence, the maximum capacity and cost of the system components. The energy required by a system to meet the heating and cooling can represent a large fraction of system operating costs. If the maximum loads are underestimated, the equipment may be undersized and fail to do its job, and if the maximum loads are overestimated, the equipment will be larger, less efficient and more expensive than necessary.

Before the advent of digital electronic computers, only a crude energy calculation was practical, and the engineer and architect had to rely mainly on experience. The effect of ambient weather was approximated by degree days, transient heat conduction was approximated by equivalent temperature differentials, and combined radiative/ convective boundary conditions were approximated using the "sol-air" temperature. Heating and cooling equipment was therefore usually grossly oversized, as a hedge against a poor guess, and energy requirements could not be predicted with enough accuracy for the user to make a rational choice of a heating, ventilating and air conditioning (HVAC) system. Now, energy requirements have become a dominant concern in the design of buildings and in the selection of heating and cooling equipment. The accurate determination of the energy requirements for a building depends on many factors including the following:

1. position of the sun
2. hourly intensity of the solar radiation
3. ambient weather conditions
4. shading of the exterior surfaces
5. heat transfer properties of materials
6. HVAC equipment and its operation
7. primary (plant) equipment and its performance
8. variable internal heat sources
9. heat storage capacity
10. solar radiation conversion systems.

Each of these factors will have various amounts of influence on the energy consumption of a building, reflecting the wide variations in architecture, use, climate, materials, equipment, etc. available to a building designer.

The LOADS program calculates the heating and cooling requirements for each space within a building. These calculations are based on the ASHRAE algorithms described in Chapter I, Ref. 1, and assume that no HVAC equipment is operating. <u>The LOADS program calculates the energy required to maintain a constant temperature within each space</u>.

Item 8 above refers to the energy deposited within a building each hour due to people, lighting, equipment, and processes within a building. Hourly variations in these effects may be rather large, especially for auditoriums, cafeterias, office buildings, schools, etc., and are determined by using the SCHEDULE instructions.

A sequence of BDL instructions describes the location of a building, its walls, floors, spaces, etc., as specified by the user. This sequence of instructions is introduced below for the LOADS program.

1. BDL Input Sequence

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

*INPUT LOADS ..

instruction which informs the BDL processor that a sequence of instructions which apply to the LOADS program will follow. This instruction may be followed by BDL program control instructions which are used to define variables, set default values, select schedules, etc. The sequence of instructions is rather arbitrary if the data hierarchy or u-named referencing features are not used. The user should study the sequence of instructions as presented in the examples, since they were specifically designed to illustrate the input sequence of BDL input instructions and the u-named referencing features, as well as good practice for naming conventions.

A sequence of input instructions will now be described to illustrate use of the library reference features, shading, variable definition, and default selection capabilities. The sequence of specifying BDL instructions for the LOADS program is introduced, while the use and keywords for each instruction are described in detail in Section B of this chapter.

The next instruction for the LOADS program is

BUILDING-LOCATION

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

If direct solar radiation is prevented from arriving at the exterior surface of the building due to a near-by surface, then the surface which shades the building needs to be described by the

BUILDING-SHADE

instruction to properly account for the effects of direct solar heat gain. This instruction may be applied to any surface which intercepts solar radiation, (e.g. a hill, tree, or nearby building).

* In Preparation

Next, the user should select and define user names (u-names) for the following instructions:

CONSTRUCTION
LAYERS
MATERIAL .

If the user desires to create and use non-library walls, roofs, floors, windows, or doors, they should all be assembled at the beginning of the program. This practice will prevent many later errors where a user may attempt to refer to a particular wall or roof construction which has not been previously defined. Collecting all the initialization,assignment, information, and schedule instructions in one group at the beginning of the LOADS input is strongly recommended as good practice.

A list of variables which the user has selected to study, or a list of command words, keywords, and abbreviations the user would like to redefine, should be inserted using the

DEFINE

instruction. One common use of this instruction is to specify a user variable and assign an initial value to it. As an example, the user may desire to study the effect on energy consumption of replacing all the windows with smaller or larger windows. Hence the user would first define a variable and a value (e.g., WINDOW-WIDTH-1 = 4.0, or perhaps WW-1 = 4.0). Once a user variable has been defined, it should be inserted by the user as the value for the appropriate keywords. The user may then study the effect on energy consumption of changing the width of all the windows by only having to change one number (e.g., WW-1 = 6.0) and running the Cal-ERDA programs again.

A list of keyword default values should be listed next if the user decides to change the preprogrammed default values using the

SET-DEFAULT

instruction. The default values will be overwritten with a new user-specified default value each time the SET-DEFAULT instruction is encountered. Hence, repeated use of this instruction in the sequence of BDL input may reduce the input data task. However, this flexibility should be tempered with the task of mentally keeping track of the current default values, and the problem of introducing errors due to user forgetfulness.

The next task is to select a set of schedules to describe the hour-by-hour occupancy, lighting, and equipment usage. If the user only desires to select a preprogrammed schedule from the schedule library, then only the SCHEDULE instruction and its library name needs to be specified.* However, if the user desires to name, specify, and enter his

* In Preparation

own schedules, then the schedule instructions must be entered in the following order:

DAY-SCHEDULE
WEEK-SCHEDULE
SCHEDULE

A DAY-SCHEDULE instruction must precede a WEEK-SCHEDULE instruction, if the WEEK-SCHEDULE instruction refers to the DAY-SCHEDULE instruction using the u-named feature. Similarly, the WEEK-SCHEDULE instruction must precede the SCHEDULE instruction if the SCHEDULE instruction refers to the WEEK-SCHEDULE instruction.

After the above schedule instructions have been specified, the user may begin to describe each space within the building. The selection of space boundaries should be done with consideration of the probability of heat transfer across the boundary. Also if the user gives forethought to which spaces will be conditioned by which heating, ventilating, and air conditioning systems, and specifies the space boundaries accordingly, then the results of the LOADS program will be available in a more useful form for the SYSTEMS program. The user should specify and name (u-name) a set of space conditions using the

SPACE-CONDITIONS

instruction. This will allow the user to easily refer to energy sources, occupancy, lighting, and equipment within a space.

Next, the first SPACE should be selected and described using the

SPACE

instruction. Immediately following the description of the SPACE keywords, the appropriate thermal boundaries for that space should be entered. To do so, the user next specifies the

EXTERIOR-WALL
INTERIOR-WALL
ROOF and
FLOOR

instructions. Any fenestrations (e.g., doors, windows, or skylights) should be described by inserting the appropriate instructions immediately following the description of the surface upon which they appear.

After all the spaces and the space boundaries have been specified for the LOADS program, the user must insert an

END ..

instruction.

This may be followed by

* COMPUTE LOADS ..
* STOP ..

to inform the BDL processor that the user desires to perform the LOADS calculations.

The BDL input instructions for the LOADS program are described in this chapter. Each instruction is a BDL sentence and contains the following sequence: Name, Command, Data List, and Terminator. To begin an instruction, the user first specifies a name (e.g., BUILDING-362, ROOM-B117, SOUTH, G2, FRONT, MIKES-ROOM). Next, a BDL command word is selected (e.g., SPACE, EXTERIOR-WALL, WINDOW). Any of the BDL keywords and their values for the command selected may then be entered, followed by a terminator (..).

There are several important keywords which greatly expand the usefulness and versatility of BDL. These keywords are named LIKE and SHAPE.

The keyword

LIKE

may be used in any BDL instruction where it appears in the keyword list. It is used to duplicate all the previuos data assigned to a command of the same type and is identified by specifying the keyword LIKE followed by the u-name of the previously entered instruction. For example, the instruction

KATHYS = SPACE LIKE MIKES-ROOM ..

duplicates all the dimensions and space conditions of the (previously named) space MIKES-ROOM and names the new space KATHYS.

If some of the data associated with the newly named SPACE are different from the reference space, then the user may redefine the values of the keyword variables. For example, if the above instruction includes

WIDTH = 10, LENGTH = 14 ..

the size of the space named KATHYS is defined differently from MIKES-ROOM.

The keyword

SHAPE

may be used to select a pre-programmed shape of a space from the shape library*. This variable is very useful for conceptual design studies. The first code-word for this keyword is BOX, and it is described in the SPACE instruction.

* In Preparation

* The keyword

LOCATION

is used to describe the location of one object with respect to an origin. The LOCATION variable is used to mathematically move, or rotate, an object (e.g., a building) in its coordinate system. There are three relative (and rotating) coordinate systems allowed in BDL: building coordinates, space coordinates, and surface coordinates. Each of these is described in more detail below.

* The command word

VERTEX

is used to describe the vertices of an arbitrarily shaped polygon.

* In preparation

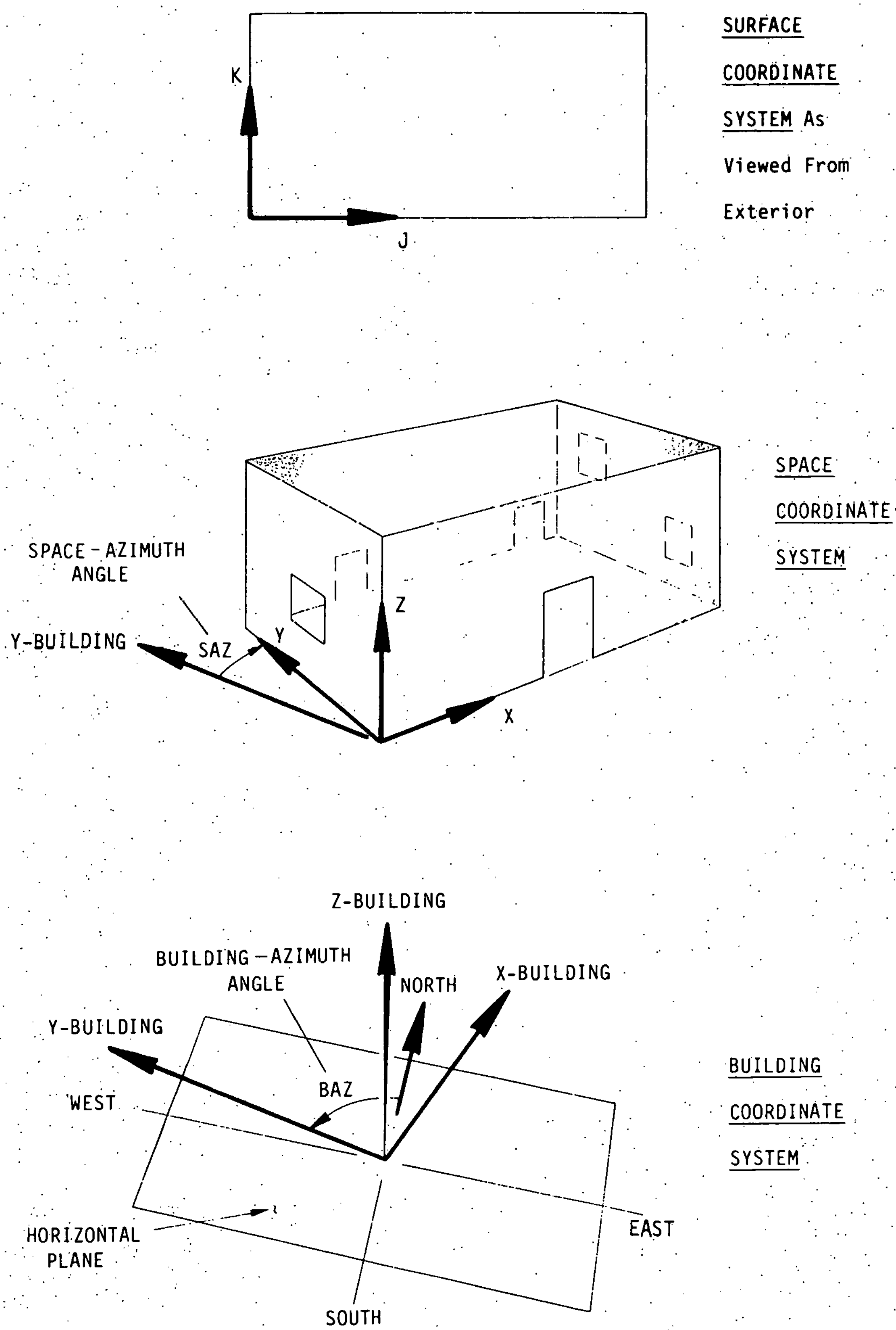
2. Rotating Coordinate Systems

Three coordinate systems are used in the Cal-ERDA computer programs. The first is the building coordinate system. The origin of the building coordinate system establishes the position of the building at one point on the earth as specified in the BUILDING-LOCATION instruction. A specific latitude, longitude, and altitude is entered by the user as the origin of the building coordinate system.

The second coordinate system is the space coordinate system. The position and orientation of various spaces or rooms within a building are specified relative to the origin of the building coordinate system. This allows the user to mathematically move, expand, contract, translate, and rotate spaces within buildings. The size and position of each surface (i.e., walls, roof, and floor) are described relative to the origin of the space coordinate system using the EXTERIOR-WALL, UNDERGROUND-WALL, ROOF, and FLOOR instructions.

The third coordinate system is the surface coordinate system. The position and orientation of various attachments (e.g., awnings, balconies, overhangs, fins, etc.) on the exterior surface of a wall or roof may be described in its own coordinate system. This capability of BDL allows the user to create a mathematical model for the thermal properties of a wall having windows, doors, balconies, and other architectural features.

The three coordinate systems are introduced in Figure III-1. The origin of the surface coordinate system may be located in either the space coordinate system or the building coordinate system. However, the origin of the space coordinate system may only be located in the building coordinate system. The effect on energy consumption of rotating the entire building may be studied by changing the value of the BUILDING-AZIMUTH angle (BAZ). The effect on energy consumption of rotating any space (e.g., a wing of a building) may be studied by changing the value of the SPACE-AZIMUTH angle (SAZ).



Three Relative Coordinate Systems

Figure III - 1

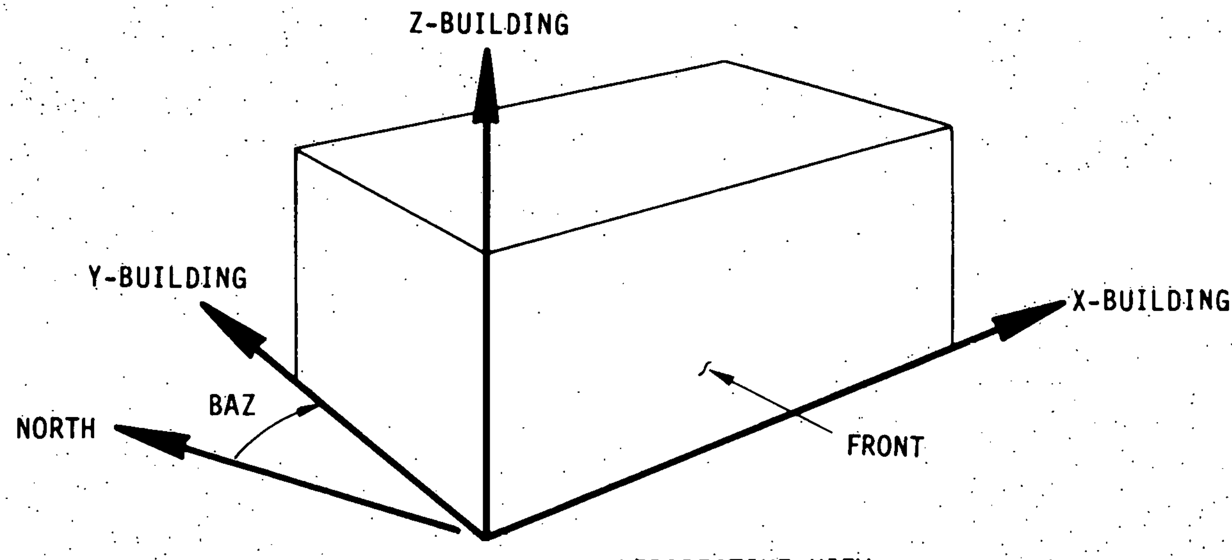
a. Building Coordinate System

In order to specify the location and orientation of a building, the user must first input the BUILDING-LOCATION instruction and its keywords. The user needs to choose one point on (or near) the building as the origin of a 3-dimensional coordinate system whose axes are labeled X-BUILDING or XB, Y-BUILDING or YB, and Z-BUILDING or ZB.

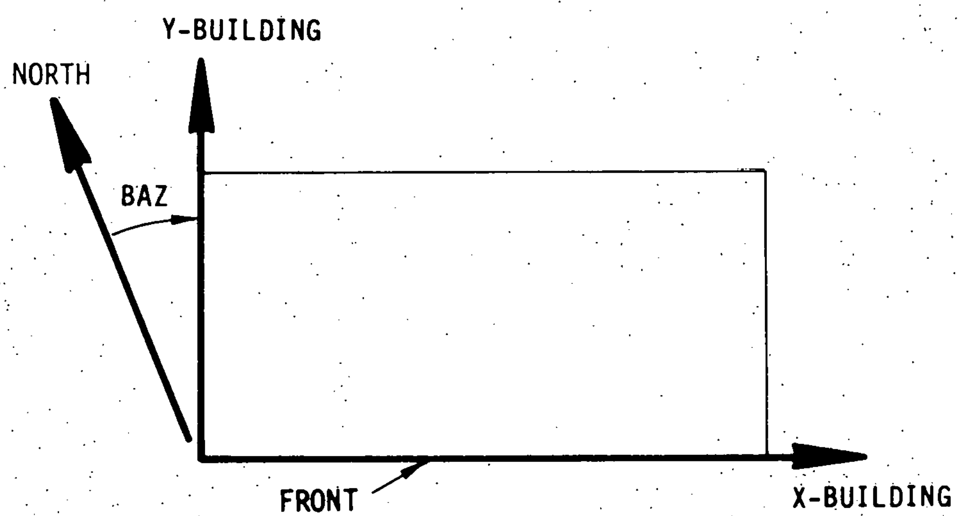
Figure III-2 illustrates in perspective and plan view an example of assigning a set of building coordinate axes to a building. In the case of a simple rectangular building, a convenient convention is to select the lower left-hand corner of the front wall as viewed from the outside. Hence, the X-BUILDING axis is at grade level along the front wall, and the Z-BUILDING axis points vertically up along the left corner edge of the building.

In general, it is recommended that the user first sketch a plan view for each typical floor of the building. The ground floor is usually then selected, an origin point chosen, and the X-BUILDING and Y-BUILDING axes drawn on the sketch. Then angle BAZ, or BUILDING-AZIMUTH, is determined by the angle as measured from the true north direction to the positive Y-BUILDING direction.

Figures III-3 and III-4 provide two examples which illustrate the definition of the building coordinate system for a U-shaped and an L-shaped building, respectively. It is suggested that the user choose an origin for the building coordinate system, such that the building resides in the first quadrant. This suggestion is most useful for non-symmetrical buildings; however, for symmetrical buildings, such as one hexagonal shaped, the user may wish to select the center of symmetry for the origin of the building coordinate system.



PERSPECTIVE VIEW

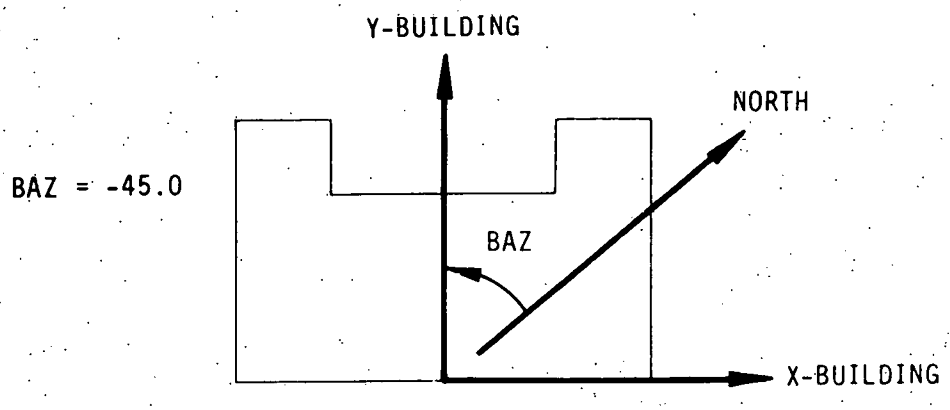


PLAN VIEW

Example of Building Coordinate System

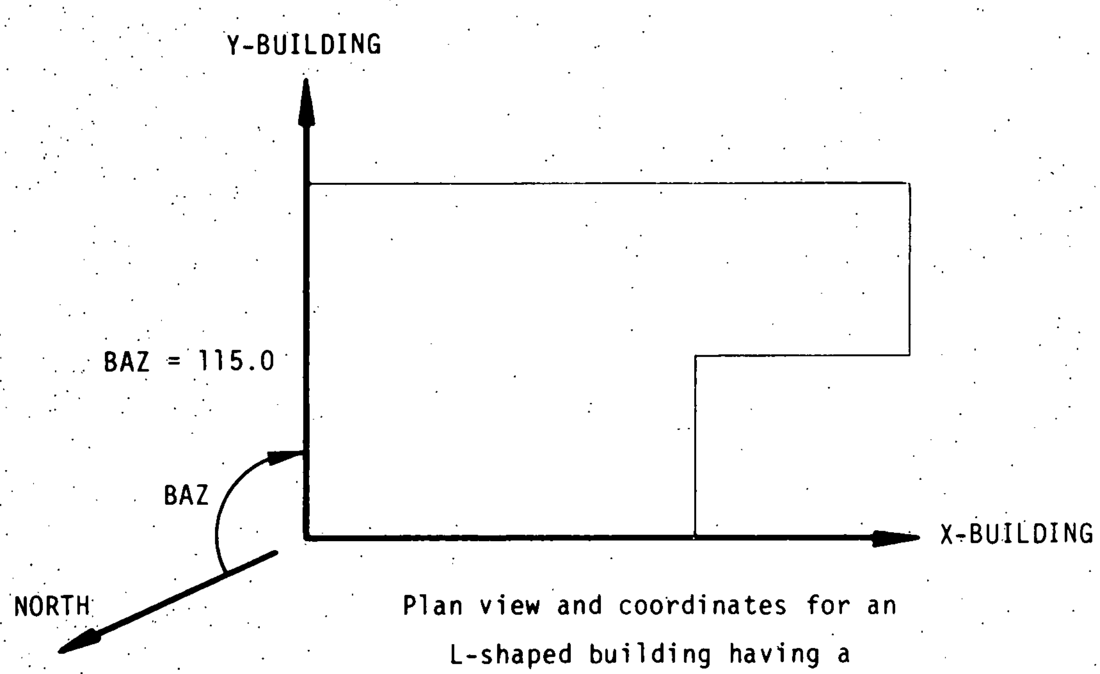
Figure III - 2

BUILDING-AZIMUTH ANGLE



Plan view and coordinates for a U-shaped building having a
BUILDING-AZIMUTH = -45.0

Figure III - 3



Plan view and coordinates for an
L-shaped building having a
BUILDING- AZIMUTH = 115.0

Figure III - 4

b. Space Coordinate System

The orientation and position of surfaces (e.g., walls and roofs) of spaces should be located by the user in the space coordinate system. The origin of the space coordinate system must be specified as a point in the building coordinate system using the SPACE instruction and assigning values to the keywords X-BUILDING or XB, Y-BUILDING or YB, and Z-BUILDING or ZB. The assumed position, or default values, of the space coordinate origin is coincident with the building coordinate system (i.e., XB = 0, YB = 0, ZB = 0, SAZ = 0). The space coordinate system may be rotated about its vertical (Z) axis by specifying a value for the SPACE-AZIMUTH (or SAZ) keyword.

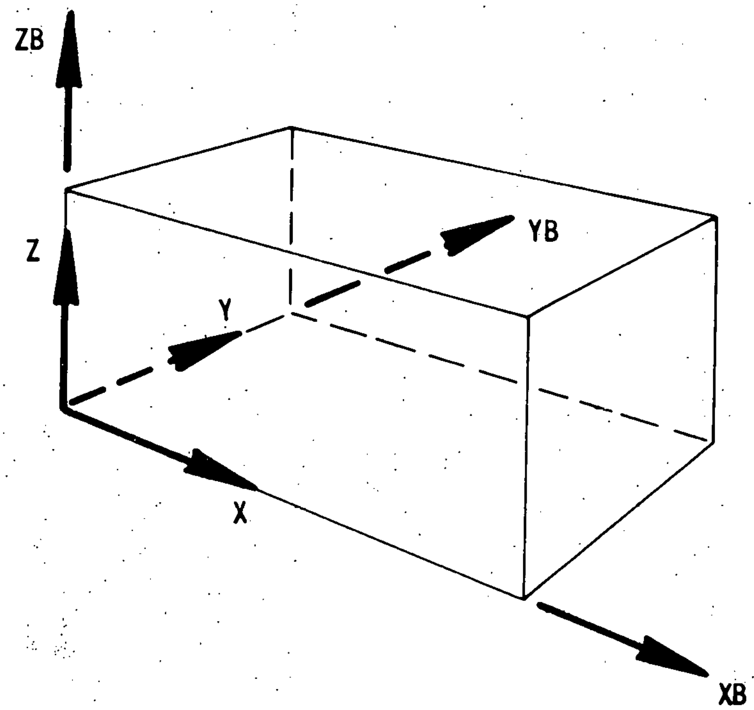
The SPACE instruction is the primary instruction by which each space is described. Several common choices are to select a room, a group of exterior rooms, or one floor of a building wing as a space. The position of the space can then be described within the building coordinate system as a translation, by specifying values for XB, YB, and ZB, and as a rotation, by specifying a value for the SPACE-AZIMUTH keyword.

Figure III-5 presents an example which illustrates a simple rectangular box, wherein the space coordinate axes coincide with the building coordinate axes, and no translation or rotation of the space within the building is desired.

Figure III-6 illustrates how a set of space coordinate axes (X, Y, and Z) may be assigned to a space in the southeast corner of the building. The position of the origin of the space coordinate system (V2) is determined relative to the origin of the building coordinate system (V1). Also, the orientation of the space coordinate system is determined by the rotation of the positive Y axis of the space coordinate system from the positive Y-BUILDING axis of the building coordinate system and is called the SPACE-AZIMUTH angle (SAZ).

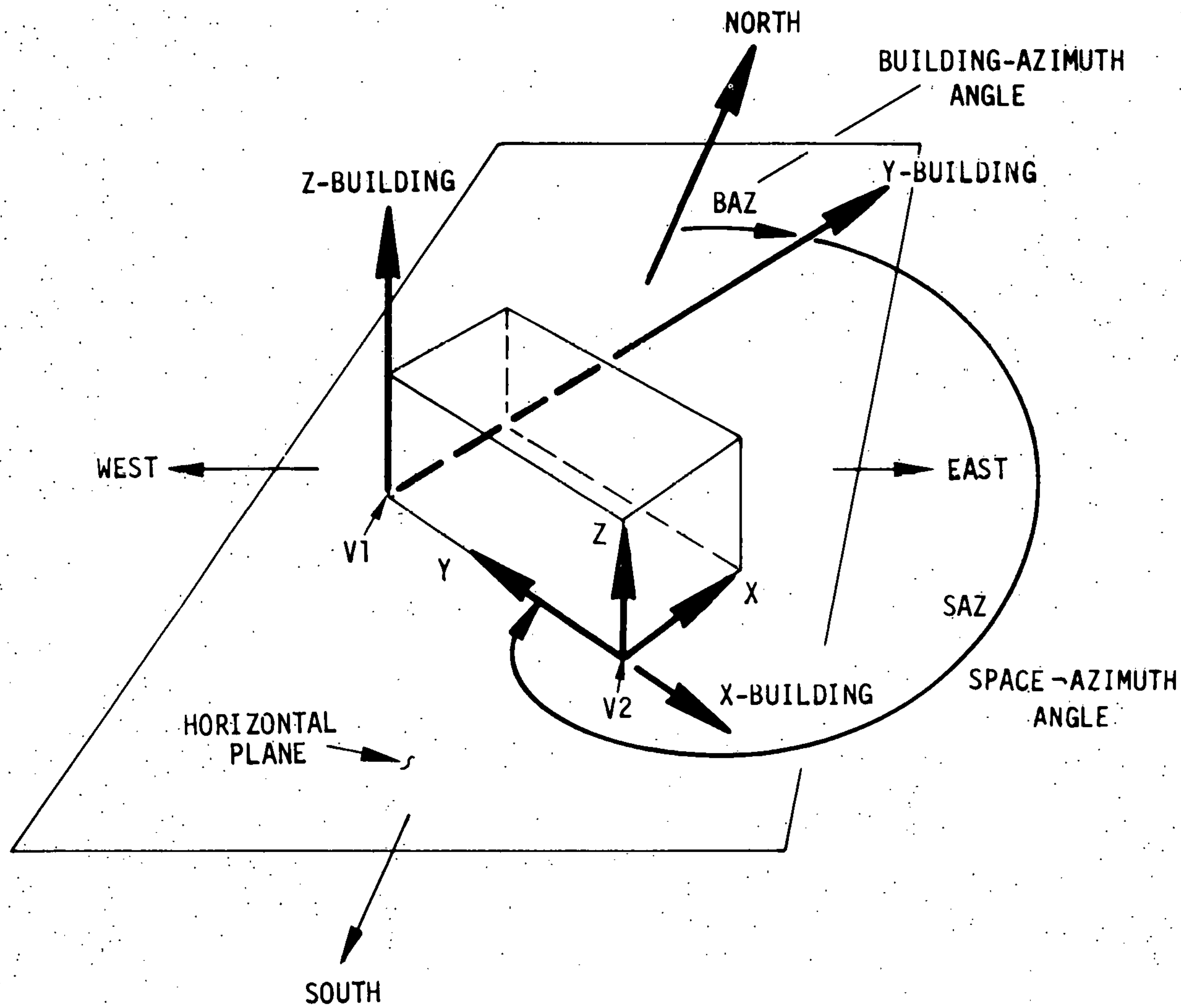
There are many equivalent ways a user may specify the position of a surface with respect to the origin of a space coordinate system. Each user should establish an input procedure. For example, a check mark on each surface on the sketch, as it is entered, will remind the user that the surface has been specified. A sequence, such as clockwise as viewed from above the spaces, is one method to be certain no surfaces are ignored or specified twice.

Figure III-7 illustrates how the position of one surface may be located within a space coordinate system. The lower left hand corner of the surface, as viewed from the outside, has been chosen as the origin of the surface. The definitions for the keywords X, Y, Z, AZIMUTH, and TILT are given under the commands to which they apply (i.e., EXTERIOR-WALL and ROOF).



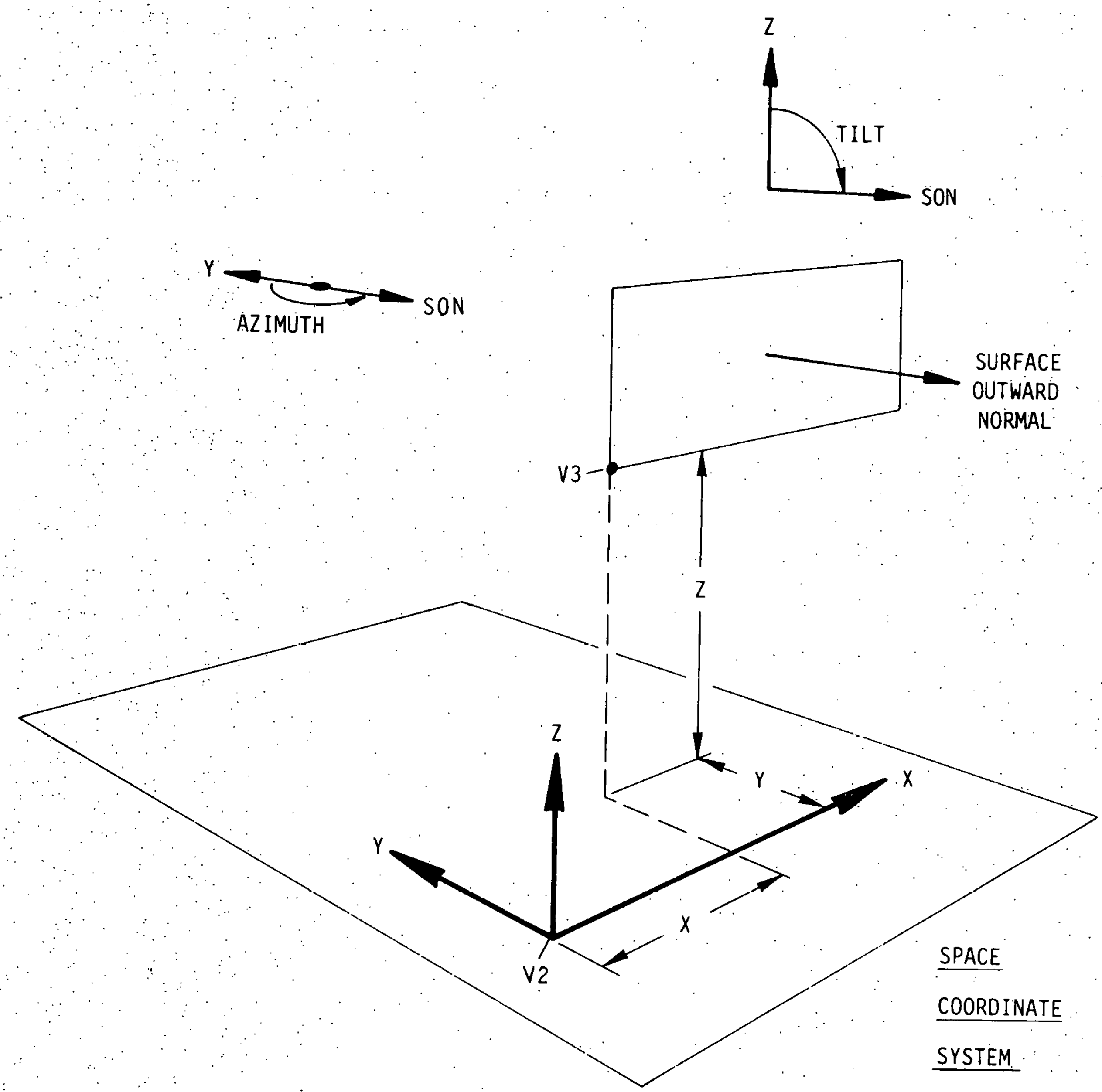
Example of a Space Coordinate System
and a Building Coordinate System
Sharing the Same Origin

Figure III - 5



Example of a Space Coordinate System (X, Y, Z) within a Building Coordinate System (X-BUILDING, Y-BUILDING, Z-BUILDING).

Figure III - 6



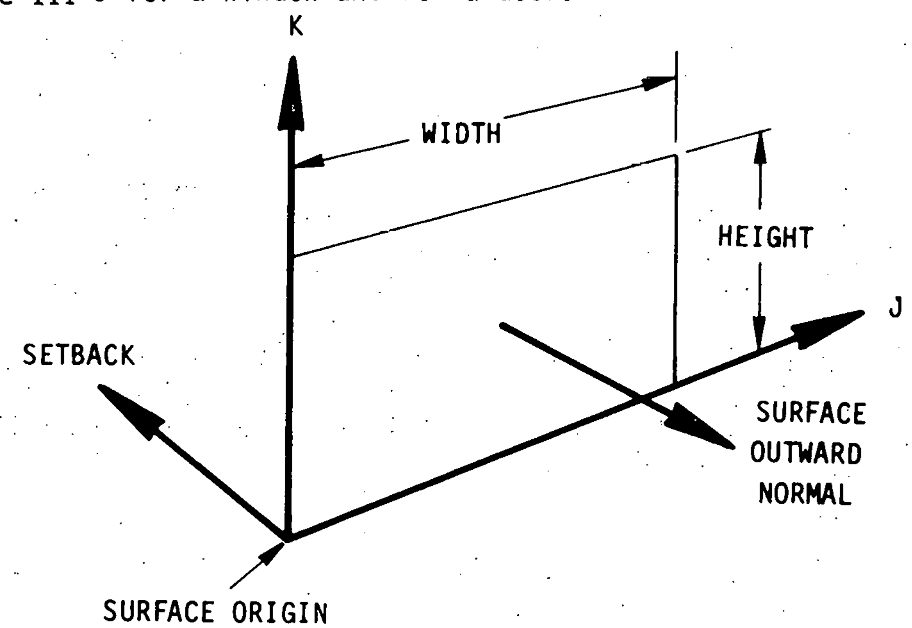
Example of a Surface Located Within a Space Coordinate System

Figure III - 7

c. Surface Coordinate System

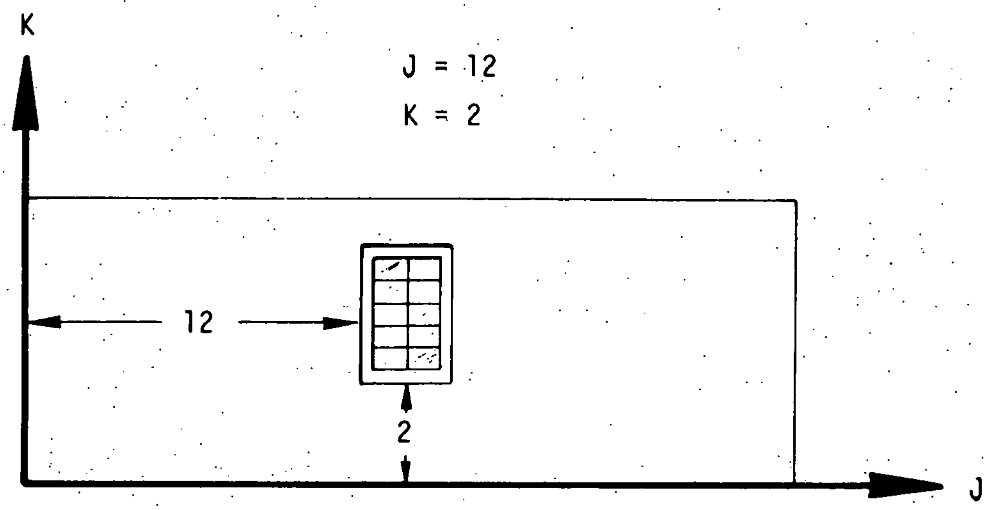
The position of architectural shading elements, such as fins, balconies, window setbacks, etc., may be located on a surface using the surface coordinate system. First, the origin of the surface coordinate system is specified as a point in a space coordinate system using the EXTERIOR-WALL or ROOF instructions and the keywords X, Y, and Z. The assumed position, or default values, of the surface coordinate origin is coincident with the space coordinate origin (i.e., X = 0, Y = 0, Z = 0, and AZIMUTH = 0). Next, the position of windows and their shading elements (e.g., fins) attached to a surface are described by specifying the location of the lower left hand corner of the element, as viewed from the exterior, with respect to the origin of the surface coordinate system. The WINDOW and DOOR commands include the keywords J, K, and SETBACK, which determine the position of the window or door in the surface coordinate system. Each window or door should be entered immediately following the surface definition instruction (e.g., EXTERIOR-WALL or ROOF) on which it resides. The heat transfer characteristics of the exterior surface are modified according to its number and position of fenestrations and shading elements.

The surface coordinate system is illustrated in Figure III-8. The position of a fenestration, such as a door or window, is assumed to be at the origin, (i.e. J = 0, K = 0, and SETBACK = 0 are the default values). The position of a fenestration may be assigned by specifying values for the surface position keywords (J, K, and SETBACK). If the window or door is flush, or in the same plane, with the surface, then the SETBACK keyword may keep its default value of zero. The position coordinates J and K are illustrated in Figure III-9 for a window and for a door.

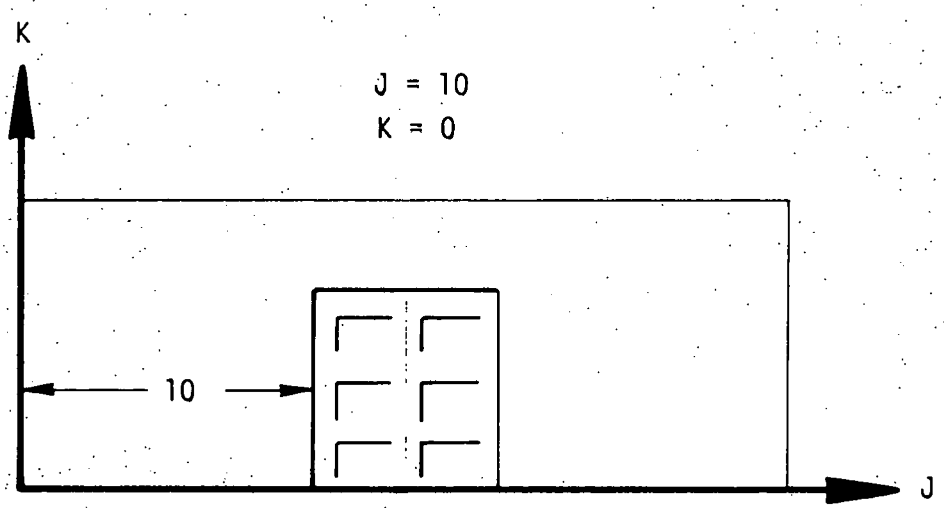


Surface Coordinate System

Figure III-8



Example of Window Location in the Surface Coordinate System



Example of Door Location in Surface Coordinate System

Figure III-9

B. BDL Input Instructions

The input instructions for the BDL LOADS program are described in this section.

* 1. WEATHER-STATION

The WEATHER-STATION instruction informs the EXECUTIVE program which weather data to retrieve from the library.

Name	Command	Data	Terminator
	WEATHER-STATION	code-word	..

Name — No user-defined names are allowed for this instruction.

* WEATHER-STATION — WEATHER-STATION is a BDL command word which specifies that the next word will be a code-word to identify a set of weather data. Note: only one WEATHER-STATION instruction may be specified for each run.

code-word — The user inserts a code-word to select the desired weather data. The list of code-words is given in Table III-1. Note: only one code-word may be entered for each WEATHER-STATION instruction.

Example: — The following instruction selects the Test Reference Year (TRY) weather data for Chicago.

```
WEATHER-STATION    CHICAGO   ..
```

* In Preparation

Table III-1

WEATHER-STATION code-words and TRY year

State	Code-word	TRY Year
Alabama	BIRMINGHAM	1965
Alaska		
Arizona	PHOENIX	1951
Arkansas		
California	FRESNO	1951
	LOS-ANGELES	1973
	SACRAMENTO	1962
	SAN-DIEGO	1974
	SAN-FRANCISCO	1974
Colorado		
Connecticut		
Delaware		
District of Columbia	WASHINGTON-DC	1957
Florida	JACKSONVILLE	1965
	MIAMI	1964
	TAMPA	1953
Georgia	ATLANTA	1975
Hawaii		
Idaho	BOISE	1966
Illinois	CHICAGO	1974
Indiana	INDIANAPOLIS	1972
Iowa		
Kansas	DODGE-CITY	1971
Kentucky	LOUISVILLE	1972
Louisiana	LAKE-CHARLES	1966
	NEW-ORLEANS	1958
Maine	PORTLAND-MAINE	1965
Maryland		
Massachusetts	BOSTON	1969
Michigan	DETROIT	1968
Minnesota	MINNEAPOLIS	1970
Mississippi	JACKSON	1964
Missouri	COLUMBIA	1968
	KANSAS-CITY	1968
	ST-LOUIS	1972

Montana	GREAT-FALLS	1956
Nebraska	OMAHA	1966
Nevada		
New Hampshire		
New Jersey		
New Mexico	ALBURQUERQUE	1959
New York	ALBANY BUFFALO NEW-YORK-CITY	1969 1974 1951
North Carolina	RALEIGH	1965
North Dakota	BISMARCK	1970
Ohio	CINCINNATI CLEVELAND	1957 1969
Oklahoma	OKLAHOMA-CITY TULSA	1951 1973
Oregon	MEDFORD PORTLAND-OREGON	1966 1960
Pennsylvania	PHILADELPHIA PITTSBURGH	1969 1957
Rhode Island		
South Carolina	CHARLESTON	1955
South Dakota		
Tennessee	MEMPHIS NASHVILLE	1964 1972
Texas	AMARILLO BROWNSVILLE EL-PASO FORT-WORTH HOUSTON LUBBOCK SAN-ANTONIO	1968 1955 1967 1975 1966 1955 1960
Utah	SALT-LAKE-CITY	1948
Vermont	BURLINGTON	1966
Virginia	NORFOLK RICHMOND	1969 1969
Washington	SEATTLE	1960
Wisconsin	MADISON	1974
Wyoming	CHEYENNE	1974

2. BUILDING-LOCATION

The BUILDING-LOCATION instruction is used to specify the position and orientation of the building coordinate system on the earth.

Name	Command	Keyword	Abbr	Notes
	BUILDING-LOCATION	LATITUDE	LAT	degrees
		LONGITUDE	LON	degrees
		ALTITUDE	ALT	feet
		TIME-ZONE	TZ	number
		DAYLIGHT-SAVINGS	DS	0 or 1
		HOLIDAY-CODE	HC	0 or 1
		BUILDING-AZIMUTH	BAZ	degrees
		* GROUND-TEMPS	GT	^{o}F
		* CLEARNESS-NUMBERS	CN	number

Rule:

* Only one BUILDING-LOCATION instruction may be entered, and it must be after an INPUT LOADS instruction and before any BUILDING-SHADE or SPACE instructions.

Name — No entry is allowed in the name field of the BUILDING-LOCATION instruction.

BUILDING-LOCATION — BUILDING-LOCATION is a BDL command word used to indicate that the user desires to specify the location of a building.

LATITUDE — LATITUDE is the angular distance north (positive) or south * (negative) of the equator, measured in degrees expressed as a decimal fraction.

LONGITUDE — LONGITUDE is entered as a positive number for positions on the earth west of Greenwich, England up to a maximum of 180.0 degrees. For locations east of Greenwich, (e.g. Europe) the longitude is entered as a negative number up to -180.0 degrees. The angle is measured in degrees expressed as a decimal fraction.

* In Preparation

ALTITUDE

ALTITUDE is the height above (positive) or below (negative) sea level of the building site, measured in feet expressed as a decimal fraction.

TIME-ZONE

The international time zone number for each of the 24 time zones is specified as the number of hours from Greenwich, England. For the United States, a user enters the keyword TIME-ZONE followed by a code-word, in this case a number, selected from the following table.

STANDARD TIME	Code-word
Atlantic	4
Eastern	5
Central	6
Mountain	7
Pacific	8
Yukon	9
Hawaii	10

The value of the TIME-ZONE keyword is entered as a negative number, from -1 to -12 for the time zones east of Greenwich, England.

DAYLIGHT-SAVINGS

The keyword DAYLIGHT-SAVINGS is to be followed by the number one if the weather data are not recorded according to daylight standard time during the summer months. This keyword informs the processor whether one 23-hour day occurs in the spring and one 25-hour day occurs in the fall. The building operation schedules are adjusted accordingly with respect to solar noon. The default value is zero which assumes that daylight savings time is enforced at the location specified for the building.

HOLIDAY-CODE

The keyword HOLIDAY-CODE is used to deactivate, or inhibit, the use of a schedule for the United States national holidays. The default value is zero which assumes the user desires to assign a DAY-SCHEDULE to the following dates:

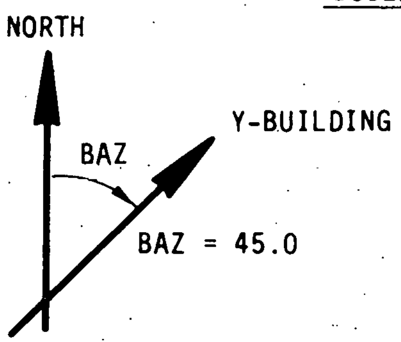
Default Values for HOL dates

JAN 1	
JAN 2	if a Monday
FEB 21	if a Friday
FEB 22	
FEB 23	if a Monday
MAY 29	if a Friday
MAY 30	
MAY 31	if a Monday
JUL 3	if a Friday
JUL 4	
JUL 5	if a Monday
First Monday in September	
Last Thursday in November	
DEC 24	if a Friday
DEC 25	
DEC 26	if a Monday
DEC 31	if a Friday

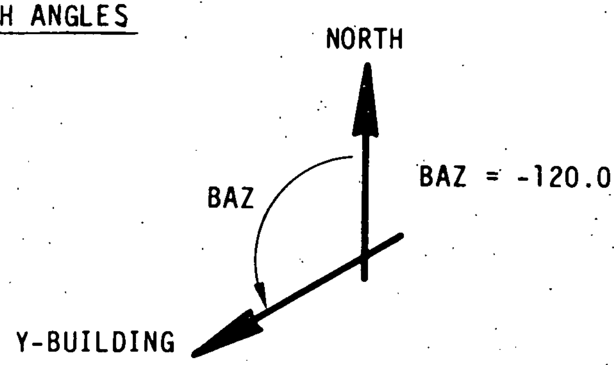
A day-schedule u-name must be specified following the keyword HOL in the WEEK-SCHEDULE instruction as previously described in Chapter II, in order to assign the day schedule desired by the user for these holidays.

If the user specifies HOLIDAY-CODE = 1 the above dates are not assigned a HOL day-schedule. The above dates may then be assigned a day-schedule by use of the DAY-SCHEDULE, WEEK-SCHEDULE and SCHEDULE instructions.

BUILDING-AZIMUTH ANGLES



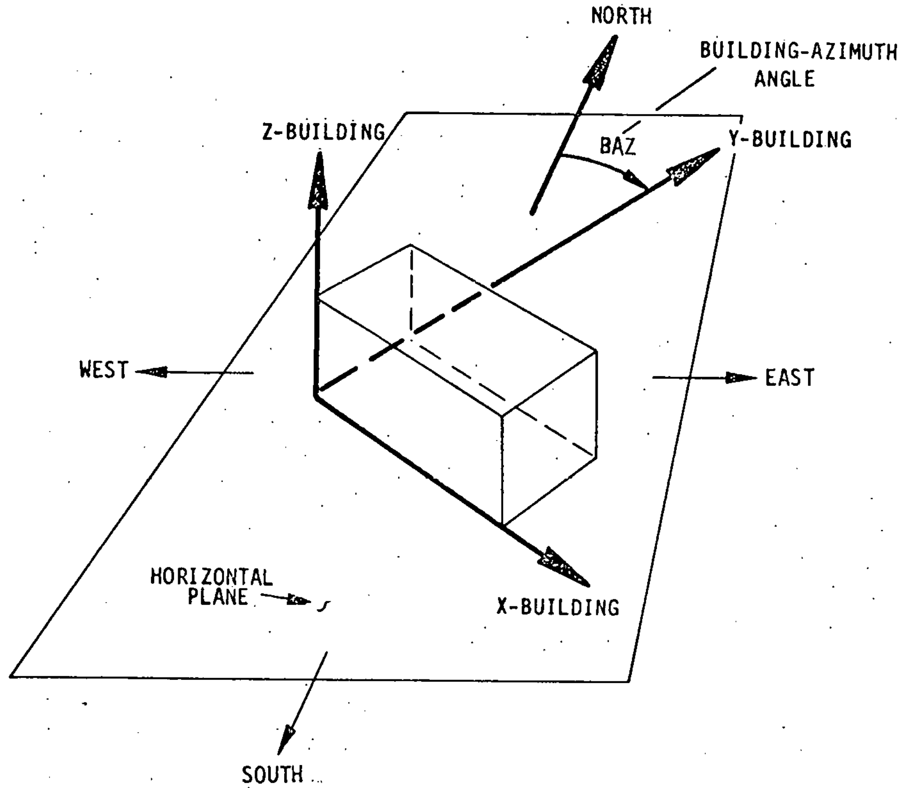
Positive (clockwise)



Negative (counterclockwise)

BUILDING-AZIMUTH The BUILDING-AZIMUTH (or BAZ) angle is defined as the angle from the direction of true north to the positive Y-axis (Y-BUILDING) of the building coordinate system. The X-BUILDING Y-BUILDING plane is assumed to be a horizontal plane at the location specified for the building, and the positive Z axis (Z-BUILDING) is specified as its outward normal (i.e., up). The user should note that the building may be rotated in the clockwise (defined as positive) or in the counterclockwise (defined as negative) direction from true north by rotating the X-BUILDING Y-BUILDING plane about the Z-BUILDING axis. BAZ is specified as a decimal fraction in degrees and tenths of degrees. Minutes and seconds of arc must be converted to a decimal fraction. (E.g., 10 degrees and 15 minutes would be specified as 10.25 degrees.)

Figure III-10 is an example of the BUILDING-AZIMUTH angle BAZ to illustrate how a building may be rotated (mathematically) about the Z-BUILDING axis by specifying various values for the angle BAZ.



Example of BUILDING-AZIMUTH Angle

Figure III - 10

* GROUND-TEMPS The GROUND-TEMPS keyword may be followed by a sequence of up to 12 numbers listing the temperature of the ground to be used in the calculation of heat flow across a surface in contact with the ground. This keyword is provided to allow the user to enter a series of monthly ground temperatures if the measured data from the weather files is not applicable. The temperatures are to be given in degrees Fahrenheit, starting with the average temperature for January (about Jan. 15) through the average temperature for December. For example, the user may desire to use measurements taken at a depth of one foot for the heat flow through a slab at grade level. In this situation the user would insert the GROUND-TEMPS keyword followed by a sequence of 12 temperatures.

* CLEARNESS-NUMBERS The CLEARNESS-NUMBERS keyword may be followed by a sequence of up to 12 numbers listing monthly values for the clearness numbers, if the user decides that the data on the weather files is not applicable. This keyword is provided so the user may modify the weather data for local conditions. The TRY or TDF-14 weather data is associated with a specific site and may not properly reflect the clearness at a specific site due to localized fog, a nearby steel mill, etc.

* In Preparation

3. BUILDING-SHADE

The BUILDING-SHADE instruction is used to specify the opacity, position, size, and orientation of an external surface which shades an exterior surface of the building. This instruction is used to simulate an adjacent object, such as a nearby building, tree, or hill.

Name	Command	Keyword	Abbr	Value	Units
u-name	BUILDING-SHADE	LIKE		u-named	
		HEIGHT	H		feet
		WIDTH	W		feet
		TRANSMITTANCE	TR		fraction
		*LOCATION		u-named	
		X-BUILDING	XB		feet
		Y-BUILDING	YB		feet
		Z-BUILDING	ZB		feet
		SURFACE-AZIMUTH	SAZ		degrees
		TILT	T		degrees

Name	Any user-defined name may be entered in the name field.
BUILDING-SHADE	BUILDING-SHADE is a BDL command word used to specify a nearby shading surface.
LIKE	LIKE is a BDL keyword used to refer to a previously entered BUILDING-SHADE instruction.
HEIGHT	The height of the shading surface is expressed as a decimal fraction in feet. (E.g., 36 feet 6 inches is expressed as 36.5.)
WIDTH	The width of the shading surface is expressed as a decimal fraction in feet.
TRANSMITTANCE	TRANSMITTANCE is the ratio of the solar radiation which passes through a surface to the incident solar radiation on the surface. If the surface is opaque, the user should set TRANSMITTANCE = 0. If the surface is transparent, the user should set TRANSMITTANCE = 1. Any other value may be specified as a decimal fraction between zero and one.

* In Preparation

* LOCATION

LOCATION specifies a user-defined name for a position. If the LOCATION keyword and a u-name is specified, then the keywords X-BUILDING, Y-BUILDING, and Z-BUILDING need not be given unless the user decides to change the values specified to by the LOCATION keyword. The u-name for the LOCATION keyword must refer to a previously defined LOCATION instruction wherein the position (XB, YB, and ZB) and orientation (SAZ, T) keywords are assigned values.

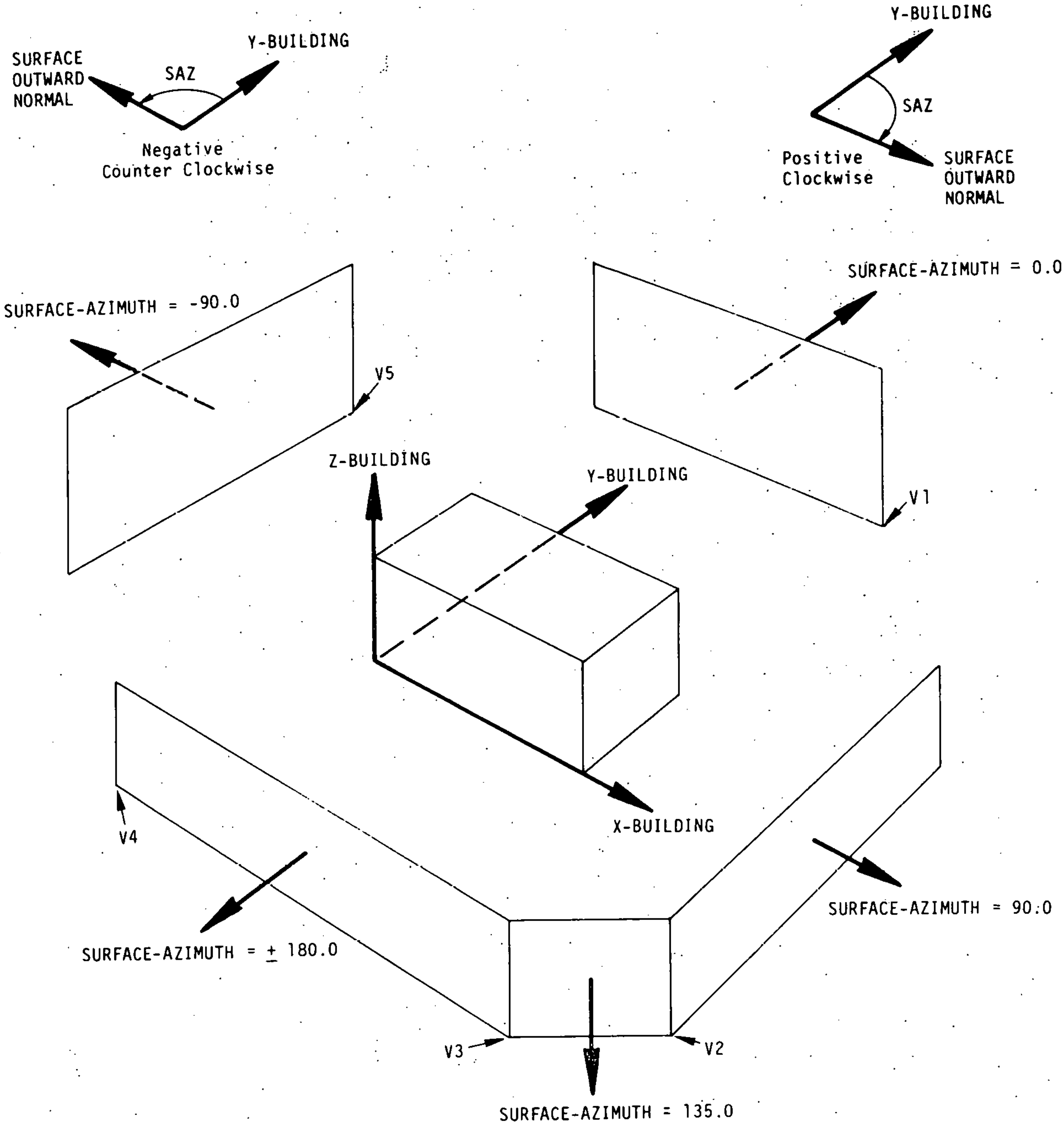
X-BUILDING
Y-BUILDING
Z-BUILDING

X-BUILDING, Y-BUILDING, and Z-BUILDING describe the coordinates, in the building coordinate system, of the lower right-hand corner of the shading surface as viewed from the origin of the building coordinate system (i.e., in the direction of the surface outward normal for the shading surface). Figure III-11 illustrates five adjacent shading surfaces and the position of each surface reference origin (V1 through V5).

SURFACE-AZIMUTH

The angle measured from the positive Y axis of the building coordinate axis (Y-BUILDING) to the horizontal projection of the surface outward normal (pointing away from the building) for the shading surface. The angle measured clockwise from the Y-BUILDING axis to the surface outward normal is defined as positive, and the angle measured counterclockwise from the Y-BUILDING axis to the surface outward normal is defined as negative.

* In Preparation



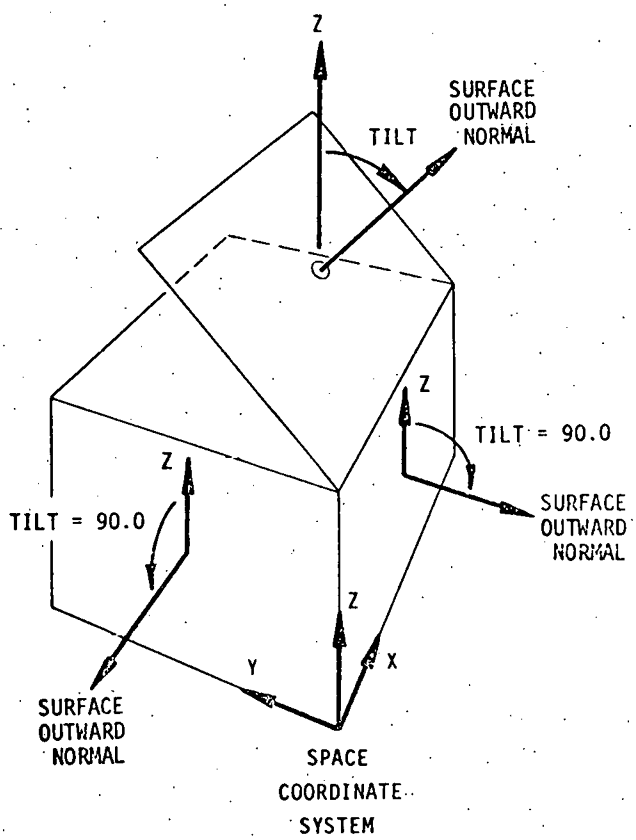
Several examples of the SURFACE-AZIMUTH keyword

Figure III - 11

TILT

TILT is the angle measured from the positive Z axis of the space coordinate system to the surface outward normal. TILT is an angle between zero and 180 expressed as a decimal fraction in degrees. Figure III-12 illustrates the TILT angle for a surface tilted up about 45 degrees from the horizontal. A horizontal roof has TILT = 0, and a vertical wall has TILT = 90.0. An exterior surface facing down, (such as an overhang) would have TILT = 180.0.

TILT



Several Examples of the TILT Keyword

Figure III - 12

4. SPACE-CONDITIONS

The SPACE-CONDITIONS instruction is used to specify a desired constant temperature for the LOADS calculation, and the energy input to each space due to internal sources, infiltration, and thermal mass.

Name	Command	Keyword	Abbr	Value	Units
u-name	SPACE-CONDITIONS SC	LIKE		u-named	
		TEMPERATURE	TEMP		°F
		PEOPLE-SCHEDULE	PS	u-named	
		NUMBER-OF-PEOPLE	NOP		number
		PEOPLE-ACTIVITY	PACT		Btu/hr·person
		LIGHTING-SCHEDULE	LS	u-named	
		LIGHTING-TYPE	LT	code-word	
		LIGHTING-KW	LKW		kW
		LIGHTING-W/SQFT	LWSF		W/ft^2
		LIGHT-TO-SPACE	LTS		%
		EQUIPMENT-SCHEDULE	EQS	u-named	
		EQUIPMENT-KW	EQKW		kW
		EQUIPMENT-W/SQFT	EQWSF		W/ft^2
		EQUIPMENT-SENSIBLE	EQSEN		%
		EQUIPMENT-LATENT	EQLAT		%
		* PROCESS-SCHEDULE	PS	u-named	
		* PROCESS-BTUH	PBTUH		Btu/hr
		* PROCESS-BTU/SQFT	PBSF		Btu/ft^2
		* PROCESS-SENSIBLE	PSEN		%
		* PROCESS-LATENT	PLAT		%
		* SOURCE-SCHEDULE	SS	u-named	
		* SOURCE-BTUH	SBTUH		Btu/hr
		* SOURCE-BTU/SQFT	SBSF		Btu/ft^2
		* RESOURCE	RE	code-word	
		INF-SCHEDULE	IS	u-named	
		INF-METHOD	IM	code-word	
		INF-CFM/SQFT	IC		cfm/ft^2
		AIR-CHANGES/HR	AC		hr^{-1}
		FLOOR-WEIGHT	FW		lb/ft^2
		NEUTRAL-ZONE-HEIGHT	NZH		ft

* In Preparation

Name	A user-defined name must be entered in the name field.
SPACE-CONDITIONS	SPACE-CONDITIONS is a BDL command word used to specify the condition and energy inputs to each space.
LIKE	The BDL keyword LIKE may be followed by the u-name of a previously entered SPACE-CONDITIONS instruction, to duplicate the keyword entries.
TEMPERATURE	TEMPERATURE is to be followed by a user defined space temperature which specifies the desired temperature in degrees Fahrenheit for the loads calculations. It is used to calculate the building loads based on the assumption that the space is held at one constant temperature. Variable temperature controls, such as evening and weekend temperature setbacks, are specified in the SYSTEMS program, using the ZONE-CONTROL instruction, and include the energy consumption of the HVAC equipment necessary to provide variations in space conditions.
PEOPLE-SCHEDULE	PEOPLE-SCHEDULE identifies a user-specified name as the name of a previously entered SCHEDULE instruction, or of a schedule library name, to be used in the hourly calculations of the energy input to a space due to its occupants. The schedule instruction multiplies the hourly schedule values, expressed as a decimal fraction of a maximum by the value of the NUMBER-OF-PEOPLE keyword.
NUMBER-OF-PEOPLE	NUMBER-OF-PEOPLE specifies the maximum number of people that will occupy the space. The energy input due to occupancy is computed using this user-specified number and multiplying it each hour by the hourly percent of maximum occupancy defined by the PEOPLE-SCHEDULE keyword.
PEOPLE-ACTIVITY	PEOPLE-ACTIVITY specifies the total rate at which sensible and latent heat is added to a space due to the presence of one person. This rate is not adjusted for the effect of temperature within a space upon the heat output of an adult person. Alternative values, or non-default values, may be selected to indicate the presence of small children, animals, heavy manual work, etc.

LIGHTING-SCHEDULE — LIGHTING-SCHEDULE identifies a user-specified name as the name of a previously entered SCHEDULE instruction, or of a schedule library name, to be used in the hourly calculations of the energy input to a space due to lighting. The hourly schedule selected describes the portion of the total available lighting that is providing heat from lights to the space at any given hour (i.e., the percentage of lights that are on).

LIGHTING-TYPE — LIGHTING-TYPE is followed by a code number selected from the following table to identify the type of lighting being specified.

Lighting Type	Code Number
Fluorescent not vented	1
Fluorescent vented to return air	2
Fluorescent vented to supply and return air	3
Incandescent	4

For mixed lighting types in one space (i.e., both incandescent and fluorescent), the user should select the dominant type and adjust the percent of heat due to lighting using the LIGHT-TO-SPACE keyword.

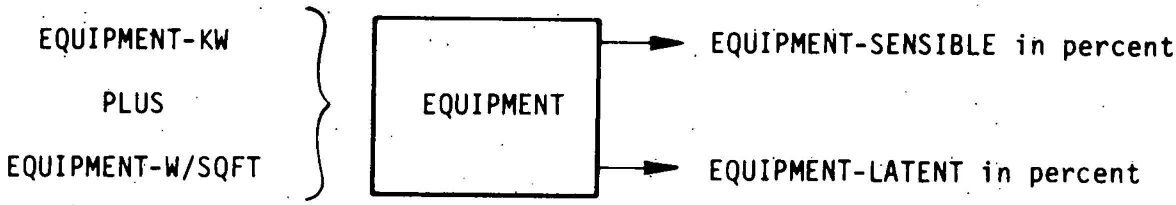
LIGHTING-KW — LIGHTING-KW specifies the number of kilowatts available in a space for lighting. This number is multiplied by the LIGHTING-SCHEDULE value assigned for each hour.

LIGHTING-W/SQFT — LIGHTING-W/SQFT specifies the number of watts per square foot entering the space due to lighting. Either this or the previous keyword should be specified. If both keywords are used, the program computes the contribution due to the sum of both values. The value for this keyword is multiplied by the hourly values assigned by the lighting schedule.

LIGHT-TO-SPACE — LIGHT-TO-SPACE specifies the percentage of heat energy generated by the lighting that enters the space. The remainder of the heat due to lighting is assumed to enter a plenum.

EQUIPMENT-SCHEDULE

EQUIPMENT-SCHEDULE identifies a user-specified name as the name of a previously entered SCHEDULE instruction, or of a schedule library name, to be used in the calculations of the effect due to electrical equipment in the space. The hourly schedule selected defines the decimal fraction of the maximum heat energy due to the operation of electrical equipment that enters a space each hour.



EQUIPMENT-KW

EQUIPMENT-KW specifies the maximum number of kilowatts that could enter a space due to electrical equipment. This number is multiplied by the value assigned for each hour by the EQUIPMENT-SCHEDULE keyword.

EQUIPMENT-W/SQFT

EQUIPMENT-W/SQFT specifies the number of watts per square foot in the space due to electrical equipment. Either this or the previous keyword should be specified. If both keywords are used, the program computes the contribution due to the sum of both values. The value for this keyword is multiplied by the hourly values assigned by the EQUIPMENT-SCHEDULE keyword.

EQUIPMENT-SENSIBLE

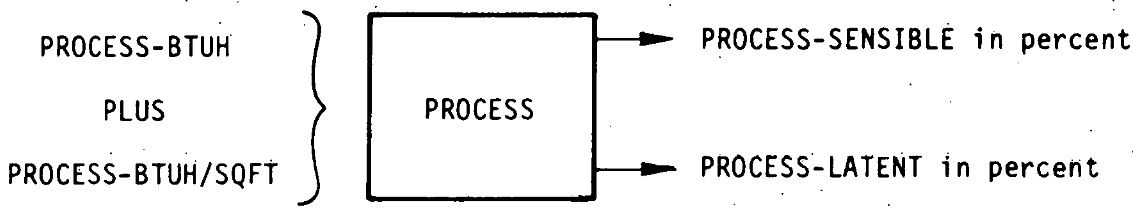
EQUIPMENT-SENSIBLE specifies the percentage of heat due to the electrical equipment in the space which becomes sensible heat.

EQUIPMENT-LATENT

EQUIPMENT-LATENT specifies the percentage of heat due to the electrical equipment in the space which becomes latent heat.

* PROCESS-SCHEDULE

PROCESS-SCHEDULE identifies a user-specified name as the name of a SCHEDULE instruction, or of a schedule library name, to be used in the hourly calculations of the energy input to a space due to a fuel converting heat source (or process). The sequence of calendar days, the associated week schedules and the hourly schedule values, expressed as a decimal fraction of maximum, are included by selecting the name of a schedule instruction.



* PROCESS-BTUH

PROCESS-BTUH specifies the maximum number of British thermal units (Btu's) per hour entering the space due to a fuel conversion device (heat source) within a space. The number specified by the user is multiplied each hour by the value of the PROCESS-SCHEDULE for that hour.

* PROCESS-BTUH/SQFT

PROCESS-BTUH/SQFT specifies the maximum number of Btu's per square foot entering the space due to a process. Either this or the previous keyword may be specified. If both keywords are used, the program computes the contribution due to the sum of both values. The number specified by the user is multiplied each hour by the value of the PROCESS-SCHEDULE for that hour.

* PROCESS-SENSIBLE

PROCESS-SENSIBLE specifies the percentage of heat due to the process equipment in the space which becomes sensible heat.

* PROCESS-LATENT

PROCESS-LATENT specifies the percentage of heat due to the process equipment which becomes latent heat.

* SOURCE-SCHEDULE

SOURCE-SCHEDULE identifies a user-specified name as the name of a previously entered SCHEDULE instruction, or of a schedule library name, to be used in the energy input to a space due to an energy source.

* In Preparation

* SOURCE-BTUH — SOURCE-BTUH specifies the maximum number of Btu's per hour entering a space due to a fuel conversion device (heat source) within a space. This keyword allows the user to enter a second source (or process) having a schedule and maximum heat input rate different from that specified using the PROCESS keywords.

* SOURCE-BTU/SQFT — SOURCE-BTU/SQFT specifies the maximum number of Btu's per square foot entering a space due to a heat source. Either this or the previous keyword may be specified. If both keywords are used, the program computes the contribution due to the sum of both values.

* RESOURCE — RESOURCE identifies one of the following code-words to specify the type of primary fuel being used to supply the energy.

Code-words

OIL
GAS
COAL

INF-SCHEDULE — INF-SCHEDULE identifies the name of a previously entered SCHEDULE instruction, or of a schedule library name, used to specify the operation of HVAC fans which pressurize a building and hence affect the infiltration calculations which depend on wind velocity.

INF-METHOD — INF-METHOD specifies a code-word which identifies the calculational method used to compute the energy losses and gains due to infiltration. The program assumes that the user desires to use the air-change method to compute infiltration loads (i.e., default = 1). If the user desires to use the crack method, he must specify the value 2 for this keyword, and he must assign a non-zero value to the NEUTRAL-ZONE-HEIGHT keyword.

Method	Code-word
AIR-CHANGE	1
CRACK	2

INF-CFM/SQFT — INF-CFM/SQFT specifies the amount of outside air that may enter a space if the air-change method without wind speed modification is desired.

AIR-CHANGES/HR — AIR-CHANGES/HR specifies the number of air changes per hour, and uses a linear correction for the wind speed.

Either the value of this keyword is used in the infiltration calculations or the value specified by the INF-CFM/SQFT keyword should be used, but not both. If both keywords are assigned values, the infiltration calculation uses the sum.

FLOOR-WEIGHT — FLOOR-WEIGHT specifies the composite weight of the floor, furnishing, and interior walls for a space. This value, expressed in pounds per square foot of floor area, is used to adjust the internal heat capacity of the building and hence affects the transient thermal behavior of the building.

NEUTRAL-ZONE-HEIGHT — NEUTRAL-ZONE-HEIGHT is the height above the floor for a space at which the pressure differential which affects infiltration becomes zero.

5. SPACE

The SPACE instruction identifies all the information that a user wishes to associate with a particular room, wing, building, or space. It is the cornerstone upon which the description of a building is based. The geometrical data (such as height, width, area) and the positional data, which describe the location and orientation of a space within a building, are described using this instruction.

Name	Command	Keyword	Abbr	Value	Unit
u-name	SPACE S	LIKE		u-named	
		FLOOR-AREA	FA		ft^2
		SPACE-HEIGHT	SH		feet
		VOLUME	V		ft^3
		SPACE-MULTIPLIER	SM		number
		SPACE-CONDITIONS	SC	u-named	
		X-BUILDING	XB		feet
		Y-BUILDING	YB		feet
		Z-BUILDING	ZB		feet
		SPACE-AZIMUTH	SAZ		degrees
		SHAPE		code-word	
		WIDTH	W		feet
		DEPTH	D		feet
		HEIGHT	H		feet

Plus any keyword listed under the SPACE-CONDITIONS instruction

Rule 1: The SPACE-CONDITIONS default values are assumed if the SPACE-CONDITIONS keyword is not used to refer to a u-named SPACE-CONDITIONS instruction.

Rule 2: It is required for Cal-ERDA 1.3 that the user specify the dimensions and position for a SPACE which correspond to a ZONE in the SYSTEMS program. One ZONE instruction must appear in the SYSTEMS program, having an identical u-name, to correspond to each SPACE entered in the LOADS program.

Name	The user must enter a user-defined name in the name field.
SPACE	SPACE is a BDL command word used to indicate to the BDL processor that the following keywords and data define the geometry, position, and conditions for a space within a building. Alternatively, an entire building may also be treated as one space.
LIKE	LIKE is a BDL keyword used to specify the name of a previously entered SPACE instruction. An example of the LIKE instruction is as follows: ROOM-2 = SPACE LIKE ROOM-1 .. ROOM-2 is the user-assigned name for a copy of the SPACE and SPACE-CONDITIONS keyword data that were previously assigned to the u-name ROOM-1. Only the SPACE and SPACE-CONDITIONS keyword data are transferred using the LIKE keyword in the SPACE instruction. The keyword data for EXTERIOR-WALL, WINDOW, ROOF, etc. are not transferred using this LIKE keyword.
FLOOR-AREA	The user enters the gross floor area, in square feet, through which heat will flow for this space.
SPACE-HEIGHT	The user enters the interior height for the space, not including the thickness of floors, plenums, or ceilings; for spaces with sloped walls or ceilings, the average or mean floor-to-ceiling height should be entered.
VOLUME	The user must enter the volume of each space in cubic feet, since it is used in the SYSTEMS program.
SPACE-MULTIPLIER	This keyword is used to multiply the space peak loads to obtain peak loads for report LO3. This allows the user to examine the results of having multiple copies of similar spaces within a building (e.g. 10 or 15 similar offices along a south wall). This number must be specified again in the SYSTEMS program, where it is called ZONE-MULTIPLIER, to obtain the correct system peak loads.

SPACE-CONDITIONS

The keyword SPACE-CONDITIONS is to be followed by the u-name of a previously defined SPACE-CONDITIONS instruction. All the values for the keywords assigned in the previously named (u-named) SPACE-CONDITIONS instruction are assigned to the SPACE being described by using this keyword. In addition, a user may also specify any of the keywords associated with the SPACE-CONDITIONS instruction as a keyword of a SPACE instruction. These features allow a user to easily duplicate energy use data including occupancy, lighting, equipment, etc., yet still make selective changes. The examples illustrate use of the SPACE-CONDITIONS keyword to refer to the data previously named in a SPACE-CONDITIONS instruction.

X-BUILDING
Y-BUILDING
Z-BUILDING

The three keywords, X-BUILDING, Y-BUILDING, Z-BUILDING are used to specify the position of the origin V2 of a space within a building coordinate system.

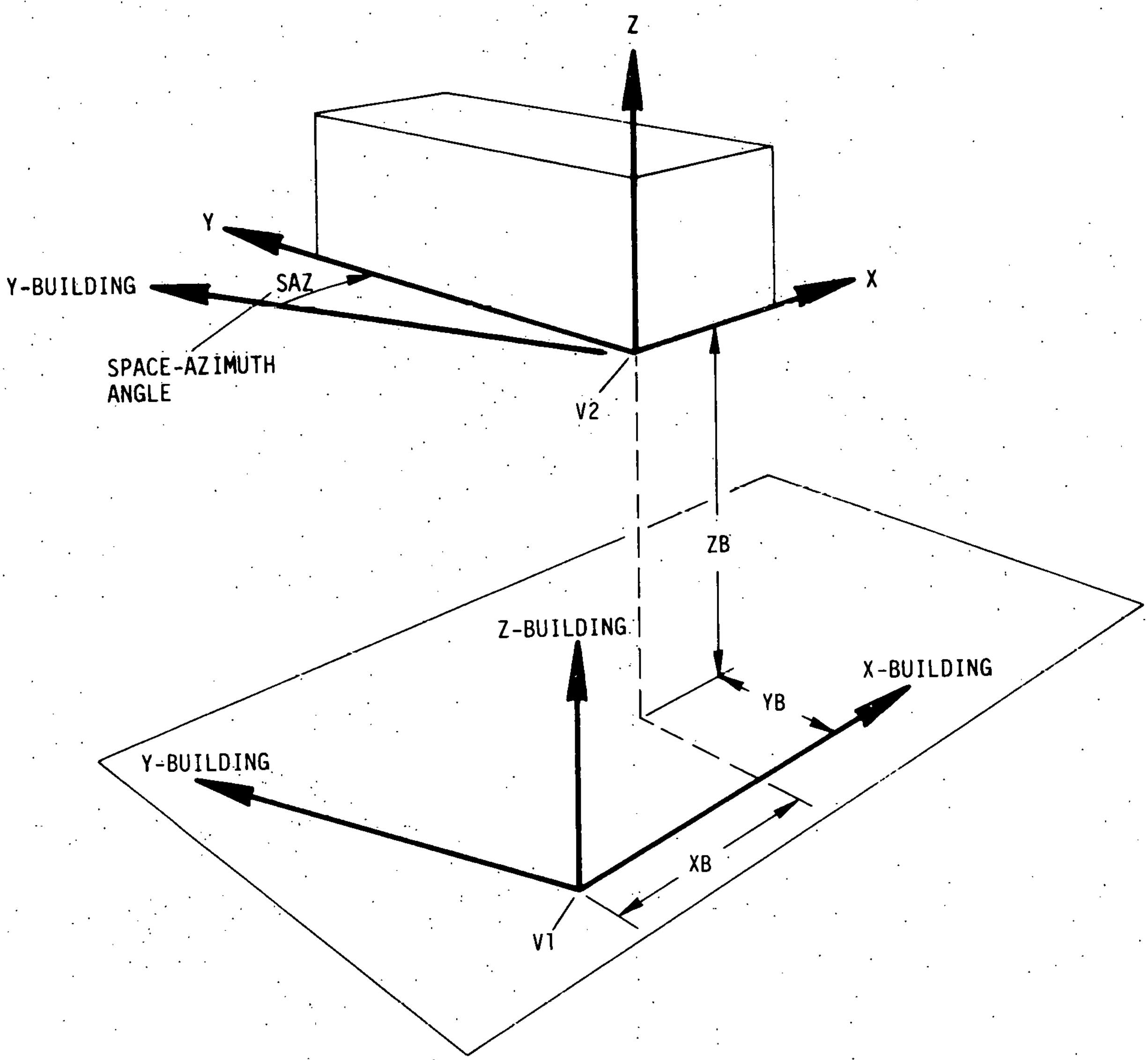
Figure III-13 illustrates the dimensions to be specified by the user for the keywords, XB, YB, and ZB. If the user does not specify any values for these keywords, then the default values, X-BUILDING = 0, Y-BUILDING = 0, and Z-BUILDING = 0 are used. This is equivalent to assuming that the origin of the space coordinate system is coincident with the origin of the building coordinate system.

The user may translate a space in the direction of the X-BUILDING axis by specifying a value, positive or negative, for the X-BUILDING keyword. In a similar fashion, the location of a space may be moved in the direction of the Y-BUILDING axis or raised or lowered in the Z-BUILDING axis direction. The examples in Chapter X illustrate the user input required to specify the position of several spaces within a building.

SPACE-AZIMUTH

The SPACE-AZIMUTH keyword is used to specify the angular rotation in degrees from the positive Y-BUILDING axis to the positive Y axis for the space being described. This angle is specified as a positive angle for a clockwise rotation and as a negative angle for counter-clockwise rotation as viewed from above. Note: both the Z-BUILDING axis and Z axis are parallel and both point up; hence, this angle may be measured in any X Y or X-BUILDING Y-BUILDING plane.

Figure III-13 also illustrates the SPACE-AZIMUTH angle.



Example of a Space Located Within a Building Coordinate System

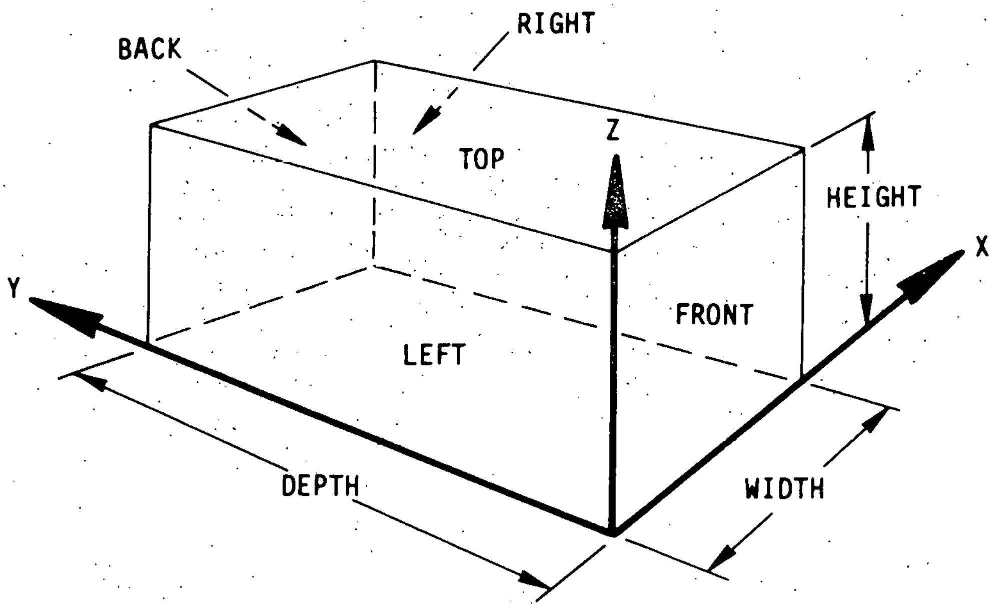
Figure III - 13

SHAPE

The SHAPE keyword is used to introduce keywords which identify the geometrical shape of a space. A user may specify SHAPE = BOX and assign values to the shape dimension keywords. A box-shaped space having dimensions as shown in Figure III-14 will be used in the heat transfer calculations to simulate the existence of a space shaped like a box. The SHAPE keyword is used as an alternate method to define a space.

WIDTH
DEPTH
HEIGHT

The keywords WIDTH, DEPTH, and HEIGHT specify the dimensions of a box-shaped space, in the direction of the X, Y, and Z coordinates of the space coordinate system, respectively. These keywords must be assigned values, they cannot use default values.



Example of SPACE Instruction keywords for SHAPE = BOX

Figure III - 14

The following example is an alternative method to describe the building shown in Figure II-1.

```
U-name = SPACE          SHAPE = BOX
                        WIDTH = 60
                        DEPTH = 100
                        HEIGHT = 20
```

6. EXTERIOR-WALL

The EXTERIOR-WALL instruction is used to specify the size, construction, shading, and position of an exterior wall for a space.

Name	Command	Keyword	Abbr	Value	Unit
u-name	EXTERIOR-WALL	LIKE		u-named	
	EW				
		HEIGHT	H		feet
		WIDTH	W		feet
		CONSTRUCTION	CONS	u-named	
		LOCATION		code-word	
		X			feet
		Y			feet
		Z			feet
		AZIMUTH	A		degrees
		TILT	T		degrees
		GND-REFLECTANCE	GR		number
		MULTIPLIER	M		number
		X-DIVISIONS	XD		number
		* FIN		u-named	
		* OVERHANG	OV	u-named	

* In preparation

Name — Any user-selected BDL name may be specified by the user. It is suggested that a convention be adopted by the user to simplify the later task of accounting for all the exterior walls, to be certain that all the exterior surfaces have been specified.

EXTERIOR-WALL — EXTERIOR-WALL is a BDL command word used to indicate that the keywords and data which follow are to be assigned to a specific exterior wall of the previous SPACE instruction.

LIKE — The LIKE keyword is used to identify a previously entered EXTERIOR-WALL instruction u-name. All the keyword data for a previously defined EXTERIOR-WALL instruction are copied using this keyword including size, construction, and values for the position keywords X, Y, Z, AZIMUTH, and TILT. A common use of this keyword is to select a similar EXTERIOR-WALL instruction and specify new values for the position keywords.

HEIGHT — The HEIGHT keyword specifies the height of an exterior wall parallel to the K axis of the surface coordinate system. An exterior measurement should be specified to be certain that all the heat transfer surface of the wall is accounted for.

WIDTH — The WIDTH keyword specifies the width of an exterior wall parallel to the J axis of the surface coordinate system.

CONSTRUCTION — The CONSTRUCTION keyword is followed by a u-name for a previously defined CONSTRUCTION instruction. All the keyword data associated with the named CONSTRUCTION instruction will be copied, which is used to enter user specified wall constructions.

LOCATION — The BDL keyword LOCATION is used to enter a code-word for the location of an exterior surface. This keyword is used to define defaults for the position and orientation keywords (i.e., X, Y, Z, AZIMUTH, and TILT). It is provided to reduce the amount of input a user must provide to describe an exterior surface when used in conjunction with the SHAPE keyword.

The numerical values of the WIDTH, DEPTH, and HEIGHT code-words are inserted into the values of the X, Y, Z, AZIMUTH and TILT keywords according to the following table, corresponding to SHAPE = BOX.

Relationship of LOCATION Code-words to the Position and Orientation Keywords for SHAPE = BOX

LOCATION	Keyword				
Code-Word	X	Y	Z	AZIMUTH	TILT
TOP	0	0	Height	180	0
FRONT	0	0	0	180	90
RIGHT	Width	0	0	90	90
BACK	Width	Depth	0	0	90
LEFT	0	Depth	0	-90	90

Example of SHAPE=BOX and LOCATION Keywords

```
U-name-1 = SPACE              SHAPE = BOX
                              WIDTH = 60
                              DEPTH = 100
                              HEIGHT = 20   ..

U-name-2 = EXTERIOR-WALL      LOCATION = TOP
                              CONSTRUCTION = roof-u-name ..

           EXTERIOR-WALL      LOCATION = FRONT
                              CONSTRUCTION = wall-u-name ..

           EXTERIOR-WALL      LOCATION = RIGHT
                              CONSTRUCTION = wall-u-name ..

           EXTERIOR-WALL      LOCATION = BACK
                              CONSTRUCTION - wall-u-name ..

           EXTERIOR-WALL      LOCATION = LEFT
                              CONSTRUCTION = wall-u-name ..
```

X
Y
Z

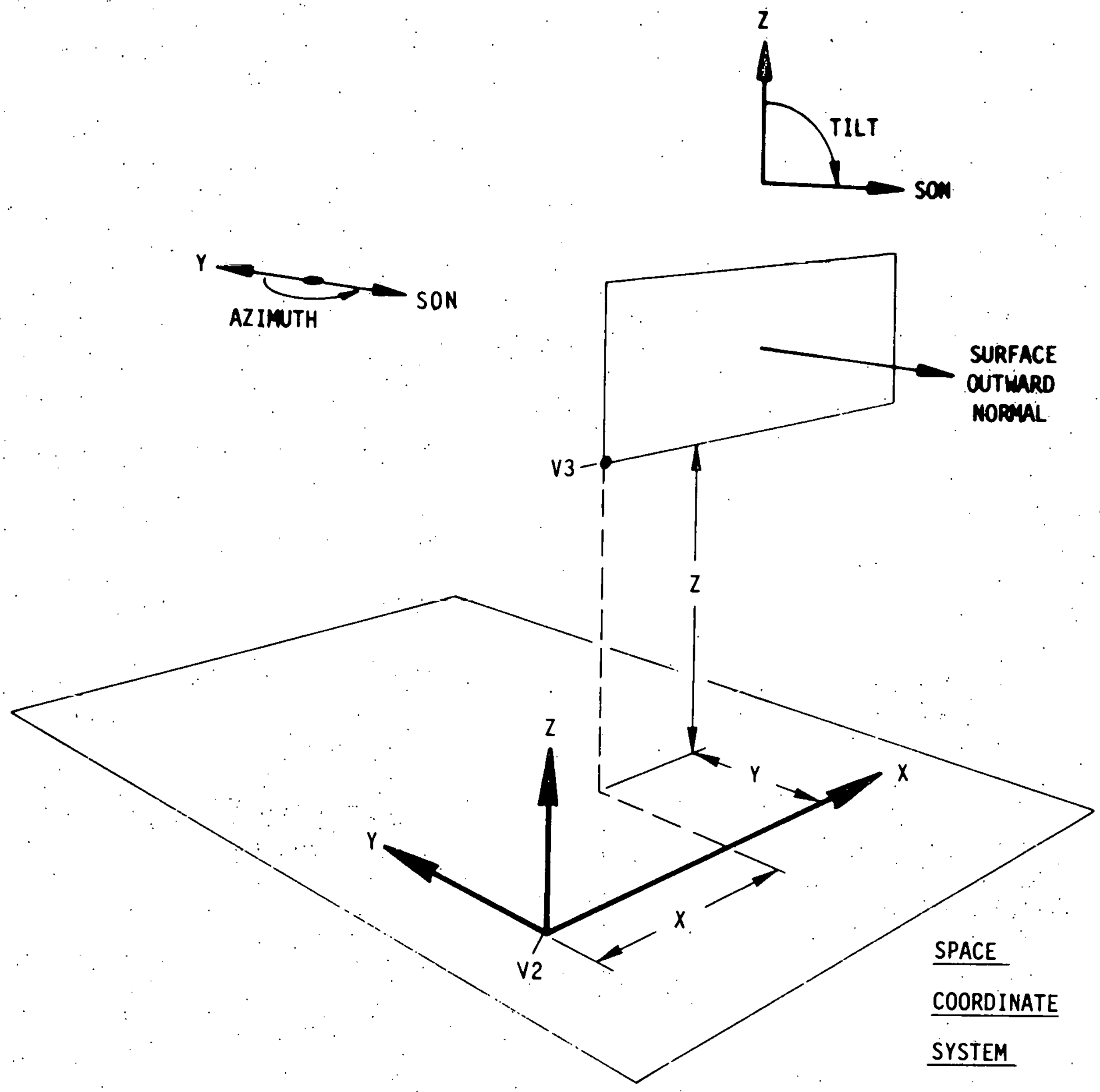
The three keywords X, Y, and Z are used to specify the position of the origin of the surface coordinate system attached to the exterior wall, in the space coordinate system. The distances, in feet, from V2 to V3 in Figure III-15 are specified as the values for these three keywords. If no values are specified, the origin of the surface is assumed to coincide with the origin of the space coordinate system. (i.e., the default values are X = 0, Y = 0, Z = 0.)

AZIMUTH

The AZIMUTH keyword specifies the angle from the positive Y axis of the space coordinate system to the surface outward normal, measured in degrees. This angle is defined as positive if measured in the clockwise direction, and as negative in the counter-clockwise direction, as viewed from above. The default value of zero assumes the surface outward normal (SON) is parallel to the positive Y axis. Figure III-16illustrates the definition of the AZIMUTH keyword.

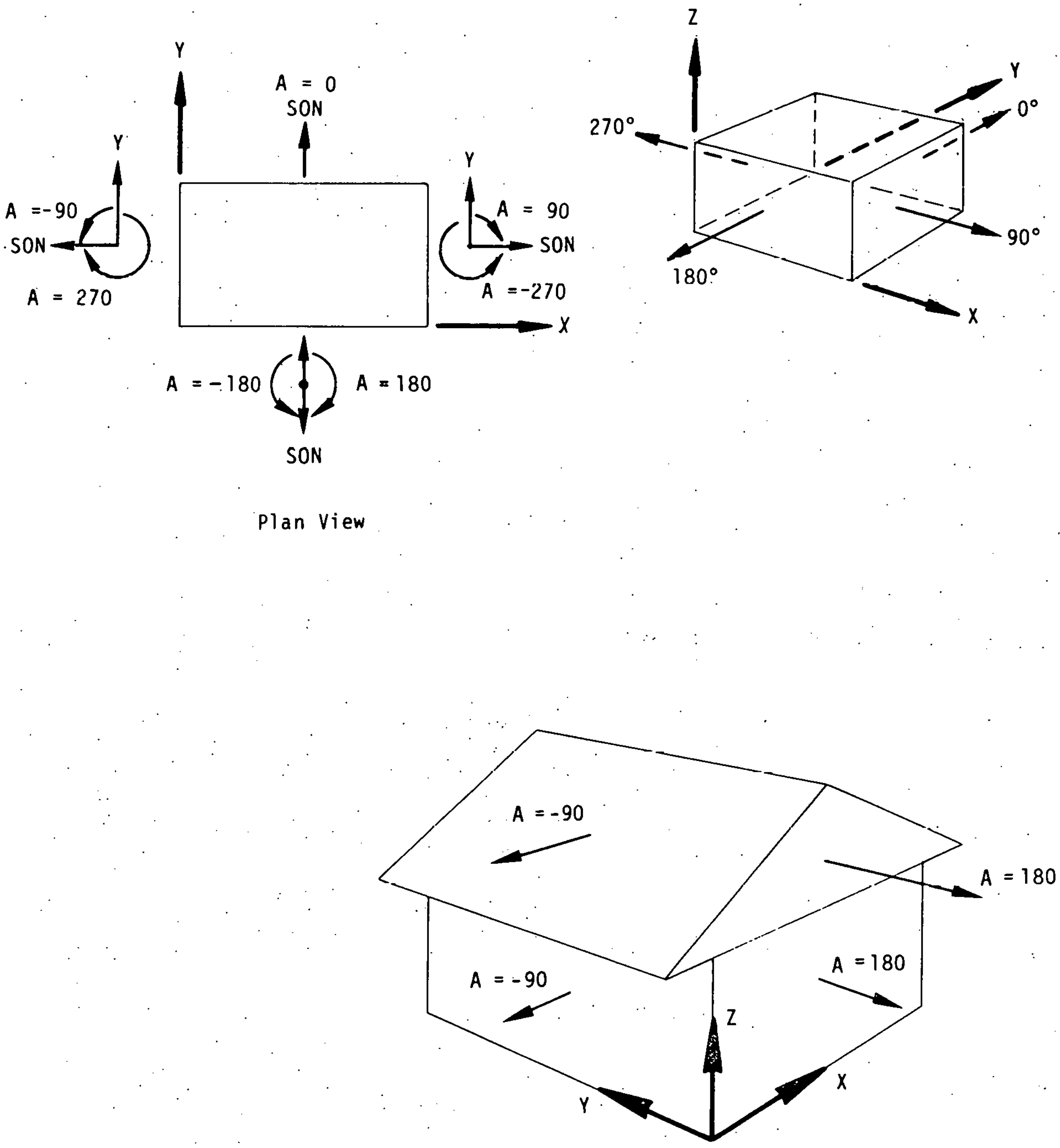
TILT

The TILT keyword specifies the angle from the vertical, or positive, Z axis of the space coordinate system to the surface outward normal, measured in degrees. Hence, a flat roof or any surface facing up has a TILT = 0.0. The default value for this keyword is TILT = 90.0,which assumes that a vertical wall is being defined. Figure III-12 illustrated the TILT keyword.



Example of a Surface Located Within a Space Coordinate System

Figure III - 15

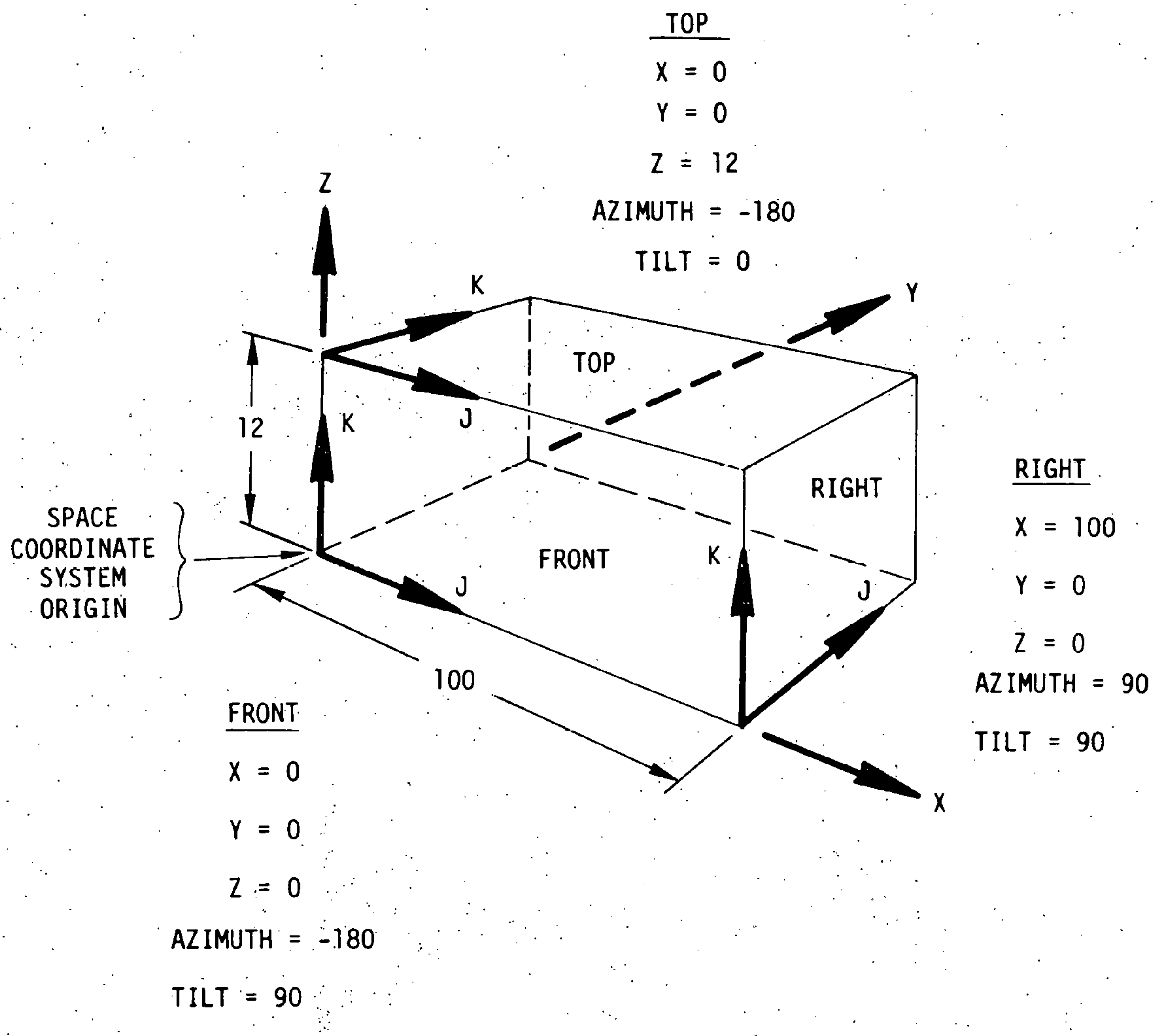


Example of the AZIMUTH Keyword for the EXTERIOR-WALL Instruction

Figure III - 16

Example

Figure III-17 provides an example of the surface position keywords (X, Y, Z, AZIMUTH and TILT) for three surfaces of a space (FRONT, RIGHT, and TOP).



Examples of Surface Position Keywords

Figure III-17

GND-REFLECTANCE — The GND-REFLECTANCE keyword is used to specify a number which may be taken from the following table. (See Ref. I-3)

Surface	GND-REFLECTANCE
Ocean	0.05
Bituminous Concrete	0.07
Wheat Field	0.07
Dark Soil	0.08
Green Field	0.12-0.25
Grass, Dry	0.20
Crushed Rock Surface	0.20
Concrete, Old	0.24
Concrete, Light Colored	0.30

Other numbers, besides those indicated in the table, may also be specified by the user. For example, if the ground facing the exterior wall surface were a paved asphalt parking lot, the user might specify: GND-REFLECTANCE = 0.18.

MULTIPLIER — A number of walls having similar heat transfer properties may be specified by the user. The area of the exterior heat transfer boundary is multiplied by the value of this keyword.

X-DIVISIONS — The X-DIVISIONS keyword is followed by an integer which specifies the number of divisions by which a user desires to segment an exterior wall, for the shading calculations. The higher the number of X-DIVISIONS, the longer the computations will require, and the more detailed the answer will be. As a general guide, selecting a number about equal to the value specified for the WIDTH keyword will give one division per foot of exterior wall width.

* FIN
* OVERHANG — These keywords refer to the u-name of an instruction which defines the position of shading attachments (e.g., fins, balconies, overhangs) on the outside of an exterior wall.

* In Preparation

7. INTERIOR-WALL

The INTERIOR-WALL instruction is used to specify the size, construction, and adjacent space for an interior wall of a space. The data are used to compute the heat transfer through the interior surface.

Name	Command	Keyword	Abbr	Value	Unit
u-name	INTERIOR-WALL IW	LIKE		u-named	
		AREA			ft^2
		CONSTRUCTION	CONS	u-named	
		MULTIPLIER	M		number
		NEXT-TO	NT		

Name — Any unique user-defined BDL name may be inserted in the name field.

INTERIOR-WALL — INTERIOR-WALL is a BDL command word used to inform the BDL processor that the data which follow describe an interior wall.

LIKE — The LIKE keyword may be used to specify the u-name of a previously named INTERIOR-WALL instruction. All the keyword data will be duplicated including the NEXT-TO assignment.

AREA — The AREA keyword specifies the area for an interior wall having the type of construction, adjacent space, and number of identical wall sections specified in the following keywords. Note: Interior partitions which contain windows should be specified using two separate INTERIOR-WALL instructions, one giving the area and construction of the panel, and the other giving the area and construction for the glazed portion. If an interior partition is not a thermal barrier across which any significant amount of heat would reasonably be expected to flow, it should not be specified. An example of this latter situation would be free-standing divider panels placed in an open plan office.

CONSTRUCTION — The CONSTRUCTION keyword identifies the u-name of a previously entered CONSTRUCTION instruction. A steady-state heat transfer coefficient, or u-value, must be specified by the CONSTRUCTION instruction. Response factor calculations are not performed on interior walls.

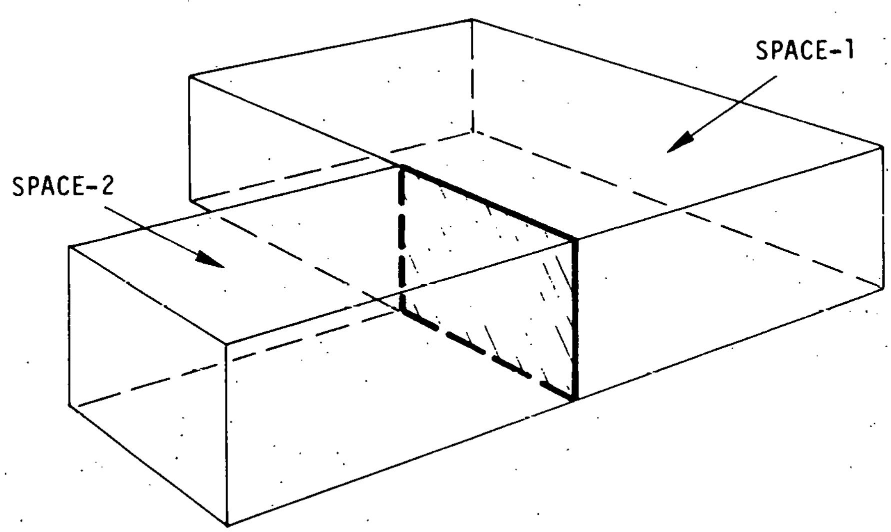
MULTIPLIER

The MULTIPLIER keyword specifies the number of identical interior surfaces having the AREA, CONSTRUCTION, and NEXT-TO data specified in the previous keywords. The default value is 1.0, which assumes the total area is specified after the AREA keyword, rather than the area of one interior panel.

NEXT-TO

The NEXT-TO keyword is to be followed by the u-name of a previously named space. This keyword informs the BDL processor how to compute the internal heat transfer across this interior surface. The need to refer to a previously named space suggests that the user identify and name interior walls in a sequence of adjacent spaces. The user is cautioned not to account for one interior surface twice. An INTERIOR-WALL instruction which describes the surface between two spaces may be entered under either SPACE instruction, but not both.

Figure III-18 illustrates a surface of SPACE-1 as NEXT-TO, or between, SPACE-2.



Example of an INTERIOR-WALL Between Two Spaces

Figure III-18

8. UNDERGROUND-WALL

The UNDERGROUND-WALL instruction is used to specify the size, construction, and adjacent space for an underground wall of a space. The data are used to compute the heat transfer through the surface.

Name	Command	Keyword	Abbr	Value	Unit
u-name	UNDERGROUND-WALL	LIKE		u-named	
	UW	AREA			ft^2
		CONSTRUCTION	CONS	u-named	
		MULTIPLIER	M		number

Name	Any unique user-defined BDL name may be inserted in the name field.
UNDERGROUND-WALL	UNDERGROUND-WALL is a BDL command word used to inform the BDL processor that the data which follow describe wall having earth against one surface.
LIKE	The LIKE keyword may be used to specify the u-name of a previously named UNDERGROUND-WALL instruction. All the keyword data will be duplicated .
AREA	The AREA keyword specifies the area for an underground wall having the type of construction and number of identical wall sections specified in the following keywords.
CONSTRUCTION	The CONSTRUCTION keyword identifies the u-name of a previously entered CONSTRUCTION instruction. A steady-state heat transfer coefficient, or u-value, must be specified by the CONSTRUCTION instruction. Response factor calculations are not performed on underground walls.
MULTIPLIER	The MULTIPLIER keyword specifies the number of identical surfaces having the same AREA, and CONSTRUCTION. The default value is 1.0 , which assumes the total area is specified after the AREA keyword.

9. FLOOR

The FLOOR instruction is used to specify the size, construction, and adjacent space for an interior floor. The data are used to compute the heat transfer through the interior surface.

Name	Command	Keyword	Abbr	Value	Unit
u-name	FLOOR	LIKE		u-named	
	FL	AREA			ft^2
		CONSTRUCTION	CONS	u-named	
		MULTIPLIER	M		number
		NEXT-TO	NT	u-named	

Name — Any unique user-defined BDL name may be inserted in the name field.

FLOOR — FLOOR is a BDL command word used to inform the BDL processor that the data which follow describe an interior floor.

LIKE — The LIKE keyword may be used to specify the u-name of a previously named FLOOR instruction. All the keyword data will be duplicated including the NEXT-TO assignment.

AREA — The AREA keyword specifies the area for an interior floor having the type of construction, adjacent space, and number of identical sections specified in the following keywords.

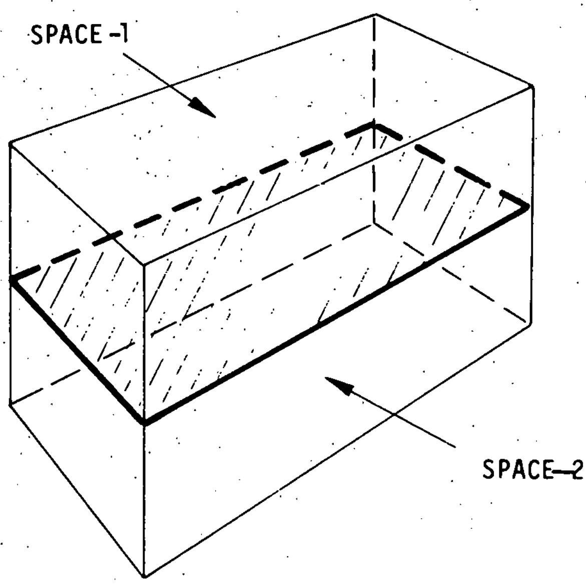
CONSTRUCTION — The CONSTRUCTION keyword identifies the u-name of a previously entered CONSTRUCTION instruction. A steady-state heat transfer coefficient, or u-value, must be specified by the CONSTRUCTION instruction. Response factor calculations are not performed on interior floors.

MULTIPLIER — The MULTIPLIER keyword specifies the number of identical interior surfaces having the AREA, CONSTRUCTION, and NEXT-TO data specified in the previous keywords. The default value is 1.0, which assumes the total area is specified after the AREA keyword.

NEXT-TO

The NEXT-TO keyword is to be followed by the u-name of a previously named space. This keyword informs the BDL processor how to compute the internal heat transfer across this interior surface. The need to refer to a previously named space suggests that the user identify and name interior surfaces in a sequence of adjacent spaces. The user is cautioned not to account for one interior surface twice. A FLOOR instruction which describes the surface between two spaces may be entered under either SPACE instruction, but not both.

Illustrations for NEXT-TO keyword
of the INTERIOR-WALL Instruction



Example of a FLOOR Between Two Spaces

10. UNDERGROUND-FLOOR

The UNDERGROUND-FLOOR instruction is used to specify the size, construction, and adjacent space for an underground floor. The data are used to compute the heat transfer through the surface.

Name	Command	Keyword	Abbr	Value	Unit
u-name	UNDERGROUND-FLOOR	LIKE		u-named	
	UF	AREA			ft^2
		CONSTRUCTION	CONS	u-named	
		MULTIPLIER	M		number

Name	Any unique user-defined BDL name may be inserted in the name field.
UNDERGROUND-FLOOR	UNDERGROUND-FLOOR is a BDL command word used to inform the BDL processor that the data which follow describe a floor constructed directly on top of earth.
LIKE	The LIKE keyword may be used to specify the u-name of a previously named UNDERGROUND-FLOOR instruction. All the keyword data will be duplicated.
AREA	The AREA keyword specifies the area for an underground floor having the type of construction, and number of identical sections specified in the following keywords.
CONSTRUCTION	The CONSTRUCTION keyword identifies the u-name of a previously entered CONSTRUCTION instruction. A steady-state heat transfer coefficient, or u-value, must be specified by the CONSTRUCTION instruction. Response factor calculations are not performed on underground floors.
MULTIPLIER	The MULTIPLIER keyword specifies the number of identical surfaces having the same AREA and CONSTRUCTION data specified in the previous keywords. The default value is 1.0, which assumes the total area is specified after the AREA keyword.

11. ROOF

The ROOF instruction is used to specify the size, construction, shading, and position of an exterior roof for a space.

Name	Command	Keyword	Abbr	Value	Unit
u-name	ROOF	LIKE		u-named	
		LENGTH	L		feet
		WIDTH	W		feet
		CONSTRUCTION	CONS	u-named	
		LOCATION		code-word	
		X			feet
		Y			feet
		Z			feet
		AZIMUTH	A		degrees
		TILT	T		degrees
		GND-REFLECTANCE	GR		number
		MULTIPLIER	M		number
		X-DIVISIONS	XD		number
		* FIN		u-named	
		* OVERHANG	OV	u-named	

Name — Any user-selected BDL name may be specified by the user. It is suggested that a convention be adopted by the user to simplify the later task of accounting for all the exterior roofs, to be certain that all the exterior surfaces have been specified.

ROOF — ROOF is a BDL command word used to indicate that the keywords and data which follow are to be assigned to a specific exterior roof of the previous SPACE instruction.

LIKE — The LIKE keyword is used to identify a previously entered ROOF instruction u-name. All the keyword data for a previously defined ROOF instruction are copied using this keyword including size, construction, and values for the position keywords X, Y, Z, AZIMUTH, and TILT. A common use of this keyword is to select a similar ROOF instruction and specify new values for the position keywords.

* In Preparation

LENGTH

The LENGTH keyword specifies the length of an exterior roof parallel to the K axis of the surface coordinate system. An exterior measurement should be specified to be certain that all the heat transfer surface of the roof is accounted for. The LENGTH multiplied by the WIDTH must equal the area of the exterior surface. For polygon surfaces other than rectangles, the user should enter an appropriate equivalent length. For example, a hip roof typically has two triangular surfaces and two trapazoidal surfaces. Hence, the user should compute an equivalent length and width to provide the appropriate heat transfer surface area.

WIDTH

The WIDTH keyword specifies the width of an exterior roof parallel to the J axis of the surface coordinate system.

CONSTRUCTION

The CONSTRUCTION keyword is followed by a u-name for a previously defined CONSTRUCTION instruction. All the keyword data associated with the named CONSTRUCTION instruction will be copied, which is used to enter user specified roof constructions.

LOCATION

The BDL keyword LOCATION is used to enter a code-word for the location of an exterior surface. This keyword is used to define defaults for the position and orientation keywords (i.e., X, Y, Z, AZIMUTH, and TILT). It is provided to reduce the amount of data a user must enter to describe an exterior surface when used in conjunction with the SHAPE keyword.

Relationship of LOCATION Code-words to the Position and Orientation Keywords for SHAPE = BOX

LOCATION	Keyword				
Code-Word	X	Y	Z	AZIMUTH	TILT
TOP	0	0	Height	180	0
FRONT	0	0	0	180	90
RIGHT	Width	0	0	90	90
BACK	Width	Depth	0	0	90
LEFT	0	Depth	0	-90	90

X
Y
Z

The three keywords X, Y, and Z are used to specify the position of the origin of the surface coordinate system attached to the roof, in the space coordinate system. The distances, in feet, from V2 to V3 in Figure III-15 are specified as the values for these three keywords. If no values are specified, the origin of the surface is assumed to coincide with the origin of the space coordinate system. (I.e., the default values are X = 0, Y = 0, Z = 0.)

AZIMUTH

The AZIMUTH keyword specifies the angle from the positive Y axis of the space coordinate system to the surface outward normal, measured in degrees. This angle is defined as positive if measured in the clockwise direction, and as negative in the counter-clockwise direction, as viewed from above. The default value of zero assumes the surface outward normal is parallel to the positive Y axis. Figure III-16 illustrates the definition of the AZIMUTH keyword.

For a horizontal ROOF the user should enter AZIMUTH=-180.0, and TILT=0.0.

TILT

The TILT keyword specifies the angle from the vertical, or positive, Z axis of the space coordinate system to the surface outward normal, measured in degrees. Hence, a flat roof or any surface facing up has a TILT = 0.0. The default value for this keyword is TILT = 90., which assumes that a vertical wall is being defined. Figure III-12 illustrates the TILT keyword.

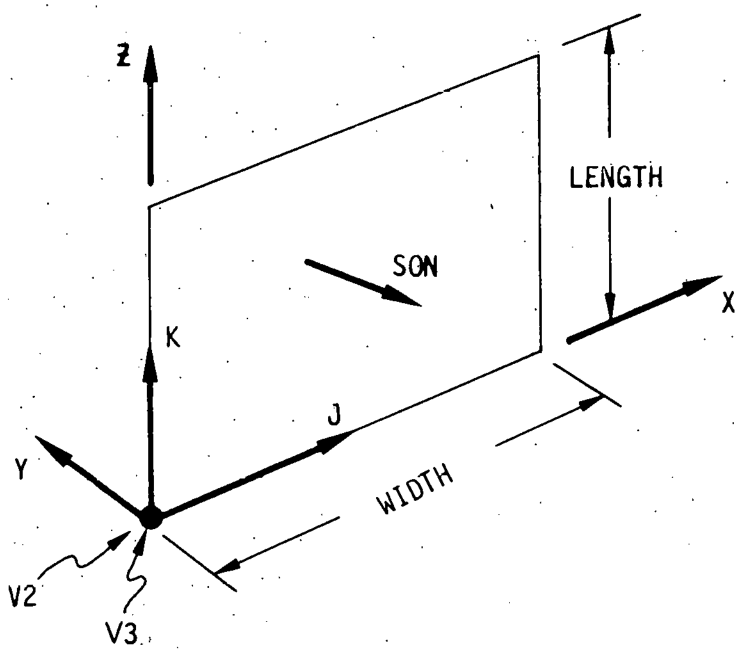
<u>Examples</u>

When a user attempts to specify the position and orientation keyword values for a roof surface, it is recommended that the user first visualize the surface as in its default position (X = 0, Y = 0, Z = 0, A = 180, T = 90). These keywords represent a vertical surface in the XZ plane, of an arbitrary size. Figure III-19 illustrates this position where the surface coordinate origin (V3) coincides with the space coordinate origin (V2).

The user should then specify the distance from the origin of the space coordinate system (V2) to the lower right hand corner (V3) of the surface being defined, as viewed from V2 in the direction of the surface outward normal (SON). This convention is equivalent to specifying the lower left hand corner of the surface being defined as viewed looking into the surface outward normal. The values for the keywords X, Y, and Z should be specified.

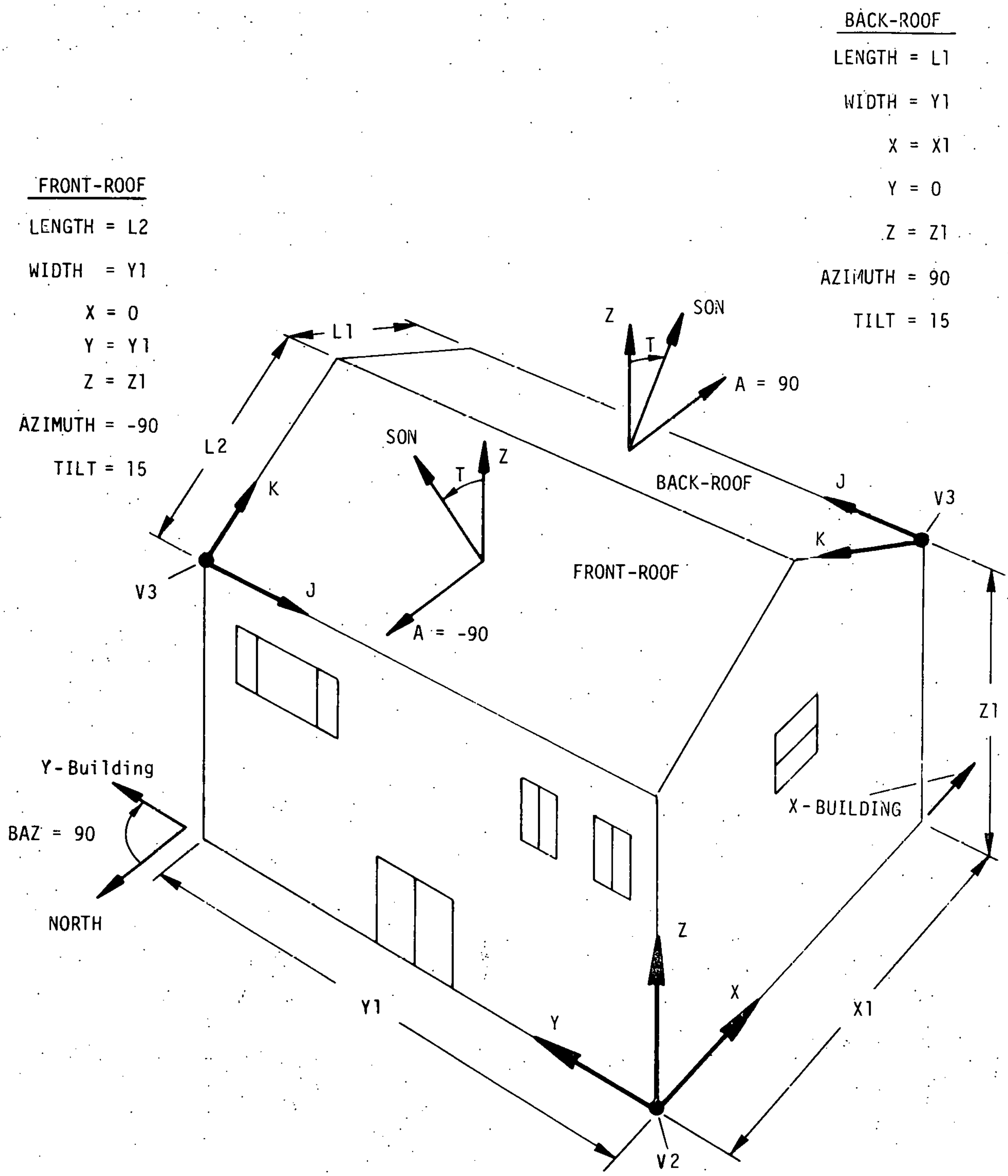
Next the user should rotate the surface and specify the proper AZIMUTH keyword such that the Surface Outward Normal (SON) points in the appropriate direction. The proper TILT angle, as measured from the vertical Z axis to the surface Outward Normal (SON), should be specified. Finally the LENGTH keyword, in the direction of the K axis, and the WIDTH keyword, in the direction of the J axis should be specified to describe the proper area of the ROOF surface.

Figure III-20 illustrates the ROOF keywords for a two surface roof, and Figure III-21 for a four surface roof.

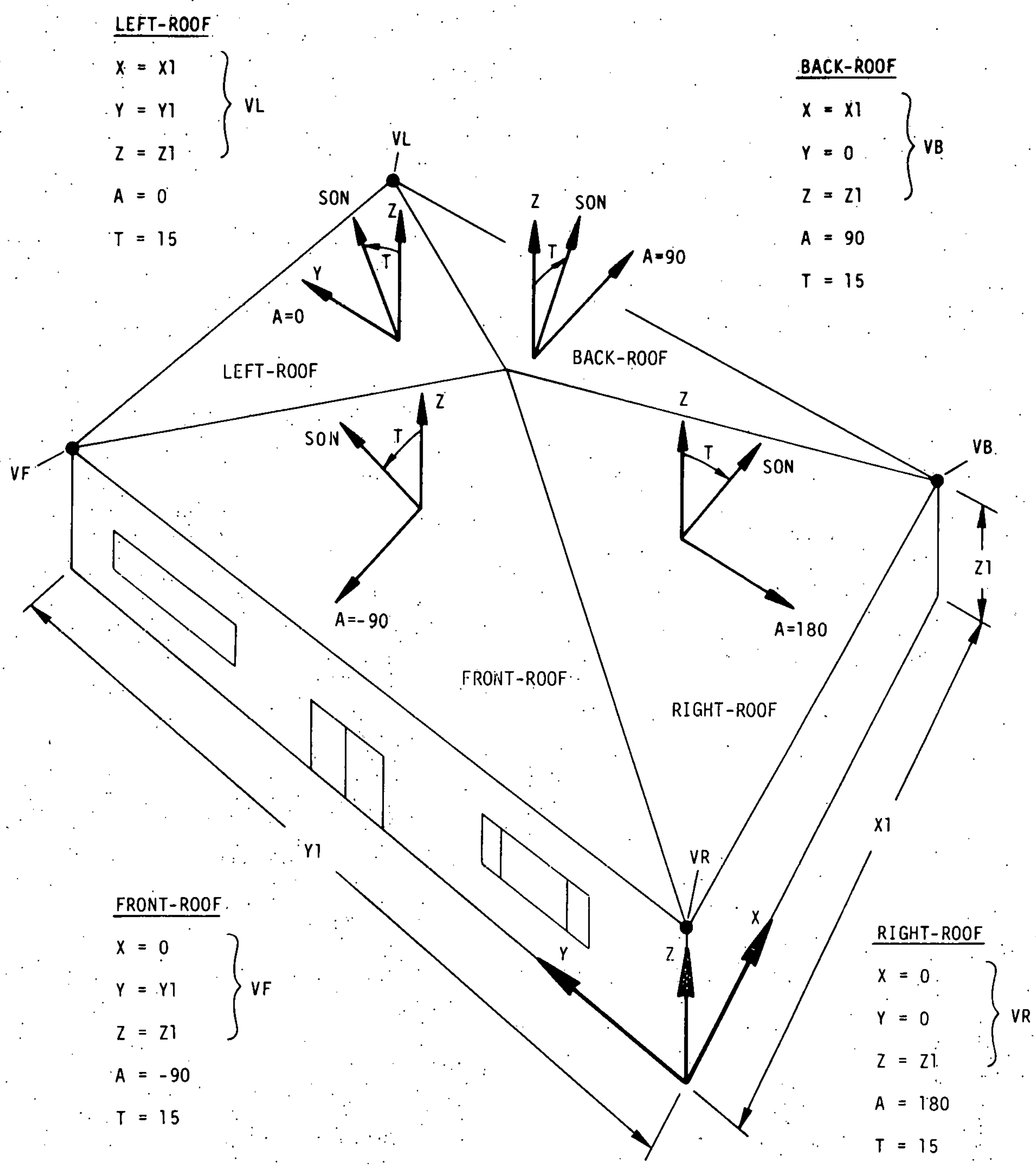


Default Position of Roof Surface

Figure III - 19



Example of ROOF Keywords
Figure III - 20



Example of ROOF Position and Orientation Keywords

Figure III - 21

GND-REFLECTANCE

The GND-REFLECTANCE keyword is used to specify a number which may be taken from the following table. (Ref. I-3)

Surface	GND-REFLECTANCE
Ocean	0.05
Bituminous Concrete	0.07
Wheat Field	0.07
Dark Soil	0.08
Green Field	0.12-0.25
Grass, Dry	0.20
Crushed Rock Surface	0.20
Concrete, Old	0.24
Concrete, Light Colored	0.30

Other numbers, besides those indicated in the table, may also be specified by the user. For example, if the ground facing the exterior wall surface were a paved asphalt parking lot, the user might specify: GND-REFLECTANCE = 0.18

These ground reflectance numbers apply to a roof mounted such that it interacts with the ground, e.g., a mansard style roof "sees" the ground. For a flat horizontal roof, the user would enter GND-REFLECTANCE = 0.

MULTIPLIER

A number of walls having similar heat transfer properties may be specified by the user. The area of the exterior heat transfer boundary is multiplied by the value of this keyword.

X-DIVISIONS

The X-DIVISIONS keyword is followed by an integer which specifies the number of divisions by which a user desires to segment an exterior roof, for the shading calculations. The higher the number of X-DIVISIONS, the longer the computations will require, and the more detailed the answer will be. As a general guide, selecting a number about equal to the value specified for the WIDTH keyword will give one division per foot of exterior roof width.

* FIN
* OVERHANG

The Fin or Overhang keyword refers to the u-name of a FIN or OVERHANG instruction which defines the position of shading attachments on the outside of an exterior wall.

* In Preparation

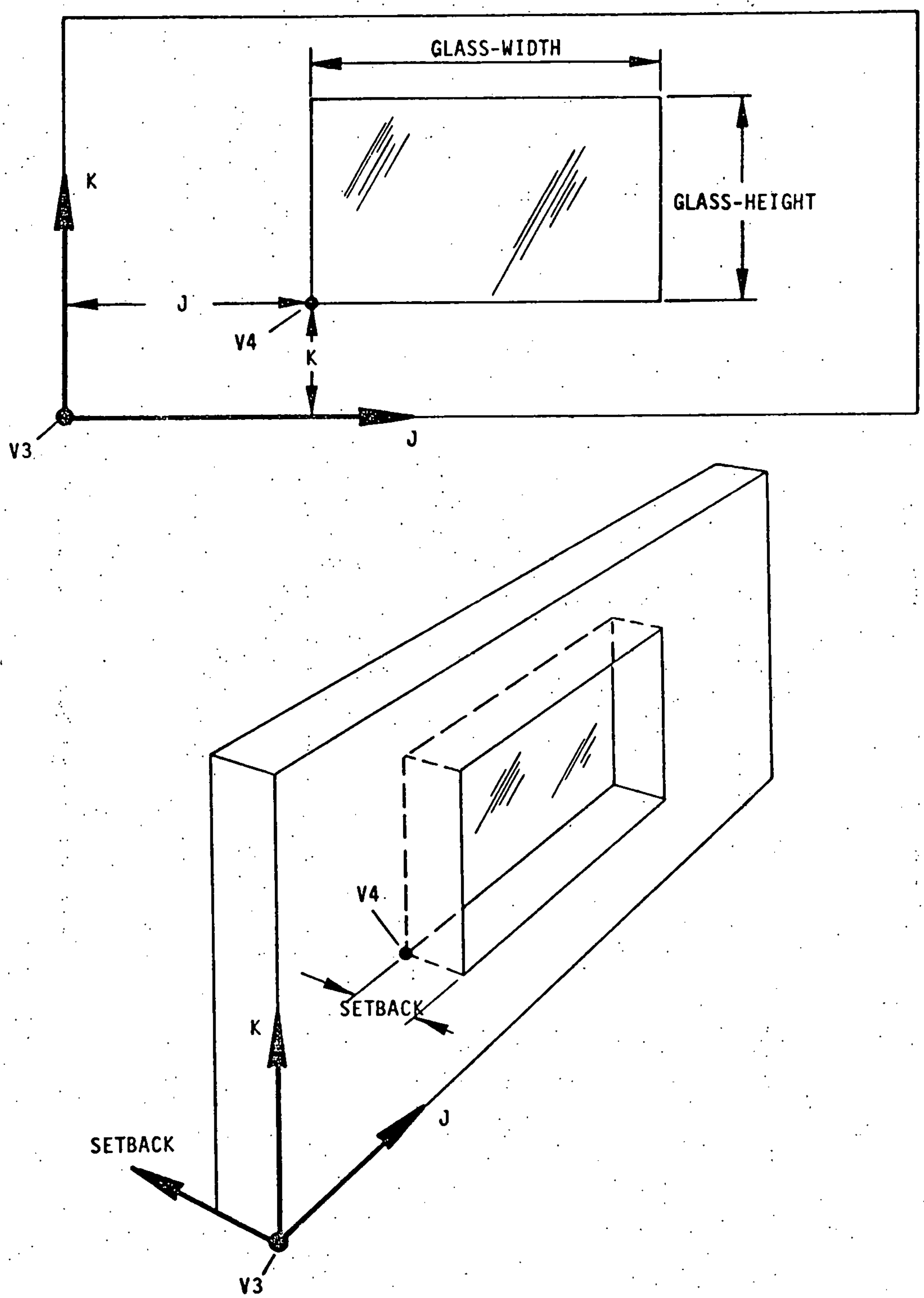
12. <u>WINDOW</u>
<u>SKYLIGHT</u>

The WINDOW, or SKYLIGHT, instruction is used to specify the heat transfer properties, size, position, shading, and number of windows on an EXTERIOR-WALL or ROOF. A WINDOW instruction must be inserted immediately following an EXTERIOR-WALL instruction to indicate that the EXTERIOR-WALL contains windows; similarly, a SKYLIGHT instruction should follow a ROOF instruction when needed. This ordering of instructions takes advantage of the data hierarchy feature described in Section II-G. The BDL processor will subtract the user-specified window or skylight area from the related exterior wall or roof area, and compute the heat transfer through the window if this instruction is specified.

Name	Command	Keyword	Abbr	Value	Units
u-name	WINDOW SKYLIGHT WI	LIKE		u-named	
		GLASS-HEIGHT	GH		feet
		GLASS-WIDTH	GW		feet
		GLASS-TYPE	GT	u-named	
		J			feet
		K			feet
		SETBACK	SET B		feet
		MULTIPLIER	M		number
		SKY-FORM-FACTOR	SFF		number
		GND-FORM-FACTOR	GFF		number
		X-DIVISIONS	XD		number
	*	FIN		u-named	
	*	OVERHANG	OV	u-named	

* In preparation

Name	A user may enter any BDL u-name in the name field of this instruction.
WINDOW	The BDL command word WINDOW or SKYLIGHT informs the BDL processor that the data which follow describe the properties of a glass surface on an exterior wall.
LIKE	The keyword LIKE may be followed by the u-name of a previously named WINDOW instruction.
GLASS-HEIGHT	The GLASS-HEIGHT keyword specifies the height of the glazed area parallel to the K axis of the surface coordinate system. If the glass area is not rectangular, for example, having a curved top, then a mean or average height should be specified.
GLASS-WIDTH	The GLASS-WIDTH keyword is used to specify the mean or average width of the glazed area, as measured parallel to the J axis of the surface coordinate system.
GLASS-TYPE	The GLASS-TYPE keyword is to be followed by the u-name of a previously defined GLASS-TYPE instruction, which is used to specify the heat transfer characteristics.
J K SETBACK	The distance from the origin of the surface coordinate system to the origin of a window, its lower left-hand corner as viewed from the outside, is specified by the J, K, and SETBACK keywords. Figure III-22 illustrates the position of the window origin (V 4) with respect to the surface coordinate origin (V 3). The SETBACK keyword may not have a negative value. If a window or skylight protrudes from a surface, it should be specified as being flush to the surface (i.e. SETBACK = 0).



Example of Surface Position Keywords (J, K, and SETBACK) for the WINDOW or SKYLIGHT Instruction.

Figure III - 22

MULTIPLIER — The MULTIPLIER keyword specifies the number of windows having identical area and heat transfer characteristics. The position data are not duplicated.

SKY-FORM-FACTOR — The SKY-FORM-FACTOR keyword specifies that fraction of a hemisphere that would be seen as sky, if viewed looking out the window or skylight from a point on the exterior surface. The default value of 0.5 assumes a vertical window mounted flush to the exterior surface of a vertical wall. An upward facing skylight would have a SKY-FORM-FACTOR equal to 1.0.

GND-FORM-FACTOR — The GND-FORM-FACTOR keyword specifies that fraction of a hemisphere that would be seen as ground, if viewed looking out the window or skylight from a point on the exterior surface. The default value of 0.5 assumes a vertical window mounted flush to the exterior surface of a vertical wall. An upward facing skylight would have a GND-FORM-FACTOR equal to 0.0.

X-DIVISIONS — The X-DIVISIONS keyword specifies the total number of segments a user selects to divide the window into for a computation of the shading on a window. Selecting a number equal to twice the window width expressed in feet results in accounting for the shading effect in six-inch increments. Selecting a large number (e.g., twenty divisions per foot of width) will result in much larger computing costs and a slightly more accurate estimate of the effect of shading.

* FIN — The FIN keyword is followed by the u-name for a FIN instruction which in turn specifies the geometrical data associated with a fin.

* OVERHANG — The OVERHANG keyword is followed by the u-name for an OVERHANG instruction which in turn specifies the geometrical data for an overhang.

13. GLASS-TYPE

The GLASS-TYPE instruction specifies the thermal properties of a window.

Name	Command	Keyword	Abbr	Value	Units
u-name	GLASS-TYPE	LIKE		u-named	
		PANES	P		number
		GLASS-TYPE-CODE	GTC		number
		GLASS-SHADING	GS		number
		GLASS-INFILTRATION	GI		number
		GLASS-CONDUCTANCE	GCON		number

Name — Any user-defined BDL name may be entered in the name field of this instruction.

GLASS-TYPE — The BDL command word GLASS-TYPE identifies the data which follow as the heat transfer characteristics for a window.

LIKE — The LIKE keyword is used to specify the u-name for a previously defined GLASS-TYPE instruction to duplicate all the keywords and their values for this instruction.

PANES — A user enters the total number of glass surfaces following the PANES keyword. An integer number must be given (i.e. for double glazing PANES = 2).

GLASS-TYPE-CODE — The user enters a code-number, selected from the following table, to identify the type of glass. The code number determines which values to use for the product of sheet thickness times extinction coefficient (see Ref. I-3).

GLASS-TYPE-CODE

Type of Glass	k * l	Code-number
1/8 inch sheet	0.05	1
	0.10	2
1/4 inch plate	0.15	3
	0.20	4
	0.40	5
	0.60	6
50% transparent H.A. plate	0.80	7
	1.00	8

GLASS-SHADING

The GLASS-SHADING keyword specifies the ratio of the solar heat gain through the given window to that for a single sheet of one-eighth inch thick double strength glass. A value of 1.0 indicates a transparency equal to one-eighth inch thick glass (i.e., clear), and a value of 0.1 indicates an almost opaque glass. The minimum allowed value of 0.0 instructs the BDL processor to use the value for transmission at normal incidence specified by the GLASS-TYPE-CODE keyword.

GLASS-INFILTRATION

The GLASS-INFILTRATION keyword defines the infiltration flow coefficient for various types of windows. A minimum value of 0.0 indicates that no infiltration will occur, and a value of 18.0 indicates that a glass door is used (see Ref. I-3, pp. 4-40 and Ref. I-5, Chapter 19; see also Carrier-Load Estimating Guide).

GLASS-INFILTRATION

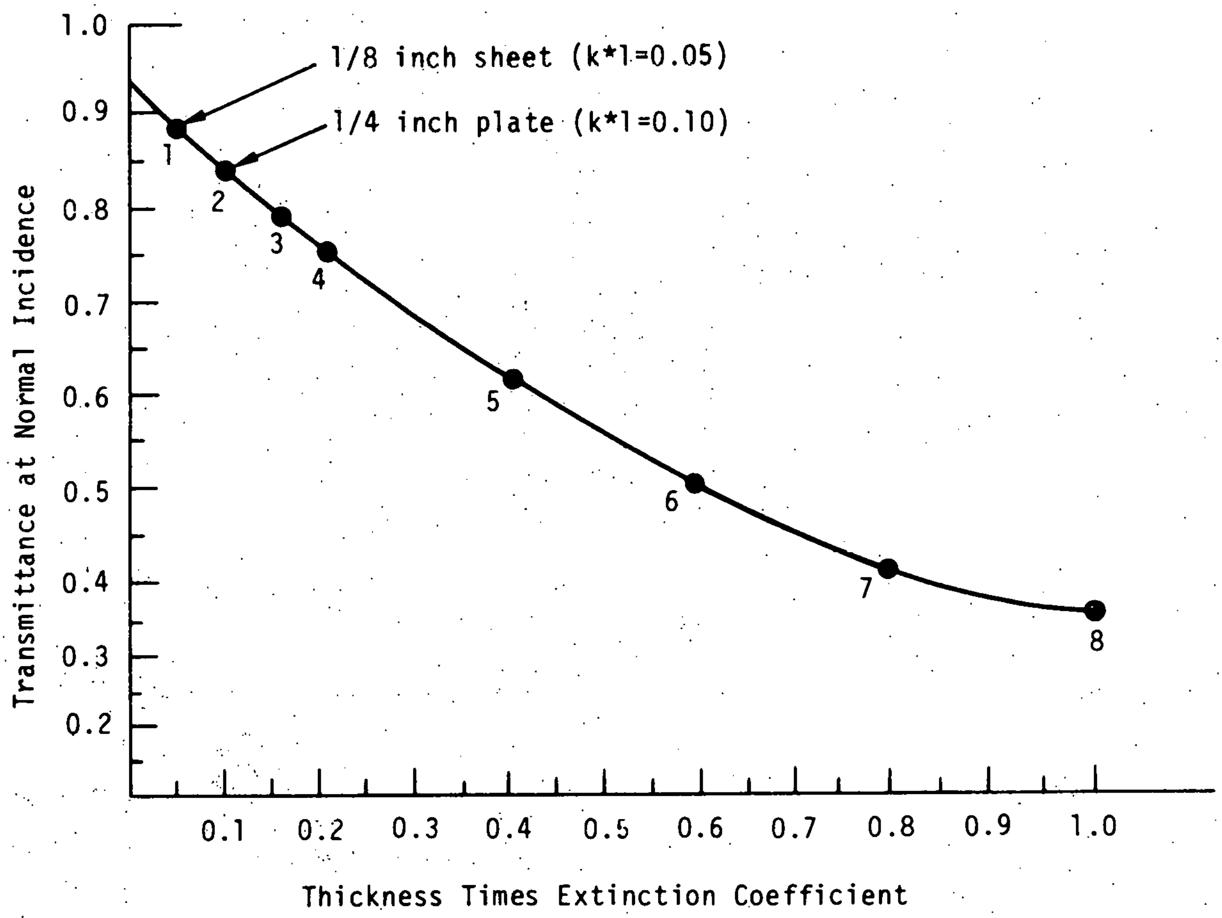
1. Casement Windows and Frame
   Assume 25% openable area and crack length equals 60% of perimeter

	Entry
a. Architectural Projected 1/64" crack	0.23
b. Architectural Projected 1/32" crack	0.94
c. Residential Casement 1/64" crack	0.41

2. Double Hung,
   Crack length equals 125% of perimeter

Wood	
a. Average with weather stripping	0.6
b. Average without weather stripping	1.1
c. Poorly fitted without weather stripping	3.2
Metal	
a. Average with weather stripping	1.0
b. Average without weather stripping	2.2

3. Glass Door, Average Use
   3.5 feet by 7 feet — 18.0



Transmittance as a Function of Thickness, Times, Extinction Coefficient

Figure III - 23

The entry for the GLASS-INFILTRATION keyword is computed from the following equation for a single pane window.

$$\text{GLASS-INFILTRATION} = \frac{Q}{\Delta p^{n} L}$$

Where: Q = infiltration flow rate (cfm/ft of crack)

Δp = pressure difference (inches of water)

n = 0.66, flow exponent

L = Length of Crack (ft)

GLASS-CONDUCTANCE — The GLASS-CONDUCTANCE keyword specifies the total conductance for the window excluding the outside air film coefficient. For a single pane window the user computes the GLASS-CONDUCTANCE (GC) using numerical values for film resistance (R1) and one pane resistance (R2) and the following equation:

$$GC = \frac{1}{R1 + R2}$$

Similarly, for a double pane window having an inside air film resistance R1, an inner pane resistance R2, an interpane air gap resistance R3, and an outer pane resistance R4, the GLASS-CONDUCTANCE GC will be

$$GC = \frac{1}{R1 + R2 + R3 + R4}$$

The outside air film coefficient is computed hourly as a function of wind speed.

* 14. DOOR

The DOOR instruction is used to specify the heat transfer properties, size, position, shading, and number of doors on an exterior wall. In order for the user to take advantage of the data hierarchy feature, illustrated in Chapter II, the DOOR instruction must be inserted immediately following the surface definition instruction (i.e., EXTERIOR-WALL or ROOF) on which the door appears.

Name	Command	Keyword	Abbr	Value	Unit
u-name	DOOR	LIKE		u-named	
		DOOR-HEIGHT	DH		feet
		DOOR-WIDTH	DW		feet
		DOOR-TYPE	DT	u-named	
		J			feet
		K			feet
		SETBACK			feet
		MULTIPLIER	M		number
		X-DIVISIONS	XD		number
		* FIN		u-named	
		* OVERHANG	OV	u-named	

Name — A user may enter any BDL u-name in the name field of this instruction.

* DOOR — The BDL command word DOOR informs the BDL processor that the data which follow describe the properties of a door.

* LIKE — The keyword LIKE may be followed by the u-name of a previously named DOOR instruction.

* In Preparation

*DOOR-HEIGHT — The DOOR-HEIGHT keyword specifies the height of the door parallel to the K axis of the surface coordinate system. If the door area is not rectangular, for example, having a curved top, then a mean or average height should be specified.

*DOOR-WIDTH — The DOOR-WIDTH keyword is used to specify the mean or average width of the door, as measured parallel to the J axis of the surface coordinate system.

*DOOR-TYPE — The DOOR-TYPE keyword is to be followed by a door library name (or code-word) or a user-defined name (u-name) of a previously defined DOOR-TYPE instruction. The heat transfer characteristics are specified by selecting a door library code-word or by inserting a user-defined DOOR-TYPE instruction.

*J
*K
*SETBACK — The distance of the origin of a door or lower left-hand corner as viewed from the outside, from the origin of the surface coordinate system, is specified by the J, K, and SETBACK keywords. Figure III-9 illustrates the position of the door origin with respect to the surface coordinate origin.

*MULTIPLIER — The MULTIPLIER keyword specifies the number of doors having identical area and heat transfer characteristics. The position data are not duplicated.

*X-DIVISIONS — The X-DIVISIONS keyword specifies the total number of segments a user selects to divide the door into for a computation of the shading on a window. Selecting a number equal to twice the door width expressed in feet results in accounting for the shading effect in six-inch increments. Selecting a large number (e.g., twenty divisions per foot of width) will result in much larger computing costs and a slightly more accurate estimate of the effect of shading.

*FIN — The FIN keyword is followed by the u-name for a FIN instruction which in turn specifies the geometrical data associated with a fin.

*OVERHANG — The OVERHANG keyword is followed by the u-name for an OVERHANG instruction which in turn specifies the geometrical data for an overhang.

* In Preparation

15. *FIN

Name	Command	Data List Keyword	Abbr	Value	Unit
u-name		LIKE		u-named	feet
	FIN	FIN- A			feet
		FIN- B			feet
		FIN- C			feet
		FIN- D			feet
		FIN- E			feet
		FIN- F			feet
		FIN- G			feet
		FIN- H			feet

* In preparation,

The BUILDING-SHADE instruction should be used to specify a shading surface until this instruction is completed.

16. *OVERHANG

Name	Command	Data List Keyword	Value	Unit
u-name	OVERHANG	LIKE	u-named	feet
		OH-A		feet
		OH-B		feet
		OH-C		feet
		OH-D		feet
		OH-E		feet
		OH-F		feet
		OH-G		feet
		OH-H		feet

* In preparation, see Fin footnote.

17. CONSTRUCTION

The CONSTRUCTION instruction is used to select heat transfer data from a library or to specify the thermodynamic properties of a wall, roof, or floor.

Name	Command	Keyword	Abbr	Value	Units
u-name	CONSTRUCTION	LIKE		u-named	
	CONS	LAYERS		u-named	
		*WALL-TYPE	WT	code-word	
		*ROOF-TYPE	RT	code-word	
		*FLOOR-TYPE	FT	code-word	
		U-VALUE	U		Btu/hr ft^2 ^{0}F
		ABSORPTANCE	ABS		number
		ROUGHNESS	RO		code-numbers
		WALL-INFILTRATION	WIF		number

Name — Any valid u-name may be specified for this instruction, but no library code-word names may be used as this entry. Extension of the library naming sequence is one possible user convention to aid in the organization of construction data.

CONSTRUCTION — The BDL command word CONSTRUCTION defines the thermal properties for a wall, floor, or roof. The BDL processor either selects an entry from the construction library or expects that a new set of user-defined data will be entered.

The ROOF or EXTERIOR-WALL instructions refer to this instruction by using their CONSTRUCTION keyword followed by the u-name specified for this instruction. The heat transfer through a roof or an exterior wall is computed using response factors, infiltration, absorptance, roughness, geometrical and climatic data.

The INTERIOR-WALL, FLOOR, UNDERGROUND-WALL, and UNDERGROUND-FLOOR instructions also refer to this instruction by using their CONSTRUCTION keyword followed by the u-name of this instruction. However, the heat transfer through these building components is computed using U-VALUE and geometrical data.

LIKE — The LIKE keyword may only be followed by the u-name of a previously named CONSTRUCTION instruction in order to identify a baseline set of construction data. Any of the following keywords may then be entered to define new values for selected keywords, layers, or materials.

LAYERS

The LAYERS keyword is used to specify the u-name for a LAYERS instruction. The LAYERS instruction, in turn, is used to specify a user defined EXTERIOR-WALL or ROOF, layer by layer. In addition, if the user decides to alter any of the layers in a library defined wall or roof, this keyword is used to specify the desired change.

*WALL-TYPE

The WALL-TYPE keyword is to be followed by a BDL library name code-word selected from the Wall library given in Chapter XI. For example, the user may specify

```
________________ CONSTRUCTION  WALL-TYPE = WA02-2   ..
   u-name
```

to instruct the LOADS program to compute the appropriate response factors for a wall having the characteristics given in the library under wall type WA02-2.

*ROOF-TYPE

The ROOF-TYPE keyword is to be followed by a BDL library name code-word selected from the roof library given in Chapter XI. For example, the user may specify

```
________________ CONSTRUCTION  ROOF-TYPE = RA51-0   ..
   u-name
```

to instruct the LOADS program to compute the appropriate response factors for a roof having the characteristics given in the library under roof type RA51-0.

*FLOOR-TYPE

The FLOOR-TYPE keyword is to be followed by a BDL library name code-word selected from the floor library given in Chapter XI. For example the user may specify

```
________________ CONSTRUCTION  FLOOR-TYPE = FA01-0  ..
   u-name
```

to instruct the LOADS program to compute the appropriate response factors for a floor having the characteristics given in the library under floor type FA01-0.

* In Preparation

U-VALUE

The U-VALUE keyword is used to specify the U-VALUE for a user-defined interior wall, floor, underground wall, or underground floor. It may also be used to temporarily alter a library U-VALUE for a particular set of computations. The Cal-ERDA library value cannot be changed by a user, only the number used for a particular run. A U-VALUE cannot be specified for the exterior envelope of a building, since a transient analysis is performed using the response factor technique.

ABSORPTANCE

The ABSORPTANCE keyword specifies the ratio of absorbed to total incident radiation on an exterior surface as a decimal fraction. The following table provides a list of typical values for various exterior surfaces. (Ref. I-3)

ABSORPTANCE for Typical Exterior Surfaces

Material	ABSORPTANCE
Tinned Surface	0.05
White Glazed Brick	0.25
White on Galvanized Iron	0.26
Gravel	0.29
Bituminous Felt-Aluminized	0.40
Aluminum Paint	0.40
Built-up Roof-White	0.50
Light Buff Brick	0.55
White Marble	0.58
Asbestos Cement, White	0.61
Uncolored Concrete	0.65
Uncolored Asbestos Cement	0.75
Wood, Smooth	0.78
Asphalt Pavement, Weathered	0.82
Roofing, Green	0.86
Blue Gray Slate	0.87
Red Brick	0.88
Bituminous Felt	0.88

ROUGHNESS

The ROUGHNESS keyword defines a code-number taken from the following table which specifies the relative smoothness of the exterior surface finish. (REF. I-3)

ROUGHNESS Code for Exterior Surface Finish

Surface Finish	Example: Wall	Example: Roof	code-number
Rough	Stucco	Wood Shingles Built-up Roof with Stones	1
	Brick Plaster		2
	Concrete	Asphalt Shingles	3
	Clear Pine		4
	Smooth Plaster Metal	Metal	5
Smooth	Glass Paint on Pine		6

WALL-INFILTRATION

The WALL-INFILTRATION keyword specifies an infiltration flow coefficient, for the crack method, to compute the infiltration due to cracks in an exterior wall or roof. A value of zero indicates a wall or roof that will not allow outside air to pass through it. See Ref. I-3, pp. 4-40, and Ref. I-5, Chapter 19. See also Carrier "Load Estimating Guide."

WALL-INFILTRATION for Typical Exterior Surfaces

(See Ref I-3 and Ref I-5 Chapter 19).

		WALL-INFILTRATION
13" brick with plastered surface	(.04 cfh/sq.ft.)	.0005
13" brick, furring, lath & plaster	(0.35)	.004
Frame wall, lath & plaster	(0.18)	.002
4" brick-6" concrete block-painted	(0.25)	.003
8" cement block-painted both sides	(0.8)	.001
8" brick-plain-poor workmanship	(8.0)	.10
16" shingles on shiplap w/building paper	(2.0)	.023
16" shingles on shiplap	(20.0)	.23
16" shingles on 1x4 boards on 5" centers	(90.0)	1.1

Values in parentheses () are typical infiltration values for a 7.5 mph wind normal to surface for the given walls. The WALL-INFILTRATION entry is computed from the following equation.

$$\text{WALL-INFILTRATION} = \frac{Q}{\Delta p^{n} A}$$

Where: Q = infiltration flow rate (cfm/ft^2)

Δp = pressure difference (inches of water)

n = 0.8

A = Area of surface (ft^2)

* In Preparation: The ABSORPTANCE, ROUGHNESS, and WALL-INFILTRATION values will be included in the wall library data, but for Cal-ERDA 1.3 the user must enter these values.

18. LAYERS

The LAYERS instruction is used to specify the sequence of materials beginning with the outside material and thereafter defining each successive layer and ending with the inside film resistance, for exterior walls and roofs.

Name	Command	Keyword	Abbr	Value
u-name	LAYERS	LIKE		
		MATERIAL-1	M1	u-named
		THICKNESS-1	T1	feet
		MATERIAL-2	M2	u-named
		THICKNESS-2	T2	feet
		MATERIAL-3	M3	u-named
		THICKNESS-3	T3	feet
		MATERIAL-4	M4	u-named
		THICKNESS-4	T4	feet
		MATERIAL-5	M5	u-named
		THICKNESS-5	T5	feet
		MATERIAL-6	M6	u-named
		THICKNESS-6	T6	feet
		MATERIAL-7	M7	u-named
		THICKNESS-7	T7	feet
		MATERIAL-8	M8	u-named
		THICKNESS-8	T8	feet
		MATERIAL-9	M9	u-named
		THICKNESS-9	T9	feet
		INSIDE-FILM-RES	IFR	hr ft^2 ^{o}F/Btu

Name — A user-defined name (u-name) must appear in the name field. It permits a user to refer to any user named LAYERS instruction, using the keyword LAYERS in the CONSTRUCTION instruction.

LAYERS — The command word LAYERS informs the BDL processor that the series of keywords and data which follow specify the materials library code names, or alternatively, user names for the sequence of materials which make up an exterior wall or roof.

LIKE	The LIKE keyword may specify the u-name of a previously defined LAYERS instruction to easily duplicate a list of keyword data.
MATERIAL-1 through MATERIAL-9	Following the first keyword, MATERIAL-1, the user enters the code-word for the outside layer of an exterior wall or roof. The outside film coefficient is not specified as a layer since it is computed hourly as a function of wind speed, roughness, and absorptance. The library code-word names for each material is given in the materials library in Chapter XI, and repeated in the wall and roof library. Each MATERIAL-n keyword entered must be followed by a library code-word name for the layer. A library code-word must be specified for each layer of material including the inside finish layer. Unused MATERIAL-n keywords are not to be specified. Alternatively, the user may wish to define a new material by specifying a u-name for a MATERIAL instruction. The properties of the newly user-defined material would then be used in the response factor calculations. MATERIAL-1 is the exterior layer of material, no exterior surface air-films are to be specified as a material by the user. The outside air-film is calculated hour-by-hour as a function of wind speed and surface roughness. MATERIAL-n should be the interior layer of material. The inside surface air-film is specified using the INSIDE-FILM-RES keyword.
THICKNESS-1 through THICKNESS-9	The THICKNESS-1 keyword specifies the thickness in feet, expressed as a decimal fraction, of the exterior layer of material if it is different from that specified in the materials library. Similarly, the remaining keywords are also used to enter the thickness for each material, if a library value is not desired.
INSIDE-FILM-RES	The INSIDE-FILM-RES keyword specifies a value for the inside film resistance of an exterior wall or roof.

19. MATERIAL

The MATERIAL instruction identifies the heat transfer properties for one layer of an exterior wall or roof.

Name	Command	Keyword	Abbr	Value	Units
u-name	MATERIAL	LIKE		u-named	
		THICKNESS	TH		feet
		DENSITY	DE		lb/ft^3
		SPECIFIC-HEAT	SPH		Btu/lb ^oF
		CONDUCTIVITY	CON		Btu ft/hr ft^2 ^oF
		RESISTANCE	RE		hr ft^2 ^oF/Btu

Name — Any valid user-defined name may be specified as the u-name for this instruction. Each element in the materials library has been assigned a unique library name, or code-word, none of which may be entered as a u-name. It is suggested that the user develop an extention of the materials library naming convention to name any new user-defined MATERIAL.

MATERIAL — The BDL command word MATERIAL informs the BDL processor that the following keywords and data describe the properties of a material. This command is used to identify and enter the data for a new user-defined material.

LIKE — The keyword LIKE may be used to copy data from the materials library by specifying the material library code-word after this keyword. Alternatively, this keyword may be used to copy the properties from a previously user-named MATERIAL instruction. Any of the following keywords may also be specified.

THICKNESS — The THICKNESS keyword defines the thickness of a material in feet, expressed as a decimal fraction.

DENSITY — The DENSITY keyword specifies the mass per unit volume of a material.

SPECIFIC-HEAT — The SPECIFIC-HEAT keyword specifies the heat capacity of the material.

CONDUCTIVITY — The CONDUCTIVITY keyword specifies the amount of heat which flows through a material per unit thickness as a function of time, area, and temperature differential.

RESISTANCE — As an alternative to the above four keywords, the user may enter the thermal resistance for a material. If this keyword is used, values for the above four keywords are not used in the calculations. Resistance is used in the case where there is no significant thermal capacitance (e.g. an air gap).

20. DESIGN-DAY

The DESIGN-DAY instruction is currently under development and review. An initial version of the instruction has been implemented in Cal-ERDA 1.3 and is available for use. However descriptive documentation was incomplete at the time this manual went to press. For the purpose of providing as much available information as possible the preliminary descriptive material on the following pages has been included.

Name	Command	Keywork	Default	Unit
U-name	DESIGN-DAY	LIKE	U-name	
		DRYBULB-HI	0	°F
		DRYBULB-LO	0	°F
		HOUR-HI	13	hr.(1-24)
		HOUR-LO	7	hr.(1-24)
		DEWPT-HI	0	°F
		DEWPT-LO	0	°F
		DHOUR-HI	8	hr.(1-24)
		DHOUR-LO	14	hr.(1-24)
		WIND-SPEED	0	mph
		WIND-DIR	0	16ths**
		CLOUD-AMOUNT	10	10ths
		CLEARNESS	1	dimensionless
		MONTH	6	mo.(1-12)
		GROUND-TEMP	50	°F
		*CLOUD-TYPE		

* _In Preparation_. (see NOTE 1 next page)

** Measured clockwise from notrh i.e., 1/16 of 360° = 22.5°

Note 1: When keyword CLOUD-TYPE is completed it will allow a choice of three cloud types: 0 = cirrus (least paque); 1 = stratus (most opaque); 2 = halfway between cirrus and stratus. At the present time cloud type is fixed as follows: hot summer design day has cirrus, CT=0; cold winter design day has stratus, CT=1; warm winter design day has mixed cloud type, CT=2.

A subroutine called CCM reads CLOUD-AMOUNT, CLOUD-TYPE, and hourly solar angle. It then returns a cloud transmittance.

Example:

	CLOUD-AMOUNT	CLOUD-TYPE	High Sun(alt.>45°)	Low sun(alt≤45°)
summer	0	1	Trans. = .88	Trans. = .60
winter	10	1	Trans. = .46	Trans. - .27

The purpose of the DESIGN-DAY command is to determine the appropriate size of the HVAC systems and supporting plant necessary to accommodate the hot and cold extremes of weather conditions. Use of the DESIGN-DAY command permits the user to choose the extremes of weather desired for sizing the heating and cooling equipment.

Up to three DESIGN-DAY conditions can be specified by the user. A cold winter day and a hot summer day are normally specified to determine extreme weather conditions. The third DESIGN-DAY is optional and is provided for user convenience.

At the present time DESIGN-DAY must be run in conjunction with a few days of weather tape input under the RUN-PERIOD command. This will result in two LOADS outputs. The one pertaining to DESIGN-DAY will have DESIGN-DAY printed at the top of the output page. It is this output of peak loads that will be passed to SYSTEMS. The peak loads resulting from the weather tape input will be ignored. The need for this duality of weather input will be eliminated at a later date.

The daily cycle of solar flux is computed hourly for each DESIGN-DAY. The hourly values of dry bulb temperature between the user assigned high and low are simulated by sine curves. Note that the sine curve for the period of increasing temperature and the sine curve for the period of decreasing temperature will be different if the time periods are different. For example, use of the default values for HOUR-LO and HOUR-HI will result in a quick rising sine curve for HOUR-LO through HOUR-HI followed by a slowly falling sine curve back to DRYBULB-LO at HOUR-LO. The hourly values of dew-point are handled similarly except that dewpoint is out of phase with drybulb. This procedure approximates reasonably will the hourly temperature computed by use of the carrier correction factors (see Carrier Handbook of Air Conditioning and System Design, Chapter 1).

Seven consecutive days of hourly loads output (day one starting on the 15th of the DESIGN-DAY month) will be generated for each specified DESIGN-DAY. The solar cycle is adjusted for each day, and schedule changes are recognized. Otherwise the variables are identical from day to day. Three days of hourly calculations are performed in order to purge transient effects prior to the seven days of calculations discussed above.

DRYBULB-HI, DRYBULB-LO, DEWPT-HI, DEWPT-LO, and MONTH are mandatory keywords. The remaining deywords may be defaulted if desired. Note that HOUR-HI is the time at which DRYBULB-HI occurs, and HOUR-LO is the time at which DRYBULB-LO occurs. DHOUR works similarly with DEWPT. A new keyword, CLOUD-TYPE, is in preparation.

* 21. VERTEX

* In Preparation

22. LOADS-REPORT

The LOADS-REPORT instruction specifies which reports of the LOADS program the user desires to receive.

Name	Command	Data List	Terminator
	LOADS-REPORT	code-word	..

Name — No entry is allowed in the name field of this instruction.

LOADS-REPORT — The LOADS-REPORT command word informs the BDL processor that the data which follow are a list of code-words used to identify reports for the LOADS program.

code-word — A list of code-words, separated by a separator, may be entered to select any of the series of reports listed in the following table III-2. The default code-word is L01.

Example: — The following instruction selects three reports from the LOADS program.

```
LOADS-REPORT    L01,   L02,   L03  ..
```

Table III-2

A. Verification of Input

Program	Report Code	Report Title
LOADS	V01	Project and Building Data
	V02	Summary of Spaces
	V03	Space Input Details
	V04	Details of Exterior Surfaces
	V05	Underground Surfaces
	V06	Interior Surfaces
	V07	Schedules
	V08	Day Schedules
	V09	Windows
	V12	Constructions
	V15	Building Shades

B. Results of Program Computations

Program	Report Code	Report Title
LOADS	L01	Space Peak Loads Summary
	L02	Space Peak Loads Components
	L03	Building Peak Loads Components

C. LOADS Instruction Summary

LOADS Program

		NOTES
/* INPUT LOADS */		
TITLE ________ ..		40 character maximum
TITLE ________ ..		40 character maximum
TITLE ________ ..		40 character maximum
TITLE ________ ..		40 character maximum
TITLE ________ ..		40 character maximum
DIAGNOSTIC ________ ..		Select ERROR WARNING or COMMENT
RUN-PERIOD ____ ____ ____ THRU ____ ____ ____ ..	month day year month day year	Select dates, use code-words from Section II-F
/* WEATHER-STATION ________ */		Select code-word from Section III-B
LOADS-REPORT ________ ..		Code-word L01 L02 L03 or V01 V02 etc.

DEFINE ________ = ________ ..
variable value

SET-DEFAULT ________ = ________ ..
keyword value

* In Preparation

Default values are underlined.

_______ = BUILDING-LOCATION or BL

u-name

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LATITUDE	LAT	= ______	degrees	38.0	0.0	90.0
LONGITUDE	LON	= ______	degrees	119.0	0.0	360.0
ALTITUDE	ALT	= ______	feet	0.0	-1000.0	20,000.0
TIME-ZONE	TZ	= ______	number	8.0	-12.0	12.0
DAYLIGHT-SAVINGS	DS	= ______	code-number	0.0	0.0	1.0
HOLIDAY-CODE	HC	= ______	code-number	0.0	0.0	1.0
BUILDING-AZIMUTH	BAZ	= ______	degrees	0.0	-360.0	360.0
* GROUND-TEMPS	GT					
		___, ___, ___, ___, ___, ___, (Jan Feb Mar Apr May Jun)	°F	55.0	-40.0	140.0
		___, ___, ___, ___, ___, ___, (Jul Aug Sep Oct Nov Dec)				
* CLEARNESS-NUMBERS	CN					
		___, ___, ___, ___, ___, ___, (Jan Feb Mar Apr May Jun)	number	0.98	0.0	1.0
		___, ___, ___, ___, ___, ___, (Jul Aug Sep Oct Nov Dec)				

* In Preparation

_______________ = BUILDING-SHADE
u-name or BS

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		________	u-named			
HEIGHT	H	= ________	feet	0.0	0.0	2000.0
WIDTH	W	= ________	feet	0.0	0.0	2000.0
TRANSMITTANCE	TR	= ________	number	0.0	0.0	1.0
* LOCATION		________	u-named			
X-BUILDING	XB	= ________	feet	0.0	-10000.0	10000.0
Y-BUILDING	YB	= ________	feet	0.0	-10000.0	10000.0
Z-BUILDING	ZB	= ________	feet	0.0	-200.0	2000.0
SURFACE-AZIMUTH	SAZ	= ________	degrees	0.0	-360.0	360.0
TILT		________	degrees	90.0	0.0	180.0

* In Preparation

_______________ = SPACE-CONDITIONS
u-name or SG

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		______	u-named			
TEMPERATURE	TEMP =	______	°F	70.0	40.0	85.0
PEOPLE-SCHEDULE	PS =	______	u-named			
NUMBER-OF-PEOPLE	NOP =	______	number	0.0	0.0	10000.0
PEOPLE-ACTIVITY	PA =	______	Btu/hr	400.0	200.0	1500.0
LIGHTING-SCHEDULE	LS =	______	u-named			
LIGHTING-TYPE	LT =	______	code	1.0	1.0	4.0
LIGHTING-KW	LKW =	______	kw	0.0	0.0	200.0
LIGHTING-W/SQFT	LWSF =	______	W/ft^2	0.0	0.0	10.0
LIGHT-TO-SPACE	LTS =	______	%	70.0	0.0	100.0
EQUIPMENT-SCHEDULE	EQS =	______	u-named			
EQUIPMENT-KW	EQKW =	______	kw	0.0	0.0	200.0
EQUIPMENT-W/SQFT	EQWSF=	______	W/ft^2	0.0	0.0	100.0
EQUIPMENT-SENSIBLE	EQSEN=	______	%	50.0	0.0	100.0
EQUIPMENT-LATENT	EQLAT=	______	%	50.0	0.0	100.0
* PROCESS-SCHEDULE	PS =	______	u-named			
* PROCESS-BTUH	PBH =	______	Bth/hr	0.0	0.0	100000.0
* PROCESS-BTU/SQFT	PBSF =	______	Btu/ft^2	0.0	0.0	100.0
* PROCESS-TO-SENSIBLE	PS =	______	%	50.0	0.0	100.0
* PROCESS-TO-LATENT	PL =	______	%	50.0	0.0	100.0
* SOURCE-SCHEDULE	SS =	______	u-named			
* SOURCE-BTUH	SBH =	______	Btu/hr			
* SOURCE-BTU/SQFT	SBSF =	______	Btu/ft^2			
* RESOURCE	RE =	______	code-word			
INF-SCHEDULE	IS =	______	u-named			
INF-METHOD	IM =	______	code-word	1.0	1.0	2.0
INF-CFM/SQFT	IC =	______	cfm/ft^2	0.0	0.0	20.0
AIR-CHANGES/HR	AC =	______	hr^{-1}	0.0	0.0	30.0
FLOOR-WEIGHT	FW =	______	lb/ft^2	50.0	0.0	200.0
NEUTRAL-ZONE-HEIGHT	NZH =	______	ft	0.0	0.0	1000.0

* In Preparation

_______________ = SPACE
u-name or S

Keyword	*Abbreviation*		User Input	Notes	Default	Range Min.	Range Max.
LIKE			________	u-named			
FLOOR-AREA	FA	=	________	ft^2	0.0	0.0	100000.0
SPACE-HEIGHT	SH	=	________	ft	8.0	1.0	50.0
VOLUME	V	=	________	ft^3	0.0	1.0	10^6
SPACE-MULTIPLIER	SM	=	________	number	1.0	0.0	99.0
SPACE-CONDITIONS	SC	=	________	u-named			
X-BUILDING	XB	=	________	ft	0.0	-2000.0	2000.0
Y-BUILDING	YB	=	________	ft	0.0	-2000.0	2000.0
Z-BUILDING	ZB	=	________	ft	0.0	-2000.0	2000.0
SPACE-AZIMUTH	SAZ	=	________	degrees	0.0	-360.0	360.0
SHAPE		=	________	code-word			
WIDTH	W	=	________	ft	0.0	0.0	2000.0
DEPTH	D	=	________	ft	0.0	0.0	2000.0
HEIGHT	H	=	________	ft	0.0	0.0	2000.0

plus any keyword listed under the SPACE-CONDITIONS instructions

= EXTERIOR-WALL or EW
u-name

Keyword	*Abbreviation*		User Input	Notes	Default	Range Min.	Range Max.
LIKE				u-named			
HEIGHT	H	=		ft	0.0	0.0	2000.0
WIDTH	W	=		ft	0.0	0.0	2000.0
CONSTRUCTION	CONS	=		u-named			
LOCATION				code-word			
X		=		ft	0.0	-10000.0	10000.0
Y		=		ft	0.0	-10000.0	10000.0
Z		=		ft	0.0	-10000.0	10000.0
AZIMUTH	A	=		degrees	180.0	-360.0	360.0
TILT	T	=		degrees	90.0	0.0	180.0
GND-REFLECTANCE	GR	=		number	0.2	0.0	1.0
MULTIPLIER	M	=		number	1.0	1.0	100.0
X-DIVISIONS	XD	=		number	20.0	1.0	120.0
* FIN		=		u-named			
* OVERHANG	OV	=		u-named			

* In Preparation

u-name = INTERIOR-WALL
or IW

Keyword	*Abbreviation*		User Input	Notes	Default	Range	
						Min.	Max.
LIKE			________	u-named			
AREA	A	=	________	ft^2	0.0	0.0	100000.0
CONSTRUCTION	CONS	=	________	u-named			
MULTIPLIER	M	=	________	number	1.0	0.0	99.0
NEXT-TO	NT	=	________	u-named			

u-name = UNDERGROUND-WALL
or UW

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		________	u-named			
AREA	A	= ________	ft^2	0.0	0.0	100000.0
CONSTRUCTION	CONS	= ________	u-named			
MULTIPLIER	M	= ________	number	1.0	0.0	99.0

u-name = FLOOR

Keyword	*Abbreviation*		User Input	Notes	Default	Range Min.	Range Max.
LIKE			____________	u-named			
AREA	AR	=	____________	ft^2	0.0	0.0	100000.0
CONSTRUCTION	CONS	=	____________	u-named			
MULTIPLIER	M	=	____________	number	1.0	0.0	99.0
NEXT-TO	NT	=	____________	u-named			

_________________ UNDERGROUND-FLOOR
u-name or UF

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		______	u-named			
AREA	A	= ______	ft^2	0.0	0.0	100000.0
CONSTRUCTION	CONS	= ______	u-named			
MULTIPLIER	M	= ______	number	1.0	0.0	99.0

u-name = ROOF

Keyword	Abbreviation	User Input	Notes	Default	Range Min.	Range Max.
LIKE		______	u-named			
LENGTH	L	= ______	ft	0.0	0.0	2000.0
WIDTH	W	= ______	ft	0.0	0.0	2000.0
CONSTRUCTION	CONS	= ______	u-named			
* LOCATION		______	code-word			
X		= ______	ft	0.0	-10000.0	10000.0
Y		= ______	ft	0.0	-10000.0	10000.0
Z		= ______	ft	0.0	-10000.0	10000.0
AZIMUTH	A	= ______	degrees	180.0	-360.0	360.0
TILT	T	= ______	degrees	0.0	0.0	180.0
GND-REFLECTANCE	GR	= ______	number	0.2	0.0	1.0
MULTIPLIER	M	= ______	number	1.0	0.0	100.0
X-DIVISIONS	XD	= ______	number	20.0	1.0	120.0
* FIN		= ______	u-named			
* OVERHANG	OV	= ______	u-named			

* In Preparation

u-name = WINDOW or WI
or SKYLIGHT

Keyword	*Abbreviation*	User Input	Notes	Default	Range	
					Min.	Max.
LIKE		________	u-named			
GLASS-HEIGHT	GH	= ________	ft	0.0	0.0	40.0
GLASS-WIDTH	GW	= ________	ft	0.0	0.0	1000.0
GLASS-TYPE	GT	= ________	u-named			
J		= ________	ft	0.0	-10000.0	10000.0
K		= ________	ft	0.0	-10000.0	10000.0
SETBACK		= ________	ft	0.0	0.0	10.0
MULTIPLIER	M	= ________	number	1.0	0.0	99.0
SKY-FORM-FACTOR	SFF	= ________	number	0.5	0.0	1.0
GND-FORM-FACTOR	GFF	= ________	number	0.5	0.0	1.0
X-DIVISIONS	XD	= ________	number	20.0	1.0	120.0
* FIN		= ________	u-named			
* OVERHANG	OV	= ________	u-named			

* In Preparation

u-name = GLASS-TYPE or GT

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		________	u-named			
PANES	P	= ________	number	1.0	1.0	2.0
GLASS-TYPE-CODE	GTC	= ________	code-word	1.0	1.0	8.0
GLASS-SHADING	GS	= ________	number	0.0	0.0	1.0
GLASS-INFILTRATION	GI	= ________	number	0.0	0.0	160.0
GLASS-CONDUCTANCE	GCON	= ________	$BTU/hr \cdot ft^2 \cdot {}^\circ F$	0.2	0.0	3.0

______________________ = DOOR *
u-name

Keyword	*Abbreviation*		User Input	Notes	Default	Range Min.	Range Max.
LIKE			____________	u-named			
* DOOR-HEIGHT	DH	=	____________	feet	0.0	0.0	40.0
* DOOR-WIDTH	DW	=	____________	feet	0.0	0.0	100.0
* DOOR-TYPE	DT	=	____________	u-named			
* J		=	____________	feet	0.0	-10000.0	10000.0
* K		=	____________	feet	0.0	-10000.0	10000.0
* SETBACK		=	____________	feet	0.0	0.0	10.0
* MULTIPLIER	M	=	____________	number	1.0	0.0	99.0
* X-DIVISIONS	XD	=	____________	number	20.0	1.0	120.0
* FIN		=	____________	u-named			
* OVERHANG	OV	=	____________	u-named			

* In Preparation

_________________ = FIN *
u-name   OVERHANG *

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		______	u-named			
A		= ______	feet	0.0	-100.0	100.0
B		= ______	feet	0.0	-100.0	100.0
C		= ______	feet	0.0	-100.0	100.0
D		= ______	feet	0.0	-100.0	100.0
E		= ______	feet	0.0	-100.0	100.0
F		= ______	feet	0.0	-100.0	100.0
G		= ______	feet	0.0	-100.0	100.0
H		= ______	feet	0.0	-100.0	100.0
I		= ______	feet	0.0	-100.0	100.0

* In Preparation

____________________ = CONSTRUCTION
u-name or CONS

Keyword	*Abbrev-iation*	User Input	Notes	Default	Range Min.	Range Max.
LIKE		__________	u-named			
LAYERS	LA	= __________	u-named			
*WALL-TYPE	WT	= __________	code-word			
*ROOF-TYPE	RT	= __________	code-word			
*FLOOR-TYPE	FT	= __________	code-word			
U-VALUE	U	= __________	$Btu/hr\cdot ft^2\cdot {}^{o}F$	0.7	0.0	20.0
ABSORPTANCE	ABS	= __________	number	0.7	0.0	1.0
ROUGHNESS	RO	= __________	code-number	3.0	1.0	6.0
WALL-INFILTRATION	WIF	= __________	number	0.0	0.0	2.0

* In Preparation

u-name = LAYERS or LA

Keyword	*Abbreviation*		User Input	Notes	Default	Range Min.	Range Max.
LIKE			________	u-named			
MATERIAL-1	M1	=	________	code-word			
THICKNESS-1	T1	=	________	feet	0.0	0.0	3.0
MATERIAL-2	M2	=	________	code-word			
THICKNESS-2	T2	=	________	feet	0.0	0.0	3.0
MATERIAL-3	M3	=	________	code-word			
THICKNESS-3	T3	=	________	feet	0.0	0.0	3.0
MATERIAL-4	M4	=	________	code-word			
THICKNESS-4	T4	=	________	feet	0.0	0.0	3.0
MATERIAL-5	M5	=	________	code-word			
THICKNESS-5	T5	=	________	feet	0.0	0.0	3.0
MATERIAL-6	M6	=	________	code-word			
THICKNESS-6	T6	=	________	feet	0.0	0.0	3.0
MATERIAL-7	M7	=	________	code-word			
THICKNESS-7	T7	=	________	feet	0.0	0.0	3.0
MATERIAL-8	M8	=	________	code-word			
THICKNESS-8	T8	=	________	feet	0.0	0.0	3.0
MATERIAL-9	M9	=	________	code-word			
THICKNESS-9	T9	=	________	feet	0.0	0.0	3.0
INSIDE-FILM-RES	IFR	=	________	$\frac{Hr \cdot ft^2 \cdot {}^\circ F}{Btu}$	0.0	0.0	5.0

_____ = MATERIAL
u-name or MAT

Keyword	*Abbreviation*	User Input	Notes	Default	Range	
					Min.	Max.
LIKE		_____	u-named			
THICKNESS	TH	= _____	feet	0.0	0.0	3.0
DENSITY	DE	= _____	lb/ft^3	0.0	0.0	300.0
SPECIFIC-HEAT	SPH	= _____	Btu/lb°F	0.0	0.0	5.0
CONDUCTIVITY	CON	= _____	Btu/hr ft^2·°F	0.0	0.0	5.0
RESISTANCE	RE	= _____	hr·ft^2 °F/Btu	0.0	0.0	10.0

IV. SYSTEMS PROGRAM

LIST OF FIGURES

LIST OF TABLES

A. Program Description

1. Introduction

The SYSTEMS program simulates the operation of equipment and systems that distribute cooling and/or heating directly to the spaces being conditioned and control the temperature and/or humidity in these spaces. These systems 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 is called PLANT and is described in Chapter V.

The hourly space loads calculated by the LOADS program are not necessarily the loads that are seen by the heating and cooling "plant." Due to ventilation air requirements, equipment operating schedules, and the temperature fluctuations required for control actuation, the buildings hourly heating and/or cooling requirement will be different from the summation of the hourly space external and internal loads. The purpose of the SYSTEMS simulation program is therefore, two-fold.

1. Based upon peak (or design day) heating and cooling requirements, provide information for sizing "secondary" energy distribution system components.

2. Simulate each distribution system as it responds to space thermal requirement and determine the requirement it is placing upon the central heating and cooling plant.

The SYSTEMS program mathematically simulates the heat and moisture exchange processes that occur in HVAC distribution systems. At the current stage of development, the user must select from a listing or menu of "standard" or "familiar" system types. Additionally, the user can select optional or alternative component and control features available for each system type. The systems are described in Section C of this chapter. It is the intention to ultimately provide a program that will permit the user more freedom in selection and arrangement of components such as fans, heating coils, cooling coils, mixing dampers, mixing boxes, etc.

The SYSTEMS Program receives as input a list of the hourly loads for each space from the LOADS program and requires a sequence of user defined BDL input instructions. The output of the SYSTEMS Program provides input to the PLANT program, and information for the REPORT GENERATOR Program.

2. Comparison Runs

The SYSTEMS program has been designed with the flexibility to permit parallel comparison runs. That is, more than one system or collection of systems can be simulated in a single run. Figure IV-A1 is an example of this arrangement. Simultaneous calculations are 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 system S-1 (serving zones 1 through 5)and S-2(serving zones 6 through 10) and plant-assignment P-2 consists of system S-3 (serving zones 1 through 3) and system S-4 (serving zones 4 through 10). This procedure which can be extended to simulate additional plant assignments each consisting of single or multiple systems of the same or different types, conserves computer time when compared to the series parametric run using the DEFINE instruction. This latter procedure, which can also be used for comparison of various system arrangements, is described in Chapter II.

3. System Combinations and Permutations

The SYSTEMS program permits the simulation of several systems working in combination to provide the heating and cooling requirements for a single zone or space. System No. 15 (Internal Variable Volume-External Fan Coil) and System No. 16 (Internal Variable Volume-External Induction) are two specifically modeled examples. In addition baseboard heating can be used in combination with any of the central fan airside systems.

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 Section C, include: optional return and exhaust fans; fixed outside air flowrate or one of three types of economizer cycles; summer and/or winter humidity control; hourly, daily and weekly operating schedules; three types of variable volume fan controls; space and supply air temperature setpoint maintained constant, scheduled or reset.

Other system combinations and component and control options can be simulated if the thermodynamic processes are the same as those specifically modeled by the program. For example:

a. Individually controlled perimeter heating units can be treated as reheat coils and combined with any airside system that permits a reheat coil temperature control option.

b. A dual duct or multi-zone system that has 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. Calculational Procedures

a. Heat Extraction/Addition Rate and Room Temperature Calculation. Instantaneous heat gains/losses and room cooling/heating loads are calculated by the LOADS program using "conduction transfer functions" and room weighting factors as described in Ref. I-1. 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 due to cooling/heating equipment characteristics and operating schedule and due to 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 calculational process, calculation of actual room temperature and heat extraction/addition rate is accomplished by the SYSTEMS program using the algorithms, described in Ref. I-2. The previously calculated loads are the input, along with the characteristics of the air conditioning equipment and the thermal characteristics of the zone. Heat extraction/addition rate and air temperature are the outputs.

b. System Sizing Calculations. System heat extraction capability and air flow rates may be assigned if known (i.e. an existing system). If these quantities are not inputted the program will calculate them based on design supply air temperatures and peak cooling/heating requirements. Alternately 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 and the program generates 24 hour weather data for summer and/or winter design days. (See Chapter III for a discussion of the user input data required). A SYSTEMS run with these data will yield the desired sizing information.

5. System Description Language

A general discussion of Building Design Language (BDL) including rules, syntax, notation, can be found in Chapter II. The system description language (SDL) is that portion of BDL that is solely applicable to the SYSTEMS program. Section B of this chapter contains a description of each BDL Instruction for the SYSTEMS Program.

In addition a number of the BDL instructions introduced in Chapter II are also applicable to the SYSTEMS Program. These are: the assignment instruction DEFINE; the message instructions DIAGNOSTIC, ABORT and SPACING: the schedule instructions DAY-SCHEDULE, WEEK-SCHEDULE and SCHEDULE; and the program control instructions, INPUT, COMPUTE, END and STOP. See Chapter II for a description of each of these instructions including definitions and instructions for the use of associated keywords. Note that the schedule instructions are used for some SYSTEMS program applications exactly as described in Chapter II but are used for other applications in the alternative form described in Section B of this chapter (see RESET-SCHEDULE instruction). Note also that if the message instructions are omitted here, the message instructions used by the LOADS program will apply to the SYSTEMS program.

6. Instruction Sequence

In general, the instructions for the systems program may be arranged in any order the user desires. There are however some rules that must be followed. These are:

a. To begin the data entry to the SYSTEMS program the user must first enter the program control instruction

* INPUT SYSTEMS *

b. U-names (with the exception of SYSTEM-NAMES, PLENUM-NAMES and ZONE-NAMES) must not appear in a value field until after they have been used in a name field. Another way of stating this is that an instruction must be entered before it is referenced. This means that each schedule instruction must be entered before the instruction it is referenced in, the supplementary zone instructions (ZONE-CONTROL and ZONE-AIR) when used, must be entered before the ZONE instruction (s) and the supplementary system instructions (SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, SYSTEM-TERMINAL, and SYSTEM-FLUID) when used, must be entered before the SYSTEM instruction (s).

* These instructions are not required for Cal-ERDA 1.3 (10/77) and can be neglected. See STATUS (10/77) Page xxiv

c. The user must enter at least one SYSTEM instruction for each computer run unless the system being simulated is a composite type (see Systems No. 15 and 16, Section C) in which case two SYSTEM instructions must be entered.

d. The user must enter a ZONE instruction for each SPACE instruction entered for the LOADS Program. The ZONE instruction must have the same u-name as the SPACE instruction and represent the same physical area of the building.

e. The user must enter the program control instruction

END

to indicate that data entry is complete.

f. The program control instruction

* COMPUTE SYSTEMS

must be entered next to instruct the processor to perform the calculations.

g. If the user does not desire to run the PLANT or ECONOMICS programs then the last instruction must be

* STOP

* These instructions are not required for Cal-ERDA 1.3 (10/77) and can be neglected. See STATUS (10/77) Page xxiv

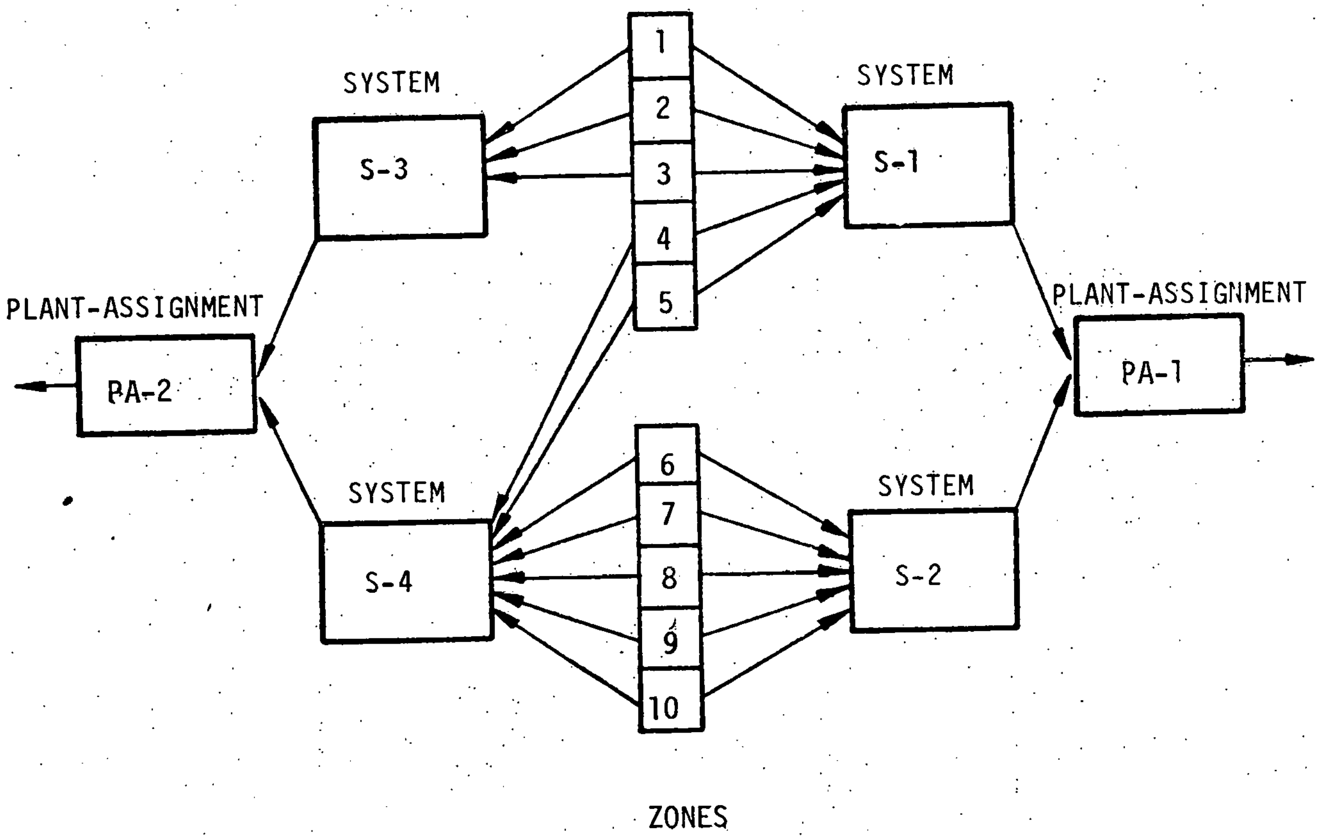


Figure IV-A1 Examples of a "Parallel" Parametric Run

The user may assign a system to any collection of zones and also assign any collection of systems to a plant. In addition, the calculations for these assignments of different collections of spaces and systems will be done in one pass through the SYSTEMS Program.

The user may assign the same zone to more than one system and may also specify more than one system to serve his facility, depending on facility size and type. However, care must be taken to insure that in any given plant assignment the same zone is not included more than once.

B. BDL Input Instructions

1. PLANT-ASSIGNMENT

The function of the PLANT-ASSIGNMENT instruction is to define the grouping of energy distribution systems being simulated in a given computer run. Note that the user may, for purposes of comparison, specify alternative systems (or sets of systems) for his facility. Calculations for all specified alternatives are done in one pass through the program. The user can omit the PLANT-ASSIGNMENT instruction if this type of comparison study is not desired. (i.e. two or more alternative systems configurations are not run at the same time).

The User Worksheet for the PLANT-ASSIGNMENT instruction is reproduced below followed by definitions and instructions for use of the command-word and associated keywords. (See Section D for complete set of SYSTEMS Program User Worksheets).

______________ = PLANT-ASSIGNMENT *or* P-A
u-name NOTE 1

Keyword	*or*	*Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SYSTEM-NAMES		S-N	= ______________	list of u-named	Note 4	N/A	N/A

For NOTES - see SECTION E.

PLANT-ASSIGNMENT

The PLANT-ASSIGNMENT is the energy distribution system (or group of systems) that are assigned to serve the facility for a given computer simulation. It is identified by a unique user defined name (u-name). Several different PLANT-ASSIGNMENTS each with a different u-name may be specified for the same facility (for comparison study purposes).

SYSTEM-NAMES

The user input for the keyword 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 30 u-names are permitted per plant assignment.

2. SYSTEM

The function of the SYSTEM instruction is to provide specifications of the energy 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. A portion of the required information is provided by the SYSTEM instruction but additional instructions are needed to complete the specification. These are the ZONE instruction, the schedule instructions (SCHEDULE and RESET-SCHEDULE) and if the user chooses, the supplementary system instructions (SYSTEM-CONTROL, SYSTEM-AIR, SYSTEM-FANS, SYSTEM-TERMINAL and SYSTEM-FLUID). An additional function of the SYSTEM instruction is to identify those specific additional instructions that are applicable to the system being specified.

The supplementary system instructions, referred to above, are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the SYSTEM instruction but the organization into sub-groups is for user convenience only. Once an instruction is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems, thus conserving data input effort. The user can, at his discretion, use one or more of the supplementary system instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the SYSTEM instruction.

The Cal-ERDA SYSTEMS Program simulates a number of commonly used energy distribution systems. In addition numerous optional features can be specified for these systems. A discussion of the features of each system is included in Section C of this Chapter. Individual BDL 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. Table IV-D1 "Applicability of BDL Command-words and Keywords to Various Systems" defines this relationship on a system by system basis (see Section D).

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, the user may, for comparison study purposes, specify and assign more than one system to serve the same space. A separate SYSTEM instruction is required for each energy distribution system simulated except that two SYSTEM instructions are required for the composite systems (i.e. System No. 15 Internal Variable Volume-External Fan Coil and System No. 16 Internal Variable Volume-External Induction) but care must be taken that each zone is included once and only once in each total facility simulation.

The User Worksheet for the SYSTEM instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords. (See SECTION D for a complete set of SYSTEMS Program User Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1) and will abort and print an error message if a required entry is ommitted. The program will also print a warning message if the value of any entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction Chapter II).

________ = SYSTEM *or* SYST   LIKE ________

u-name   NOTE 1   NOTE 3   *u-named*

Keyword	*or Abbreviation*		User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SYSTEM-TYPE	S-TYPE	=	________	code-word	Note 4	N/A	N/A
SYSTEM-CONTROL	S-C	=	________	u-named	Note 5	N/A	N/A
SYSTEM-AIR	S-A	=	________	u-named	Note 5	N/A	N/A
SYSTEM-FANS	S-FAN	=	________	u-named	Note 5	N/A	N/A
SYSTEM-TERMINAL	S-T	=	________	u-named	Note 5	N/A	N/A
SYSTEM-FLUID	S-FLU	=	________	u-named	Note 5	N/A	N/A
VARIABLE-TEMP	V-T	=	________	ON/OFF	ON	N/A	N/A
SIZING-RATIO	S-R	=	________	number	1.0	0.5	2.0
EXT-COOL-RATIO	E-C-R	=	________	decimal	Note 23	0.0	0.7
RETURN-AIR-PATH	R-A-P	=	________	code-word	DUCT	N/A	N/A
RECOVERY-EFFECT	R-E	=	________	decimal	0.0	0.2	0.8
FACE-AND-BYPASS	F-A-B	=	________	YES/NO	NO	N/A	N/A
ECONO-LIMIT-TEMP	E-L-T	=	________	°F	60	50	70
PLENUM-NAMES	P-N	=	________	u-named (3 max)	Note 24	N/A	N/A
ZONE-NAMES	Z-N	=	________	u-named (64 max)	Note 4	N/A	N/A
			________				

For NOTES - see SECTION E

SYSTEM	The SYSTEM command is a group of data related to the design and operation of a specific energy distribution system serving one or more zones of the facility. It is identified by a unique user defined name (u-name).
LIKE	Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named SYSTEM instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. (and for keywords PLENUM-NAMES and ZONE-NAMES). All other information is extracted by the program, from the referenced instruction.
SYSTEM-TYPE	The user input for the keyword SYSTEM-TYPE is a code-word that identifies the type of system to be simulated. The user must select one of sixteen (16) types of commonly used energy distribution systems. A discussion of the features of each system is included in Section C of this chapter.

The systems and their code-words are listed in Table IV-B1. The first listed code-word (SUM) does not simulate a system but is used to provide a summation of zone loads. Note that two (2) SYSTEM Instructions are required for each Internal Variable Volume-External Fan Coil System (code-word IVEF, System No. 15) and for each Internal Variable Volume-External Induction System (code-word IVEI, System No. 16). The user identifies the first instruction with the SYSTEM-TYPE code-word for the combined system (i.e. IVEF or IVEI) and inputs values for the other keywords to describe the variable volume system that serves the internal part of each zone. The second instruction is for the system selected to serve the external part of each zone (i.e. TPFC, or FPFC or TPIU or FPIU).

TABLE IV-B1

Code-word	System Number	SYSTEM-TYPE
SUM	0	Sums Building Loads (no system simulation)
SZRH	1	Single Zone Fan System w/optional reheat
MZS	2	Multi-zone Fan System
DDS	3	Dual Duct Fan System
SZCI	4	Single Zone Fan System w/Sub-Zone Induction Boxes
UHT	5	Unit Heater
UVT	6	Unit Ventilator
FPH	7	Floor Panel Heating System
TPFC	8	Two-Pipe Fan Coil System
FPFC	9	Four-Pipe Fan Coil System
TPIU	10	Two-Pipe Induction Unit System
FPIU	11	Four-Pipe Induction Unit System
VAVS	12	Variable Volume Fan System w/optional reheat
RHFS	13	Constant Volume Reheat Fan System
HP	14	Unitary Hydronic Heat Pump
IVEF	15	Internal Variable Volume-External Fan Coil
IVEI	16	Internal Variable Volume-External Induction

SYSTEM-CONTROL The user input for the keyword SYSTEM-CONTROL is the u-name of the previously named SYSTEM-CONTROL instruction that applies to the particular system being specified, thus referencing the previously defined keyword-value relationships contained in that instruction. This data entry is omitted if no SYSTEM-CONTROL instruction has been specified (i.e. if the instruction is not applicable to the type of system being simulated, if the default value for all applicable keywords is acceptable or if the user chooses to enter these keywords and their values with the SYSTEM instruction. Note that the term SYSTEM-CONTROL, used here as a keyword, is also used as a command-word in the supplementary system instruction of that name.

SYSTEM-AIR	The discussion above for keyword SYSTEM-CONTROL applies equally to this keyword when the keyword names are interchanged.
SYSTEM-FANS	The discussion above for keyword SYSTEM-CONTROL applies equally to this keyword when the keyword names are interchanged.
SYSTEM-TERMINAL	The discussion above for keyword SYSTEM-CONTROL applies equally to this keyword when the keyword names are interchanged.
SYSTEM-FLUID	The discussion above for keyword SYSTEM-CONTROL applies equally to this keyword when the keyword names are interchanged.
VARIABLE-TEMP	The user input for the keyword VARIABLE-TEMP is the code-word that informs the program to call (or not call) the subroutine TEMDEV that computes zone loads and temperatures based on actual conditions. The code-words are ON and OFF. If the code-word OFF is input, the SYSTEM program uses the heat quantities calculated by the LOADS program, calculations that are made on the assumption that the space temperature in each zone remains constant. If the code-word ON is input, the SYSTEM program recalculates the heating/cooling loads to obtain the hourly space temperature for each zone based on factors such as: equipment operating schedule; equipment size; thermostat setpoint; thermostat control characteristics; and inter-zone heat transfer. Since the default value for this keyword is ON, this entry can be omitted unless the user has a specific reason for preventing the TEMDEV calculation.
SIZING-RATIO	The keyword SIZING-RATIO is used to oversize or undersize all equipment in the system being specified. The user input for this keyword is the ratio of the maximum capacity of the system that the user wishes to simulate to the capacity assigned by the user in the appropriate BDL instructions and/or to the capacity required to meet peak (or design day) loads (ratio can be more or less than unity). This data entry can be omitted when the desired SIZING-RATIO is unity (default value).

EXT-COOL-RATIO

The keyword EXT-COOL-RATIO is used only when system type IVEF (internal variable volume-external fan coil) or system type IVEI (internal variable volume-external induction) is specified. The user input for this keyword is the ratio of the cooling supplied by the system serving the external portion of the zone (i.e. fan coil or induction units) to the maximum cooling available (from both internal and external systems).

RETURN-AIR-PATH

The user input for the keyword RETURN-AIR-PATH is the code-word that describes the route that return air takes in getting back to the air supply unit. Input of code-word DUCT indicates that return air path is via duct (or direct) and the program calculates return air temperature plus return air fan heat input. Input of the code-word PLENUM-ZONES indicates that return air passes through and mixes with the air in the plenum-zones assigned to this system before returning to the air handling unit (see keyword PLENUM-NAMES). Return air temperature, plenum temperatures and system loads are recalculated to account for this mixing effect. This data entry can be omitted for the ducted (or direct) return air path since DUCT is the default value.

RECOVERY-EFFECT

The keyword RECOVERY-EFFECT 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 user input for this keyword is the ratio (decimal) of the energy actually exchanged to the total sensible energy that would be exchanged if the exhaust air were cooled down (or heated up) to outside air temperature. The program uses this ratio (plus outside air and return air temperatures and flowrates) to calculate the energy that can be added (or extracted) from 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.

* FACE-AND-BYPASS

The user input for the keyword FACE-AND-BYPASS is the code-word that informs the program if face and bypass type cooling is to be simulated. The code-words are YES or NO. This data entry can be neglected if face and bypass cooling is not desired since NO is the default value.

* In Preparation

ECONO-LIMIT-TEMP — The user input for the keyword ECONO-LIMIT-TEMP is the outside air temperature above which the temperature type economizer returns to minimum outside air operation. (See Figure IV-BO below)

PLENUM-NAMES — The user input for the keyword PLENUM-NAMES is a listing of the u-names of those zones (maximum of three) that have been assigned to this system that are return air plenums. The SYSTEM program recalculates the cooling/heating loads and temperatures in the plenum zones similar to other zones (see discussion for keyword VARIABLE-TEMP) except that the effect of return air flow through the plenum is considered in lieu of direct air supply.

ZONE-NAMES — The user input for the keyword ZONE-NAMES is a listing of the u-names of all the zones, (conditioned, unconditioned and plenum), that are assigned to this system. (see applicable ZONE instructions). The unconditioned and plenum zones must be listed in order that the temperature and interactions with surrounding zones may be tracked.

This data entry with at least one u-name is required. Note that if the system being simulated is the type that can serve both a central zone and a sub-zone (i.e. SZRH and SZCI) the u-name of the central zone must be listed first. Also for those systems that are actually a composite of two different system types (i.e. IVEF and IVEI) and thus require two separate SYSTEM instructions, the u-names must be identical and listed in the same order on each instruction.

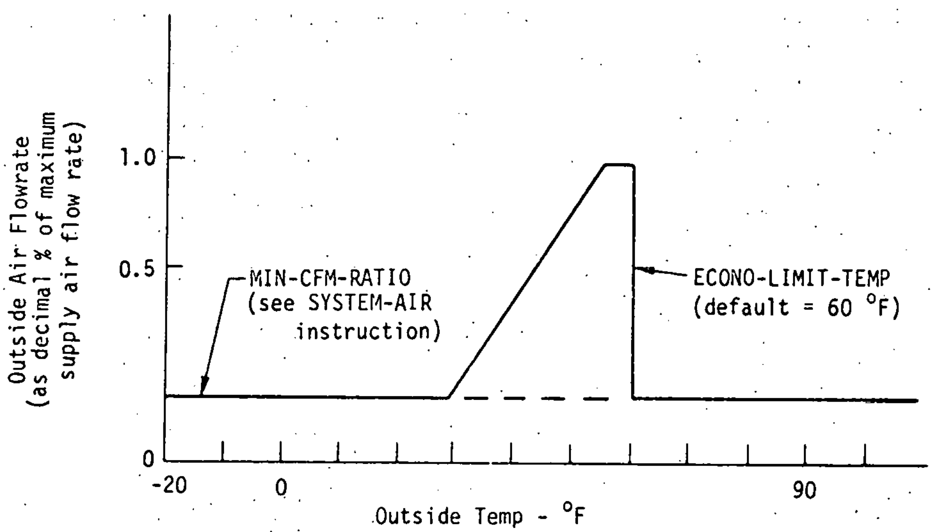


Figure IV-BO Typical Curve of Air Flow vs Outside Air Temperature for Systems with Temperature Type Economizer (Illustrating use of Keyword ECONO-LIMIT-TEMP)

3. SYSTEM-CONTROL

The function of the SYSTEM-CONTROL instruction is to provide information on supply air temperature (set-point, control strategy, limits) and humidity (limits) and to identify the appropriate equipment operating schedules. Several SYSTEM-CONTROL instructions (maximum of ten) may be specified if the facility is served by more than one type of system and/or it is desired to determine the effect of varying any of the parameters specified by this instruction.

This instruction and the other supplementary system instructions, are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the SYSTEM instruction but the organization into sub-groups is for user convenience only. Once one of these instructions is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems (by use of the keyword in the SYSTEM instruction that identifies the supplementary instruction type) thus conserving data entry effort. The user can, at his discretion, use one or more of the supplementary system instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the SYSTEM instruction.

The User Worksheet for the SYSTEM-CONTROL instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords. (see Section D for a complete set of SYSTEMS Program Users Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1) and will abort and print an error message if a required entry is ommitted. The program will also print a warning message if the value of an entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction Chapter II).

________________ = SYSTEM-CONTROL *or* S-C   LIKE ________________
u-name   NOTE 1   NOTE 3   *u-named*

Keyword *or*	*Abbreviation*		User Input NOTE 2	Notes	Default	Range Min.	Range Max.
MAX-SUPPLY-TEMP	MAX-S-T	=	________	°F	120	70	200
HEATING-SCHEDULE	H-S	=	________	u-named	Note 10	N/A	N/A
HEAT-CONTROL	H-C	=	________	code word	CONSTANT	N/A	N/A
HEAT-SET-TEMP	H-S-T	=	________	°F	120	70	200
HEAT-RESET-SCHED	H-R-S	=	________	u-named	Note 11	N/A	N/A
MIN-SUPPLY-TEMP	MIN-S-T	=	________	°F	60°	50°	70°
COOLING-SCHEDULE	C-S	=	________	u-named	Note 10	N/A	N/A
COOL-CONTROL	C-C	=	________	code word	CONSTANT	N/A	N/A
COOL-SET-TEMP	C-S-T	=	________	°F	60°	50°	70°
COOL-RESET-SCHED	C-R-S	=	________	u-named	Note 12	N/A	N/A
MAX-HUMIDITY	MAX-H	=	________	lbs H_2O/lbs air	1.00	0.006	0.013
MIN-HUMIDITY	MIN-H	=	________	lbs H_2O/lbs air	0.000	0.002	0.012
BASEBOARD-SCHED	B-S	=	________	u-named		N/A	N/A

For NOTES - see SECTION E

SYSTEM-CONTROL	The SYSTEM-CONTROL command is a group of data related to system temperature control, humidity control and operating schedule and is identified by a unique user defined name (u-name).
LIKE	Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named SYSTEM-CONTROL instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted, by the program, from the referenced instruction.
MAX-SUPPLY-TEMP	The user input for keyword MAX-SUPPLY-TEMP is the highest allowable temperature for air supplied to the space. The program will use this value to determine the air flow required to satisfy peak (or design day) heating loads.
HEATING-SCHEDULE	The user input for the keyword 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 the system being specified. If no data entry is made the program will assume that no such schedule exists and that heating is always available when needed.
HEAT-CONTROL	The user input for the keyword HEAT-CONTROL is the code-word that identifies the strategy to be used for control of heating air temperature. See Table IV-B2 for the code-words and a brief description of the control strategy each represents. Note that for single duct multiple zone type systems (i.e. VAVS and RHFS) the temperature control strategy for air discharging from the central air handling system is determined on a year around basis by user input for the keyword COOL-CONTROL. (i.e. the keyword HEAT-CONTROL is not applicable to these systems). A program revision that will permit seasonal change of control strategy and/or setpoint for these systems is being considered but plans for implementing the revision have not yet been formalized.

TABLE IV-B2

CODE-WORD	HEAT-CONTROL and COOL-CONTROL
CONSTANT	Sets heating supply air temperature and/or cooling supply air temperature at a fixed value. Values must then be entered for keywords HEAT-SET-TEMP and/or COOL-SET-TEMP respectively.
COLDEST	Sets heating air supply temperature to satisfy the zone requiring the most heating. Program determines this value based on zone heating load calculations and system air flow. Value cannot exceed MAX-SUPPLY-TEMP.
WARMEST	Sets cooling air supply temperature to satisfy the zone requiring the most cooling. Program determines this value as above. Value cannot be less than MIN-SUPPLY-TEMP.
RESET	Implements use of HEAT-RESET-SCHEDULE or COOL-RESET-SCHEDULE for control of heating air supply and/or cooling air supply temperature.

HEAT-SET-TEMP — The user input for the keyword HEAT-SET-TEMP is the value for heating air supply temperature when the control strategy selected requires this temperature to be maintained constant (i.e. entry for keyword HEAT-CONTROL is code-word CONSTANT, see Table IV-B2).

HEAT-RESET-SCHEDULE — The user input for the keyword HEAT-RESET-SCHEDULE 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 keyword HEAT-CONTROL is code-word RESET, see Table IV-B2.

MIN-SUPPLY-TEMP — The user input for the keyword MIN-SUPPLY-TEMP is the lowest allowable temperature for air supplied to the space. The program will use this temperature to determine the air flow required to satisfy peak (or design day) cooling loads. Also, where applicable, this becomes the preheat coil leaving temperature and is used to calculate the preheat load that is passed to the PLANT Program.

COOLING-SCHEDULE — The user input for the keyword 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 the system being specified. If no data entry is made the program will assume that no such schedule exists and that cooling is always available when needed (for systems with cooling capability).

COOL-CONTROL — The user input for the keyword COOL-CONTROL is the code-word that identifies the strategy to be used for control of cooling air temperature. See Table IV-B2 for the code-words and a brief description of the control strategy each represents.

COOL-SET-TEMP — The user input for the keyword COOL-SET-TEMP is the value that the program uses for cooling air supply temperature when the control strategy selected requires this temperature to be maintained constant (i.e. entry for keyword COOL-CONTROL is the code-word CONSTANT, see Table IV-B2.

COOL-RESET-SCHED — The user input for the keyword COOL-RESET-SCHED 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 code-word RESET, see Table IV-B2.

MAX-HUMIDITY — The user input for the keyword MAX-HUMIDITY is the highest allowable absolute humidity in the space or spaces served by the system being specified. 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.

Since most HVAC systems actually control on relative humidity rather than absolute humidity, the program is being revised and expanded to permit this option. The program will then determine when excess cooling for humidity control purposes is required based on the prevailing space temperatures and latent loads as well as the inputted relative humidity limit. Implementation of this revision by about 1/78 is expected.

Summer humidity control for Multi-Zone (MZS) and Dual Duct (DDS) Systems is normally accomplished by overriding hot deck control to increase hot deck temperature when space relative humidity exceeds the limit. The existing program (10/77) cannot simulate this control strategy. Incorporation of this feature is being considered but plans to implement the revision have not yet been formalized.

MIN-HUMIDITY. The user input for the keyword MIN-HUMIDITY is the lowest allowable absolute humidity in the space or spaces served by the system being specified. This data entry should be used only for those systems that have the components required for humidity control (i.e. humidistat and humidifier). If no entry the program will assume that this humidity control capability does not exist. See definition of MAX-HUMIDITY above for discussion of relative humidity control that applies here as well.

BASEBOARD-SCHED. The user input for the keyword BASEBOARD-SCHED 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. Note that the keywords SUPPLY-HI and SUPPLY-LO (in the RESET-SCHEDULE instruction) that usually specify temperatures are used here to specify baseboard output (as a decimal percentage of design heat addition rate). See RESET-SCHEDULE instruction for additional information. (See Chapter II for information on SCHEDULE instruction).

4. SYSTEM-AIR

The function of the SYSTEM-AIR instruction is to provide information on system air flowrate, both supply air and outside air. Several SYSTEM-AIR instructions may be required (maximum of ten) if the facility is served by more than one system and/or the user desires to determine the effect of varying any of the parameters specified by this instruction.

This instruction and the other supplementary system instructions, are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the SYSTEM instruction but the organization into sub-groups is for user convenience only. Once one of these instructions is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems (by use of the keyword in the SYSTEM instruction that identifies the supplementary instruction type) thus conserving data entry effort. The user can, at his discretion, use one or more of the supplementary system instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the SYSTEM instruction.

The User Worksheet for the SYSTEM-AIR instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (See Section D for a complete set of SYSTEMS Program Users Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1). The program will also print a warning message if the value of an entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction Chapter II).

______ = SYSTEM-AIR *or* S-A LIKE ______

u-name NOTE 1 NOTE 3 *u-named*

Keyword or	*Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SUPPLY-CFM	S-CFM	= ______	cfm	Note 7	50	$9.9x10^5$
RETURN-CFM	R-CFM	= ______	cfm	Note 8	50	$9.9x10^5$
MIN-OUTSIDE-AIR	M-O-A	= ______	decimal	Note 9	0.0	1.0
OUTSIDE-CONTROL	O-C	= ______	code-word	FIXED	N/A	N/A

For NOTES - see SECTION E

SYSTEM-AIR

The SYSTEM-AIR command is a group of data related to system air flow (supply air and outside air) and is identified by a unique user defined name (u-name).

LIKE

Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named SYSTEM-AIR instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted, by the program, from the referenced instruction.

SUPPLY-CFM

The user input for the keyword SUPPLY-CFM is the design capacity of the system air supply fan. This entry is normally omitted unless fan capacity is different than the maximum air flow rate assigned by the user (using ZONE-AIR instruction) or calculated by the program. The program uses this value as the basis for determining fan part-load operation. Fan horsepower is calculated based on typical part load characteristics of the selected mode of capacity control (see keyword FAN-CONTROL in the SYSTEM-FANS instruction) and on 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.

As noted above, the program will calculate design flow rate when data entry for this keyword is omitted. For those systems that can simulate a variable flowrate (DDS, SZCI, VAVS, RHFS) the program will use the concurrent peak flowrate rather than the sum of individual zone peaks. (The above is true, in the current version of the program, only when the facility is served by a single system. When several systems are specified, the sum of individual zone peaks is used. A program revision that will permit use of concurrent peak flowrate regardless of the number of systems specified is currently under consideration but plans to implement the revision have not been formalized as yet.)

RETURN-CFM — The user input for the keyword RETURN-CFM is the design capacity of the system return air fan. Discussion above applies here except that if there is no data entry the program always assumes that return air flow is actual supply air flow minus zone exhaust (keyword EXHAUST-CFM in ZONE-AIR instructions).

MIN-OUTSIDE-AIR — The user input for the keyword MIN-OUTSIDE-AIR is the minimum acceptable flowrate of fresh air expressed as a percentage (decimal) of the maximum air supply flowrate. Note that the maximum flowrate for multiple zone variable volume type systems may be the concurrent peak flowrate rather than the sum of individual zone peaks. (see discussion for keyword SUPPLY-CFM above).

The user may alternately or in addition specify outside air quantities at the zone level (keywords OUTSIDE-CHANGES or OUTSIDE-CFM/PER or OUTSIDE-AIR-CFM in the ZONE-AIR instruction). If minimum outside air is specified both here and at the zone level, the program will select the higher of the two values.

OUTSIDE-CONTROL — The user input for the keyword OUTSIDE-CONTROL is the code-word for the type of outside air control strategy selected. See Table IV-B3 for the code-words and a brief description of the control strategy each represents.

TABLE IV-B3

Code-word	OUTSIDE-CONTROL
FIXED	Outside air flowrate is controlled at a fixed user specified volume (see keyword MIN-OUTSIDE-AIR).
TEMP	Temperature controlled Economizer. Outside air flowrate is increased, during cool weather, to provide free cooling. Flowrate is controlled so mixed air temperature approaches required supply air temperature (or cold deck temperature). Outside air flowrate returns to a fixed minimum volume whenever outside air temperature increases to a predetermined limit. (see keyword ECONO-LIMIT-TEMP in SYSTEM instruction).
ENTHALPY	Enthalpy controlled economizer. As above except outside air flow is returned to a minimum based on a comparison of supply and return air enthalpy rather than on outside air temperature.
ENTHALPY-LOGIC	As above except system compares enthalpies of outside air, return air, and supply air to optimize supply/return ratio for both heating and cooling.

5. SYSTEM-FANS

The function of the SYSTEM-FANS instruction is to provide information on supply and return fan operating schedule, control mode, static pressure and efficiency. In short this instruction provides everything the program needs to know in addition to fan capacity to calculate 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 and EXHAUST-EFF in the ZONE-AIR instruction). Several SYSTEM-FANS instructions may be required if the facility is served by more than one system and/or user desires to determine the effect of varying any of the parameters specified by this instruction.

This instruction and the other supplementary system instructions, are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the SYSTEM instruction but the organization into sub-groups is for user convenience only. Once one of these instructions is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems (by use of the keyword in the SYSTEM instruction that identifies the supplementary instruction type) thus conserving data entry effort. The user can, at his discretion, use one or more of the supplementary system instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the SYSTEM instruction.

The User Worksheet for the SYSTEM-FAN instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (see Section D for a complete set of SYSTEMS Program Users Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1), and will abort and print an error message if a required entry is omitted. The program will also print a warning message if the value of an entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction - Chapter II).

____________ = SYSTEM-FANS *or* S-FAN   LIKE ____________

u-name   NOTE 1   NOTE 3   *u-named*

Keyword	*or*	*Abbrev-iation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
FAN-SCHEDULE		F-S	= ________	u-name	Note 10	N/A	N/A
FAN-CONTROL		F-C	= ________	code-word	Note 13	N/A	N/A
SUPPLY-STATIC		S-S	= ________	inches W.G.	Note 25	0.05	10
SUPPLY-EFF		S-E	= ________	decimal	Note 25	0.10	0.90
RETURN-STATIC		R-S	= ________	inches W.G.	0.0	0.05	10
RETURN-EFF		R-E	= ________	decimal	0.80	0.10	0.9

For NOTES - see SECTION E

SYSTEM-FAN — The SYSTEM-FANS command is a group of data related to the operation of system supply and return fans. It is identified by a unique user defined name (u-name).

LIKE — Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named SYSTEM-AIR instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted, by the program, from the referenced instruction.

FAN-SCHEDULE — The user input for the keyword FAN-SCHEDULE is the u-name of the SCHEDULE instruction that specifies the time periods (hours and days) during which the system fans (supply, return and exhaust) are operating (see Chapter II for information on SCHEDULE instruction). If this data entry is not used the program will assume these fans run continuously.

FAN-CONTROL — The user input for the keyword FAN-CONTROL is the code word that identifies the kind of flow reduction or control methods to be simulated. See Table IV-B4 for the code-words and a brief description of the method each represents. This data entry is mainly applicable to variable volume type systems. The program calculates the part load horsepower consumption for the supply fan and return fan (if any) based on the part load versus fan horsepower characteristics that are typical for the control mode selected (see Figure IV- B1 below). Program assumes that both supply and return fans have the same kind of flow control.

TABLE IV-B4

Code-word	FAN-CONTROL DESCRIPTION
SPEED	Variable speed motor
INLET	Fan inlet vanes
DISCHARGE	Damper in fan discharge

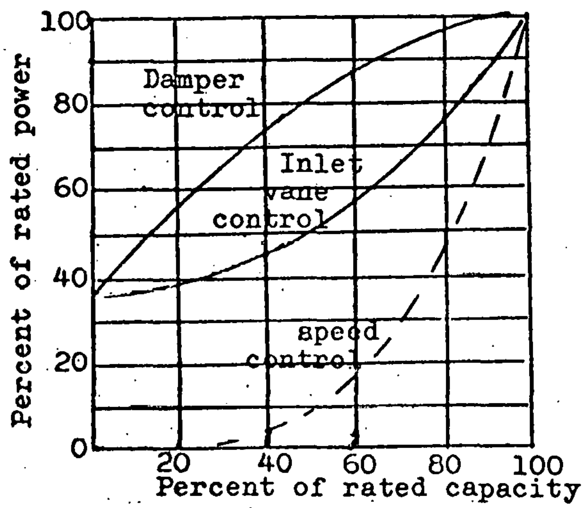


Figure IV-B1 Typical Power Requirements at Part-load Operation for Three Different Methods of Capacity Control

SUPPLY-STATIC — The user input for the keyword SUPPLY-STATIC is the total pressure produced by the system supply fan at design flowrate. Design flowrate is the user inputted 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) flowrates for each zone.

SUPPLY-EFF — The user input for SUPPLY-EFF is the overall efficiency (decimal) of the supply fan at design conditions. (Overall efficiency is the combined efficiency of the fan and motor).

RETURN-STATIC — The user input for RETURN-STATIC is the total pressure produced by the system return air fan at design flowrate. Design flowrate is the user inputted value for the keyword RETURN-CFM (see SYSTEM-AIR instruction) or if no data entry is made for that keyword, the calculated return air flowrate.

RETURN-EFF — The user input for the keyword RETURN-EFF is the overall efficiency (decimal) of the return air fan at design conditions. (Overall efficiency is the combined efficiency of the fan and motor).

6. 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 or the user desires to determine the effect of varying any of the parameters specified by this instruction.

This instruction and the other supplementary system instructions, are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the SYSTEM instruction but the organization into sub-groups is for user convenience only. Once one of these instructions is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems (by use of the keyword in the SYSTEM instruction that identifies the supplementary instruction type) thus conserving data entry effort. The user can, at his discretion, use one or more of the supplementary system instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the SYSTEM instruction.

At the present time the value of any characteristic specified in the SYSTEM-TERMINAL instruction (i.e. reheat ΔT or minimum air supply or induced air ratio) must be identical for all zones served by the system being specified. A program change that will permit zone by zone variation is presently under consideration but plans for implementing the revision have not yet been formalized.

The User Worksheet for the SYSTEM-TERMINAL instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (see Section D for a complete set of SYSTEMS Program User Worksheets). Note that the program will use the default value if no entry is made for an optional entry keyword (see Table IV-D1). The program will also print a warning message if the value of an entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction Chapter II).

__________ = SYSTEM-TERMINAL *or* S-T LIKE __________
u-name NOTE 1 NOTE 3 *u-named*

Keyword *or*	*Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
REHEAT-DELTA-T	R-D-T	= ________	°F	Note 14	0.0	80
INDUCTION-RATIO	I-R	= ________	fraction	Note 26	2.0	6.0
MIN-CFM-RATIO	M-C-R	= ________	fraction	1.0	0.0	1.0

For NOTES - see SECTION E

SYSTEM-TERMINAL — The SYSTEM-TERMINAL command is a group of data related to zone temperature control components such as reheat coils, induction units and VAV boxes. It is identified by a unique user defined name (u-name).

LIKE — Data input may be simplified by using the keyword LIKE to reference the u-name of a previously named SYSTEM-TERMINAL instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted, by the program, from the referenced instruction.

REHEAT-DELTA-T — The user input for the keyword REHEAT-DELTA-T is the maximum increase in temperature for supply air passing through zone (or sub-zone) reheat coils.

INDUCTION-RATIO — The user entry for the keyword 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 sub-zone temperature control (System type SZCI).

MIN-CFM-RATIO — The user input for this keyword is the minimum allowable air supply flowrate expressed as a percentage (decimal) of maximum flowrate. The keyword MIN-CFM-RATIO is applicable only to variable volume type systems.

7. SYSTEM-FLUID

The function of the SYSTEM-FLUID instruction is to provide information that is applicable specifically to the hydronic part of an air-water type system (TPFC, FPFC, TPIU, FPIU and HP). Several SYSTEM-FLUID instructions may be required if the facility is served by more than one type of mixed air-water system and/or it is desired to determine the effect of varying any of the parameters specified by this instruction.

This instruction and the other supplementary system instructions are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the SYSTEM instruction but the organization into sub-groups is for user convenience only. Once one of these instructions is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems (by use of the keyword in the SYSTEM instruction that identifies the supplementary instruction type) thus conserving data entry effort. The user can, at his discretion, use one or more of the supplementary system instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the SYSTEM instruction.

Note that pumping horsepower is accounted for by the PLANT Program rather than the SYSTEM Program. User input required to calculate this quantity is provided via keyword ELEC-INPUT-RATIO (see Chapter V PLANT Program).

The User Worksheet for the SYSTEM-FLUID instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (see Section D for a complete set of SYSTEMS Program Users Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1). The program will also print a warning message if the value of an entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction Chapter II).

________________ = SYSTEM-FLUID *or* S-FLU LIKE ________________
u-name NOTE 1 NOTE 3 *u-named*

Keyword *or*	*Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
CHANGE-OVER-HI	C-O-H =	________	°F	Note 30	40	80
CHANGE-OVER-LO	C-O-L =	________	°F	Note 30	40	60
MIN-FLUID-TEMP	MIN-F-T =	________	°F	Note 29	40	80
MAX-FLUID-TEMP	MAX-F-T =	________	°F	Note 29	80	100
FLUID-HEAT-CAP	F-H-C =	________	BTU/°F	N/A	N/A	N/A

For NOTES - see SECTION E

SYSTEM-FLUID — The SYSTEM-FLUID command is a group of data related to hydronic type systems or the hydronic part of air-water type systems and is identified by a unique user defined name (u-name).

LIKE — Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named SYSTEM-FLUID instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted by the program, from the referenced instruction.

CHANGE-OVER-HI — The keyword CHANGE-OVER-HI is applicable only to the Two Pipe Fan Coil System (TPFC) and the Two Pipe Induction Unit System (TPIU) and only when these systems are equipped with controls to automatically switch from heating to cooling (and visa-versa) based on outside temperature. The user entry for this keyword is the value of outside temperature at which the system changes from heating to cooling.

CHANGE-OVER-LO — The user entry for the keyword CHANGE-OVER-LO is the value of outside air temperature at which system operating mode is switched from cooling to heating. See definition of keyword CHANGE-OVER-HI, above for discussion that applies as well to this keyword.

MIN-FLUID-TEMP — The keyword MIN-FLUID-TEMP is applicable to the Unitary Hydronic Heat Pump (System No. 14) and to the Two Pipe Fan Coil (System No. 8) and Two Pipe Induction Unit (System No. 10) type systems. It applies to these systems in a somewhat different manner as described below.

When simulating the unitary heat pump system, the user entry for this keyword is the minimum allowable temperature for the circulating heat removal/heat source fluid. The program simulates addition of heat, as required to prevent fluid temperature from falling below this value. The heat addition component is specified by the user in a BDL instruction for the PLANT Program and is simulated by the PLANT Program (see Chapter V).

When simulating a two pipe system the user entry for this keyword is the design cooling temperature of the circulating fluid. The program uses this value, plus the entries for keywords MAX-FLUID-TEMP and FLUID-HEAT-CAP to calculate heating to cooling or cooling to heating change-over energy .

MAX-FLUID-TEMP

The keyword MAX-FLUID-TEMP is applicable to the Unitary Heat Pump (System No. 14) and to the Two Pipe Fan Coil (System No. 8) and Two Pipe Induction Unit (System No. 10) type systems. It applies to these systems in a somewhat different manner as described below.

When simulating the unitary heat pump system, the user entry for this keyword is the maximum allowable temperature for the circulating heat removal/heat source fluid. The program simulates heat rejection, as required to prevent fluid temperature from exceeding this value. The heat rejection component is specified by the user in a BDL instruction for the PLANT Program and is simulated by the PLANT Program (see Chapter V).

When simulating a two pipe system the user entry for this keyword is the design heating temperature of the circulating fluid. The program uses this value, plus the entries for MIN-FLUID-TEMP and FLUID-HEAT-CAP to calculate heating to cooling and cooling to heating change-over energy.

FLUID-HEAT-CAP

The keyword FLUID-HEAT-CAP is applicable to the unitary heat pump (HP) and the two pipe systems (TPFC or TPIU). The user entry for this keyword is the heat that must be added (or removed) from the system fluid to change the temperature 1^{o}F. The user must calculate this value based on the total volume of fluid in the system and the specific heat of the cooling fluid.

8. ZONE

The function of the ZONE instruction is to provide information on those system characteristics that may vary from one zone to another. The information provided includes; air flowrate (supply air and outside air), space temperature setpoint, thermostat characteristics and the maximum heating and/or cooling available. A portion of the required information is provided by the ZONE instruction but one or more additional instructions are needed to complete the specification. These are the schedule instructions (SCHEDULE) and if the user chooses, the supplementary zone instructions (ZONE-AIR and ZONE-CONTROL). An additional function of the ZONE instruction is to identify those specific additional instructions that are applicable to the zone being specified.

The supplementary zone instructions, referred to above, are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the ZONE instruction but the organization into sub-groups is for user convenience only. Once an instruction is labeled and data is entered for the applicable keywords, it can be referenced to any number of different systems, thus conserving data input effort. The user can, at his discretion, use one or more of the supplementary zone instructions or alternately 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) served by the system (s) being specified. 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, there will be a ZONE instruction to represent a physically identical portion of the building.

The User Worksheet for the ZONE instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (see Section D for a complete set of SYSTEMS Program User Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords, (see Table IV-D1) and will abort and print an error message if a required entry is omitted. The program will also print a warning message if the value of any entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction - Chapter II).

______ = ZONE *or* Z LIKE ______

u-name NOTE 1 NOTE 3 *u-named*

Keyword *or*	*Abbreviation*	User Input NOTE 2	Notes	Default	Range	
					Min.	Max.
ZONE-TYPE	Z-T	= ______	code-word	Note 22	N/A	N/A
ZONE-AIR	Z-A	= ______	u-named	Note 5	N/A	N/A
ZONE-CONTROL	Z-C	= ______	u-named	Note 5	N/A	N/A
ZONE-MULTIPLIER	Z-M	= ______	number	1.0	1	200
HEAT-MAX	H-M	= ______	BTU/hr	Note 15	0.0	10^6
COOL-MAX	C-M	= ______	BTU/hr	Note 15	0.0	10^6
BASEBOARD-RATIO	B-R	= ______	number	0.0	0.4	1.2
PANEL-LOSS-RATIO	P-L-R	= ______	decimal	0.0	0.05	1.0

For NOTES see SECTION E

ZONE The ZONE command is a group of data related to those system characteristics that may vary on a zone by zone basis. It is identified by a unique user defined name (u-name). 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 Chapter III). The u-name for this data entry must therefore match the u-name entered for the corresponding SPACE instruction.

LIKE Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named ZONE instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted by the program, from the referenced instruction.

ZONE-TYPE

The user entry for the keyword ZONE-TYPE is the code-word (from Table IV-B5) that identifies whether the zone is a conditioned space, an unconditioned space or a plenum.

TABLE IV-B5

Code-word	ZONE-TYPE
CONDITIONED	The zone is heated and/or cooled depending on the type of system selected.
UNCONDITIONED	The zone is neither heated nor cooled but is located adjacent to one or more of the conditioned zones assigned to this system. (false ceilings not used as return air plenums are in this category).
PLENUM	The zone is a false ceiling space used as a plenum for return air.

ZONE-AIR

The user input for the keyword ZONE-AIR is the u-name of the previously named ZONE-AIR instruction that applies to the particular zone being specified, thus referencing the previously defined keyword-value relationships contained in that instruction. This data entry is omitted if no ZONE-AIR instruction has been specified. (i.e. if the default value for all applicable keywords is acceptable or if the user chooses to enter these keywords and their values under the ZONE instruction). Note that the term ZONE-AIR, used here as a keyword, is also used as a command-word in the supplementary system instruction of that name.

ZONE-CONTROL — The discussion above for keyword ZONE-AIR applies equally to this keyword when the keyword names are interchanged.

ZONE-MULTIPLIER — The user input for the keyword ZONE-MULTIPLIER is the number of zones in the facility that are identical to the zone being specified and are to be assigned to the same system. This data entry is used only when the facility has a number of identical rooms or spaces, and the user, to simplify LOADS Program input, has specified them all with a single SPACE instruction by use of the analogous keyword SPACE-MULTIPLIER (see SPACE instruction Chapter III). The value entered here should match the value entered for that keyword in the SPACE instruction.

HEAT-MAX — The user input for the keyword HEAT-MAX is the maximum heat addition rate for the zone being specified. This data entry, if used, will override capacity calculations based on peak (or design day) loads. The program will use the value entered with this keyword along with specified sizing ratio, temperature control setpoint, thermostat characteristics and equipment operating schedules to recalculate the actual heat addition rate and zone space temperature for each hour.

COOL-MAX — The user input for the keyword COOL-MAX is the maximum heat extraction rate for the zone being specified. This data entry, if used, will override capacity calculations based on peak (or design day) loads. The program will use the value entered with this keyword, along with specified sizing ratio, temperature control setpoint, thermostat characteristics and equipment operating schedules, to recalculate the actual heat extraction rate and zone temperature for each hour.

BASEBOARD-RATIO — The user input for the keyword BASEBOARD-RATIO is the ratio of baseboard heating element capacity to total zone transmission heat loss (neglecting solar effect). The program uses the value entered with this keyword along with calculated peak (or design day) heat loss, the baseboard schedule, and outside air temperatures to calculate the heat added every hour by the zone baseboard element. The program assumes that baseboard heating capacity varies in direct proportion to the temperature difference between room air and outside air (i.e. circulating fluid temperature is referenced to outside air temperature). This data entry is used, of course, only for those zones that are equipped with baseboard heating elements.

PANEL-LOSS-RATIO — The user input for the keyword PANEL-LOSS-RATIO is the heat loss from the floor heating panel in the zone being specified, expressed as a decimal percentage 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.

9. ZONE-AIR

The function of the ZONE-AIR instruction is to provide information on the flow of air into and out of the 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 if it is desired to determine the effect of varying any of the parameters specified by this instruction.

This instruction, and the other supplementary zone instruction (ZONE-CONTROL), are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the ZONE instruction but the organization into sub-groups is for user convenience only. Once one of these instructions is labeled and data is entered for the applicable keywords, it can be referenced to any number of different zones (by use of the keyword in the ZONE instruction that identifies the supplementary instruction type) thus conserving data entry effort. The user can, at his discretion, use one or more of the supplementary zone instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the ZONE instruction.

The User Worksheet for the ZONE-AIR instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (see Section D for a complete set of SYSTEMS Program User Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1). The program will also print a warning message if the value of an entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction - Chapter II).

________ = ZONE-AIR *or* Z-A   LIKE ________
u-name   NOTE 1   NOTE 3   *u-named*

Keyword	*or Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
AIR-CHANGES/HR	A-C/HR	= ________	number	Note 16	0.5	100
CFM/SQFT		= ________	number	Note 16	0.2	20
ASSIGNED-CFM	A-CFM	= ________	cfm	Note 16	50	5×10^5
OUTSIDE-CHANGES	O-C	= ________	number	Note 17	0.01	100
OUTSIDE-CFM/PER	O-CFM/PER	= ________	cfm	Note 17	5	100
OUTSIDE-AIR-CFM	O-A-CFM	= ________	cfm	Note 17	5	5×10^4
EXHAUST-CFM	E-CFM	= ________	cfm	0.0	50	5×10^5
EXHAUST-EFF	E-E	= ________	decimal	0.65	0.1	0.9
EXHAUST-STATIC	E-S	= ________	inches W.G.	0.0	0.05	20

For NOTES - see SECTION E

ZONE-AIR — The ZONE-AIR command is a group of data related to zone air flow (supply air, exhaust air and outside air) and is identified by a unique user defined name (u-name).

LIKE — Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named ZONE-AIR instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted by the program, from the referenced instruction.

AIR-CHANGES/HR — The user input for the keyword AIR-CHANGES/HR is the design supply air flowrate that the user wants to assign to the zone being specified, expressed in terms of how many times in one hour this flowrate would replace the total volume of air in the zone. This data entry if used will override the otherwise used value of maximum supply air flowrate that the program calculates based on peak (or design day) loads and temperature differential. Alternatively or in addition, the user can assign design supply air flowrate by use of a data entry for keyword CFM/SQFT or keyword ASSIGNED-CFM. If data entry is made for both keywords AIR-CHANGES/HR and CFM/SQFT the program will calculate a flowrate based on each entry and use the largest value. Any data entry made for keyword ASSIGNED-CFM will override the other entries and be used by the program.

CFM/SQFT — The user input for the keyword CFM/SQFT is the design supply air flowrate that the user wants to assign to the zone being specified, expressed as the ratio of this flowrate to the total floor area of the zone. This data entry, if used, will override the otherwise used value of maximum supply air flowrate that the program calculates based on peak (or design day) loads and temperature differential. For a discussion of alternative ways to specify zone air flowrate see keyword AIR-CHANGES/HR above.

ASSIGNED-CFM

The user input for the keyword ASSIGNED-CFM is the design supply air flowrate that the user wants to assign to the zone being specified. This data entry, if used, will override the otherwise used value of maximum supply air flowrate that the program calculates based on peak (or design day) loads and temperature limits.

For a discussion of alternative ways to specify zone air flowrate see keyword AIR-CHANGES/HR.

OUTSIDE-CHANGES

The user input for the keyword OUTSIDE-CHANGES is the minimum flowrate of outside air for the zone being specified, expressed in terms of how many times in one hour this flowrate would replace the total volume of air in the zone. Note that the user may, alternatively, or in addition specify outside air flowrate by data entry for the keywords OUTSIDE-CFM/PER and OUTSIDE-AIR-CFM in this instruction and the keyword MIN-OUTSIDE-AIR in the SYSTEM-AIR instruction. The program will calculate outside air flowrate based on each entry and use the largest value except that any data entry made for keyword OUTSIDE-AIR-CFM will override the other entries and be used by the program.

OUTSIDE-CFM/PER

The user input for the keyword OUTSIDE-CFM/PER is the minimum flowrate of outside air for the zone being specified, per zone occupant at peak occupancy. For a discussion of alternate ways to specify outside air flowrate see keyword OUTSIDE-CHANGES above.

OUTSIDE-AIR-CFM

The user input for the keyword OUTSIDE-AIR-CFM is the minimum flowrate of outside air for the zone being specified. For a discussion of alternate ways to specify outside air flowrate see keyword OUTSIDE-CHANGES above.

EXHAUST-CFM

The user input for the keyword EXHAUST-CFM is the flowrate of direct exhaust from the zone being specified. This data entry can of course be omitted if there is no exhaust from this zone or if there is only central exhaust by way of the system return fan.

EXHAUST-STATIC

The user input for the keyword EXHAUST-STATIC is the total pressure produced by the exhaust fan serving the zone being specified. This data entry is applicable only if a data entry is made for the keyword EXHAUST-CFM.

EXHAUST-EFF

The user input for the keyword EXHAUST-EFF is the efficiency (decimal) of the zone exhaust fan at design conditions. This data entry is applicable only if a data entry is made for the keyword EXHAUST-CFM. The program calculates exhaust fan horsepower based on the value of this data entry and the entries for keywords EXHAUST-CFM and EXHAUST-STATIC. The exhaust fan is assumed to be constant flow and to operate only when the system supply and return fans operate (see keyword FAN-SCHEDULE in the SYSTEM-FANS instruction).

A program revision that will permit simulation of variable volume exhaust flow and the scheduling of exhaust fan operation independent of the supply and return fans is currently under consideration but plans to implement this revision have not as yet been formalized.

10. ZONE-CONTROL

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

This instruction, and the other supplementary zone instruction (ZONE-AIR) are each groups of data that are related with respect to subject or category of information. The information is needed to supplement that provided in the ZONE instruction but the organization into sub-groups is for user convenience only. Once an instruction is labeled and data is entered for the applicable keywords, it can be referenced to any number of different zones (by use of the keyword in the ZONE instruction that identifies the supplementary instruction type)thus economizing the data input effort. The user can, at his discretion, use the supplementary zone instructions or alternately select the applicable keywords from these instructions and make a data entry for each with the ZONE instruction.

The User Worksheet for the ZONE-CONTROL instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords (see Section D for a complete set of SYSTEMS Program User Worksheets). Note that the program will use the default values indicated if no entry is made for optional entry keywords (see Table IV-D1). The program will also print a warning message if the value of an entry is outside the indicated range unless instructed not to do so (see MESSAGE instruction - Chapter II).

_______________ = ZONE-CONTROL *or* Z-C LIKE _______________
u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
DESIGN-HEAT-TEMP	D-H-T	= ________	°F	68	40	80
HEAT-TEMP-SCHED	H-T-S	= ________	u-named	Note 18	N/A	N/A
DESIGN-COOL-TEMP	D-C-T	= ________	°F	78	60	100
COOL-TEMP-SCHED	C-T-S	= ________	u-named	Note 19	N/A	N/A
THERMOSTAT-TYPE	T-T	= ________	code-word	Note 20	N/A	N/A
THROTTLING-RANGE	T-R	= ________	°F	2	0.5	20

For NOTES - see SECTION E

ZONE-CONTROL — The ZONE-CONTROL command is a group of data related to control of zone temperature and is identified by a unique user defined name (u-name).

LIKE — Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named ZONE-CONTROL instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted by the program, from the referenced instruction.

DESIGN-HEAT-TEMP — The user input for the keyword DESIGN-HEAT-TEMP is the space temperature that the program uses to calculate the supply air flowrate required to meet peak (or design day) heating loads for the zone being specified. This flowrate calculation is based: on the peak (or design day) heat loads received from the LOADS program; on the temperature difference between the supply air and the space; and on a user inputted sizing factor (if data entry is made for the keyword SIZING-RATIO in the SYSTEM instruction). The supply air temperature used in this calculation is specified in the SYSTEM-CONTROL instruction (by data entry for keyword MAX-SUPPLY-TEMP) The program will also calculate, in a similar manner, the supply air flowrate required for cooling and will use the larger of the two flowrates. Note that the user can nullify these calculations and directly assign zone supply air flowrate (by data entry to one of three keywords provided specifically for this purpose in the ZONE-AIR instruction).

HEAT-TEMP-SCHED — The user input for the keyword HEAT-TEMP-SCHED is the u-name of the SCHEDULE instruction that defines the heating season and the space temperature set point of the zone being specified as a function of the time of the day and the day of the week during this season (see Chapter II for information on SCHEDULE instruction). A data entry for this keyword is required (as is the referenced SCHEDULE instruction) if the system being specified has heating capacity. If no data entry is made, the program will assume that the zone being specified is not heated.

DESIGN-COOL-TEMP The user input for the keyword DESIGN-COOL-TEMP is the space temperature that the program uses to calculate the supply air flowrate required to meet peak (or design day) cooling loads for the zone being specified. The discussion above for keyword DESIGN-HEAT-TEMP is also directly applicable to this keyword.

COOL-TEMP-SCHED The user input for the keyword COOL-TEMP-SCHED is the u-name of the SCHEDULE instruction that defines the cooling season and the space temperature setpoint of the zone being specified as a function of the time of the day and the day of the week during this season (see Chapter II for information on SCHEDULE instruction). A data entry for this keyword is required (as is the referenced SCHEDULE instruction) if the system being specified has cooling capability. If no data entry is made the program will assume that the zone being specified is not cooled.

THERMOSTAT-TYPE The user input for the keyword THERMOSTAT-TYPE is the code-word that identifies the type of thermostat that is to be simulated for the zone being specified. See Table IV-B6 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 for both cooling and heating.

TABLE IV-B6

Code-word	THERMOSTAT-TYPE
PROPORTIONAL	Thermostat throttles heat addition rate (or heat extraction rate) in linear proportion to the difference between space setpoint temperature and actual space temperature. The proportional-band is input by the user (see keyword THROTTLING-RANGE). Program will simulate either direct or reverse action as required.
TWO-POSITION	On-Off type thermostat with very narrow fixed deadband.
DUAL-SET-POINT	Single thermostat with two independent set points (or two separate thermostats) On-Off or proportional operation at each set point is simulated based on user input for keyword THROTTLING-RANGE. No heat addition or extraction when space temperature is between setpoints (as extended by throttling range).

11. RESET-SCHEDULE

The function of the RESET-SCHEDULE instruction is to define the relationship between a controlled system parameter and outside air temperature and to specify the time periods during which this relationship applies. The RESET-SCHEDULE instruction is applicable to controlled parameters such as hot deck temperature and cold deck temperature only when the reset control strategy has been specified (see keywords HEAT-RESET-SCHED and COOL-RESET-SCHED in the SYSTEM-CONTROL instruction). It is always applicable to baseboard heating (see keyword BASEBOARD-SCHED in the SYSTEM-CONTROL instruction).

The RESET-SCHEDULE instruction is directly analagous to the SCHEDULE instruction described in Chapter II with one exception. As for the SCHEDULE instruction, supplementary schedule instructions (WEEK-SCHEDULE and DAY-SCHEDULE) must be specified to complete data entry. The WEEK-SCHEDULE instruction is as defined in Chapter II but the DAY-SCHEDULE instruction is different when used in this context. Rather than the 24 hourly related values normally entered for the DAY-SCHEDULE instruction, four keywords and their values are entered. These keywords are defined on the next page.

Note that the BDL words SCHEDULE, WEEK-SCHEDULE and DAY-SCHEDULE are equivalenced to the BDL words RESET-SCHEDULE, WEEK-RESET-SCHED and DAY-RESET-SCHED respectively. These words can be used interchangeably but use of the latter set of BDL words is recommended to more clearly identify the function of the instruction.

The User Worksheet for the DAY-RESET-SCHED instruction is reproduced below followed by definitions and instructions for use of the command-word and associated keywords. (see Section D for a complete set of SYSTEMS Program User Worksheets). See Chapter II for information on use of the SCHEDULE (i.e. RESET-SCHEDULE) instruction and the WEEK-SCHEDULE (i.e. WEEK-RESET-SCHED) instruction.

________________ = DAY-RESET-SCHED *or* D-R-S   LIKE ________________
u-name   NOTE 1   NOTE 3   *u-named*

Keyword	*or Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SUPPLY-HI	S-H	= ________	°F	Note 21	Note 27	Note 27
SUPPLY-LO	S-L	= ________	°F	Note 21	Note 27	Note 27
OUTSIDE-HI	O-H	= ________	°F	Note 21	50	100
OUTSIDE-LO	O-L	= ________	°F	Note 21	-20	40

For NOTES - see SECTION E

DAY-RESET-SCHED	The DAY-RESET-SCHED command is a group of data that defines how a controlled parameter is to vary in response to outside air temperature changes and is identified by a unique user defined name (u-name).
LIKE	Data entry may be simplified by using the keyword LIKE to reference the u-name of a previously named DAY-RESET-SCHED instruction. Additional data entry is required only where keyword values are different than those specified in the referenced instruction. All other information is extracted by the program, from the referenced instruction.
SUPPLY-HI	The user input for the keyword SUPPLY-HI is the set point temperature (or output ratio) of the controlled system parameter being specified at the outside air temperature corresponding to the user input value for the keyword OUTSIDE-LO. The user input for this keyword is a temperature when this instruction is specified for the reset of cooling air or heating air temperature (see keywords HEAT-RESET-SCHED and COOL-RESET-SCHED in the SYSTEM-CONTROL instruction). Figure No. IV-B2 illustrates this application. The user input for this keyword is a heating output ratio when this instruction is specified for baseboard heating (see keyword BASEBOARD-SCHED in the SYSTEM-CONTROL instruction). The heating output is expressed as a decimal percentage of the maximum zone baseboard heating capacity (see keyword BASEBOARD-RATIO in the ZONE-CONTROL instruction). Figure No. IV-B3 illustrates this application.
SUPPLY-LO	The user input for the keyword SUPPLY-LO is the set point temperature (or output ratio) of the controlled system parameter being specified at the outside air temperature corresponding to the user input value for the keyword OUTSIDE-HI. See discussion for keyword SUPPLY-HI above.
OUTSIDE-HI	The user input for the keyword OUTSIDE-HI is the outside temperature at which the set point temperature of the controlled system parameter corresponds to the user input value for the keyword SUPPLY-LO.
OUTSIDE-LO	The user input for the keyword OUTSIDE-LO is the outside temperature at which the setpoint temperature of the controlled system parameter being specified corresponds to the user inputted value for the keyword SUPPLY-HI.

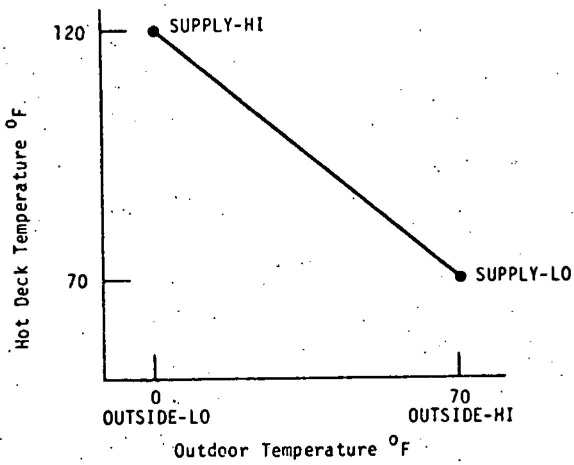


Figure IV-B2 Typical DAY-RESET-SCHED When Used for Simulation of Hot Deck Temperature Control

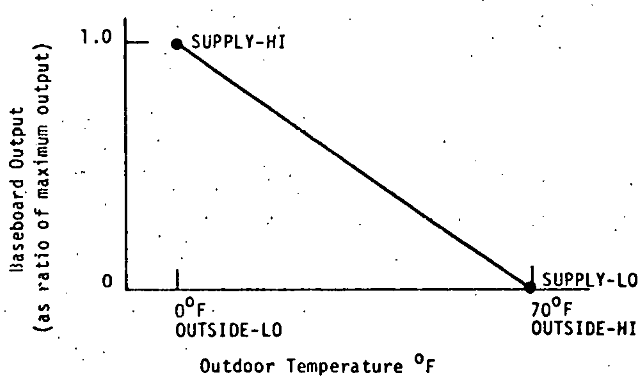


Figure IV-B3 Typical DAY-RESET-SCHED When Used for Simulation of Baseboard Heating Output

12. SYSTEMS-REPORT

The function of the SYSTEMS-REPORT instruction is to specify which of the standard verification, summary and detailed reports are to be printed and to specify those days for which detailed hourly reports (if specified) are required.

The User Worksheet for the SYSTEMS-REPORTS instruction is reproduced below followed by definitions and instructions for use of the command-word and keywords.

SYSTEMS REPORT *or* S-R

NOTE 31

Keyword *or*	*Abbrev-iation*	User Input NOTE 2	Notes	Default	Range Min.	Max.
VERIFICATION	VERI	= ____________	code-word	None	N/A	N/A
SUMMARY	SUMM	= ____________	code-word	SS-A	N/A	N/A
DETAIL-LEVEL	D-L	= ____________	code-word	None	N/A	N/A
DETAIL-SCHEDULE	D-SCH	= ____________	u-named	NOTE 28	N/A	N/A

For NOTES - see SECTION E

SYSTEMS-REPORT — The SYSTEMS-REPORT command is a group of data that identifies the standard reports that are to be printed and the days for which hourly reports (if required) are printed. The data entry is the command-word itself, no u-name identifier is required or permitted.

VERIFICATION

The user input for the keyword VERIFICATION is the code-word that identifies the standard verification type report (containing information on the design parameters that have been used for system simulation) to be printed. See Table IV-B7 for the code-words and a description of the report each represents.

TABLE IV-B7

Code-word	VERIFICATION
SV-A	Prints out design parameters for each system and each zone. These parameters are user assigned, and/or calculated by the program. System parameters include: maximum and design supply and return flowrate; minimum outside air ratio; minimum flow ratio (for variable volume type systems); maximum supply and return fan Kw; and altitude multiplier. Zone parameters include: supply air flowrate; outside air quantities, maximum heat addition and extraction rates; maximum number of people; and zone multiplier.
REPORT-ONLY	Verification report as above except program does not proceed with the actual hour by hour simulation.

SUMMARY

The user input for the keyword SUMMARY is the code-word that identifies the standard summary type report (containing peak and summed monthly loads) to be printed. See Table IV-B8 for the code-words and a description of the report each represents.

TABLE IV-B8

Code-word	SUMMARY
SS-A	Prints out total heating, cooling and electrical energy and peak energy addition and extraction rates during the specified run period for each specified system. Also summarizes the above information on a month by month basis and prints out the time of occurrence of the run-period and monthly peaks.
SS-AM	As above but print out is in metric units.

DETAIL-LEVEL — The user input for the keyword DETAIL-LEVEL is the code-word that identifies the standard hourly type report that is to be printed. See Table IV-B9 for the code-words and a description of the report each represents.

TABLE IV-B9

Code-word	DETAIL-LEVEL
PLANT-LEVEL	Prints out hourly values summarized for each plant assignment. Values are total heating/cooling and electrical energy.
SYSTEM-LEVEL	Prints out PLANT-LEVEL report described above plus hourly values for each system in the plant assignment grouping. These values are: total heating, cooling and electrical energy; supply air CFM; cooling and heating CFM; cooling and heating supply air temperatures; ratio of outside air and infiltration air (to supply air); ratios of hot and cold air (to total); total cooling and heating provided to the zones; return air temperature and absolute humidity (downstream of return air fan); mixed air temperature and absolute humidity, total fan Kw.
ZONE-LEVEL	Prints out SYSTEM-LEVEL report described above plus hourly values for each zone. These values are: sensible, latent, electrical, plenum, and infiltration (from LOADS program); zone temperature (actual and setpoint); heat addition/extraction rate; hot and/or cold CFM; and zone heating or cooling energy (from local units such as reheat coils, fan coil units and induction units).

DETAIL-SCHEDULE — The user input for the keyword DETAIL-SCHEDULE is the u-name of the SCHEDULE instruction that specifies those days, during the run period, for which a detailed hourly report is to be printed. The SCHEDULE instruction required for this purpose is as described in Chapter II with one exception. The supplementary schedule instruction DAY-SCHEDULE requires entry of a single value in lieu of the 24 hourly values normally entered. If this value is a one, the program will print an hourly report for the day specified. If the value is zero the hourly report for that day will be suppressed.

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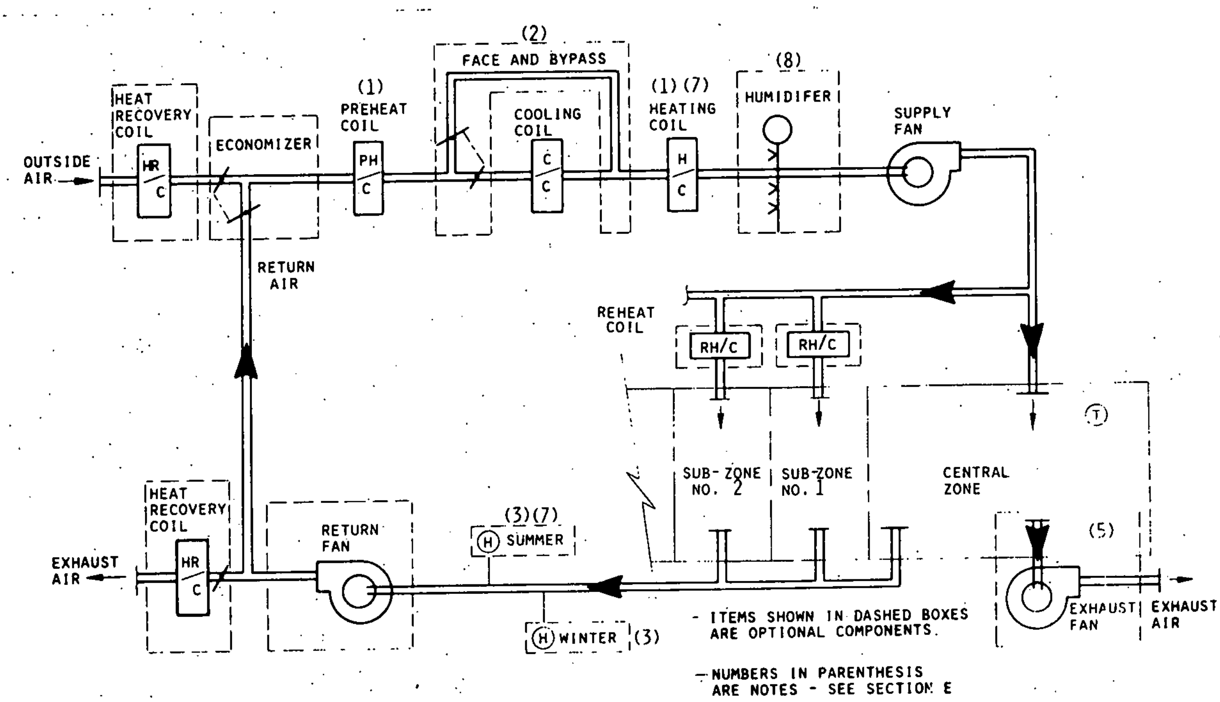


SYSTEM NO. 1 Single Zone Fan System w/Optional Sub-Zone Reheat (SZRH)

The single zone type fan system (w/optional sub-zone 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 from an air handling unit containing a heating coil, a cooling coil, filters (not shown), and a supply fan. The temperature of discharge air is controlled from a thermostat sensing space conditions. 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 Cal-ERDA Program can simulate the basic system described above when provided with user input data such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction and keyword FAN-CONTROL in the SYSTEM-FANS instruction); space temperature control (see keywords HEAT-TEMP-SCHED, COOL-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); outside air quantities (see SYSTEM-AIR and ZONE-AIR instructions); fan characteristics (see SYSTEM-FANS instruction); and identification of the zones served by the system (see keyword ZONE-NAMES in the SYSTEM instruction). In addition a number of optional features can be specified. These options are discussed below with reference made to the BDL language used to specify them.

1. Sub-Zones Option: One or more sub-zones with reheat coil temperature control can be specified (see keyword ZONE-NAMES in the SYSTEM instruction and keyword REHEAT-DELTA-T in the SYSTEM-TERMINAL instruction).

2. Mixed Air Options: A fixed quantity of outside air or one of three different types of economizer cycles can be specified. (see keywords OUTSIDE-CONTROL and MIN-OUTSIDE-AIR).

3. Return Air Options: 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-STATIC and RETURN-EFF in SYSTEM-FANS instruction). 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 instruction).

4. Exhaust Fan Option: Direct exhaust, independent of the return air system, may be specified for the central zone and/or one or more sub-zones. (see keywords EXHAUST-CFM, EXHAUST-STATIC and EXHAUST-EFF in the ZONE-AIR instruction).

5. Winter Humidity Control Option: Winter humidity control, by control of absolute humidity in the return air can be specified (see keyword MIN-HUMIDITY in the SYSTEM-CONTROL instruction). The program converts any increase in absolute humidity into a heat load (btu/hr) and passes this load to the PLANT. A planned program revision will permit winter humidity control based on return air relative humidity as an option. Implementation of this revision by January 1978 is anticipated.

6. Summer Humidity Control Option: Summer humidity control, by control of the absolute humidity in the return air can be specified (see keyword MAX-HUMIDITY in the SYSTEM-CONTROL instruction). A planned program revision will permit control based on return air relative humidity as an option. Implementation of this revision by January 1978 is anticipated. The program assumes that a heating coil is installed downstream of the cooling coil whenever summer humidity control is specified.

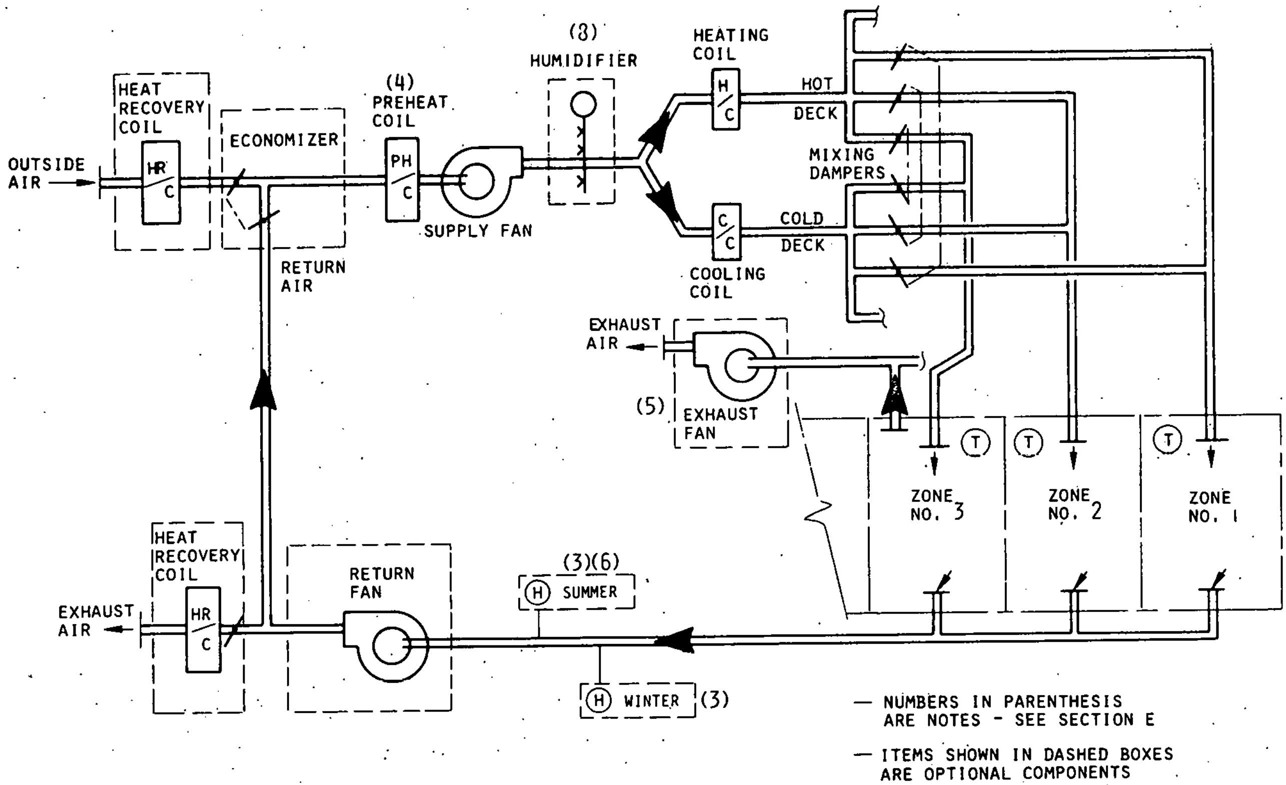
7. Face and By-Pass Cooling Option: (See keyword FACE-AND-BYPASS in the SYSTEM instruction).

8. Heat Recovery Option: (See keyword RECOVERY-EFFECT in the SYSTEM instruction).

9. <u>Baseboard Heat Option:</u> Baseboard heating may be specified for the central zone and/or one or more sub-zones. (see keywords BASEBOARD-RATIO in the ZONE instruction and BASEBOARD-SCHED in the SYSTEM-CONTROL instruction).

10. <u>System Sizing Option:</u> The user may directly assign system parameters such as: zone flowrate, (see keyword AIR-CHANGES/HR or CFM/SQFT or ASSIGNED-CFM in the ZONE-AIR instruction); fan capacity (see keyword SUPPLY-CFM and RETURN-CFM in the SYSTEM-AIR instruction) and maximum heat addition and extraction rates (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction). Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between supply air temperature (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperature (see keywords DESIGN-HEAT-TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction). The user may adjust the calculated or assigned values by application of a sizing factor (see keyword SIZING-RATIO in the SYSTEM instruction).

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 2 Multi-Zone Fan System (MZS)

The multi-zone 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. Air is ducted separately from the discharge of the air handling unit to each zone. Temperature is controlled in each zone through the mixing of two air streams at different temperatures (hot and cold deck) by the mixing dampers located in the air handling unit.

The Cal-ERDA Program can simulate the basic system described above when provided with user input data such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction and keyword FAN-CONTROL in the SYSTEM-FANS instruction); space temperature control (see keywords HEAT-TEMP-SCHED, COOL-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); outside air quantities (see SYSTEM-AIR and ZONE-AIR instructions); fan characteristics (see SYSTEM-FANS instruction); and identification of the zones served by the system (see keyword ZONE-NAMES in the SYSTEM instruction). In addition a number of optional components and control strategies can be specified. These options are discussed below with reference made to the BDL language used to specify them.

1. Mixed Air Option: A fixed quantity of outside air or one of three different types of economizer cycles can be specified. (See keywords OUTSIDE-CONTROL and MIN-OUTSIDE-AIR).

2. Return Air Options: 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-STATIC and RETURN-EFF in SYSTEM-FANS instruction). 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 instruction).

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-STATIC and EXHAUST-EFF in the ZONE-AIR instruction).

4. Winter Humidity Control Option: Winter humidity control by control of absolute humidity in the return air can be specified (see keyword MIN-HUMIDITY in the SYSTEM-AIR instruction). The program converts any increase in absolute humidity into a heat load (btu/hr) and passes this load to the PLANT. A planned program revision will permit winter humidity control based on return air relative humidity as an option. Implementation of this revision by January 1978 is anticipated.

   The multi-zone system is in general not well suited for applications requiring winter humidity control, particularly if a related humidity level above about 30% is required.

5. Summer Humidity Control Option: Summer humidity control for the Multi-Zone type system is normally accomplished by over-riding hot deck control to increase hot deck temperature when space relative humidity exceeds the limit. The existing program (10/77) cannot simulate this control strategy. Incorporation of this feature is being considered but plans to implement the revision have not yet been formalized.

6. Face and By-Pass Cooling Option: (See keyword FACE-AND-BYPASS in the SYSTEM instruction).

7. Heat Recovery Option: (See keyword RECOVERY-EFFECT in the SYSTEM instruction).

8. Hot Deck Temperature Control Option: Hot deck temperature can be maintained constant; reset in accordance with outside air temperature; or based on the requirements of the coldest zone served by the system (see keywords HEAT-CONTROL, HEAT-SET-TEMP and HEAT-RESET-SCHEDULE in the ZONE-CONTROL instruction).

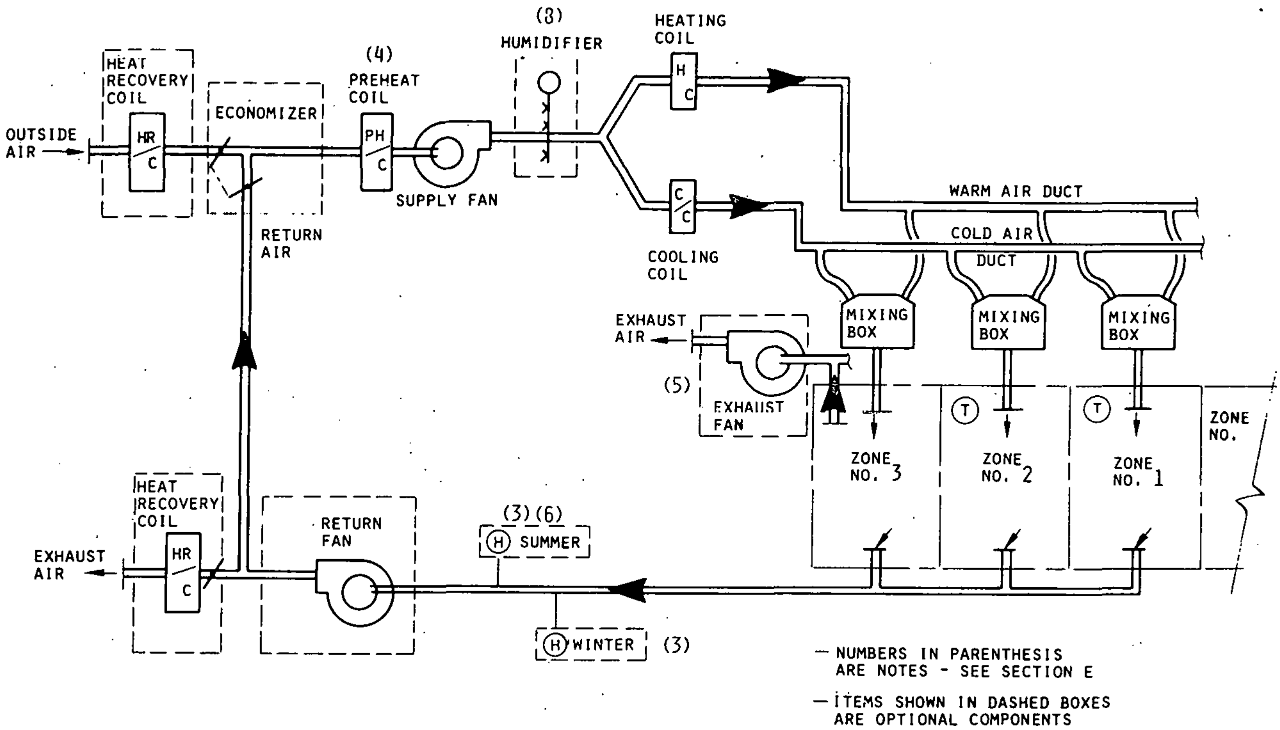
9. <u>Cold Deck Temperature Control Option:</u> Cold deck temperature can be: maintained constant; reset in accordance with outside air temperature; or based on the requirements of the warmest zone served by the system (see keywords COOL-CONTROL, COOL-SET-TEMP and COOL-RESET-SCHEDULE in the ZONE-CONTROL instruction).

10. <u>Baseboard Heat Option:</u> Baseboard heating may be specified for the one or more zones. (See keyword BASEBOARD-RATIO in the ZONE instruction and BASEBOARD-SCHED in the SYSTEM-CONTROL instruction).

11. <u>Thermostat Option:</u> Three different types of thermostat action can be specified, i.e., on-off proportional band, and dual set-point (see keyword THERMOSTAT-TYPE in the ZONE-CONTROL instruction).

12. <u>System Sizing Option:</u> The user may directly assign system design parameters such as: zone flowrate, (see keyword AIR-CHANGES/HR or CFM/SQFT or ASSIGNED-CFM in the ZONE-AIR instruction); fan capacity (see keyword SUPPLY-CFM and RETURN-CFM in the SYSTEM-AIR instruction) and maximum heat addition and extraction rates (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction). Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between supply air temperature (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperature (see keywords DESIGN-HEAT -TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction). The user may adjust the calculated or assigned values by application of a sizing factor (see keyword SIZING-RATIO in the SYSTEM instruction).

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program. including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-DI with the applicability of each of this system (and other systems) noted.



SYSTEM NO. 3 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 multi-zone type system (see System No. 2 for description) except that the hot and cold air streams (warm air duct and cold air duct) are extended to individual mixing boxes, located in the zone being served, where mixing of the two air streams take place.

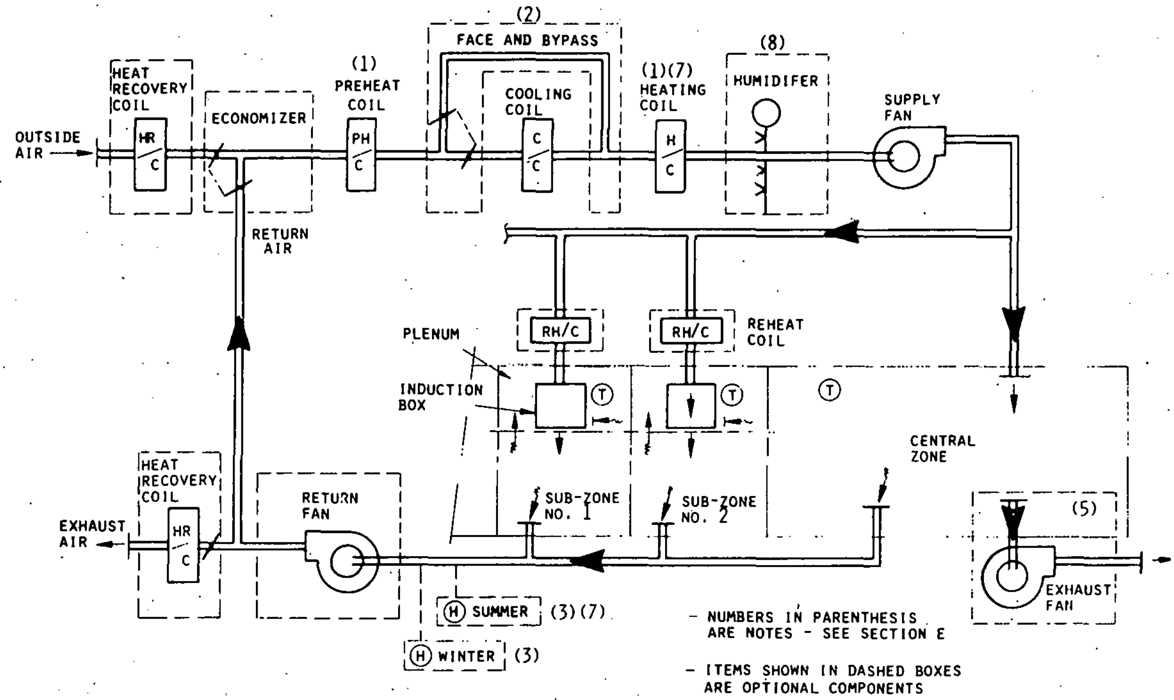
The variable volume type dual duct system is as described above except that the type of mixing box used in this system has the capability to reduce flow on a decrease in cooling demand. Mixing of the cold and hot air streams occurs only after flow has been reduced to a prescribed minimum thus reducing total energy usage.

The Cal-ERDA SYSTEMS Program can simulate the basic system described above when provided with user input data such as: operating schedules, space temperature control, supply air temperature control, outside air quantities, fan characteristics and identification of the zones served by the system (see System No. 2 Multi Zone Fan System for identification of BDL words used). In addition the optional components and control strategies described for System No. 2 and the BDL language used to specify these options apply equally well to both the constant and variable volume type dual duct system. Additional options that apply only to the variable volume type dual duct system are discussed below.

1. Minimum Flow Option: The user specifies the flow reduction permitted before mixing of the hot and cold air streams is initiated to prevent any additional decrease in flow (see keyword MIN-CFM-RATIO in the SYSTEM-TERMINAL instruction). The allowable reduction is expressed as a percentage (decimal) of design flow rate and must be the same for all zones served by this system. A program revision that will permit zone by zone variation is presently under consideration, but plans for implementing the revision have not yet been formalized.

2. Fan Control Option: The user can specify one of three different methods for reducing system fan capacity in accordance with system flow requirements, i.e., fan discharge damper, fan inlet vanes or a variable speed motor (see keyword FAN-CONTROL in the SYSTEM-FANS instruction).

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-DI with the applicability of each of this system (and other systems) noted.



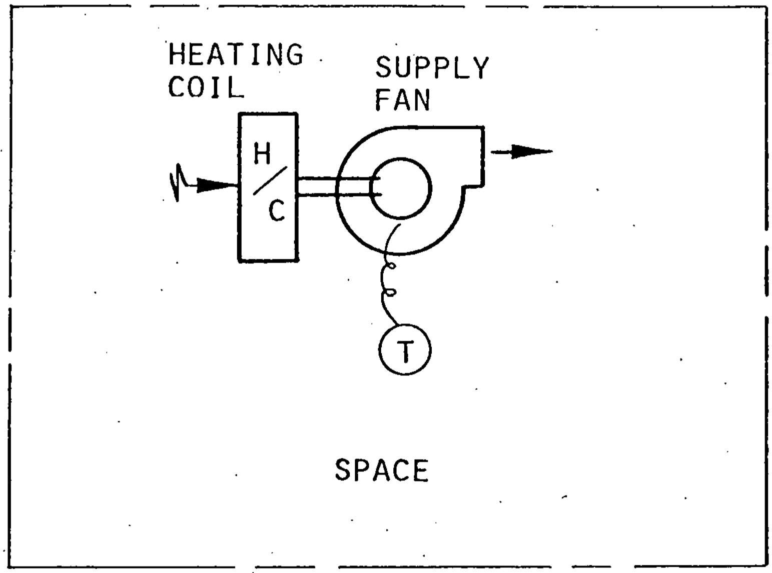
SYSTEM NO. 4 Single Zone Fan System with Sub-Zone Induction Mixing Boxes

This system is identical to the Single Zone Fan System w/optional Reheat (System No. 1) in any of its optional configurations, with the addition of induction mixing boxes to provide individual temperature control for one or more sub-zones. In general, the total air volume supplied to sub-zones will be considerably less than the air supplied to the central zone. Although the air supply to the central zone is assumed to remain constant, total system air flow is effected 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 sub-zone, while simultaneously inducing room (or ceiling plenum) air into the mixing box so that the flow of air into the space remains relatively constant. Since induction flow is limited to maximum of 50%, reheat coils may be installed if further primary air heating is required.

With exceptions as noted above, the discussion of system design features, options and BDL input language for System No. 1 applies as well to this system. An additional option that applies to this system is discussed below.

> Fan Control Option: The user can specify one of three different methods for reducing system fan capacity in accordance with system flow requirements, i.e., fan discharge damper, fan inlet vanes or a variable speed motor (see keyword FAN-CONTROL in the SYSTEM-FANS instruction). This option would probably be used only if the air supply to the sub-zones was a significant portion of total flow.

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEM Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-DI with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 5 Unit Heater (UHT)

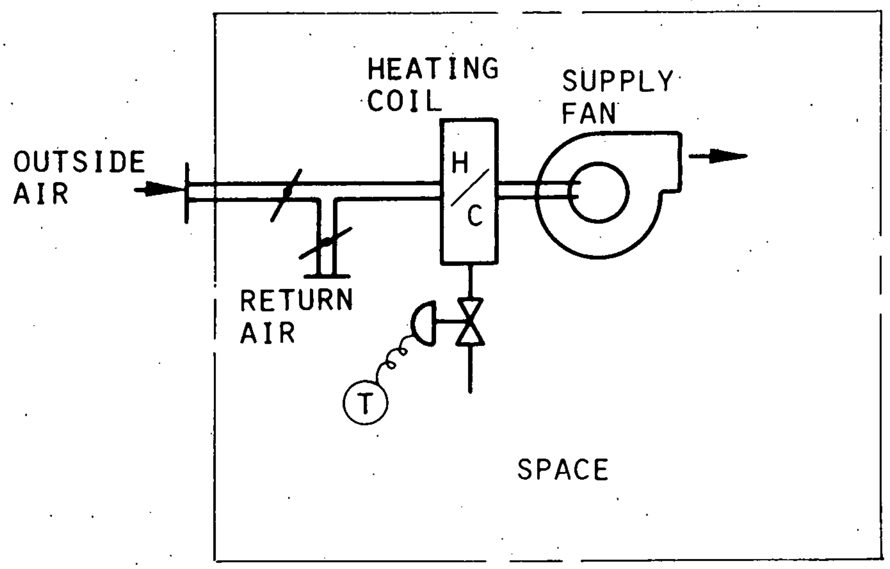
This simulation is primarily designed for a unit heater serving one space (i.e., a unit heater free standing in a room). It may, however, be extended to simulate heating of several spaces (distribution ductwork provided) if these spaces are combined into a single zone. This system is not capable of introducing outside air. Space temperature control is accomplished by throttling or on-off control of the heating fluid. A program revision to permit simulation of fan on-off temperature control is being considered, but plans to implement this revision have not yet been formalized.

The Cal-ERDA SYSTEMS Program can simulate unit heater operation when provided with user input data such as: operating schedule (see keyword HEATING-SCHEDULE in the SYSTEM-CONTROL instruction and FAN-SCHEDULE in the SYSTEM-FANS instruction); space temperature control (see keywords HEAT-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction) and identification of the zone served (see keyword ZONE-NAMES in the SYSTEM instruction).

The user can directly assign system design parameters such as fan capacity (see keyword ASSIGNED-CFM in the ZONE-AIR instruction) and maximum heat addition rate (see keyword HEAT-MAX in the ZONE instruction. Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between the maximum temperature of discharge air (see keyword MAX-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperature (see keyword DESIGN-HEAT-TEMP in the ZONE-CONTROL instruction).

When calculated (rather than assigned) values are used to simulate unit heater fan capacity, these values are rounded, by the program, to the next higher unit of ten. Note that unit heaters are generally equipped with direct drive fans and may not be available with fan capacities that match the calculated values. Therefore user assignment of a specific commercially available unit heater fan capacity is recommended for improved simulation accurracy.

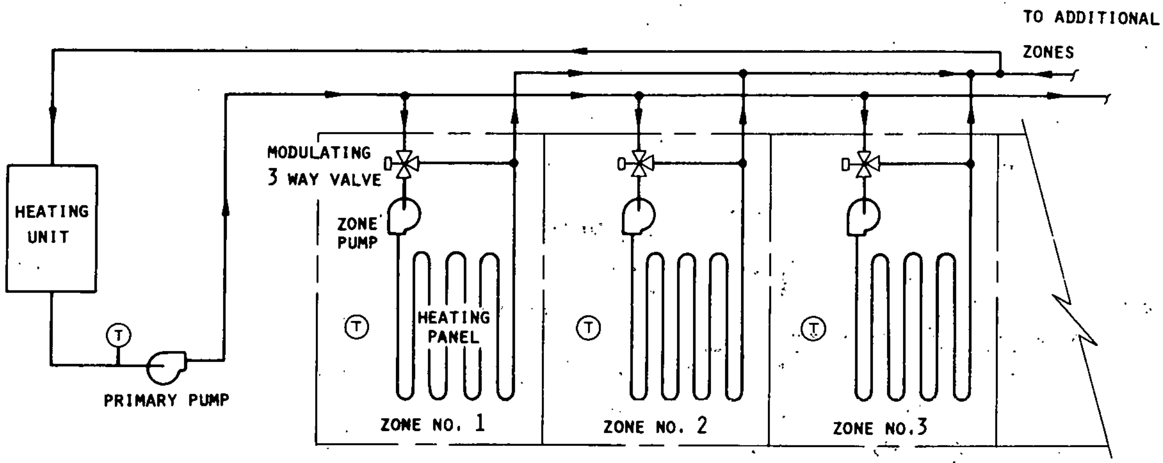
See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 6 Unit Ventilator

This simulation is the same as described for System No. 5 (unit heater) except that the unit ventilator is capable of introducing a fixed amount of outside air (see SYSTEM-AIR and ZONE-AIR instructions). The discussion of design features, options and BDL input language for the unit heater applies as well to the unit ventilator.

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



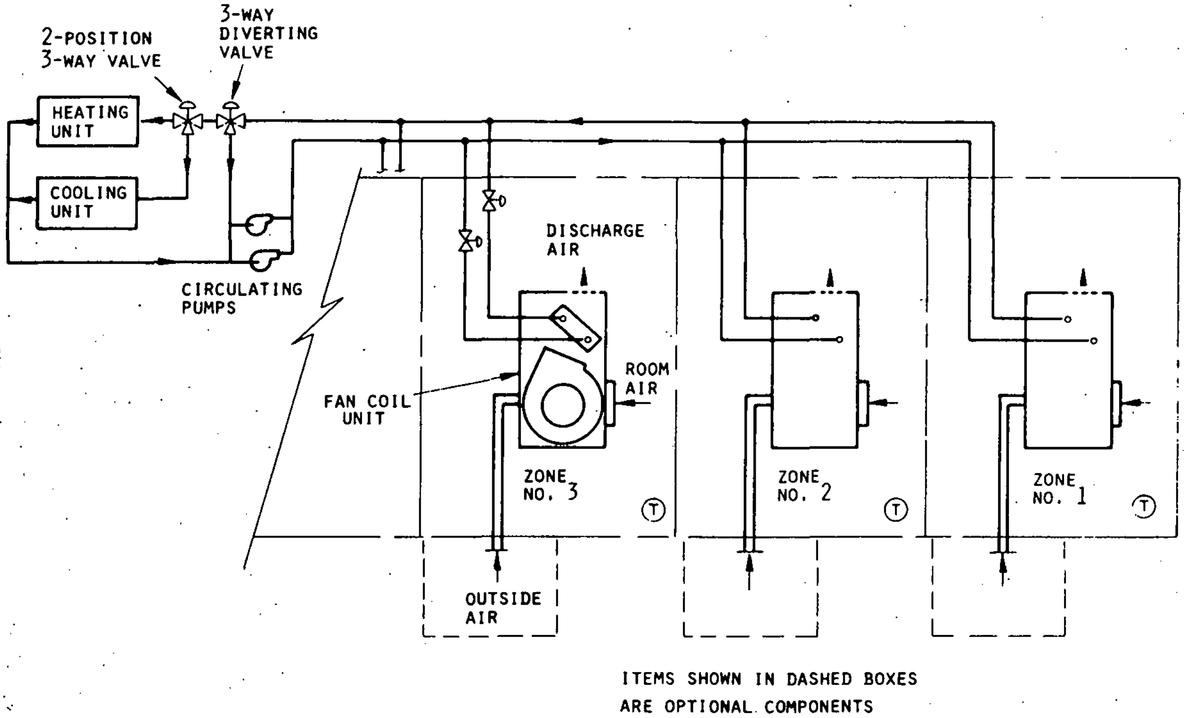
SYSTEM NO. 7 Floor Panel Heating System

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 inbedded in the floor or ceiling. A single pump, rather than the primary-secondary pumping arrangement shown, is installed for single zone systems. Space temperature is controlled in each zone 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 Section A paragraph 4 of this Chapter). No attempt is made to simulate the effect of the panel slab thermal inertia on the performance of the panel heating system, either on system start up and shut down or in response to rapid changes in heat loads (other than by the light medium and heavy weighting factors used in the TEMDEV sub-routine). Note that pumping energy associated with this system is accounted for by the PLANT Program rather than the SYSTEMS program (see Chapter V).

The user must estimate the ratio of panel heat losses to panel heating output (see keyword PANEL-HEAT-LOSS in the Zone instruction). The program assumes this ratio of heat loss to heat output to remain constant over the full range of panel output. Additional user input data required for system simulation include: operating schedule (see keyword HEATING-SCHEDULE in the SYSTEM-CONTROL instruction); space temperature control (see keywords HEAT-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); and identification of the zones served (see keyword ZONE-NAMES in the ZONE instruction).

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 8 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 multiple number of individually controlled zones. However, all zones served by the system must, at any given time, be operating in the same mode (i.e. heating or cooling.)

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 (depending on the prevailing mode of operation). The unit can provide a fixed quantity of outside air ventilation (see keyword OUTSIDE-CONTROL in the SYSTEM-AIR instruction) or merely recirculate conditioned air.

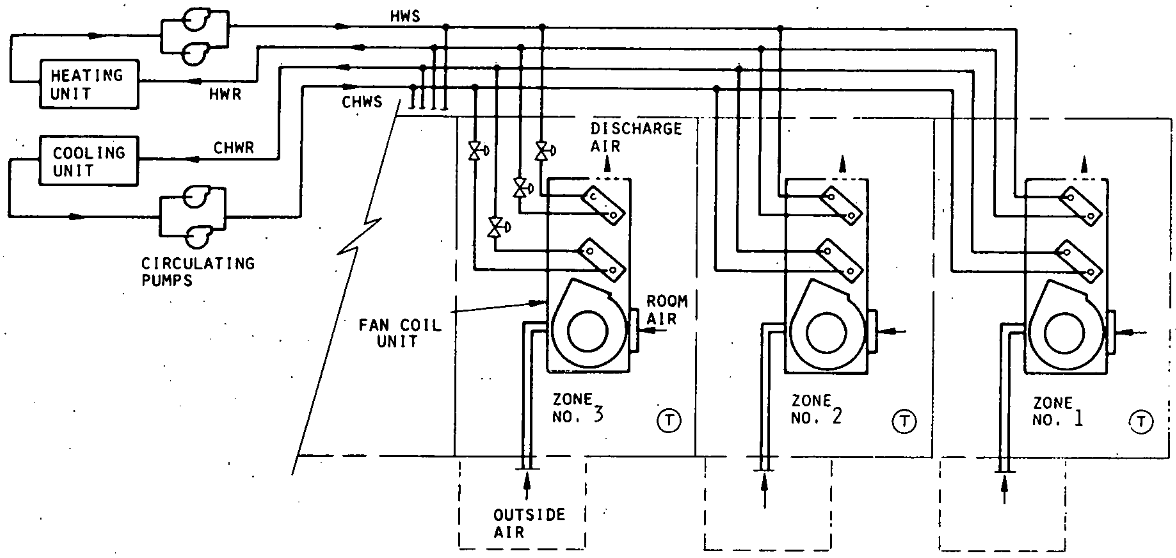
Temperature control is achieved by throttling the flow of water through the heating/cooling coil. The control thermostat commonly used for this type of system (see code-word DUAL-SET-POINT for keyword THERMOSTAT-TYPE in the ZONE-CONTROL instruction) has separate heating and cooling setpoints, Thermostat setpoint and action (i.e. direct or reverse) is alternated with each change-over from heating to cooling and from cooling to heating. Change-over is initiated automatically based on outdoor temperature (see keywords CHANGEOVER-HI and CHANGEOVER-LO in the SYSTEM-FLUID instruction).

The program calculates the energy added (or extracted) from the circulating fluid in each changeover based on user input cooling water design temperature, heating water design temperatures, and system heat capacity (see keywords MIN-FLUID-TEMP, MAX-FLUID-TEMP and FLUID-HEAT-CAP in the SYSTEM-FLUID instruction. Note that the pumping energy associated with this system, is accounted for in the Plant Program rather than the SYSTEM Program.

The Cal-ERDA SYSTEMS Program can simulate the system described above when provided with additional user input data such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction and the keyword FAN-SCHEDULE in the SYSTEM FANS instruction); space temperature control (see keywords HEAT-TEMP-SCHED, COOL-TEMP-SCHED, and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); fan characteristics (see keywords SUPPLY-FAN-STATIC and SUPPLY-EFF in SYSTEM-FANS instruction), and identification of the zones served by the system (see keyword ZONE-NAMES in the SYSTEM instruction). The user may directly assign system design parameters such as fan capacity (see ZONE-AIR instruction) and maximum heat addition and extraction rates (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction). Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between the temperature of air discharged from the fan coil unit (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY TEMP in the SYSTEM-CONTROL instruction) and design space temperatures (see keywords DESIGN-HEAT-TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction).

When calculated (rather than assigned) values are used to simulate fan capacity, these values are rounded by the program, to the next higher unit of ten. 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 user assignment of a specific commercially available unit fan capacity is recommended for improved simulation accuracy.

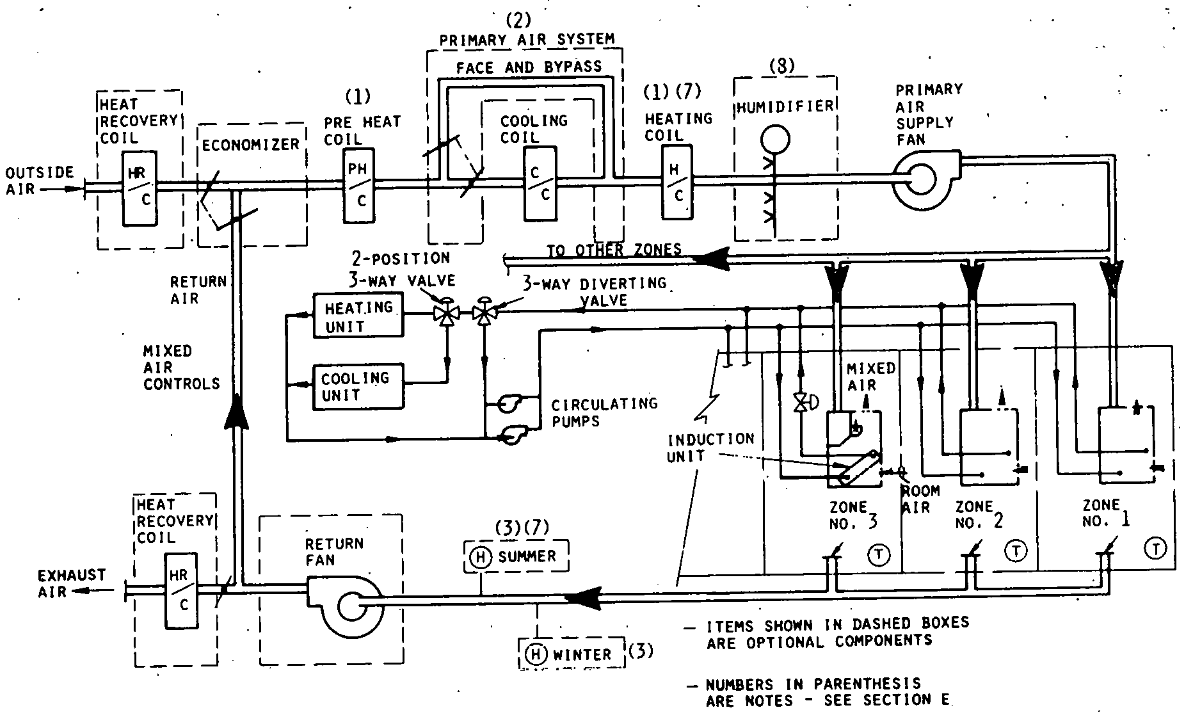
See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 9 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 (System No. 8) with the following exceptions: the fan coil units have separate heating and cooling coils (rather than a combined heating/cooling coil); 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 those in another zone are heating and change-over energy losses are minimal. Additionally, humidity control by sub cooling and reheating in the same fan coil unit is possible. With exceptions as noted above, the discussion of system design features, options and BDL input language for System No. 8 applies as well to this system.

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 10 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 multiple number of individually controlled zones. However, all zones served by the system must, at any given time, be operating in the same mode (i.e. either heating or cooling).

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 (depending on the prevailing mode of operation). These systems are commonly designed so that only sensible cooling can be done in the induction unit and no dehumidification.

The primary air system, in its most basic configuration consists of a filter (not shown), cooling and heating coils, a draw through supply fan and air distribution ducts. It is often designed to provide 100% outside air but 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. The control thermostat commonly used for this type of system (see code-word DUAL-SETPOINT for keyword THERMOSTAT-TYPE in the ZONE-CONTROL instruction) has separate heating and cooling setpoints. Thermostat setpoint and action (i.e. direct or reverse) is alternated with each change-over from heating to cooling and from cooling to heating. Change-over is initiated automatically based on outdoor temperature (see keywords CHANGEOVER-HI and CHANGEOVER-LO in the SYSTEM-FLUID instruction).

The program calculates the energy added (or extracted) from the circulating fluid in each changeover based on user input cooling water design temperature, heating water design temperature and system heat capacity (see keywords MIN-FLUID-TEMP, MAX-FLUID-TEMP and FLUID-HEAT-CAP in the SYSTEM-FLUID instruction). Note that the pumping energy associated with this system, is accounted for in the PLANT Program rather than the SYSTEM Program.

The Cal-ERDA Program can simulate the basic system described above when provided with user input data such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction and keyword FAN-SCHEDULE in the SYSTEM-FANS instruction); space temperature control (see keywords HEAT-TEMP-SCHED and COOL-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); outside air quantities (see SYSTEM-AIR and ZONE-AIR instructions) and fan characteristics (see SYSTEM-FANS instruction); ratio of induced to primary air (see keyword INDUCED-AIR-RATIO in the SYSTEM-TERMINAL instruction). And identification of the zones served by the system (see keywords ZONE-NAMES in the SYSTEM instruction). In addition a number of optional features can be specified. These options are discussed below with reference made to the BDL language used to specify them.

1. <u>Mixed Air Option</u>: A fixed quantity of outside air or one of three different types of economizer cycles can be specified. (See keywords OUTSIDE-CONTROL and MIN-OUTSIDE-AIR).

2. <u>Return Air Fan Options</u>: Return air may be pulled back to the primary air system by the supply fan or a separate return air fan may be specified for this purpose. (see keywords RETURN-STATIC and RETURN-EEF in SYSTEM-FANS instruction). 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 instruction).

3. <u>Exhaust Fan Option</u>: Direct exhaust, independent of the return air system, may be specified for one or more zones. (see keywords EXHAUST-CFM, EXHAUST-STATIC and EXHAUST -EFF in the ZONE-AIR instruction).

4. Winter Humidity Control Option: Winter humidity control by control of absolute humidity in the return air can be specified (see keyword MIN-HUMIDITY in the SYSTEM-AIR instruction). The program converts any increase in absolute humidity into a heat load (btu/hr) and passes this load to the PLANT. A planned program revision will permit winter humidity control based on space relative humidity as an option. Implementation of this revision by January 1978 is anticipated.

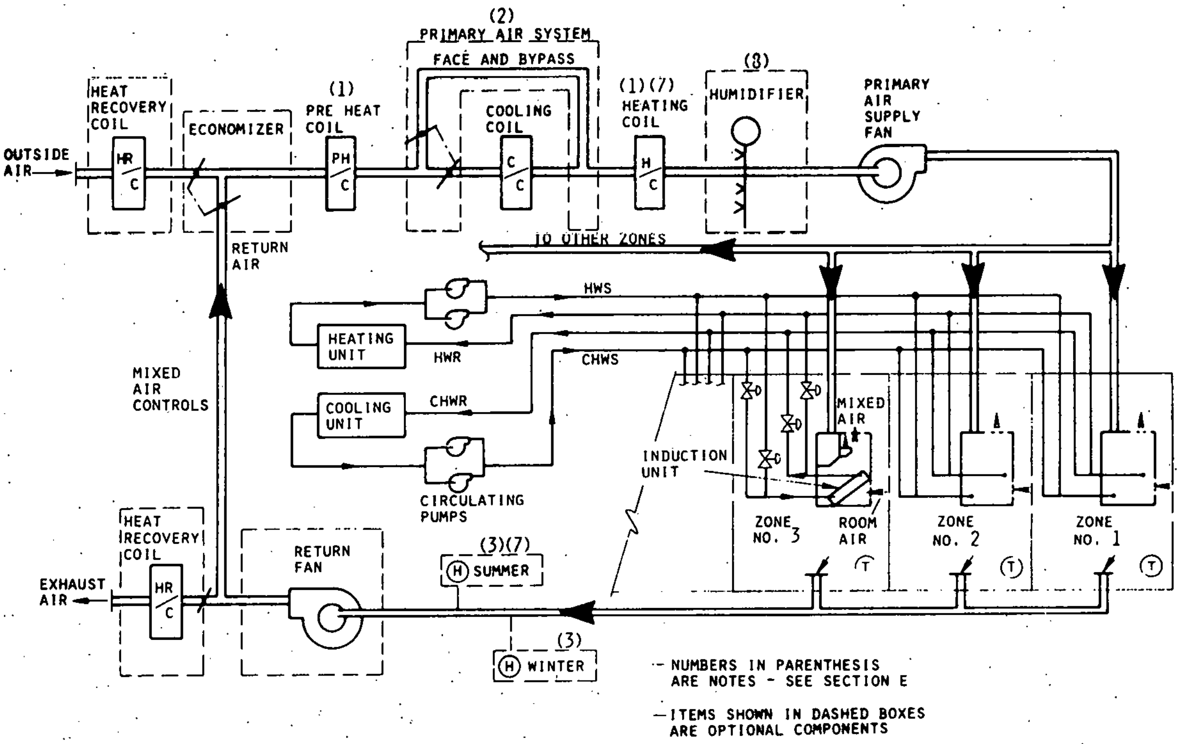
5. Face and By-Pass Cooling Option: (See keyword FACE-AND-BYPASS in the SYSTEM instruction).

6. Heat Recovery Option: (See keyword RECOVERY-EFFECT in the SYSTEM instruction).

7. Supply Air Temperature Control Option: The temperature of supply air discharging from the primary air supply unit can be maintained constant or reset in accordance with outside air temperature (see keyword COOL-CONTROL in the SYSTEM-CONTROL instruction). Note RESET temperature control is most commonly used with the two-pipe induction system.

8. System Capacity Option: The user may directly assign system design parameters such as: zone flowrate, (see keyword AIR-CHANGES/HR, CFM/SQFT, and ASSIGNED-CFM in the ZONE-AIR instruction); fan capacity (see keyword SUPPLY-CFM and RETURN-CFM in the SYSTEM-AIR instruction) and maximum heat addition and extraction rates (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction). Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between supply air temperature (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperature (see keywords DESIGN-HEAT-TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction. The user may adjust the calculated values or assigned by application of a sizing factor (see keyword SIZING-RATIO in the SYSTEM instruction).

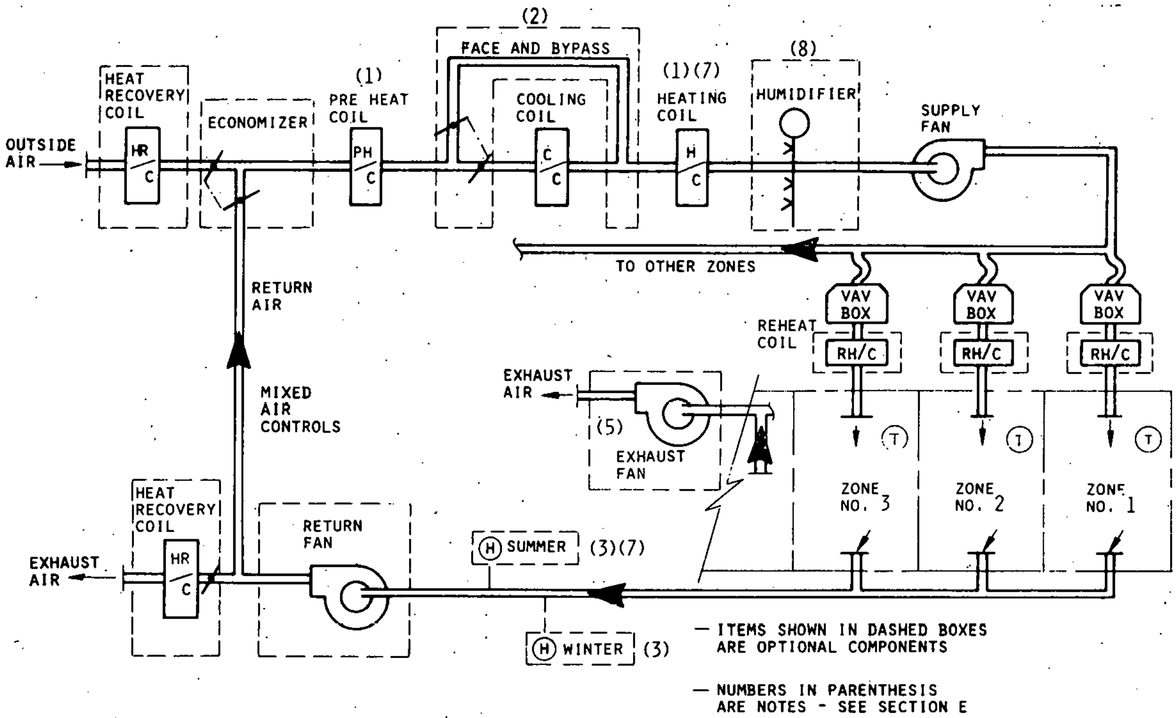
See Section B of this chapter for a complete set of BDL instructions for the SYSTEMS Program, including definitions of all command-words, keywords, and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 11 Four Pipe Induction Unit System (FPIU)

The four pipe induction unit system illustrated above is identical to the two pipe induction unit system (System No. 10) with the following exception; 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 circulating piping at the same time a unit in another zone is providing cooling by selecting flow from the cold fluid circulating system. Change-over 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 exceptions as noted above the discussion of system design features, options and BDL input language for System No. 10 applies as well to this system.

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 12 Variable Volume Fan System (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 heating coils, and a draw through type supply air fan. 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 achieve temperature control. 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 minimum flow rate defined as user input. If less cooling is required than that given at minimum air flow, the reheat coil (if specified) is activated.

The Cal-ERDA Program can simulate the basic system described above when provided with user input data such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction and keyword FAN-SCHEDULE in the SYSTEM-FANS instruction); space temperature, control (see keywords HEAT-TEMP-SCHED and COOL-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); minimum air supply (see keyword MIN-CFM-RATIO in the SYSTEM-TERMINAL instruction) outside air quantities (see SYSTEM-AIR and ZONE-AIR instruction); and fan characteristics (see SYSTEM-FANS instruction); and identification of the zones served by the system (see keyword ZONE-NAMES in the SYSTEM instruction). In addition a number of optional features can be specified. These options are discussed below with reference made to the BDL language used to specify them.

1. Mixed Air Option: A fixed quantity of outside air or one of three different types of economizer cycles can be specified. (See keywords OUTSIDE-CONTROL and MIN-OUTSIDE-AIR).

2. Return Air Options: 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-STATIC and RETURN-EFF in SYSTEM-FANS instruction). 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 instruction).

3. Flow Control Option: The user can specify one of three different methods for reducing system fan capacity in accordance with system flow requirements, i.e fan discharge damper, fan inlet vanes or a variable speed motor (see keyword FAN-CONTROL in the SYSTEM-FANS instruction).

4. Winter Humidity Control Option: Winter humidity control by control of absolute humidity in thereturn air can be specified (see keyword MIN-HUMIDITY in the SYSTEM-AIR instruction). The program converts any increase in absolute humidity into a heat load (btu/hr) and passes this load to the PLANT. A planned program revision will permit winter humidity control based on space relative humidity as an option. Implementation of this revision by January 1978 is anticipated.

5. Supply Air Temperature Control Option: The temperature of supply air discharging from the air handling unit can be maintained constant or reset in accordance with outside air temperature. (see keyword COOL-CONTROL in the SYSTEM-CONTROL option).

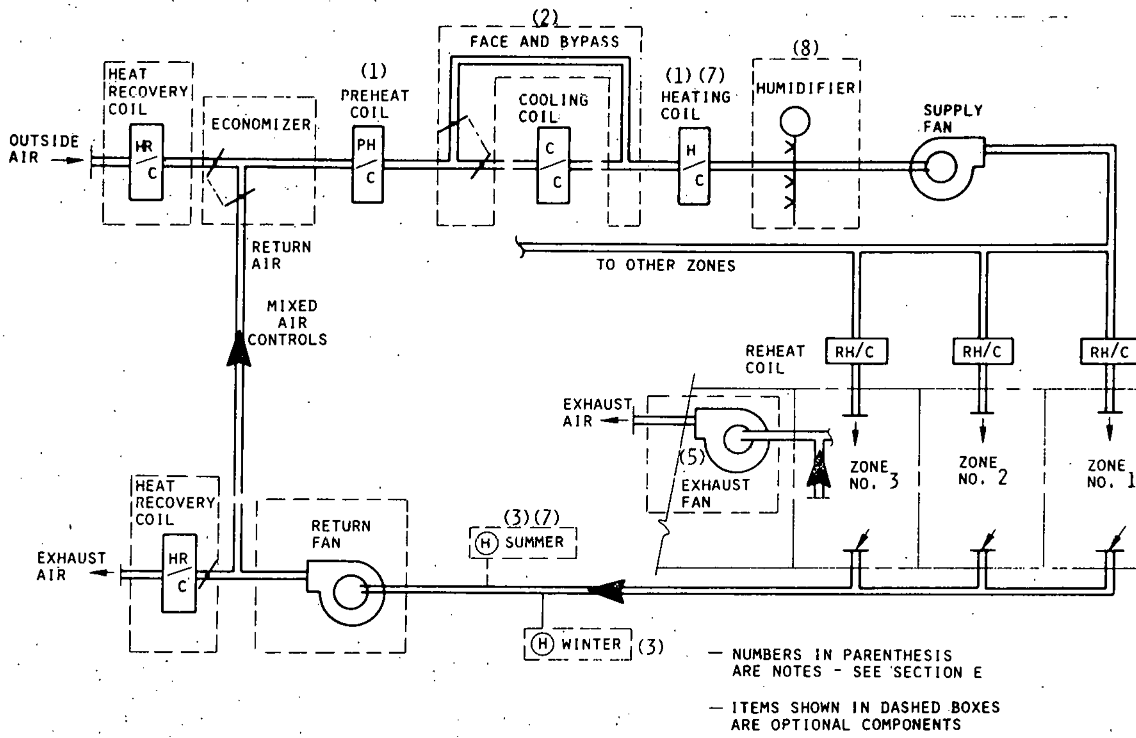
6. Face and By-Pass Cooling Option: (See keyword FACE-AND-BYPASS in the SYSTEM instruction).

7. Heat Recovery Option: (See keyword RECOVERY-EFFECT in the SYSTEM instruction).

8. Baseboard Heat Option: Baseboard heating may be specified for any of the zones served by the system being specified. (see keywords BASEBOARD-RATIO in the ZONE instruction and BASEBOARD-SCHED in the SYSTEM-CONTROL instruction).

9. System Capacity Option: The user may directly assign system design parameters such as: zone flowrate, (see keyword AIR-CHANGES/HR or CFM/SQFT or ASSIGNED-CFM in the ZONE-AIR instruction); fan capacity (see keyword SUPPLY-CFM and RETURN-CFM in the SYSTEM-AIR instruction) and maximum heat addition and extraction rates (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction). Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between supply air temperature (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperature (see keywords DESIGN-HEAT-TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction. The user may adjust the calculated or assigned values by application of a sizing factor (see keyword SIZING-RATIO in the SYSTEM instruction).

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program, including definitions of all command-words, keywords, and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 13 Constant Volume Reheat Fan System (RHFS)

The constant volume reheat system is illustrated in the schematic above. In its most basic configuration the system provides constant volume forced flow heating and cooling to multiple individually controlled zones from an air handling unit consisting of a filter (not shown) heating and cooling coils, and a draw through supply fan. A reheat coil is installed in the supply air distribution duct serving each individual zone. Space temperature is controlled by throttling of heating fluid flow to these reheat coils.

The Cal-ERDA Program can simulate the basic system described above when provided with user input data such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction and keyword FAN-SCHEDULE in the SYSTEM-FAN instruction); space temperature, control (see keywords HEAT-TEMP-SCHED and COOL-TEMP-SCHED and THERMOSTAT-TYPE in the ZONE-CONTROL instruction); outside air quantities (see SYSTEM-AIR and ZONE-AIR instructions); fan characteristics (see SYSTEM-FANS instruction): zone reheat coil capability (see keyword REHEAT-DELTA-T in the SYSTEM-TERMINAL instruction) and identification of the zones served by the system (see keyword ZONE-NAMES in the SYSTEM instruction). In addition a number of optional components and control strategies can be specified. These options are discussed below with reference made to the BDL language used to specify them.

1. Mixed Air Option: A fixed quantity of outside air or one of three different types of economizer cycles can be specified. (See keywords OUTSIDE-CONTROL and MIN-OUTSIDE-AIR).

2. Return Air Options: 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-STATIC and RETURN-EFF in SYSTEM-FANS instruction). 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 instruction).

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-STATIC and EXHAUST-EFF in the ZONE-AIR instruction).

4. Winter Humidity Control Option: Winter humidity control by control of absolute humidity in the return air can be specified (see keyword MIN-HUMIDITY in the SYSTEM-AIR instruction). The program converts any increase in absolute humidity into a heat load (btu/hr) and passes this load to the PLANT. A planned program revision will permit winter humidity control based on space relative humidity as an option. Implementation of this revision by January 1978 is anticipated.

5. Summer Humidity Control Option: Summer humidity control, by control of the absolute humidity in the return air can be specified (see keyword MAX-HUMIDITY in the SYSTEM-AIR instruction). A planned program revision will permit control based on return air relative humidity as an option. Implementation of this revision by January 1978 is anticipated. The program assumes that a heating coil is installed downstream of the cooling coil whenever summer humidity control is specified. Summer humidity control may be inherent if supply air temperature is maintained CONSTANT at a low enough apparatus dewpoint (see option no. 7 below).

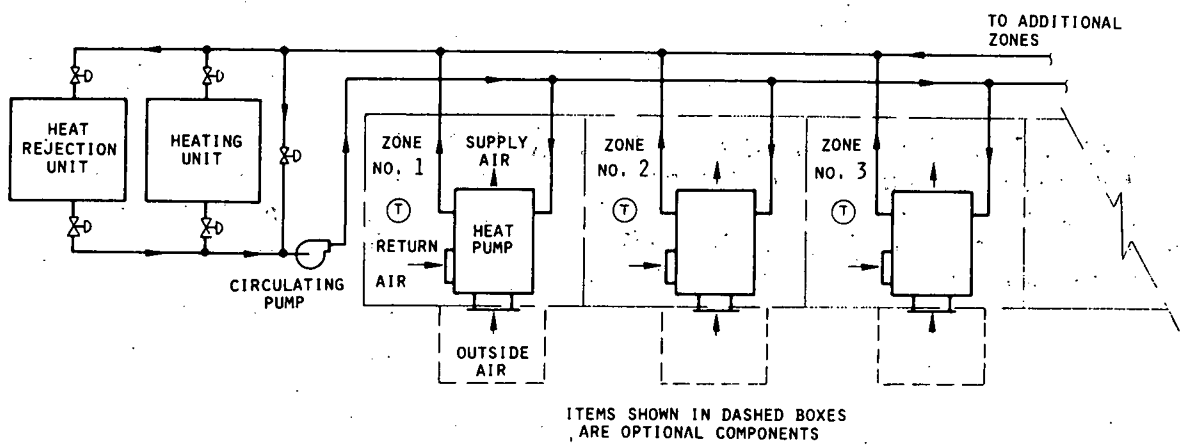
6. Face and By-Pass Cooling Option: (See keyword FACE-AND-BYPASS in the SYSTEM instruction).

7. Supply Air Temperature Control Option: The temperature of supply air discharging from the air handling unit can be: maintained constant; reset in accordance with outside air temperature; or based on the coldest or warmest zone, depending on the season. (see keyword COOL-CONTROL, in the SYSTEM-CONTROL instruction).

8. Thermostat Option: Three different types of thermostat action can be specified, i.e., on-off, proportional band, and dual setpoint) (see keyword THERMOSTAT-TYPE in the ZONE-CONTROL instruction).

9. System Capacity Option: The user may directly assign system design parameters such as: zone flowrate, (see keyword AIR-CHANGES/HR or CFM/SQFT or ASSIGNED-CFM in the ZONE-AIR instruction); fan capacity (see keyword SUPPLY-CFM and RETURN-CFM in the SYSTEM-AIR instruction) and maximum heat addition and extraction rates (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction). Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between the supply air temperature (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperature (see keywords DESIGN-HEAT-TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction. The user may adjust the calculated or assigned values by application of a sizing factor (see keyword SIZING-RATIO in the SYSTEM instruction).

See Section B of this chapter for a complete set of BDL instructions for the SYSTEMS Program, including definitions of all command-words, keywords, and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 14 Unitary Heat Pump System

The unitary hydronic heat pump system illustrated above, provides heating and cooling for multiple individually controlled zones by operation of heat pump units located in each space to be conditioned. Each heat pump unit may provide outside air ventilation or merely recirculate conditioned air. (The current program can only simulate recirculation but a planned revision will allow the user to specify a fixed quantity of outside air. Implementation of this revision by 1/78 is anticipated).

Temperature is controlled in each zone by on-off operation of the heat pump unit, (fan and compressor). The thermostat type used for this system has two individual setpoints. 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. The unit does not operate when space temperature is between setpoints. (A planned program revision will allow the user to specify constant fan operation in lieu of the cycling operation currently simulated. Implementation of this revision by 1/78 is anticipated.)

The heat pump unit consists of a filter, an air circulating fan and a refrigeration system. The refrigeration system consists of a reciprocating compressor, a room air to refrigerant heat exchanger, a water to refrigerant heat exchanger, and controls to switch the evaporating and condensing functions from one heat exchanger to the other. In the heating cycle the room air to refrigerant heat exchanger is used for refrigerant condensing and the reverse is true for the cooling cycle.

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 heat mode. Since some Zones may be cooling while others are heating, the fluid circulating temperature will depend on the relative quantities of each. When cooling exceeds heating and the fluid temperature increases to the highest allowable value (see Keyword MAX-FLUID-TEMP in the SYSTEM-FLUID instruction), heat is dissipated to the atmosphere through a cooling tower or an evaporative cooler. When heating exceeds cooling and the fluid temperature decreases to the minimum allowable value (see keyword MIN-FLUID-TEMPERATURE 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.

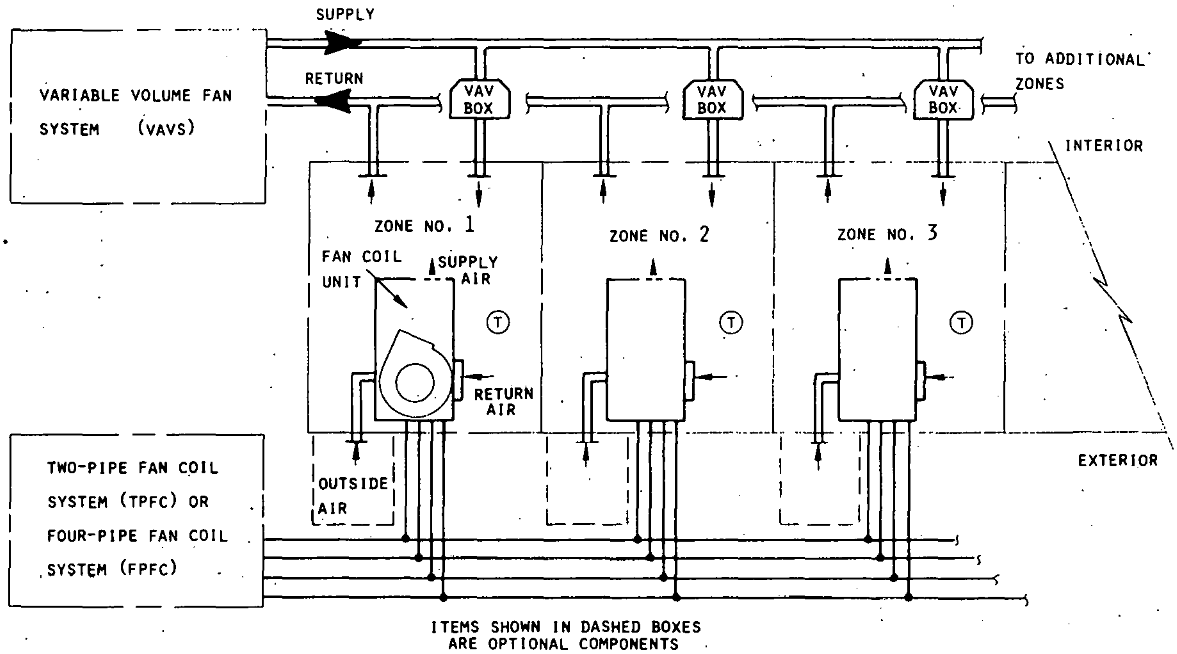
The heat rejection unit, heating unit, and circulating pump are simulated by the PLANT program. The existing PLANT Program has no mechanism for simulating operation of the heat rejection unit (cooling tower) directly from the cooling load output of the SYSTEMS Program, that is without simulating an intermediate chiller. A program revision that will permit this is under consideration with implementation anticipated by 1/78.

The program assumes that the heat pump requires 0.3 BTU of equivalent electrical energy for each BTU of heat extracted from the space and 0.4 BTU of equivalent electrical energy for each BTU of heat added to the space. A program revision that will allow the user to specify heat pump performance is under consideration but plans for implementing the revision have not been formalized yet.

The Cal-ERDA Program can simulate the basic system described above when provided with user input such as: operating schedules (see keywords HEATING-SCHEDULE and COOLING-SCHEDULE in the SYSTEM-CONTROL instruction); space temperature control (see keywords HEAT-TEMP-SCHED and COOL-TEMP-SCHED in the ZONE-CONTROL instruction) and identification of the zones served by the system (see keyword ZONE-NAMES in the SYSTEM instruction). The user may directly assign system design parameters such as fan capacity (see ZONE-AIR instruction) and maximum heat addition and extraction rate (see keywords HEAT-MAX and COOL-MAX in the ZONE instruction. Alternately the program will calculate these quantities based on peak (or design day) loads and the difference between the temperature of air discharged from the heat pump unit (see keywords MAX-SUPPLY-TEMP and MIN-SUPPLY-TEMP in the SYSTEM-CONTROL instruction) and design space temperatures (see keywords DESIGN-HEAT-TEMP and DESIGN-COOL-TEMP in the ZONE-CONTROL instruction).

When calculated (rather than assigned) values are used to simulate fan capacity, these values are rounded by the program, to the next highest unit of ten. 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 user assignment of the heating capacity, cooling capacity and fan capacity of a specific commercially available heat pump unit is recommended for improved simulation accuracy.

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 15 Internal Variable Volume-External Fan Coil

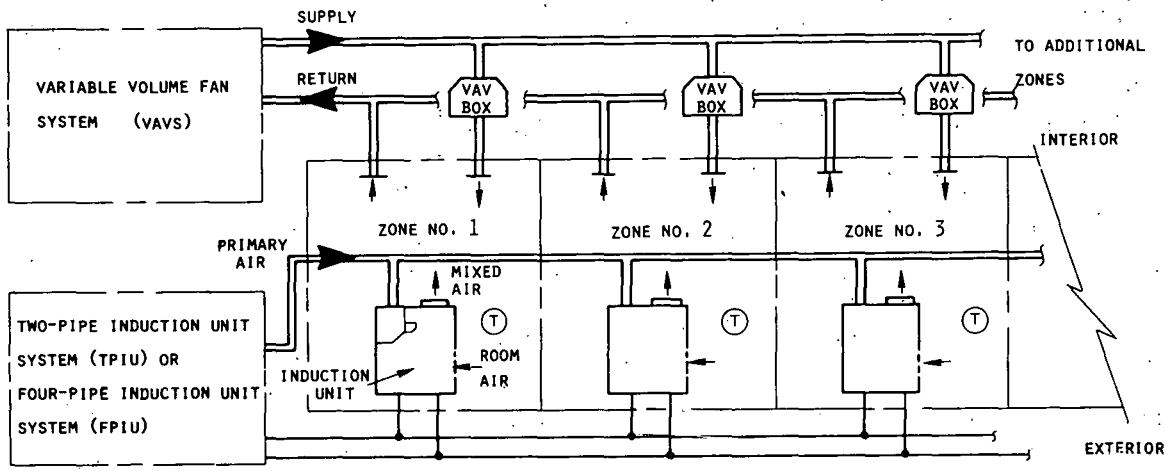
The Internal Variable Volume - External Fan Coil System as illustrated in the schematic above and as the name implies, is the combination of two different systems serving the same zone(s). The variable volume type system provides cooling for the interior portion of each zone while the two or four pipe fan coil system provides cooling and/or heating for the external portion of each zone. This type of system is mostly applicable to those zones with extended distances between exterior and interior walls.

The program assumes that all the heating is done by the external fan coil system and that the internal variable volume system flow rate to each zone will not increase above the minimum value until after the fan coil heat extraction rate has been increased to its maximum (the user specifies maximum fan coil heat extraction rate by data entry for the keyword EXT-COOL-RATIO in the SYSTEM instruction). Outside air can be supplied by the variable volume system, the fan coil system or both; but is mostly commonly supplied by the variable volume system.

The external fan coil system used here is exactly as described for System No.8 or System No. 9 including design features, options and BDL input language. The internal variable volume system used here is as described for System No. 12 except that it cools only and does not have any reheat capability.

The user must prepare two (2) SYSTEM instructions, one for the internal system and a separate one for the external system. These SYSTEM instructions are prepared as though the systems being specified were totally independent of each other with the following exceptions or restrictions: date input for the internal variable volume SYSTEM instruction must precede data input, for the fan coil SYSTEM instruction; the code-word IVEF is entered for the keyword SYSTEM-TYPE in the variable volume SYSTEM-INSTRUCTION; user must specify fan coil heat extraction rate by data entry for keyword EXT-COOL-RATIO in the SYSTEM instruction for the variable volume system; and the same zones must be specified for each SYSTEM instruction and listed in the exact order (see keyword ZONE-NAMES).

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.



SYSTEM NO. 16 Internal Variable Volume-External Induction

The Internal Variable Volume - External Induction Unit System as illustrated in the schematic above and as the name implies, is the combination of two different systems serving the same zone (s). The variable volume type system provides cooling for the interior portion of each zone while the two or four pipe induction unit system provides cooling and/or heating for the external portion of each zone. This type of system is mostly applicable for those zones, with extended distances between exterior and interior walls.

The program assumes that all the heating is done by the external induction unit system and that the internal variable volume system flow rate to each zone will not increase above the minimum value until after the induction unit heat extraction rate has been increased to its maximum (the user specifies maximum induction unit heat extraction rate by data entry for the keyword EXT-COOL-RATIO in the SYSTEM instruction). Outside air can be supplied by the variable volume system, the induction unit system or both.

The external induction unit system used here is exactly as described for System No. 10 or System No. 11 including design features, options, and BDL input language. The internal variable volume system used here is as described for System No. 12 except that it cools only and does not have any reheat capability.

The user must prepare two (2) SYSTEM instructions, one for the internal system and a sepaerate one for the external system. These SYSTEM instructions are prepared as though the systems being specified were totally independent of each other with the following exceptions or restrictions: data input for the internal variable volume SYSTEM instruction must precede data input, for the induction unit SYSTEM instruction; the code-word IVEU is entered for the keyword SYSTEM-TYPE in the variable volume SYSTEM-INSTRUCTION; user must specify induction unit heat extraction rate by data entry for keyword EXT-COOL-RATIO in the SYSTEM instruction for the variable volume system; and the same zones must be specified for each SYSTEM instruction and listed in the exact order (see keyword ZONE-NAMES)

See Section B of this chapter for a complete set of BDL Instructions for the SYSTEMS Program including definitions of all command-words, keywords and code-words. A complete listing of the command-words and keywords is provided in Table IV-D1 with the applicability of each to this system (and other systems) noted.

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TABLE IV-D1 APPLICABILITY OF COMMAND-WORDS AND KEYWORDS TO VARIOUS SYSTEMS

COMMAND-WORDS AND KEYWORDS	SYSTEM IDENTIFICATION																
SYSTEM NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CODE-WORD	SUM	SZRH	MZS	DDS	SZCI	UHT	UVT	FPH	TPFC	FPFC	TPIU	FPIU	VAVS	RHFS	HP	IVEF	IVEI
PLANT-ASSIGNMENT	(3)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SYSTEM-NAMES	⟨6⟩	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SYSTEM	[4]	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SYSTEM-TYPE	[1]	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SYSTEM-CONTROL	//	(5)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SYSTEM-AIR	//	(5)	→	→	→	→	→	//	(5)	→	→	→	→	→	→	→	→
SYSTEM-FANS	//	(5)	→	→	→	→	→	//	(5)	→	→	→	→	→	→	→	→
SYSTEM-TERMINAL	//	(5)	//	(5)	→	//	//	//	//	//	(5)	→	→	→	//	(5)	→
SYSTEM-FLUID	//	//	//	//	//	//	//	//	(5)	//	(5)	//	//	//	(5)	//	//
VARIABLE-TEMP	(10)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SIZING-RATIO	(7)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
EXT-COOL-RATIO	//	//	//	//	//	//	//	//	//	//	//	//	//	//	//	[ ]	→
RETURN-AIR-PATH	//	(11)	→	→	→	→	→	//	//	//	(11)	→	→	→	//	(11)	→
RECOVERY-EFFECT	//	(9)	→	→	→	//	//	//	//	//	(9)	→	→	→	//	(9)	→
FACE-AND-BYPASS	//	(9)	→	→	→	//	//	//	//	//	(9)	→	→	→	//	(9)	→
ECONO-LIMIT-TEMP	//	(7)	→	→	→	//	//	//	//	//	(7)	→	→	→	//	(7)	→
PLENUM-NAMES	(11)	→	→	→	→	→	→	//	//	//	(11)	→	→	→	//	(11)	→
ZONE-NAMES	[8]	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

[1] Required Entry   // Not Applicable To This System   ○ Optional Entry   ⟨2⟩ Dependent Entry   ( ) Numbers Inside Symbols are NOTES - see SECTION E

TABLE IV-D1 (CONTINUED)

COMMAND-WORDS AND KEYWORDS	SYSTEM IDENTIFICATION																
SYSTEM NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CODE-WORD	SUM	SZRH	MZS	DDS	SZCI	UHT	UVT	FPH	TPFC	FPFC	TPIU	FPIU	VAVS	RHFS	HP	IVEF	IVEI
SYSTEM-CONTROL	(17)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
MAX-SUPPLY-TEMP	///	(7)	→	→	→	→	→	///	(7)	→	→	→			[1]		
HEATING-SCHEDULE	(12)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
HEAT-CONTROL	///	///	(7)	→	///	///	///	///	///	///	///	///	///	///	///	///	///
HEAT-SET-TEMP	///	///	⟨13⟩	→	///	///	///	///	///	///	///	///	///	///	///	///	///
HEAT-RESET-SCHED	///	///	⟨14⟩	→	///	///	///	///	///	///	///	///	///	///	///	///	///
MIN-SUPPLY-TEMP	///	(7)	→	→	→	///	///	(7)	→	→	→	→	→	→	→	→	→
COOLING-SCHEDULE	(12)	→	→	→	→	///	///	///	(12)	→	→	→	→	→	→	→	→
COOL-CONTROL	///	///	(7)	→	///	///	///	///	///	///	(7)	→	→	→	///	(7)	→
COOL-SET-TEMP	///	///	⟨15⟩	→	///	///	///	///	///	///	⟨15⟩	→	→	→	///	⟨15⟩	→
COOL-RESET-SCHED	///	///	⟨16⟩	→	///	///	///	///	///	///	⟨16⟩	→	→	→	///	⟨16⟩	→
MAX-HUMIDITY	///	(9)	→	→	→	///	///	///	///	(9)	///	(9)	→	→	///	(9)	→
MIN-HUMIDITY	///	(9)	→	→	→	///	///	///	(9)	→	→	→	→	→	///	(9)	→
BASEBOARD-SCHED	///	(12)	→	→	→	→	→	///	(12)	→	→	→	→	→	→	→	→

[1] Required Entry /// Not Applicable To This System ( ) Optional Entry ⟨2⟩ Dependent Entry ( ) Numbers Inside Symbols are NOTES - see SECTION E

TABLE IV-D1 (CONTINUED)

COMMAND-WORDS AND KEYWORDS	SYSTEM NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	CODE-WORD	SUM	SZRH	MZS	DDS	SZCI	UHT	UVT	FPH	TPFC	FPFC	TPIU	FPIU	VAVS	RHFS	HP	IVEF	IVEI
SYSTEM-AIR			17							17								
SUPPLY-CFM			13									19					19	
RETURN-CFM			20									20					20	
MIN-OUTSIDE-AIR			21					21		21							21	
OUTSIDE-CONTROL			7									7					7	
SYSTEM-FANS		17								17								
FAN-SCHEDULE		12								12								
FAN-CONTROL			9		9									9			9	
SUPPLY-STATIC			1							1								
SUPPLY-EFF			1							1								
RETURN-STATIC			9									9					9	
RETURN-EFF			7									9					9	
SYSTEM-TERMINAL			17		17							17					17	
REHEAT-DELTA-T			9											9	1		17	
INDUCTION-RATIO													1					
MIN-CFM-RATIO					7									7			7	

Required Entry Not Applicable To This System Optional Entry Dependent Entry ( ) Numbers Inside Symbols are NOTES - see SECTION E

TABLE IV-D1 (CONTINUED)

COMMAND-WORDS AND KEYWORDS — SYSTEM NO. / CODE-WORD	SYSTEM IDENTIFICATION																
SYSTEM NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CODE-WORD	SUM	SZRH	MZS	DDS	SZCI	UHT	UVT	FPH	TPFC	FPFC	TPIU	FPIU	VAVS	RHFS	HP	IVEF	IVEI
SYSTEM-FLUID	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(17)	N/A	(17)	N/A	N/A	N/A	(17)	N/A	N/A
CHANGE-OVER-HI	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(9)	N/A	(9)	N/A	N/A	N/A	N/A	N/A	N/A
CHANGE-OVER-LO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	(9)	N/A	(9)	N/A	N/A	N/A	N/A	N/A	N/A
MIN-FLUID-TEMP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[1]	N/A	[1]	N/A	N/A	N/A	[1]	N/A	N/A
MAX-FLUID-TEMP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[1]	N/A	[1]	N/A	N/A	N/A	[1]	N/A	N/A
FLUID-HEAT-CAP	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	[1]	N/A	[1]	N/A	N/A	N/A	[1]	N/A	N/A
ZONE	[22]	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
ZONE-TYPE	(31)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
ZONE-AIR	N/A	(5)	→	→	→	→	→	N/A	(5)	→	→	→	→	→	→	→	→
ZONE-CONTROL	(5)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
ZONE-MULTIPLIER	⟨23⟩	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
HEAT-MAX	(24)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
COOL-MAX	(24)	→	→	→	→	N/A	N/A	N/A	(24)	→	→	→	→	→	→	→	→
BASEBOARD-RATIO	N/A	(9)	→	→	→	→	→	N/A	(9)	→	→	→	→	→	→	→	→

[1] Required Entry ▨ Not Applicable To This System ○ Optional Entry ⟨2⟩ Dependent Entry ( ) Numbers Inside Symbols are NOTES - see SECTION E

TABLE IV-D1 (CONTINUED)

COMMAND-WORDS AND KEYWORDS	SYSTEM IDENTIFICATION																
SYSTEM NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CODE-WORD	SUM	SZRH	MZS	DDS	SZCI	UHT	UVT	FPH	TPFC	FPFC	TPIU	FPIU	VAVS	RHFS	HP	IVEF	IVEI
ZONE-AIR	N/A	(17)	→	→	→	→	→	N/A	(17)	→	→	→	→	→	→	→	→
AIR-CHANGES/HR	N/A	(25)	→	→	→	→	→	N/A	(25)	→	→	→	→	→	→	→	→
CFM/SQFT	N/A	(25)	→	→	→	→	→	N/A	(25)	→	→	→	→	→	→	→	→
ASSIGNED-CFM	N/A	(25)	→	→	→	→	→	N/A	(25)	→	→	→	→	→	→	→	→
OUTSIDE-CHANGES	N/A	(26)	→	→	→	N/A	(26)	N/A	(26)	→	→	→	→	→	N/A	(26)	→
OUTSIDE-CFM/PER	N/A	(26)	→	→	→	N/A	(26)	N/A	(26)	→	→	→	→	→	N/A	(26)	→
OUTSIDE-AIR-CFM	N/A	(26)	→	→	→	N/A	(26)	N/A	(26)	→	→	→	→	→	N/A	(26)	→
EXHAUST-CFM	N/A	(9)	→	→	→	N/A	(9)	N/A	(9)	→	→	→	→	→	N/A	(9)	→
EXHAUST-EFF	N/A	(7)	→	→	→	N/A	(7)	N/A	(7)	→	→	→	→	→	N/A	(7)	→
EXHAUST-STATIC	N/A	(9)	→	→	→	N/A	(9)	N/A	(9)	→	→	→	→	→	N/A	(9)	→
ZONE-CONTROL	(18)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
DESIGN-HEAT-TEMP	(7)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
HEAT-TEMP-SCHED	27	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
DESIGN-COOL-TEMP	(7)	→	→	→	→	N/A	N/A	N/A	→	→	→	→	→	→	→	→	→
COOL-TEMP-SCHED	28	→	→	→	→	N/A	N/A	N/A	28	→	→	→	→	→	→	→	→
THERMOSTAT-TYPE	(29)	→	→	→	→	→	→	→	→	→	→	→	→	→	1	(29)	→
THROTTLING-RANGE	(7)	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

[i] Required Entry   ▨ Not Applicable To This System   ◯ Optional Entry   ⬡2 Dependent Entry   ( )Numbers Inside Symbols are NOTES - see SECTION I

TABLE IV-D1 (CONTINUED)

COMMAND-WORDS AND KEYWORDS	SYSTEM IDENTIFICATION																
SYSTEM NO.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CODE-WORD	SUM	SZRH	MZS	DDS	SZCI	UHT	UVT	FPH	TPFC	FPFC	TPIU	FPIU	VAVS	RHFS	HP	IVEF	IVEI
DAY-RESET-SCHEDULE			30	→							30	→	→	→		30	→
SUPPLY-HI			32	→							32	→	→	→		32	→
SUPPLY-LO			32	→							32	→	→	→		32	→
OUTSIDE-HI			32	→							32	→	→	→		32	→
OUTSIDE-LO			32	→							32	→	→	→		32	→
SYSTEMS-REPORT																	
VERIFICATION		7	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
SUMMARY		7	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
DETAIL-LEVEL		7	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→
DETAIL-SCHEDULE		7	→	→	→	→	→	→	→	→	→	→	→	→	→	→	→

Required Entry

Not Applicable To This System

Optional Entry

Dependent Entry

( ) Numbers Inside Symbols are NOTES - see SECTION E

______________ = PLANT-ASSIGNMENT *or* P-A
u-name NOTE 1

Keyword	*or* *Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SYSTEM-NAMES	S-N	= ______________	list of u-named	Note 4	N/A	N/A

For NOTES - see SECTION E

______________ = SYSTEM *or* SYST LIKE ______________
u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or* *Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SYSTEM-TYPE	S-TYPE	= ______________	code-word	Note 4	N/A	N/A
SYSTEM-CONTROL	S-C	= ______________	u-named	Note 5	N/A	N/A
SYSTEM-AIR	S-A	= ______________	u-named	Note 5	N/A	N/A
SYSTEM-FANS	S-FAN	= ______________	u-named	Note 5	N/A	N/A
SYSTEM-TERMINAL	S-T	= ______________	u-named	Note 5	N/A	N/A
SYSTEM-FLUID	S-FLU	= ______________	u-named	Note 5	N/A	N/A
VARIABLE-TEMP	V-T	= ______________	ON/OFF	ON	N/A	N/A
SIZING-RATIO	S-R	= ______________	number	1.0	0.5	2.0
EXT-COOL-RATIO	E-C-R	= ______________	decimal	Note 23	0.0	0.7
RETURN-AIR-PATH	R-A-P	= ______________	code-word	DUCT	N/A	N/A
RECOVERY-EFFECT	R-E	= ______________	decimal	0.0	0.2	0.8
FACE-AND-BYPASS	F-A-B	= ______________	YES/NO	NO	N/A	N/A
ECONO-LIMIT-TEMP	E-L-T	= ______________	^{o}F	60	50	70
PLENUM-NAMES	P-N	= ______________	u-named (3 max)	Note 24	N/A	N/A
ZONE-NAMES	Z-N	= ______________	u-named (64 max)	Note 4	N/A	N/A
		______________				

For NOTES - see SECTION E

_______________ = SYSTEM-CONTROL *or* S-C LIKE _______________

u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or* *Abbreviation*		User Input NOTE 2	Notes	Default	Range Min.	Range Max.
MAX-SUPPLY-TEMP	MAX-S-T	=	____________	°F	120	70	200
HEATING-SCHEDULE	H-S	=	____________	u-named	Note 10	N/A	N/A
HEAT-CONTROL	H-C	=	____________	code word	CONSTANT	N/A	N/A
HEAT-SET-TEMP	H-S-T	=	____________	°F	120	70	200
HEAT-RESET-SCHED	H-R-S	=	____________	u-named	Note 11	N/A	N/A
MIN-SUPPLY-TEMP	MIN-S-T	=	____________	°F	60°	50°	70°
COOLING-SCHEDULE	C-S	=	____________	u-named	Note 10	N/A	N/A
COOL-CONTROL	C-C	=	____________	code word	CONSTANT	N/A	N/A
COOL-SET-TEMP	C-S-T	=	____________	°F	60°	50°	70°
COOL-RESET-SCHED	C-R-S	=	____________	u-named	Note 12	N/A	N/A
MAX-HUMIDITY	MAX-H	=	____________	lbs H_2O/lbs air	1.00	0.006	0.013
MIN-HUMIDITY	MIN-H	=	____________	lbs H_2O/lbs air	0.000	0.002	0.012
BASEBOARD-SCHED	B-S	=	____________	u-named		N/A	N/A

For NOTES - see SECTION E

_______________ = SYSTEM-AIR *or* S-A LIKE _______________

u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or* *Abbreviation*		User Input NOTE 2	Notes	Default	Range Min.	Range Max.
SUPPLY-CFM	S-CFM	=	____________	cfm	Note 7	50	$9.9x10^5$
RETURN-CFM	R-CFM	=	____________	cfm	Note 8	50	$9.9x10^5$
MIN-OUTSIDE-AIR	M-O-A	=	____________	decimal	Note 9	0.0	1.0
OUTSIDE-CONTROL	O-C	=	____________	code-word	FIXED	N/A	N/A

For NOTES - see SECTION E

______________________ = SYSTEM-FANS *or* S-FAN LIKE ______________________

u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or* *Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
FAN-SCHEDULE	F-S	= ______________	u-name	Note 10	N/A	N/A
FAN-CONTROL	F-C	= ______________	code-word	Note 13	N/A	N/A
SUPPLY-STATIC	S-S	= ______________	inches W.G.	Note 25	0.05	10
SUPPLY-EFF	S-E	= ______________	decimal	Note 25	0.10	0.90
RETURN-STATIC	R-S	= ______________	inches W.G.	0.0	0.05	10
RETURN-EFF	R-E	= ______________	decimal	0.80	0.10	0.9

For NOTES - see SECTION E

______________________ = SYSTEM-FLUID *or* S-FLU LIKE ______________________

u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or* *Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
CHANGE-OVER-HI	C-O-H	= ______________	°F	Note 30	40	80
CHANGE-OVER-LO	C-O-L	= ______________	°F	Note 30	40	60
MIN-FLUID-TEMP	MIN-F-T	= ______________	°F	Note 29	40	80
MAX-FLUID-TEMP	MAX-F-T	= ______________	°F	Note 29	80	100
FLUID-HEAT-CAP	F-H-C	= ______________	BTU/°F	N/A	N/A	N/A

For NOTES - see SECTION E

______________________ = SYSTEM-TERMINAL *or* S-T LIKE ______________________

u-name NOTE 1 NOTE 3 *u-named*

Keyword	*or* *Abbreviation*	User Input NOTE 2	Notes	Default	Range Min.	Range Max.
REHEAT-DELTA-T	R-D-T	= ______________	°F	Note 14	0.0	80
INDUCTION-RATIO	I-R	= ______________	fraction	Note 26	2.0	6.0
MIN-CFM-RATIO	M-C-R	= ______________	fraction	1.0	0.0	1.0

For NOTES - see SECTION E

__________ = ZONE *or* Z   LIKE __________

u-name   NOTE 1   NOTE 3   *u-named*

Keyword	*or Abbreviation*	User Input NOTE 2	Notes	Default	Range	
					Min.	Max.
ZONE-TYPE	Z-T	= ________	code-word	Note 22	N/A	N/A
ZONE-AIR	Z-A	= ________	u-named	Note 5	N/A	N/A
ZONE-CONTROL	Z-C	= ________	u-named	Note 5	N/A	N/A
ZONE-MULTIPLIER	Z-M	= ________	number	1.0	1	200
HEAT-MAX	H-M	= ________	BTU/hr	Note 15	0.0	10^6
COOL-MAX	C-M	= ________	BTU/hr	Note 15	0.0	10^6
BASEBOARD-RATIO	B-R	= ________	number	0.0	0.4	1.2
PANEL-LOSS-RATIO	P-L-R	= ________	decimal	0.0	0.05	1.0

For NOTES see SECTION E

__________ = ZONE-AIR *or* Z-A   LIKE __________

u-name   NOTE 1   NOTE 3   *u-named*

Keyword	*or Abbreviation*	User Input NOTE 2	Notes	Default	Range	
					Min.	Max.
AIR-CHANGES/HR	A-C/HR	= ________	number	Note 16	0.5	100
CFM/SQFT		= ________	number	Note 16	0.2	20
ASSIGNED-CFM	A-CFM	= ________	cfm	Note 16	50	5×10^5
OUTSIDE-CHANGES	O-C	= ________	number	Note 17	0.01	100
OUTSIDE-CFM/PER	O-CFM/PER	= ________	cfm	Note 17	5	100
OUTSIDE-AIR-CFM	O-A-CFM	= ________	cfm	Note 17	5	5×10^4
EXHAUST-CFM	E-CFM	= ________	cfm	0.0	50	5×10^5
EXHAUST-EFF	E-E	= ________	decimal	0.65	0.1	0.9
EXHAUST-STATIC	E-S	= ________	inches W.G.	0.0	0.05	20

For NOTES - see SECTION E

_______________ = ZONE-CONTROL *or* Z-C LIKE _______________

u-name NOTE 1 NOTE 3 *u-named*

Keyword or	*Abbreviation*	User Input NOTE 2	Notes	Default	Range	
					Min.	Max.
DESIGN-HEAT-TEMP	D-H-T	= _______________	°F	68	40	80
HEAT-TEMP-SCHED	H-T-S	= _______________	u-named	Note 18	N/A	N/A
DESIGN-COOL-TEMP	D-C-T	= _______________	°F	78	60	100
COOL-TEMP-SCHED	C-T-S	= _______________	u-named	Note 19	N/A	N/A
THERMOSTAT-TYPE	T-T	= _______________	code-word	Note 20	N/A	N/A
THROTTLING-RANGE	T-R	= _______________	°F	2	0.5	20

For NOTES - see SECTION E

_______________ = DAY-RESET-SCHED *or* D-R-S LIKE _______________

u-name NOTE 1 NOTE 3 *u-named*

Keyword or	*Abbreviation*	User Input NOTE 2	Notes	Default	Range	
					Min.	Max.
SUPPLY-HI	S-H	= _______________	°F	Note 21	Note 27	Note 27
SUPPLY-LO	S-L	= _______________	°F	Note 21	Note 27	Note 27
OUTSIDE-HI	O-H	= _______________	°F	Note 21	50	100
OUTSIDE-LO	O-L	= _______________	°F	Note 21	-20	40

For NOTES - see SECTION E

SYSTEMS REPORT *or* S-R

NOTE 31

Keyword or	*Abbreviation*	User Input NOTE 2	Notes	Default	Range	
					Min.	Max.
VERIFICATION	VERI	= _______________	code-word	None	N/A	N/A
SUMMARY	SUMM	= _______________	code-word	SS-A	N/A	N/A
DETAIL-LEVEL	D-L	= _______________	code-word	None	N/A	N/A
DETAIL-SCHEDULE	D-SCH	= _______________	u-named	NOTE 28	N/A	N/A

For NOTES - see SECTION E

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Notes to System Schematics

1. The program (as of 10/77) does not differentiate between preheat coil and heating coil loads for the single zone systems (system No. 1, 5 SZRH and system No. 4,SZCI). A single heating coil load is calculated regardless of whether both of only one of these coils is actually installed.

2. Simulation of face and bypass cooling has not been implemented (as of 10/77). Implementation of this optional feature by about 12/77 is expected.

3. The program (as of 12/77) simulates control of absolute humidity rather than control of relative humidity (see definition of keywords MAX-HUMIDITY and MIN-HUMIDITY). The program will be revised to permit optional relative humidity control. Implementation of this revision by about 1/78 is expected.

4. Program assumes existance of a preheat coil and calculates preheat load if and when mixed air temperature falls below required cold deck temperature. However this load is combined with heating coil load (if any) into a single central unit heating load when printed on the system level reports (see code-word SYSTEM-LEVEL for keyword DETAIL-LEVEL in the SYSTEMS-REPORT instruction).

5. Exhaust fan (s) are optional for any or all zones.

6. Summer humidity control, for Multi-zone and Dual Duct Systems, is normally accomplished by overriding hot deck control to increase hot deck temperature when space relative humidity exceeds limit. The existing program (10/77) cannot simulate this control strategy. Incorporation of this feature is being considered, but plans to implement the revision have not yet been formalized.

7. Program assumes that a heating coil is installed (downstream of cooling coil) if summer humidity control is specified (keyword: MAX-HUMIDITY).

8. Program (as of 10/77) identifies humidifier load only as lbs. of moisture added to air stream. Revisions are planned that will identify any associated electrical or steam loads and assign these loads to the overall plant load in these categories. Implementation of this revision by 2/78 is expected.

Notes to SYSTEMS Program User Worksheets

NOTE 1 Data entry consists of a unique user defined name (u-name) followed by the command-word or its abbreviation. An equal sign must be inserted between the command-word and u-name. See Chapter II for discussion of BDL rules, notation, syntax, etc.

Example entries:

PA-1 = PLANT-ASSIGNMENT	S-1 = SYSTEM
PA-2 = P-A	S-2 = SYST

NOTE 2 Data entry consists of the keyword or its abbreviation followed by a u-name, code-word or value as indicated. A separator (equal sign, comma or blank) must be inserted between the keyword and the user input and a terminator (double period) must be used following the last data entry in the instruction. When the user input is a list of words, a separater must be inserted between each word. See Chapter II for discussion of BDL rules, notation, syntax, etc.

NOTE 3 Data entry consists of the keyword LIKE followed by the u-name of a previously named BDL instruction of the same type. A separator (equal sign, comma or blank) must be inserted between the words. See Chapter II for discussion of BDL rules, notation, syntax, etc.

Example top line entries:

PA-2 = PLANT-ASSIGNMENT	LIKE, PA-1
S-2 = SYST	LIKE, S-1

NOTE 4 This is a required data entry therefore no default value is listed.

NOTE 5 A data entry is required for this keyword if the user has specified one or more BDL instructions of the type identified by a command-word identical to this keyword. If no data entry, the program will use default values from the applicable keywords in that instruction.

NOTE 6 If no data entry is made for this keyword the program will assume that return air path is direct or ducted (code-word DUCT).

NOTE 7 If no data entry is made for this keyword the program will use the flowrate that is assigned by the user (in the ZONE-AIR instruction) or the program will calculate the flowrate based on cooling/heating loads, supply air to space temperature differential, and a user inputted sizing factor.

NOTE 8 If no data entry is made for this keyword the program will use the maximum supply air flowrate minus the sum of zone exhaust flowrate for this quantity (for systems equipped with a return air fan).

NOTE 9 If no data entry is made for this keyword, the program will determine minimum outside air flowrate from value inputted to the appropriate keyword in the ZONE-AIR instruction. If no entry is made in the ZONE-AIR instruction, outside air flow is assumed to be zero. If entries are made in both places, the program selects the highest value.

NOTE 10 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."

NOTE 11 A data entry for this keyword is required if the data entry for keyword HEAT-CONTROL is the code-word RESET. If otherwise, this keyword is not applicable.

NOTE 12 A data entry for this keyword is required if the data entry for keyword COOL-CONTROL is the code-word RESET. If otherwise, this keyword is not applicable.

NOTE 13 If no data entry is made for this keyword the program will assume flow reduction by fan speed control (code-word SPEED).

NOTE 14 This is a required entry for the Reheat Fan System (RHFS). Default value for systems with optional reheat coils (i.e. SZRH, SZCI, VAVS, IVEF, and IVEI) is zero. The keyword is not applicable to other types of systems. Therefore no default value is listed.

NOTE 15 If no data entry is made for this keyword, the program will determine this value based on calculated peak or (design day) loads and on the user input for the keyword SIZING-RATIO (see SYSTEM Instruction).

NOTE 16 If no data entry is made for this keyword (or alternative keywords) the program will calculate zone supply air flowrate based on heating/cooling loads, supply air to space temperature differential, and a sizing-factor. For additional discussion see Section B (ZONE-AIR instruction).

NOTE 17 If no data entry is made for this keyword (or alternative keywords), the program will determine minimum outside air flowrate from the data entry made for keyword MIN-OUTSIDE-AIR (see SYSTEM-AIR instruction). If no data entry is made in either instruction, outside air flow is assumed to be zero. For additional discussion see Section B (ZONE-AIR instruction).

NOTE 18 A data entry for this keyword (and for the referenced SCHEDULE instruction) is required if the zone being specified is heated. WARNING! The program will run but NO HEATING WILL BE PROVIDED FOR THE ZONE BEING SPECIFIED IF THIS DATA ENTRY IS OMITTED!

NOTE 19 A data entry for this keyword (and for the referenced SCHEDULE instruction) is required if the zone being specified is cooled. WARNING! The program will run but NO COOLING WILL BE PROVIDED FOR THE ZONE BEING SPECIFIED IF THIS DATA ENTRY IS OMITTED!

NOTE 20 If no data entry is made for this keyword the program will assume a throttling type thermostat (code-word PROPORTIONAL) except that this is a required entry for the Unitary Heat Pump System (HP).

NOTE 21 A data entry for this keyword is required if the RESET-SCHEDULE instruction is used.

NOTE 22 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. (code-word CONDITIONED).

NOTE 23 This is a required data entry for the Internal Variable Volume-External Fan Coil (IVEF) and the Internal Variable Volume-External Induction (IVEI) Systems but is not applicable to other system types. Therefore no default value is listed.

NOTE 24 If no data entry program assumes that for the system being specified, return air (if any) does not pass through any ceiling plenums.

NOTE 25 This entry is required for all fan systems and is not applicable to other system types (hydronic). Therefore no default value is listed.

NOTE 26 This entry is required for the Two Pipe Induction Unit (TPIU) and Four Pipe Induction Unit (FPIU) systems. It is not applicable to the other systems. Therefore no default value is listed.

NOTE 27 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. Therefore no normal range is possible.

NOTE 28 If no data entry is made for this keyword, hourly reports will not be printed.

NOTE 29 This entry is required for the Two Pipe Induction Unit (TPIU), the Four Pipe Induction Unit (FPIU) and the Unitary Heat Pump (HP) systems. It is not applicable to other systems therefore no default value is listed.

NOTE 30 This keyword is required for two-pipe fan-coil and induction systems and is not applicable to other systems. Therefore no default value is listed.

NOTE 31 Data entry consists of the command-word itself or its abbreviation. No u-name identifier is required or permitted.

Notes to Table IV-D1 - "Applicability of Command-words and Keywords to Various Systems"

1. The program will print an error message and abort if any required entry is omitted.

2. A dependent entry is either required or not applicable depending on the data entry for an associated keyword. Additionally a keyword may be required when the optional instruction which it is attached to is used and not applicable if the instruction is not used.

3. The PLANT-ASSIGNMENT instruction is optional, generally used only when the user wishes to compare different types of systems or systems with different optional features.

4. At least one SYSTEM instruction is required for each computer run except that two SYSTEM instructions are required for each composite system specified (Systems No. 15 and 16).

5. A data entry for this keyword is required only when the keyword values from a supplementary instruction of the same name are to be used for the system being specified.

6. A data entry with at least one u-name is required for this keyword, for each PLANT-ASSIGNMENT instruction used.

7. If no data entry is made for this keyword and the keyword is applicable, the program will use the default value (see User Worksheet and SECTION B).

8. A data entry with at least one u-name is required for this keyword, for each SYSTEM instruction used. (Note this entry is required even if keyword values from another SYSTEM instruction are referenced by use of keyword LIKE).

9. A data entry for this keyword is required to simulate the optional component or control strategy that the keyword is related to. If no data entry, the program assumes that this optional feature does not exist.

10. If no data entry is made for this keyword, the program will procede with the TEMDEV calculation.

11. If data entry for either keyword RETURN-AIR-PATH or PLENUM-NAMES is omitted the program will assume that there are no return air plenums for the system being specified.

12. Data entry for this keyword is required to simulate a specific operational schedule for the component that the keyword is related to. If no data entry the program assumes that this component, if specified, operates continuously or is always available when needed.

13. Data entry for this keyword is required if code-word CONSTANT is entered for keyword HEAT-CONTROL and is otherwise not applicable.

14. Data entry for this keyword is required if code-word RESET is entered for keyword HEAT-CONTROL and is otherwise not applicable.

15. Data entry for this keyword is required if code-word CONSTANT is entered for keyword COOL-CONTROL and is otherwise not applicable.

16. Data entry for this keyword is required if code-word RESET is entered for keyword COOL-CONTROL and is otherwise not applicable.

17. This is an optional instruction that is provided for the users convenience. When more than one system is to be specified, use of this instruction can reduce data input effort. (see Section B).

18. This is an optional instruction that is provided for the users convenience. When more than one zone is to be specified, use of this instruction can reduce data input effort. (see Section B).

19. If no data entry is made for this keyword the program will use the flowrate that is assigned by the user (in the ZONE-AIR instruction) or the program will calculate the flowrate based on cooling/heating loads, supply air to space temperature differential, and a user inputted sizing factor.

20. If no data entry is made for this keyword the program will use the maximum supply air flowrate minus the sum of zone exhaust flowrate for this quantity (for systems equipped with a return air fan).

21. If no data entry is made for this keyword the program will use the value assigned in the ZONE-AIR instruction. If values are entered here and in the ZONE-AIR instruction, the program will use the larger value. If no entry is made here or in the ZONE-AIR instruction the program will assume that the system being specified has no outside air capability.

22. At least one ZONE instruction is required per computer run.

23. This entry must match the entry for the analogous keyword SPACE-MULTIPLIER in the LOADS program in order for the SYSTEMS simulation to be correct.

24. If no data entry is made for this keyword the program will use calculated peak (or design day) loads adjusted by the user input value (if any) for keyword SIZING-RATIO (see SYSTEM instruction).

25. If no data entry is made for this keyword (or alternative keywords) the program will calculate zone supply air flowrate based on heating/cooling loads, supply air to space temperature differential, and a sizing factor. For additional discussion see Section B (ZONE-AIR instruction).

26. If no data entry is made for this keyword (or alternative keywords), the program will determine minimum outside air flowrate from the data entry made for keyword MIN-OUTSIDE-AIR (see SYSTEM-AIR instruction). If no data entry is made in either instruction, outside air flow is assumed to be zero. For additional discussion see Section B (ZONE-AIR instruction).

27. A data entry for this keyword (and for the referenced SCHEDULE instruction) is required if the zone being specified is heated. WARNING! The program will run but NO HEATING WILL BE PROVIDED FOR THE ZONE BEING SPECIFIED IF THIS DATA ENTRY IS OMITTED!

28. A data entry for this keyword (and for the referenced SCHEDULE instruction) is required if the zone being specified is cooled. WARNING! The program will run but NO COOLING WILL BE PROVIDED FOR THE ZONE BEING SPECIFIED IF THIS DATA ENTRY IS OMITTED!

29. If no data entry is made for this keyword the program will assume that a proportional type thermostat is installed.

30. This instruction is used only when the code-word RESET is entered for the keywords HEAT-CONTROL or COOL-CONTROL (see SYSTEM-CONTROL instruction) or if a baseboard heating system is specified (see keyword BASEBOARD-SCHED in the SYSTEM-CONTROL instruction).

31. If no data entry is made for this keyword the program will assume that the zone being specified in CONDITIONED, that is heated and/or cooled.

32. A data entry for this keyword is required for each DAY-RESET-SCHED instruction used (unless value is referenced from another DAY-RESET-SCHED by use of keyword LIKE).

V. PLANT EQUIPMENT SIMULATION PROGRAM

* In Preparation

V. PLANT EQUIPMENT SIMULATION PROGRAM

A. Introduction

The PLANT program is used to simulate the primary equipment which uses fuel (e.g., oil, gas, or sunshine) to provide heating and cooling. The program requires user input data to specify the type and control conditions of the plant equipment, and it requires an hourly file of HVAC thermal requirements from the SYSTEMS Program. The plant equipment may include on-site electric generating and heat recovery capabilities which can satisfy coincident electrical, heating, and cooling demands of a building. This program uses these hourly demands for a typical year to calculate the energy consumption on an hourly basis, and summarizes it by month and by year. Conventional central plant equipment (e.g., boilers, chillers) or selective energy plants (a hybrid configuration having utility electricity and on-site electric generation capability) can be simulated using this program.

The PLANT program can be run with minimal specification of plant equipment consisting only of identifying the TYPE of equipment, its SIZE, the total number of installed units and the maximum number of units which are simultaneously available or MAX-NUMBER-AVAIL. If the user does not enter any other commands, the PLANT program will use the default value for each variable within the program.

Each class of input data has its own BDL command for identification. The only instructions which are mandatory are INPUT PLANT, PLANT-EQUIPMENT, and END. An INPUT PLANT instruction must precede the plant instructions, and an END command is required at the end.

The input data to the PLANT program from the SYSTEMS program consists of the following information for each hour:

Heating load in MBtu (10^6 Btu)
Cooling load in MBtu
Electrical load in kWh
Ambient air temperature (dry bulb) in ^oF
Humidity ratio (mass of water/mass of dry air)
Weighted average mixed air temperature in ^oF
Total heating coil energy in Btu/hr
Total zone coil energy in Btu/hr
Total supply air quantity in CFM

Using this program, one may also model plant equipment having seasonal changes of components. It may be run several times and the results manually selected to obtain a composite which represents a full year of operation.

B. Input Instructions

B. <u>BDL Input Instructions</u>

In order to use the PLANT program, the user must first enter an

/* INPUT PLANT */

instruction. The BDL Processor will next expect a

PLANT-EQUIPMENT

instruction. At least one PLANT-EQUIPMENT instruction must be entered by the user in order to inform the Processor which piece of equipment should be simulated. The following instructions may then be entered as desired or required by the user:

PART-LOAD-RATIO
PERFORMANCE-COEFFICIENTS
EQUIPMENT-ASSIGNMENT
or
PLANT-CONSTANTS

The following ECONOMICS instructions are to be entered next:

ENERGY-COST
EQUIPMENT-COST
PLANT-RATES
LIFE-CYCLE-COSTS

These instructions are described in the ECONOMICS Chapter.

If a user desires to use the solar equipment simulation program, it is necessary to enter one

SOLAR-EQUIPMENT ..

instruction. A user may then enter the following instructions to describe the solar equipment configuration: one

SYSTEM

instruction and as many

COMPONENT .

instructions as required by the type of SYSTEM selected.

Section D "Solar Design Package" provides a description of these instructions, which are used to specify a liquid or air solar heating system.

Following the necessary specification of the keywords and values required by the above instructions, the user must enter an

END ..

instruction to indicate that the input data is finished. A

/* COMPUTE PLANT .. */

instruction must be entered next, to instruct the processor to perform the calculations. If the user does not desire to run the ECONOMICS programs, then the last instruction must be:

/* STOP .. */

Each of the instructions for the PLANT program will now be described.

/* These instructions are inserted as comments for Cal-ERDA 1.3. They are included to illustrate their reserved positions for future versions which will require their use.

The PLANT program can be used to obtain improved design configurations for total energy plants, conventional energy plants, and selective energy plants (a hybrid combination of the first two). The effective use of the program depends upon an understanding of the problem. The output reports of the program contain statistics on equipment use that can be used to obtain better configurations than the initial one. Since the execution time of PLANT is small (typically 20 CPU) seconds on a CDC 6600 for one simulation run) one can afford to run it several times in order to find an "optimal" or "near-optimal" configuration.

Users who have even a little experience with PLANT will undoubtedly develop their own methods of using it effectively. Below we present, as a guidance, a method for the new user:

<u>Step 1:</u>

Run the LOADS and SYSTEMS Programs to produce the hourly energy demands.

<u>Step 2:</u>

Identify all physical and environmental constraints and list them to eliminate infeasible configurations. (For example, if we have a total energy plant at the top floor of a hospital, diesel engines may be infeasible to install because of noise level).

<u>Step 3:</u>

Identify types of equipment under consideration and their available sizes or ranges of sizes.

Make an estimate of maximum loads for choosing equipment for the initial test run.

<u>Step 4:</u>

Identify all quantities which are known for the proposes installation and prepare input data to override default values. (For example, if the boilers are going to be designed for 30 PSIG steam, enter PSTEAM = 30.0 using the PLANT-CONSTANTS command since the default value is either 12 PSIG or 150 PSIG depending on whether or not 2-stage absorption chillers are specified). If no actual values are known for data items, no input is necessary, since default values will be supplied by the program.

Step 5:

If a specific brand of equipment is being considered, compare its performance coefficients with the model in the program. If they differ significantly, use the PERFORMANCE instruction to override built-in default values.

Step 6:

CASE A. If one or more configurations are already given by types of components, sizes (capacities) and number of units, then prepare separate decks containing equipment size and availability cards, etc., and put them one following another, separating them with END cards. A single run will produce outputs for each configuration. Then compare results and choose the best one.

CASE B. If one or more configurations are given only by equipment type combination, then unit sizes and number of units may be determined by using program output. This can be done best by successively running PLANT and using the information obtained in each run to decide the input for the next. The first run is mainly to find out peak loads of each type of equipment. These enable one to determine total capacity needed in each type of component. In the successive runs, break the total capacity into various sizes. The trade-off here is that while smaller sizes increase the total first cost, they will usually decrease energy consumption. This is because it will be more likely for them to operate at or near optimal part load ratios. This is a trial-and-error procedure. After each run one can examine the average operating part load ratios (the first column of the Equipment Use Statistics Report) to determine the effect of the partition of the total capacity made in the current run, comparing it with previous one (s). One should try to get as close as possible to optimum operating ratios. If the average operating ratio is too low for an equipment type then add at least one small equipment unit.

Operating hours are also a good indicator of equipment use. For example, if the total number of operating hours of a double bundle chiller is small, the additional first cost cannot be justified. Again examining operating hours, one can easily determine this and delete that equipment from consideration in the following runs.

After this experiment with equipment size assignments, Case B will turn into Case A, and the reasoning given above will apply.

CASE C. This is the most general case, in which one is supposed to determine not only sizes but also equipment type sombination (s) which will give near optimal configurations.

This is actually not much more involved than the previous case. The only difference is that, in the first run specify all equipment types (except choose only one absorption chiller type, one compression chiller type, and one cooling tower type). Using a similar argument to that employed above one can then delete certain types in the following runs. It should also be noted that in PLANT it is assumed in the load allocation that gas turbines and diesel engines do not normally coexist. Environmental considerations, investment costs and other constraints usually rule out one anyway, so this is not an unrealistic restriction. If the user does specify both types of internal combustion engines, the program will split the load between them in proportion to their total capacities.

In any of the above cases one will end up with several Computer outputs which will have to be evaluated further for final selection.

<u>Step 7:</u>

For making a final selection the outputs of PLANT contain several pieces of useful information, of which the user can consider one, some, or all in the decision making process. For instance one can take the life-cycle cost as an objective function to be minimized while imposing constraints on first cost, total fuel input and average plant efficiency. Alternatively one might be more interested in minimizing initial cost, annual fuel usage, or electricity needed from a utility. Only the user can know which of these are more important, and which less for each specific problem.

1. PLANT-EQUIPMENT (mandatory)

The PLANT-EQUIPMENT instruction is used to enter the TYPE, SIZE, and number of plant components

Name	Command	Data List Keyword	Abbr	Notes
U-name	PLANT-EQUIPMENT	TYPE		code-word
	EQUIPMENT	SIZE		10^6Btu/hr
	PE	INSTALLED-NUMBER	IN	number
		MAX-NUMBER-AVAIL	MNA	number

Rules

1. At least one PLANT-EQUIPMENT instruction must follow an INPUT PLANT.. instruction.

2. Equipment sizes must be entered in ascending order for each type of equipment.

3. All sizes must be specified in MBTUH (one million Btu/hr).

4. The PLANT program will only allow 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 it never operates. The rule employed by the program to determine which equipment type to operate is a precedence rule based purely on the equipment types. Specifically: a two-stage absorption chiller with economizer always excludes all other absorption chiller types; a two-stage absorption chiller always excludes all one-stage absorption chillers; a reciprocating compression chiller always excludes all open centrifugal and hermetic compression chillers; an open centrifugal compression chiller always excludes all hermetic compression chillers; and a ceramic cooling tower always excludes all non-ceramic cooling towers.

5. Each different TYPE and SIZE of equipment should be described in a separate PLANT-EQUIPMENT instruction. This will allow the user more flexibility later in the program to assign different cost items to specific equipment using the EQUIPMENT-COST instruction.

U-name	A unique U-name may be given to identify this instruction.
PLANT-EQUIPMENT	The PLANT-EQUIPMENT command word is used to specify the equipment data. If a PLANT-EQUIPMENT instruction is not specified by the user, the PLANT program will not operate successfully.
TYPE	The user specifies a code-word selected from Table V-1 to identify the type of equipment to be used in the simulation calculations.

Table V-1

Equipment Type Code-Words

Equipment	Code-word
Heating Equipment	
Steam boiler	STMB
* Hot water	
* Gas furnace	
Cooling Equipment	
One-stage absorption chiller	ABS1
Two-stage absorption chiller	ABS2
Two-stage absorption chiller with economizer	ABS2E
Hermetic compression chiller	COMPH
Open centrifugal compression chiller	COMPC
Reciprocating compression chiller	COMPR
Double bundle chiller	DBUN
Cooling tower	CTOWR
Ceramic cooling tower	CTOWC
Electrical Generating Equipment	
Diesel engine	DIESL
Steam turbine	STURB
Gas turbine	GTURB
Storage	
* Hot water tank	WTANK
* Cold water tank	CTANK

* In preparation

SIZE

The size of each separate piece of equipment is the maximum rated capacity specified in units of one million Btu's per hour (MBTUH). As examples, 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.

Note: For CAL-ERDA version 1.3 the user must enter in ascending order.

INSTALLED-NUMBER

INSTALLED-NUMBER specifies the total number of installed separate units which have the type and size previously specified. As an example, if three 100-ton chillers have been installed, enter INSTALLED-NUMBER = 3.0.

MAX-NUMBER-AVAIL

MAX-NUMBER-AVAIL specifies the total number of separate units which are simultaneously available having the type and size previously specified. The value of this keyword is a number which can equal but not exceed the value of the above keyword. (i.e., it is an error to specify that five units are available if only four are installed)

Example:

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 decide to name a PLANT-EQUIPMENT instruction "CHILLERS" the entry would be:

```
CHILLERS = PLANT-EQUIPMENT      TYPE = ABS1
                                SIZE = 1.2
                                INSTALLED-NUMBER = 3
                                MAX-NUMBER-AVAIL = 2 ..
```

Only one TYPE and SIZE of equipment should be specified for each PLANT-EQUIPMENT instruction. This will simplify the use of assignment and cost association instructions.

2. PART-LOAD-RATIO

The equipment PART-LOAD-RATIO instruction specifies the part load ratios.

Name	Command	Data List Keyword	Abbr	Notes
U-name	PART-LOAD-RATIO	TYPE		code-word
	PLR	MIN-RATIO	MIN	number
		MAX-RATIO	MAX	number
		OPTIMUM-RATIO	OPT	number
		ELECTRIC-INPUT-RATIO	EIR	number

Name — A unique U-name may be used to identify this instruction.

PART-LOAD-RATIO — PART-LOAD-RATIO is a BDL command word to identify the information which follows as the part load ratio data.

TYPE — The user enters a code-word selected from Table V-2 to identify the TYPE of equipment for which the user wishes to specify the part load ratios. Only one TYPE may be specified for each PLR command.

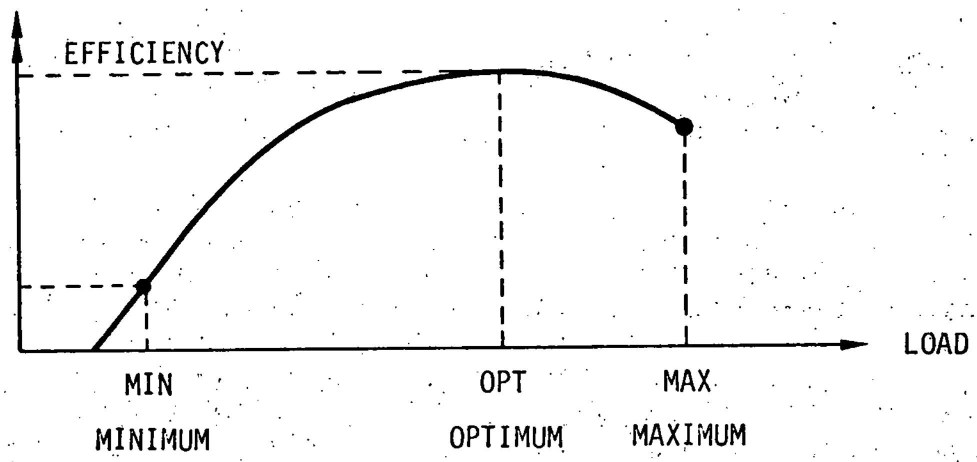
MIN-RATIO — The minimum part-load ratio specifies the minimum fraction of a machine's nominal rated load (i.e., of maximum output) at which the machine will come on-line. For a piece of equipment which requires 2% of full load capacity in order to bring it on-line, the user specifies:

MIN-RATIO = 0.02

MAX-RATIO — The maximum part load ratio specifies the maximum fraction of loading or overloading allowed, if any. If the maximum load is the rated load (size), and no overload is allowed, the user should specify

MAX-RATIO = 1.0

OPTIMUM-RATIO The optimum part load ratio specifies a point, usually taken from a performance curve, that represents the most desirable operating condition. The following sketch illustrates the three part load ratio points used in the mathematical modelling of the part load performance of equipment. For the case of performance curves which do not have a clearly desired "optimum," the user should not specify any point (i.e., no input is required).



ELECTRIC-INPUT-RATIO The electric input to nominal capacity ratio is to be expressed as a dimensionless ratio (e.g., BTU/BTU). This ratio may be zero for equipment which does not have any electrical inputs, as an example, it may be very small (i.e., EIR = 0.006) to represent the electrical input required to operate a feed water pump for a boiler.

Table V-2

Equipment PART-LOAD-RATIO Default Values

TYPE Code-word	Equipment	Part-Load Ratios Min	Max	Optimum	Electric Input to Nominal Capacity
	Heating Equipment				
STMB	Steam boiler	0.01	1.00	0.8700	0.0000
	Cooling Equipment				
ABS1	1-stage absorption chiller	0.05	1.10	0.6500	0.0077
ABS2	2-stage absorption chiller	0.05	1.10	0.6500	0.0077
ABS2E	2-stage absorption chiller with economizer	0.05	1.10	0.6500	0.0077
COMPH	Hermetic compression chiller	0.10	1.05	0.6500	0.2275
COMPC	Open centrifugal chiller	0.10	1.05	0.6500	0.2275
COMPR	Reciprocating chiller	0.10	1.05	0.6500	0.2275
DBUN	Double bundle chiller	0.10	1.05	0.6500	0.2275
CTOWR	Cooling tower	0.00	0.00	0.4365	0.0120
CTOWC	Ceramic cooling tower	0.00	0.00	0.4365	0.0120
	Electric Generating Equipment				
DIESL	Diesel engine	0.02	1.05	0.6000	0.0000
STURB	Steam turbine	0.02	1.10	0.900	0.0000
GTURB	Gas turbine	0.02	1.05	0.6000	0.0000
	Storage				
* HTANK	Hot water tank	0.00	0.00	0.0000	0.0000
* CTANK	Cold water tank	0.00	0.00	0.0000	0.0000

* See SOLAR package

3. PERFORMANCE

The equipment PERFORMANCE instruction defines the coefficients for the quadratic curve used to model the equipment performance.

Data List

Name	Command	Keyword	Abbr.	Notes
U-name	PERFORMANCE			
	PC	COEFFICIENT	C	code-word
		CONSTANT-TERM	CT	number
		LINEAR-TERM	LT	number
		QUADRATIC-TERM	QT	number

Name — A unique U-name may be used to identify this instruction.

PERFORMANCE — The BDL command word PERFORMANCE is used to identify the equipment performance coefficient data.

COEFFICIENT — The COEFFICIENT keyword entry is a code-word selected from Table V-3 to identify the performance variable.

CONSTANT-TERM

LINEAR-TERM

QUADRATIC-TERM — The CONSTANT-TERM, LINEAR-TERM, and QUADRATIC-TERM keywords are used to assign values to the coefficients.

Example: The ratio of energy input to design energy input for an hermetic centrifugal chiller may be modelled using the following instruction:

```
PERFORMANCE  COEFFICIENT    = RPWR1C
             CONSTANT-TERM  = 0.185
             LINEAR-TERM    = 0.332
             QUADRATIC-TERM= 0.471  ..
```

As a result of including this instruction, the equation used to model the energy input to design energy ratio (RPWR1C) for an hermetic centrifugal chiller would be:

$$y = CT + LT\ x + QT\ x^2$$
$$y = 0.185 + 0.332x + 0.471x^2$$

where y is RPWR1C and x is the part-load ratio.

Table V-3

PERFORMANCE Coefficient Default Values

Code-word	Equipment Name	Constant Term	Linear Term	Quadratic Term
	Heating Equipment			
	Steam Boiler			
RFVELB	Energy I/O Ratio	0.60	0.88889	-0.493827
	Cooling Equipment			
	One-Stage Absorption Chillers			
CAVL1A	Available Capacity	1.0	0.0	0.0
REN1A	Energy I/O Coefficient	0.08375	0.63170	0.267050
TCON1A	Condensate Temp Coefficient	1.0	0.0	0.0
SRID1A	Steam Rate Coefficient	1.0	0.0	0.0
	Two-Stage Absorption Chillers			
CAVL2A	Available Capacity	1.0	0.0	0.0
REN2A	Energy I/O Coefficient	0.11467	0.67212	0.212120
SR2DTA	Steam Rate Coefficient	1.0	0.0	0.0
TCON2A	Condensate Temp Coefficient	1.0	0.0	0.0
REN2AE	Energy I/O Coeff (with economizer)	0.12917	0.36902	0.511360
	Chillers			
RPWR1C	Energy I/O Coeff (Hermetic compression)	0.16017	0.31644	0.518940
RPWR2C	Energy I/O Coeff (Open centrifugal)	0.04864	0.54542	0.388850
RPWR3C	Energy I/O Coeff (Reciprocal compression)	-0.01200	0.44727	0.560610
	Double Bundle			
RCAVDB	Available Capacity Ratio	1.0	-0.03300	-0.005601
RPWRDB	Energy I/O Coefficient	0.16017	0.31644	0.518940
ADJTDB	Condensate Cooling Water Temp Adjust	95.0	2.50	44.0
ADJEDB	Energy Ratio Adjustment Factor	1.61000	-0.61000	0.0
	Tower			
RF1	Rating Factor Temp Coeff 1-3	7.6680	-0.12796	0.000594
RF2	Rating Factor Temp Coeff 4-6	7.47850	-0.14145	0.000749
RF3	Rating Factor Temp Coeff 7-9	4.69600	-0.08080	0.000400
RF4	Rating Factor Temp Coeff 10-12	4.20850	-0.07881	0.000432
RF5	Rating Factor Temp Coeff 13-15	3.18760	-0.05461	0.000277
RF6	Rating Factor Temp Coeff 16-18	2.63970	-0.04440	0.000224
RFR	Rating Factor Range Coeff	0.0	0.1	0.0

Table V-3 (cont'd)

Electrical Generating Equipment

	Diesel			
RELD	Power Out/Fuel Input Coeff	0.09755	0.63180	-0.416500
RJACD	Jacket Heat/Fuel Input Coeff	0.39220	-0.43670	0.277960
RLUBD	Lube Heat/Fuel Input Coeff	0.08830	-0.13710	0.080300
REXD	Exhaust Heat/Fuel Input Coeff	0.31440	-0.13530	0.097260
TEXD	Exhaust Temp Coeff	720.0	60.0	0.0
	Steam Turbine			
RFSTOR	Steam Flow Coeff	1.0	0.0	0.0
	Gas Turbine			
FUEL1G	Fuel I/O Coeff 1-3	7.6830	-13.480	8.0
FUEL2G	Fuel I/O Coeff 4-6	1.8822	-0.00433	0.000014
EXFG	Exhaust Flow Coeff	0.01823	0.00003	0.0
TEX1G	Exhaust Temp Coeff 1-3	1.0	0.38450	0.028150
TEX2G	Exhaust Temp Coeff 4-6	406.96	0.63170	0.000224
ELUBG	Lube Oil Coeff	0.22300	-0.40000	0.228600
UACG	Stack U-Factor * Area Coefficient	0.03805	0.9000	0.0

4. EQUIPMENT-ASSIGNMENT

The EQUIPMENT-ASSIGNMENT instruction is used to describe the sequence in which the PLANT-EQUIPMENT is to be assigned to serve the load.

Name	Command	Keyword	Abbr.	Notes
U-name	EQUIPMENT-ASSIGNMENT			
	ASSIGNMENT	TYPE	TY	Code-word
	EA	MAX-LOAD	ML	10^6 Btu/hr
		SIZE1	S1	u-name
		ASSIGN1	A1	number
		SIZE2	S2	u-name
		ASSIGN2	A2	number
		SIZE3	S3	u-name
		ASSIGN3	A3	number
		SIZE4	S4	u-name
		ASSIGN4	A4	number
		SIZE5	S5	u-name
		ASSIGN	A5	number
		SIZE6	S6	u-name
		ASSIGN6	A6	number

Name — Any user defined name may be given to this instruction.

EQUIPMENT-ASSIGNMENT
ASSIGNMENT
EA — This command word informs the BDL Processor that the user desires to specify a sequence by which the PLANT-EQUIPMENT is to be assigned (or turned on).

One EQUIPMENT-ASSIGNMENT, or ASSIGNMENT instruction is required for each different type of equipment and maximum load range. In order to specify a sequence or load dependent EQUIPMENT-ASSIGNMENT schedule, the user must enter a series of ASSIGNMENT instructions. The example illustrates a series of four ASSIGNMENT instructions.

TYPE — Following the keyword TYPE the user enters a code-word selected from Table V-1 to describe the type of equipment that will be assigned a loading schedule.

MAX-LOAD — The user enters a maximum load that one piece, or a group, of equipment is to meet in millions of Btu's per hour. For example, if one unit is to provide the necessary cooling energy up to a maximum load of 500,000 Btu/hr, then the user specifies:

MAX-LOAD = 0.5.

If a combination of two units are to supply the load from 500,001 Btu/hr to 1,000,000 Btu/hr, the user would enter a second ASSIGNMENT instruction, having the following keyword specification

MAX-LOAD = 1.0.

This second ASSIGNMENT statement must then specify an adequate capacity to meet the load.

SIZE1 — The first size keyword, SIZE1, is to be followed by a u-name for the smallest SIZE equipment of the specified TYPE. The u-name entered by a user is the u-name for a PLANT-EQUIPMENT, or an EQUIPMENT instruction, which must define the same TYPE of equipment, and give the SIZE of the equipment in MBtu/hr, the INSTALLED-NUMBER, and the MAX-NUMBER-AVAILABLE.

ASSIGN1 — A user enters the number of SIZE1 units to be assigned or operated for loads up to the limit specified by MAX-LOAD. For example, the user may decide to assign two units having the same SIZE1 characteristics using:

ASSIGN1 = 2.0.

SIZE2 through SIZE6

The user enters the EQUIPMENT instruction u-name for the next larger sized equipment, in increasing order.

ASSIGN2 through ASSIGN6

The user enters the number of SIZEn units to be assigned to meet the loads up to the limit set by MAX-LOAD.

Example: The user may define two double bundle chillers, each having a rating of 50 tons (0.600 MBtu/hr), using the instruction named DB-SMALL. Two units are specified as being installed and simultaneously available. A user may also specify one double bundle chiller having a rating of 200 tons (2.40 MBtu/hr) using the instruction named DB-LARGE.

A user may then instruct the program to assign one small unit up to a load of 0.5MBtu/hr, using the first ASSIGNMENT instruction. The second ASSIGNMENT instruction assigns two small units, up to a load of 1.0 MBtu/hr. Above 1.0 MBtu/hr the user may assign the entire load to the one large unit, up to say 2.3 MBtu/hr, by specifying the third ASSIGNMENT instruction. Above 2.3 MBtu/hr the load is assigned to all three units.

Example of EQUIPMENT-ASSIGNMENT Instruction

```
DB-SMALL  =  EQUIPMENT   TYPE= DBUN, SIZE = 0.6
                         INSTALLED-NUMBER = 2
                         MAX-NUMBER-AVAIL = 2 ..

DB-LARGE  =  EQUIPMENT   TYPE = DBUN, SIZE = 2.4
                         INSTALLED-NUMBER = 1
                         MAX-NUMBER-AVAIL = 1 ..

             ASSIGNMENT  TYPE = DBUN, MAX-LOAD = 0.5
                         SIZE1 = DB-SMALL, ASSIGN1 = 1
                         SIZE2 = DB-LARGE, ASSIGN2 = 0 ..

             ASSIGNMENT  TYPE = DBUN, MAX-LOAD = 1.0
                         SIZE1 = DB-SMALL, ASSIGN1 = 2
                         SIZE2 = DB-LARGE, ASSIGN2 = 0 ..

             ASSIGNMENT  TYPE = DBUN, MAX-LOAD = 2.3
                         SIZE1 = DB-SMALL, ASSIGN1 = 0
                         SIZE2 = DB-LARGE, ASSIGN2 = 1 ..

             ASSIGNMENT  TYPE = DBUN, MAX-LOAD = 3.6
                         SIZE1 = DB-SMALL, ASSIGN1 = 2
                         SIZE2 = DB-LARGE, ASSIGN2 = 1 ..
```

5. PLANT-CONSTANTS

The PLANT-CONSTANTS instruction is used to change the value of any of the variables used by the PLANT program in the simulation of the various plant components.

Name	Command	Keyword	Terminator
u-name	PLANT-CONSTANTS PC	Keyword = value	..

u-name — The user may enter any u-name to identify this instruction.

PLANT-CONSTANTS — The PLANT-CONSTANTS command word informs the BDL processor that a variable name will be specified as a keyword and a new default value will be assigned to it by the user. The original default value is never erased, it is only overwritten for the particular run which contains a PLANT-CONSTANTS instruction.

Keyword — The keyword (s) to be specified by the user are selected from Table V-4. Any value may be assigned by the user, including absurd values, since no check is performed on any user entries.

Example — To select a plant type that uses both utility supplied energy and on-site generation, the user would specify:

```
PLANT-CONSTANTS        CPTYPE = 2      ..
```

Any group of keyword variables may be defined within one PLANT-CONSTANTS instruction.

TABLE V-4

PLANT-CONSTANTS Default Values

Name	Keyword	Default Value	Units
Plant Type: Utility Only = 1, Mixed = 2	CPTYPE	1.0	code-number
Heating			
Boiler			
Steam Enthalpy	HSTEAM	1199.578	Btu/lb
Steam Saturation Temperature	TSATUR	369.635	°F
Boiler Stack Leaving Temperature (Boiler)	TLEAVE	550.0	°F
Boiler Flash Water/Steam Feed	RFLASH	0.071	
Steam Pressure	PSTEAM	150.0	psig
Elect Input to Circulation Pump/Heating Load	PELHT	0.006	Btu/Btu
Air/Fuel Stoichometric Ratio	SRATB	17.0	lb/lb
Heat Content of Fuel	HFUELB	20000.0	Btu/lb
Heat Recovery			
Make Up Water Temperature (Heatrec)	TWMAKE	55.0	°F
Recovered Heat/Flash Steam Energy (Heatrec)	RHFLASH	0.50	Btu/Btu
Cooling			
Full Load Steam Rate (1-Storage Absorption Chiller)	SR1A	18.70	MBTUH
Full Load Steam Rate (2-Storage Absorption Chiller)	SR2A	12.20	MBTUH
Chilled Water Temperature	TCOOL	44.0	°F
Chilled Water Temperature Rise	DTCOOL	15.0	°F
Recoverable Heat Ratio (Double Bundle)	RAVRHDB	0.95	fraction
Elect Input to Circulation Pump/Cooling Load	PELCL	0.018	Btu/Btu
Tower			
Entering Tower Water Temperature	TTOWR	60.0	°F
Leaving Condenser Water Temperature	TCW	110.0	°F
Electric Input to Tower/Tower Cool Load	PELTWR	0.013	Btu/Btu
Tower Water/Absorption Chiller Capacity Factor	RWCA	3.0	gpm/ton
Tower Water/Compression Chiller Capacity	RWCC	3.0	gpm/ton
Tower Water/Double Bundle Chiller Capacity	RWCDB	3.0	gpm/ton

Electrical Generations

Diesel

Maximum Exhaust Flow/kW Output (Diesel)	RMXKWD	5.0	cfm/kW

Steam Turbine

Entering Steam Pressure	PSTMTUR	150.0	psig
Entering Steam Temperature	TSTMTUR	494.635	°F
Nominal Exhaust Steam Pressure	PEXSTUR	-12.7	psig
Nominal Speed	RPMNOM	10000.0	RPM
Condensate/Entering Steam	RWSTUR	0.97	lb/lb
Total Efficiency of Utility Electricity Generation (EFFIC)	TOTUEF	0.30	Btu/Btu

Gas Turbine

Maximum Exhaust Flow/kW Output (Gasturb)	RMXKWG	40.0	cfm/kW

Storage

Minimum Tank Temperature For Heating (Soluse)	TMINH	100.0	°F
Minimum Tank Temperature for Cooling (Soluse)	TMINC	180.0	°F

6. SOLAR-EQUIPMENT

The SOLAR-EQUIPMENT instruction is used to instruct the processor that the user desires to use the SOLAR design package (subroutines).

Name	Command	Terminator
	SOLAR-EQUIPMENT	..

Rule	One SOLAR-EQUIPMENT instruction must immediately precede the use of any of the solar design instructions (e.g. SYSTEM, or COMPONENT), and be after all the ordinary PLANT instructions.
Name	No u-names are allowed for this instruction.
SOLAR-EQUIPMENT	Identifies the following instructions as solar design instructions. No keywords, values, or abbreviations are allowed in this instruction.

* 7. PLANT-REPORTS

The PLANT-REPORTS instruction is used to select reports for the PLANT program.

Name	Command	Keywords	Terminator
	PLANT-REPORTS	code-words	..

Name — No u-names are allowed for this instruction.

* PLANT-REPORTS — A BDL command word to inform the processor which reports from the PLANT program the user desires to select. A series of code-words, selected from Table V-5 are used to specify the desired reports.

Example — The following instruction selects three plant output reports

PLANTS-REPORTS P1, P2, P3 ..

Note — For CAL-ERDA 1.3 the user receives all the plant output reports, they can not be selected, individually.

* In Preparation

TABLE V - 5

PLANT Program Reports

Plant Input Verification Reports	Code-word
PLANT-EQUIPMENT Size and Availability	PV1
PART-LOAD-RATIO Input Data	PV2
PERFORMANCE-COEFFICIENTS	PV3
* EQUIPMENT-ASSIGNMENT	PV4
PLANT-CONSTANTS	PV5
** ENERGY-COST	EV1
** EQUIPMENT-COST	EV2
** PLANT-RATES	EV3
**LIFE-CYCLE-COSTS ** BASELINE	EV4

Plant Output Reports	Code-word
Energy Utilization Summary	P1
Equipment Use Statistics	P2
Monthly Peak and Total Energy Use	P3
** Life Cycle Equipment Cost Summary	E1
** Life Cycle Plant Cost Summary	E2

* In Preparation
** To be moved to the ECONOMICS Program , In the PLANT program for Cal-ERDA 1.3.

P1, Central Plant Energy Utilization Summary

The following monthly and total annual values are tabulated.

HT	Total heat energy, which needs to be purchased or produced by the central plant equipment, including the energy needed for cooling.
ET	Total electrical energy, which needs to be purchased or produced by the central plant equipment, including the energy needed for cooling.
C	Total cooling energy produced or purchased.
HR	Recovered energy.
HW	Wasted recoverable energy.
HC/QH	Ratio of heat consumed for cooling to fuel energy input.
EC/QE	Ratio of electricity consumed for cooling to fuel energy input.
HT/QH	Ratio of heating energy to fuel energy input.
ET/QE	Ratio of electricity to fuel energy input.
EP	Total fuel energy input.
FT	Total energy input including fuel to utility supplying electricity to plant. An efficiency of generating electricity is assumed to be 33 %.

$\frac{ET + HT}{FT}$	Average Plant Efficiency
QH	Fuel energy input for heating
QE	Fuel energy input for electricity
QU	Utility Energy

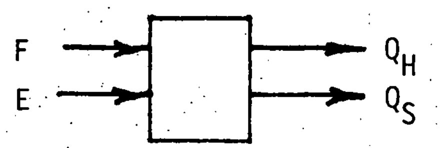
C. Plant Equipment Characteristics

This section contains a brief description of the equipment models used in the PLANT program. It should be noted that in certain cases (absorption or compression cooling) one model will apply to a number of equipment types. Since, in general, quadratic equations are used to represent performance characteristics, using one model for more than one equipment type only requires modifications of the coefficients of the quadratics modelling that component. In all cases, the user has the option of inputing his own quadratic coefficients or other parameters used in the calculation. This section contains graphs of most of the default curves used in modelling the components of PLANT. This allows the user to make sure that the performance of his own equipment does not deviate drastically from the equipment specified by the default coefficients and parameters used by the program.

1. Heating Equipment

a. Boilers

The input/output of a steam or hot water boiler can be illustrated as follows:



$$F + E = Q_H + Q_S$$

where

F = Boiler fuel energy input

E = Electrical energy input

Q_H = Demanded heat energy output

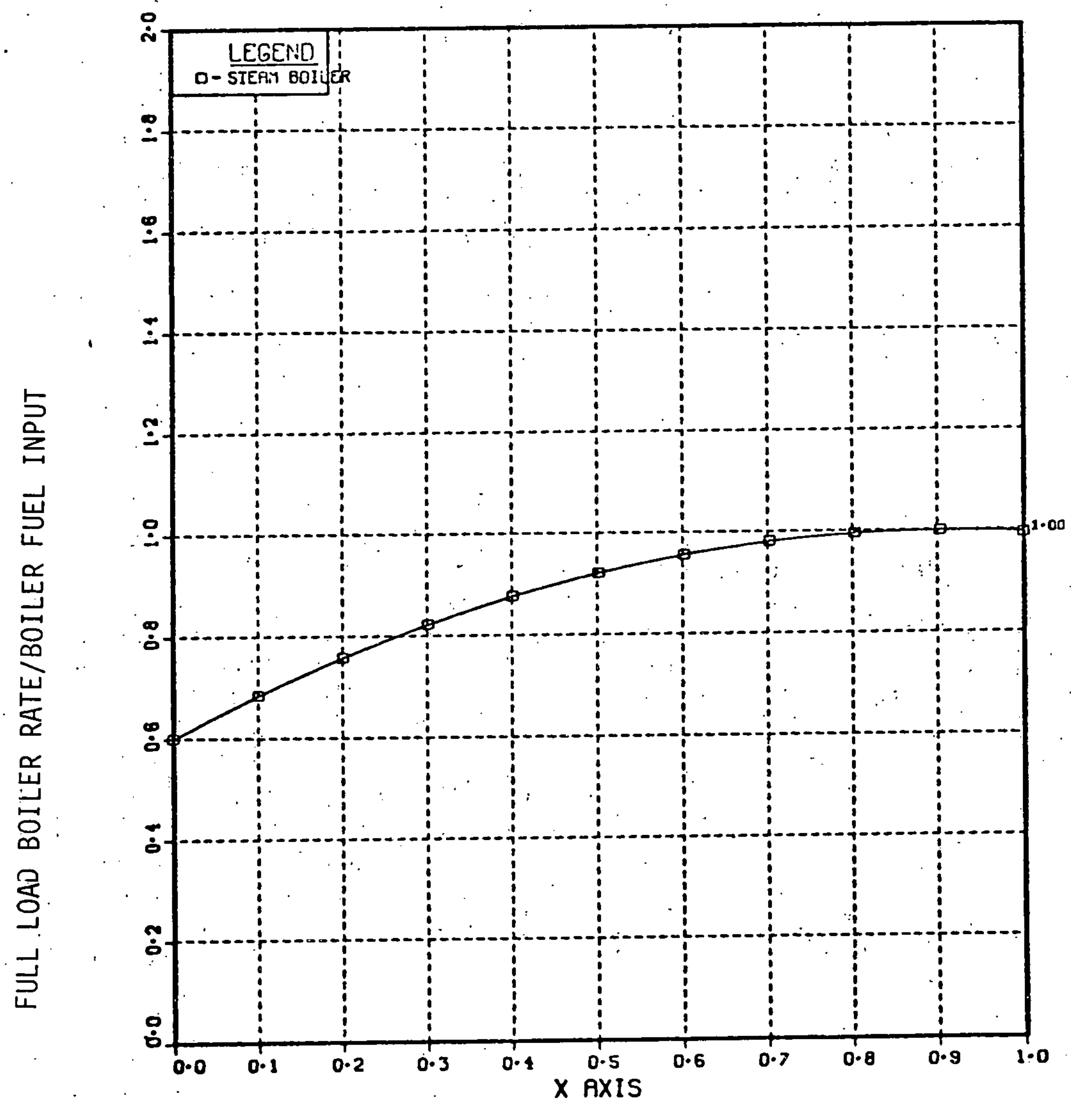
Q_S = Unrecovered heat energy

Given the ratio of electric input to the nominal capacity, the electrical energy input is calculated. The net energy output, heat content of fuel and the temperature rise and humidity of the combustion air (as well as the stoichiometric ratio) are used to determine the full load boiler fuel rate. The full load boiler fuel rate and a quadratic function of the part load ratio are used to determine the boiler fuel input.

Boiler

This model represents the ratio (y) of the full load boiler rate to the boiler fuel input as a function of part load (x).

$$y = .6 + .888888889(x) - .493827161\ (x^2)$$

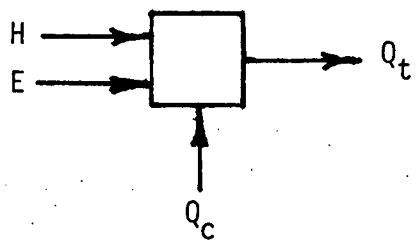


BOILER PART LOAD

2. Cooling Equipment

a. Absorption Chillers

Three generic types of steam driven absorption chillers can be simulated by the PLANT program: one-stage, two-stage and two-stage with an economizer. The three types can be modelled by the same subroutine. The following diagram depicts physical input/output of an absorption chiller.



$$H + E + Q_c = Q_t$$

where

H = steam energy input

E = electrical energy input (for pump)

Q_t = heat removed by the cooling tower

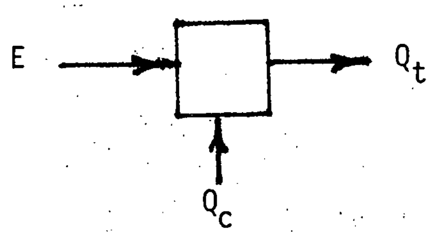
Q_c = cooling load

The electrical energy input is calculated as a function of nominal capacity (independent of part load). Since the available cooling capacity of the chiller decreases as the difference between the condenser water out temperature and the chilled water out temperature increases, a quadratic model is used to calculate the available capacity as a function of this temperature difference.

The energy input ratio and condensate temperature are given as quadratic functions of the part load ratio, while the full load steam rate is represented as a function of the chilled water temperature. This information is used to calculate the part load steam rate and finally the steam energy input. The cooling load, power input and steam energy input determine the tower cooling load.

b. <u>Compression Chillers</u>

The PLANT program can simulate three generic types of compression chillers: Hermetic Centrifugal, Open Centrifugal, and Reciprocating. For simulation purposes, the three types are modelled using the same subroutine. The following diagram depicts the physical input/output of a compression chiller.



$$E + Q_c = Q_t$$

where

E = electric input

Q_t = heat removed by the cooling tower

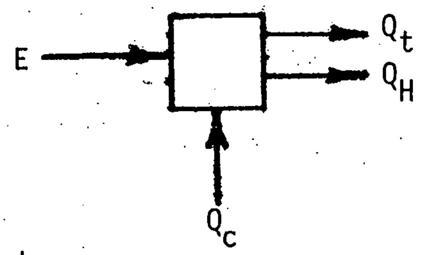
Q_c = cooling load

Given the nominal capacity of the chiller, the cooling load, and the coefficients of a quadratic model representing the ratio of electric input to nominal capacity as a function of the part load ratio, the electric input is calculated. Even though power input and actual operating capacity is dependent upon the condenser and/or chilled water temperatures, this dependence is not simulated at the present time.

Once the electrical input is determined, the cooling tower load, Qt, is known. The values are used for the quadratic coefficients determine which type of compression chiller is being simulated. The user has the option of specifying his own quadratic coefficients or using the default values.

c. Double-Bundle Chiller

The double-bundle chiller simulated by PLANT includes all inherent heat recovery equipment. The following diagram depicts the physical input/output of a double-bundle chiller.



$$E + Q_c = Q_t + Q_H$$

where

E = electric input

Q_t = heat energy removed by the cooling tower

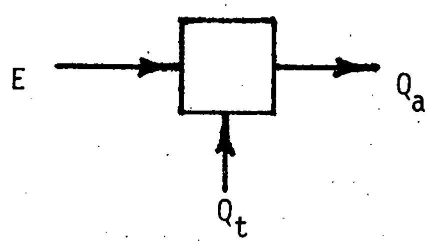
Q_H = recovered heat

Q_c = cooling load

The available cooling capacity of the chiller is determined from a quadratic model as a function of the leaving condenser water temperature and the leaving chilled water temperature. The available capacity also depends on whether or not there is a heating requirement because the leaving condenser water temperature may need to be increased for heating. The part load ratio is used to determine the electric input to the chiller and the recoverable heat. If the recoverable heat can not be used, the wasted recoverable heat is known. The cooling load, recovered heat and the electric input is used to calculate the cooling tower load.

d. Cooling Tower

PLANT has the capability of simulating two generic types of cooling towers, conventional and ceramic. Since the difference between the two is primarily in maintenance costs and not in performance, the same algorithum can be used to simulate both. The cooling tower is assumed to have a variable water rate although the fixed water rate operating mode will be included later. The physical input/output of the tower can be depicted as follows:



$$E + Q_t = Q_a$$

where

E = electrical energy input (fan power)

Q_t = tower cooling load

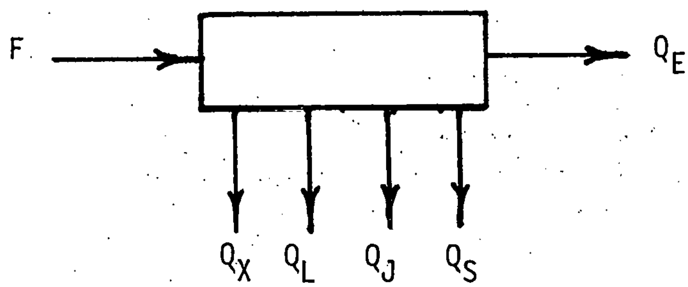
Q_a = energy dissipated by the tower

The cooling load in conjunction with the condenser water temperature, flow rate and outdoor air wet bulb temperature are used to calculate the number of tower cells to be operating, which in turn determines the electricity requirements for the fan motor power. The fans are assumed to run at either full speed or half speed. Even though most of the components simulated by PLANT result in a simple sequential calculation of equations, the tower simulation requires some iterative calculation. A lower bound on the temperature of the leaving water is taken to be two degrees above the wet bulb air temperature.

3. Electrical Generation Equipment

a. Diesel Engine

The PLANT program simulates the diesel engine assuming that it is driving a generator. The physical input/output of the diesel engine-generator set can be depicted as follows:



$$F = Q_E + Q_X + Q_L + Q_J + Q_S$$

where

F = fuel energy input

Q_E = electric load

Q_X = recoverable exhaust heat

Q_L = recoverable lube oil heat energy

Q_J = recoverable jacket heat energy

Q_S = unrecovered heat energy

Given the electrical load and nominal electrical output capacity, the part load ratio is determined. The fuel input, available jacket heat, available lube oil heat, the exhaust gas flow rate, the heat energy of the exhaust gases and the exhaust gas temperature are calculated as quadratic functions of the part load ratio. The above information and the stack re-factor are used to calculate the available recoverable exhaust heat.

Diesel engine - generator set:

The 1st curve represents the ratio of electric output to fuel input.

The 2nd is the ratio of total heat energy of exhaust gases to fuel input.

The 3rd is the ratio of available jacket heat to fuel input.

The 4th is the ratio of available lube-oil heat to fuel input.

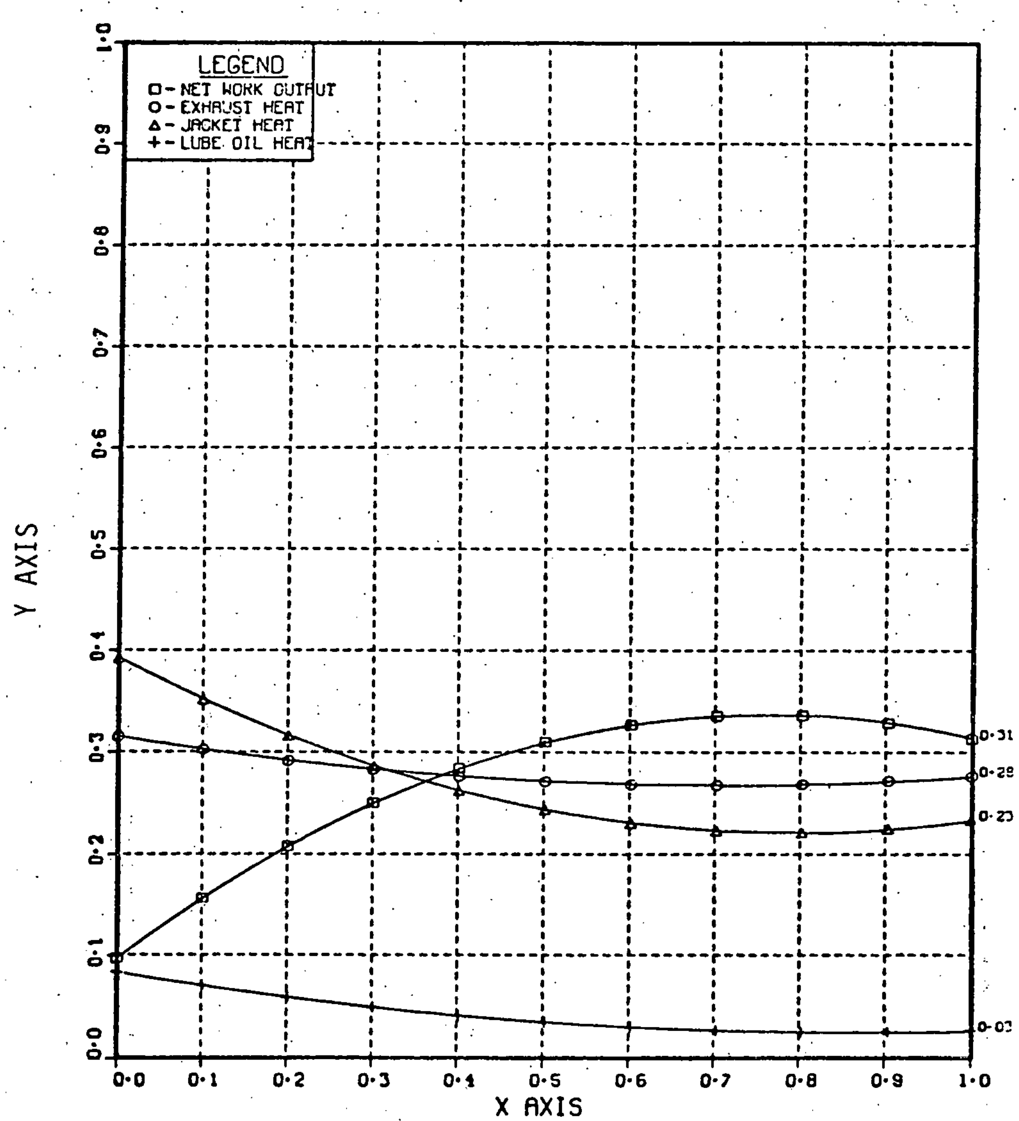
Net work: $y = .09755 + .6318 (x) - .4165 (x^2)$

Exhuast: $y = .3144 - .1353 (x) + .09726 (x^2)$

Jacket Heat: $y = .3922 - .4367 (x) + .27796 (x^2)$

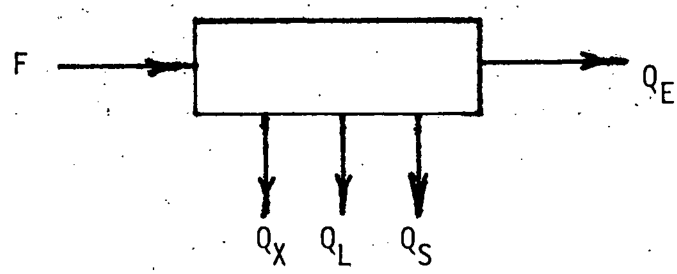
Lube oil: $y = .0883 - .1371 (x) + .0803 (x^2)$

x = part load ratio



b. <u>Gas Turbine</u>

The gas turbine generator simulated by PLANT can be illustrated as follows:



$$F = Q_E + Q_X + Q_L + Q_S$$

where

F = fuel energy input

Q_E = electrical load

Q_X = recoverable exhaust heat energy

Q_L = recoverable lube oil heat energy

Q_S = unrecovered heat energy

The gas turbine fuel input is represented as a product of two quantities the first, a function of the part load, and the second, a function of the air temperature. The exhaust gas temperature is determined similarly. The recoverable exhaust heat is determined from the exhaust gas flow and the temperature, while the recoverable lube oil heat is represented as a quadratic function of the part load.

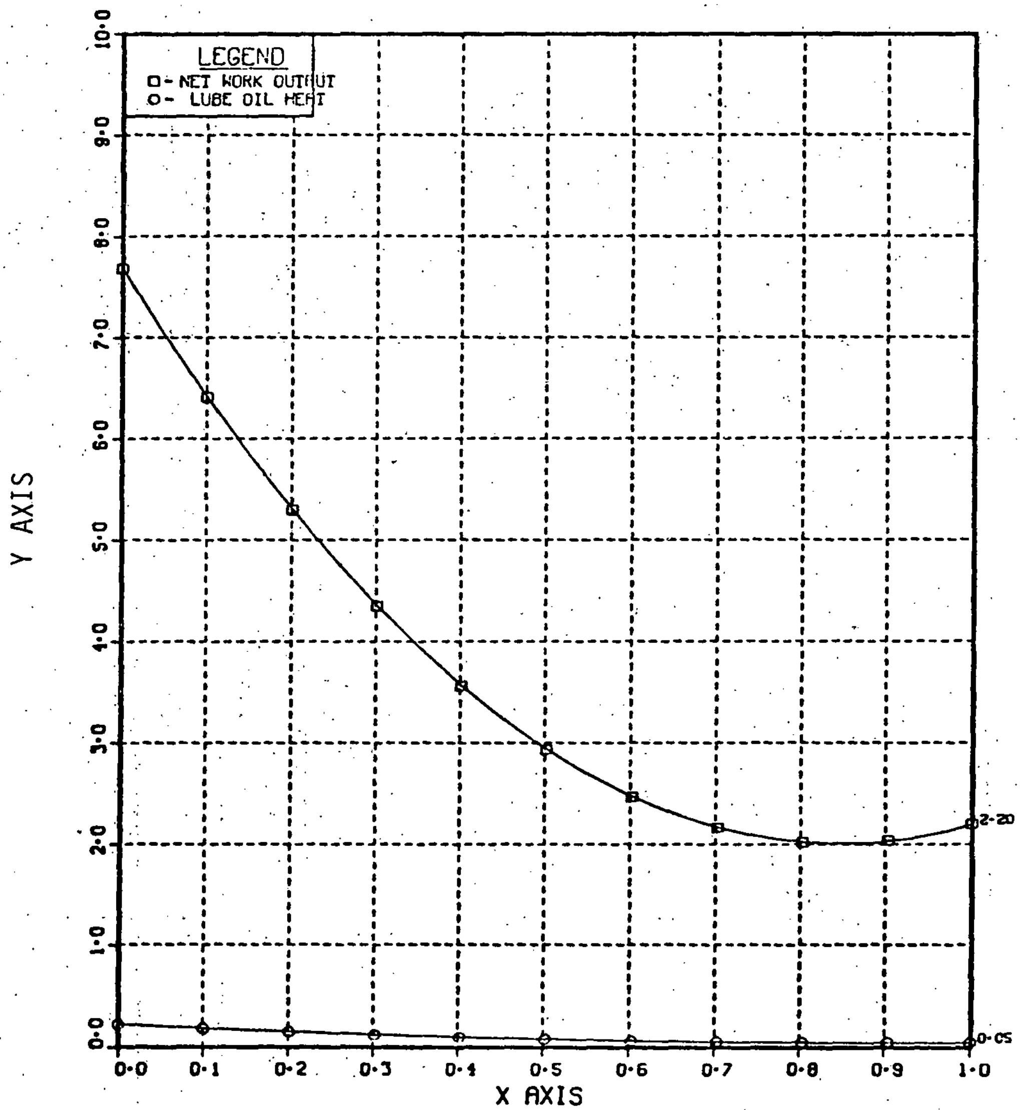
Gas turbine:

The top curve represents the ratio of fuel input energy to electric power output as a function of part load. The lower curve represents the ratio of available lube heat to electric power output as a function of part load.

$$\text{Net work output:} \quad y = 7.683 - 13.48\,x + 8.0\,x^2$$

$$\text{Lube oil heat:} \quad y = 0.223 - 0.40\,x + 0.2286\,x^2$$

$$x = \text{part load ratio}$$

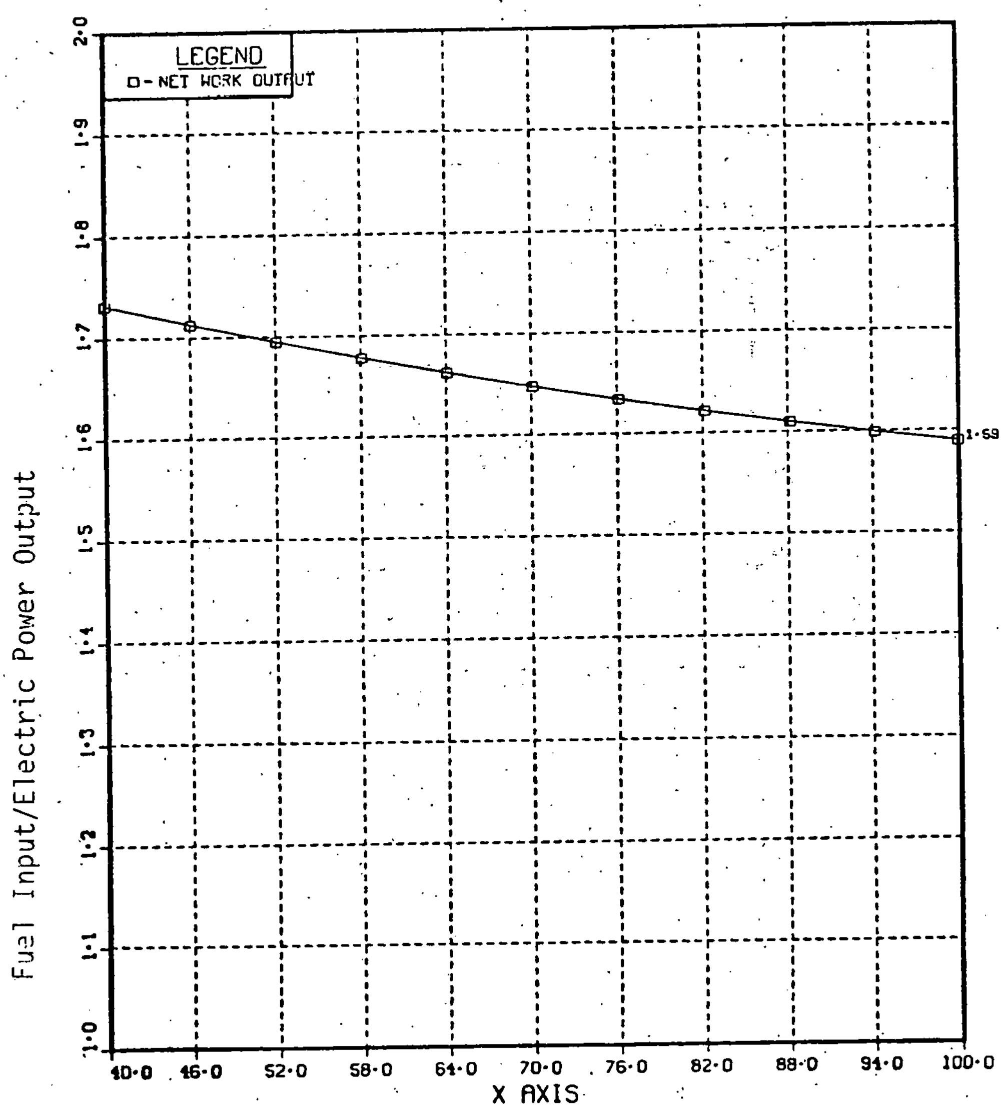


Gas turbine:

This model represents the ratio (y) of fuel input to electric power output as a function of the air temp (x).

$$\text{Net work: } y = 1.8822 - 0.00433\,x + 0.000014\,x^2$$

$$x = \text{air temperature } (^\circ F)$$



Air Temperature

* D. SOLAR Design Package

1. Introduction

The solar equipment simulation package of Cal-ERDA is a multi-level design tool for analysis of both liquid and air solar energy systems. It was developed by the Los Alamos Scientific Laboratory and uses the same basic component connection philosophy of the University of Wisconsin TRNSYS program (Ref. I-8), however substantial modifications have been incorporated to produce a code which operates in conjunction with the Cal-ERDA PLANT program, requires minimal user instructions, and is less expensive to use.

The insolation model used is the Cloud Cover Modifier method, which is the same as that used in the LOADS program. This method uses calculated clear day insolation modified by cloud cover. Future versions of the solar simulation programs will include hourly direct and diffuse insolation on a horizontal surface and SOLMET data.

The BDL instructions required to use the solar equipment simulation package are illustrated in this section. Examples are given to illustrate the input sequence and use of the solar simulator. The keywords are defined for each component, as it is described.

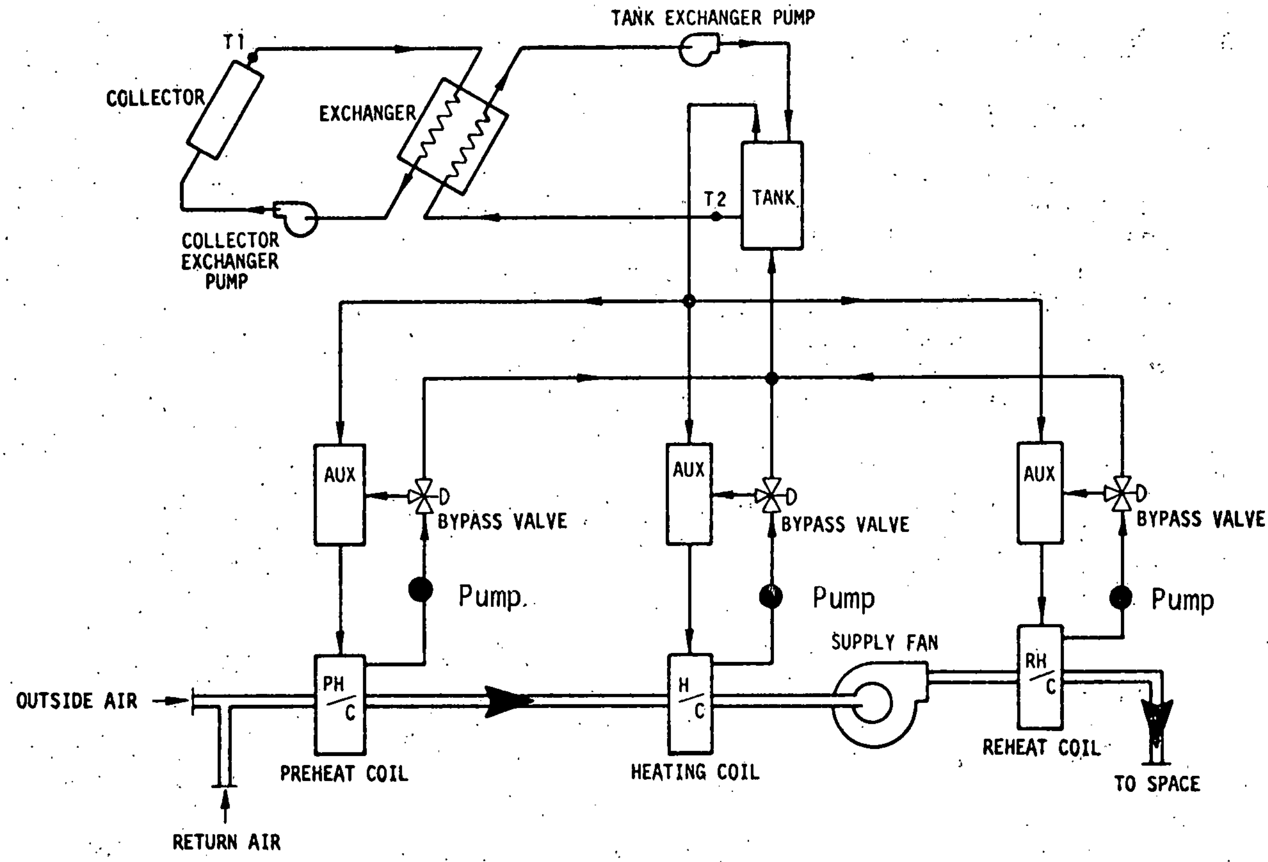
The basis of the solar simulator is the modeling of equipment on a component basis. Each component is a separate subroutine, and several components are also combined in other subroutines. Each component (e.g. collector, tank, pump, etc.) may be connected to other components. Standard systems, composed of "preconnected" components, are available to the user to minimize the amount of data the user must supply. Each of the liquid and air systems has two levels of modeling complexity. The complexity pertains to the detail involved which implies a tradeoff between accuracy and computing time. The preconnected liquid and air systems are described in this section.

Cal-ERDA 1.3 includes four preconnected systems; a fully user-configured approach will be implemented in the near future. While only solar heating is simulated in the solar simulator, solar cooling is modeled by the subroutine SOCOOL in the PLANT program.

* Rule 1. No abbreviations are allowed for any command words or keywords in the SOLAR design package for Cal-ERDA 1.3, October, 1977.

* This description applies to Cal-ERDA 1.3, October, 1977.

2. Liquid Systems



Example Liquid System Schematic

Figure V-1

Figure V-1 illustrates a basic liquid solar equipment system. The computational model for this system includes: a flat-plate collector, a heat exchanger, a collector to exchanger pump, a storage tank, a tank to exchanger pump, and a differential controller. The energy may be taken out of the tank and distributed to either a preheat coil, a heating coil, or a reheat coil. Also, an auxiliary energy source (AUX) may be used to supply additional energy, if the heating loads required by the SYSTEMS program cannot be met entirely by solar heated water.

The primary difference between LIQ-SYSTEM-1 and LIQ-SYSTEM-2 is the amount of detail in the computational models. LIQ-SYSTEM-1 uses a constant collector loss coefficient, while LIQ-SYSTEM-2 calculates an hourly value of collector loss coefficient based upon the number of glazings, collector tilt, wind speed, absorber emittance, etc. This additional flexibility allows the user to obtain an initial set of answers, and to study the effect of variations in collector design.

a. LIQ-SYSTEM-1

An example of the instructions a user enters to use the LIQ-SYSTEM-1 computational model is as follows:

Command	Data List	Terminator
SOLAR-EQUIPMENT		..
SYSTEM	TYPE = LIQ-SYSTEM-1	..
COMPONENT	TYPE = INSOLATION LATITUDE = 36 LONGITUDE = 106 TIME-ZONE = 7 TILT = 46	..
COMPONENT	TYPE = SUBSYSTEM DT-MIN = 6 AREA = 1000 FLOW-COL-XCH = 10000 FLOW-TNK-XCH = 10000 VOL-TNK = 250	..
COMPONENT	TYPE = AUX-CNTRL FLOW-MAX-PHC = 10000	..
END		..

No u-names or name field is allowed in the SOLAR instructions for Cal-ERDA 1.3.

The SOLAR-EQUIPMENT instruction informs the BDL processor that a sequence of solar equipment instructions will be specified. The SYSTEM instruction is used to select the solar equipment system the user desires to model. The keyword TYPE is followed by the code-word LIQ-SYSTEM-1 to identify the first liquid system model.

The first COMPONENT instruction, having TYPE = INSOLATION, specifies the location of the building and the tilt of the collector (TILT-COL). The second COMPONENT instruction, having TYPE = SUBSYSTEM, specifies various parameters for the liquid system. A minimum differential temperature (DT-MIN) was set to 6^{o}F. The area of the collector (AREA-COL) was set to 1000 $Feet^{2}$. The flow rate of the collector to heat exchanger pump (FLOW-COL-XCH) is 10,000 lbs/hr, and the flow rate of the tank to heat exchanger pump (FLOW-TNK-XCH) is also 10,000 lbs/hr. The volume of the tank (VOL-TNK) is selected as 250 $Feet^{3}$. The third COMPONENT instruction, having TYPE = AUX-CNTRL, specifies the maximum flow for the preheat coil (FLOW-MAX-PHC) as 10,000 lbs/hr for the auxiliary controller. An END statement must be the last instruction of the sequence.

The TYPE keyword of the COMPONENT instruction specifies the type of component the user desires. The LIQ-SYSTEM-1 model requires the user to specify three COMPONENT instructions having the code-words given below. Each of these code-words refers to a specific model, or subroutine, used in the simulation of LIQ-SYSTEM-1. The default values, additional optional keywords, and preconnected subroutines used by the LIQ-SYSTEM-1 model are given in the following component models for LIQ-SYSTEM-1:

LIQ-SYSTEM-1 Components

Component TYPE Code-word	Component Model
INSOLATION	INSOLATION-1
AUX-CNTRL	LIQ-AUX-CNTRL-1
SUBSYSTEM	SUBSYSTEM-1

The user enters one component TYPE code-word following the keyword TYPE of a COMPONENT instruction. Each code-word selects a component model, from the component library, to use in the calculations.

b. LIQ-SYSTEM-2

An example of the instructions the user enters to use the LIQ-SYSTEM-2 computational model is as follows:

Command	Data List	Terminator
SOLAR-EQUIPMENT		..
SYSTEM	TYPE = LIQ-SYSTEM-2	..
COMPONENT	TYPE = INSOLATION LATITUDE = 36 LONGITUDE = 106 TIME-ZONE = 7 TILT = 46	..
COMPONENT	TYPE = COLLECTOR AREA = 1000	..
COMPONENT	TYPE = COL-XCH-PUMP FLOW-MAX = 10000	..
COMPONENT	TYPE = COL-PUMP-CNTRL DELTA-T-1 = 6 DELTA-T-2 = 6	..
COMPONENT	TYPE = TANK HEIGHT = 20 VOLUME = 250	..
COMPONENT	TYPE = TNK-XCH-PUMP FLOW-MAX = 10000	..
COMPONENT	TYPE = AUX-CNTRL FLOW-MAX-PHC = 10000	..
END		..

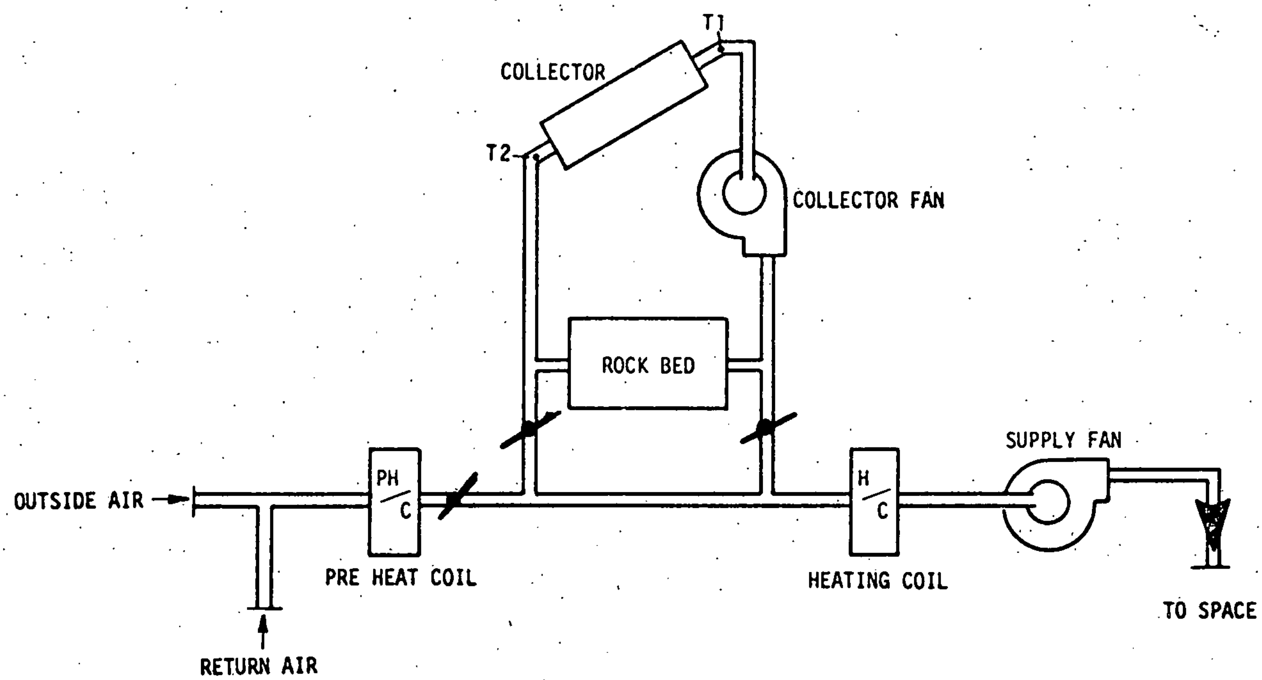
The SOLAR-EQUIPMENT and SYSTEM instructions perform the same functions as previously described in LIQ-SYSTEM-1.

Seven COMPONENT instructions are illustrated in the above example. Each COMPONENT instruction includes the keyword TYPE which is followed by a code-word. Each of these code-words refer to a specific model, or subroutine, used in the simulation of LIQ-SYSTEM-2. The default values, additional optional keywords, and preconnected subroutines used by the LIQ-SYSTEM-2 model are given in the following component models for LIQ-SYSTEM-2:

LIQ-SYSTEM-2 Components

Component TYPE Code-word	Component Model
INSOLATION	INSOLATION-1
COLLECTOR	LIQ-COLLECTOR-1
COL-XCH-PUMP	PUMP-1
COL-PUMP-CNTRL	DIF-TEMP-CNTRL-1
EXCHANGER	EXCHANGER-1
TANK	TANK-1
TNK-XCH-PUMP	PUMP-1
AUX-CNTRL	LIQ-AUX-CNTRL-1

3. Air Systems



Example Air System Schematic

Figure V-2

Figure V-2 illustrates a basic solar equipment system using air as the transport fluid. The computational model for this system includes: a flat-plate collector, a differential controller, a collector fan, a rock bed, and an auxiliary control model. A set of dampers control the amount of mixed (return and outside) air to be diverted through the rock bed. Auxiliary energy is added only when the rock bed in unable to provide sufficient heating.

The primary difference between AIR-SYSTEM-1 and AIR-SYSTEM-2 is the amount of detail in the computational models. AIR-SYSTEM-1 requires three COMPONENT instructions, while AIR-SYSTEM-2 requires five COMPONENT instructions. An example of a user input sequence for each of these air systems, and their component models are listed in this section.

a. AIR-SYSTEM-1

An example of the instructions the user enters to use the AIR-SYSTEM-1 computational model is as follows:

Command	Data List	Terminator
SOLAR-EQUIPMENT		..
SYSTEM	TYPE = AIR-SYSTEM-1	..
COMPONENT	TYPE = INSOLATION LATITUDE = 36 LONGITUDE = 106 TIME-ZONE = 7 TILT = 46	..
COMPONENT	TYPE = SUBSYSTEM AREA = 1000 FLOW-COL = 10000 VOL-BED = 729 EXT-AREA-BED = 324	..
COMPONENT	TYPE = AUX-CNTRL FLOW-MAX = 10000	..
END		..

The SOLAR-EQUIPMENT and SYSTEM instructions identify the following instructions as solar data and specify the system model, respectively. The COMPONENT instructions describe the minimum set of keywords required to specify an air based solar heating system. An END .. statement must be the last instruction of the sequence.

The TYPE keyword of each COMPONENT instruction specifies a particular code-word which refers to a specific model, or subroutine, used in the simulation of AIR-SYSTEM-1. The default values, additional optional keywords and preconnected subroutines used by the AIR-SYSTEM-1 model are given in the following component models for AIR-SYSTEM-1:

AIR-SYSTEM-1 Components

Component TYPE Code-word	Component Model
INSOLATION	INSOLATION-1
SUBSYSTEM	SUBSYSTEM-2
AUX-CNTRL	AIR-AUX-CNTRL-1

b. AIR-SYSTEM-2

An example of the instructions the user enters to use the AIR-SYSTEM-2 computational model is as follows:

Command	Data List	Terminator
SOLAR-EQUIPMENT		..
SYSTEM	TYPE = AIR-SYSTEM-2	..
COMPONENT	TYPE = INSOLATION LATITUDE = 36 LONGITUDE = 106 TIME-ZONE = 7 TILT = 46	..
COMPONENT	TYPE = COLLECTOR AREA = 1000	..
COMPONENT	TYPE = COLLECTOR-FAN FLOW-MAX = 10000	..
COMPONENT	TYPE = ROCK-BED LENGTH = 9 CROSS-SEC-AREA = 81 PERIMETER = 36	..
COMPONENT	TYPE = AUX-CNTRL FLOW-MAX = 9999	..
END		..

The SOLAR-EQUIPMENT and SYSTEMS instructions identify the following instructions as solar data and specify the system model, respectively. The COMPONENT instructions describe the minimum set of keywords required to specify an air based solar heating system. An END .. statement must be the last instruction of the sequence.

The TYPE keyword of each COMPONENT instruction specifies a particular code-word which refers to a specific model, or subroutine, used in the simulation of AIR-SYSTEM-2. The default values, additional optional keywords and preconnected subroutines used by the AIR-SYSTEM-2 model are given in the following component models for AIR-SYSTEM-2:

Component TYPE Code-word	Component Model
INSOLATION	INSOLATION-1
COLLECTOR	AIR-COLLECTOR-1
COLLECTOR-FAN	PUMP-1
COL-FAN-CNTRL	DIF-TEMP-CNTRL-2
ROCK-BED	ROCK-BED-1
AUX-CNTRL	AIR-AUX-CNTRL-1

SYSTEM

The SYSTEM instruction is used to select a configuration of solar equipment from the preprogrammed system library.

Command	Data List	Terminator
SYSTEM	TYPE = Code-word	..

SYSTEM — A BDL command word used to inform the processor that a user desires to simulate the operation of a solar heating system.

TYPE — The keyword TYPE is used to specify one of the following code-words:

System TYPE Code-words

AIR-SYSTEM-1
AIR-SYSTEM-2
LIQ-SYSTEM-1
LIQ-SYSTEM-2

Each of these code-words refers to a configuration of solar components and a set of subroutines used to model them. A sketch of the air and liquid systems used in the above models was given in the introductory examples.

COMPONENT

The COMPONENT instruction is used to identify a mathematical model for one piece of equipment (e.g. a collector, pump, tank, etc.) or of a group of equipment (e.g. a subsystem).

Command	Data List	Terminator
COMPONENT	TYPE = Code-word Keyword List	..

COMPONENT — A BDL command word used to inform the Processor that a user desires to specify the keywords and data for a solar component.

TYPE — The keyword TYPE is used to specify one of the code-words selected from Table V-5. This keyword is used to identify a generic component type.

TABLE V-5

COMPONENT TYPE Code-words

INSOLATION
SUBSYSTEM
AUX-CNTRL
COLLECTOR
TANK

COL-PUMP-CNTRL
COL-XCH-PUMP
TNK-XCH-PUMP
EXCHANGER
AUX-CNTRL

ROCK-BED
COL-FAN-CNTRL
COLLECTOR-FAN

Each of these code-words is associated with a specific component model for each preprogrammed system, as listed in the previous examples.

Keyword List

The list of keywords and their default values, minimum and maximum values associated with each keyword are given for each component model. The list of keywords that the user specifies in a COMPONENT instruction depends upon the code-word selected for its TYPE keyword.

Component Models

The following component models are available in Cal-ERDA 1.3, October, 1977.

Component Model	Comment
INSOLATION-1	initial data
SUBSYSTEM-1	liquid subsystem
LIQ-AUX-CNTRL-1	liquid auxiliary controller
SUBSYSTEM-2	air subsystem
AIR-AUX-CNTRL-1	air auxiliary controller
LIQ-COLLECTOR-1	
AIR-COLLECTOR-1	
PUMP-1	for pumps and fans
DIF-TEMP-CNTRL-1	differential temperature controllers
DIF-TEMP-CNTRL-2	differential temperature controllers
EXCHANGER-1	constant effectiveness
TANK-1	stratified
ROCK-BED-1	stratified

INSOLATION-1

The INSOLATION-1 component specifies the location and position of the collector as well as general ambient conditions.

Keyword	Default	Units
LATITUDE	none	degrees
LONGITUDE	none	degrees
TIME-ZONE	none	number
TILT	none	degrees
BUILDING-AZIMUTH	0.0	degrees
AZIMUTH-COL	180.0	degrees
GND-REFLECTANCE	0.2	number
CLEARNESS-SUMMER	1.0	number
CLEARNESS-WINTER	1.0	number

Rule: The user must enter all the above keywords which do not have defaults (none) and assign an appropriate value to each, in order to use the solar design package.

Note: For Cal-ERDA 1.3, hourly values of clear sky insolation are computed and modified by cloud cover data. SOLMET data is not being used yet.

LATITUDE — LATITUDE is the angular distance north (positive) or south * (negative) of the equator, measured in degrees expressed as a decimal fraction.

LONGITUDE — LONGITUDE is entered as a positive number for positions on the earth west of Greenwich, England up to a maximum of 180.0 degrees. For locations east of Greenwich, (e.g. Europe) the longitude is entered as a negative number up to -180.0 degrees. The angle is measured in degrees expressed as a decimal fraction.

TIME-ZONE — The international time zone number for each of the 24 time zones is specified as the number of hours from Greenwich, England. For the United States, a user enters the keyword TIME-ZONE followed by a code-word, in this case a number, selected from the following table.

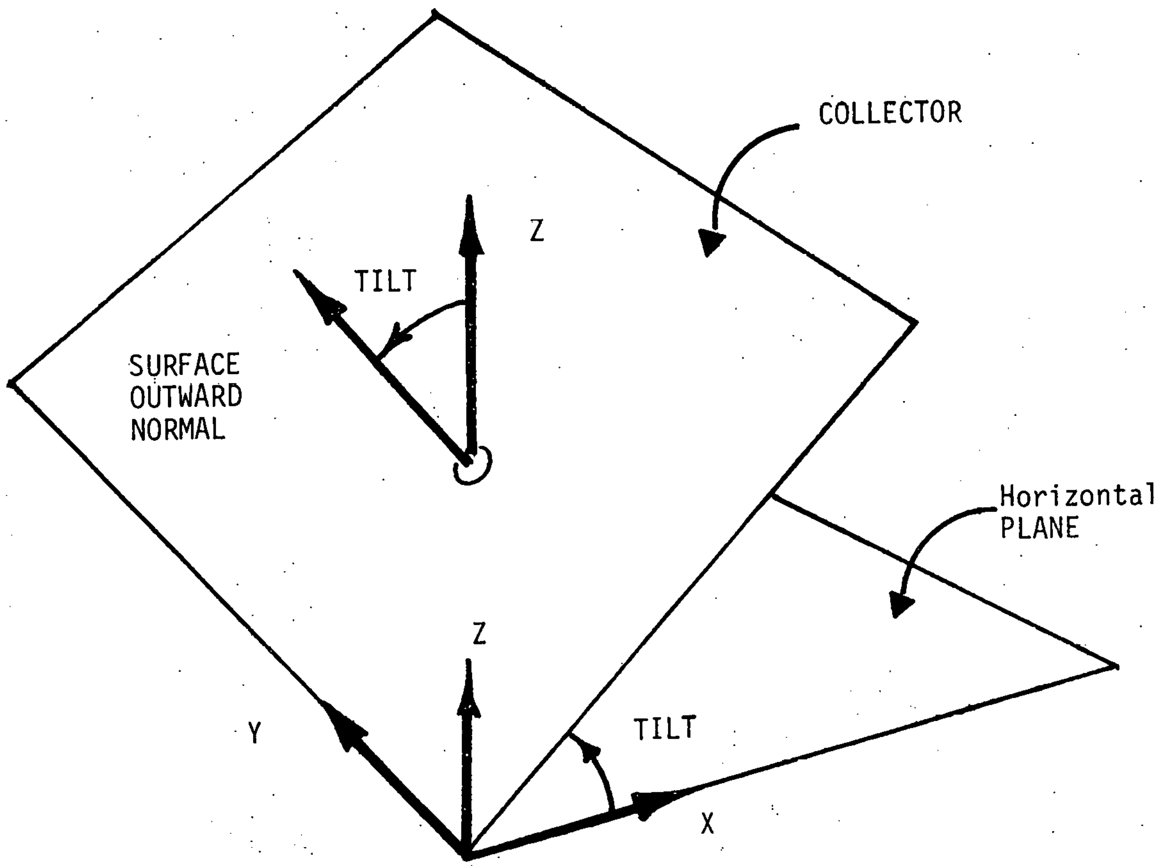
STANDARD TIME	Code-word
Atlantic	4
Eastern	5
Central	6
Mountain	7
Pacific	8
Yukon	9
Hawaii	10

The value of the TIME-ZONE keyword is entered as a negative number, from -1 to -12 for the time zones east of Greenwich, England.

TILT

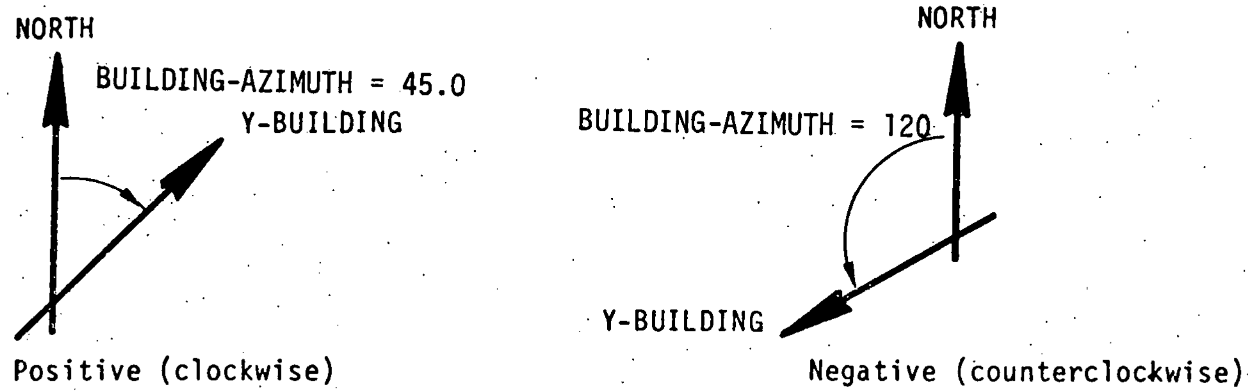
TILT is the angle measured from the positive Z axis of the building coordinate system to the surface outward normal of the collector. TILT is an angle between zero and 180 expressed as a decimal fraction in degrees. Figure V-3 illustrates the TILT angle for a surface tilted up about 45 degrees from the horizontal. A horizontal collector has TILT = 0, and a vertical collector on a wall has TILT = 90.0.

The default value is 45.0, which assumes the building is located in the northern hemisphere.



Example of the Collector TILT angle

Figure V-3



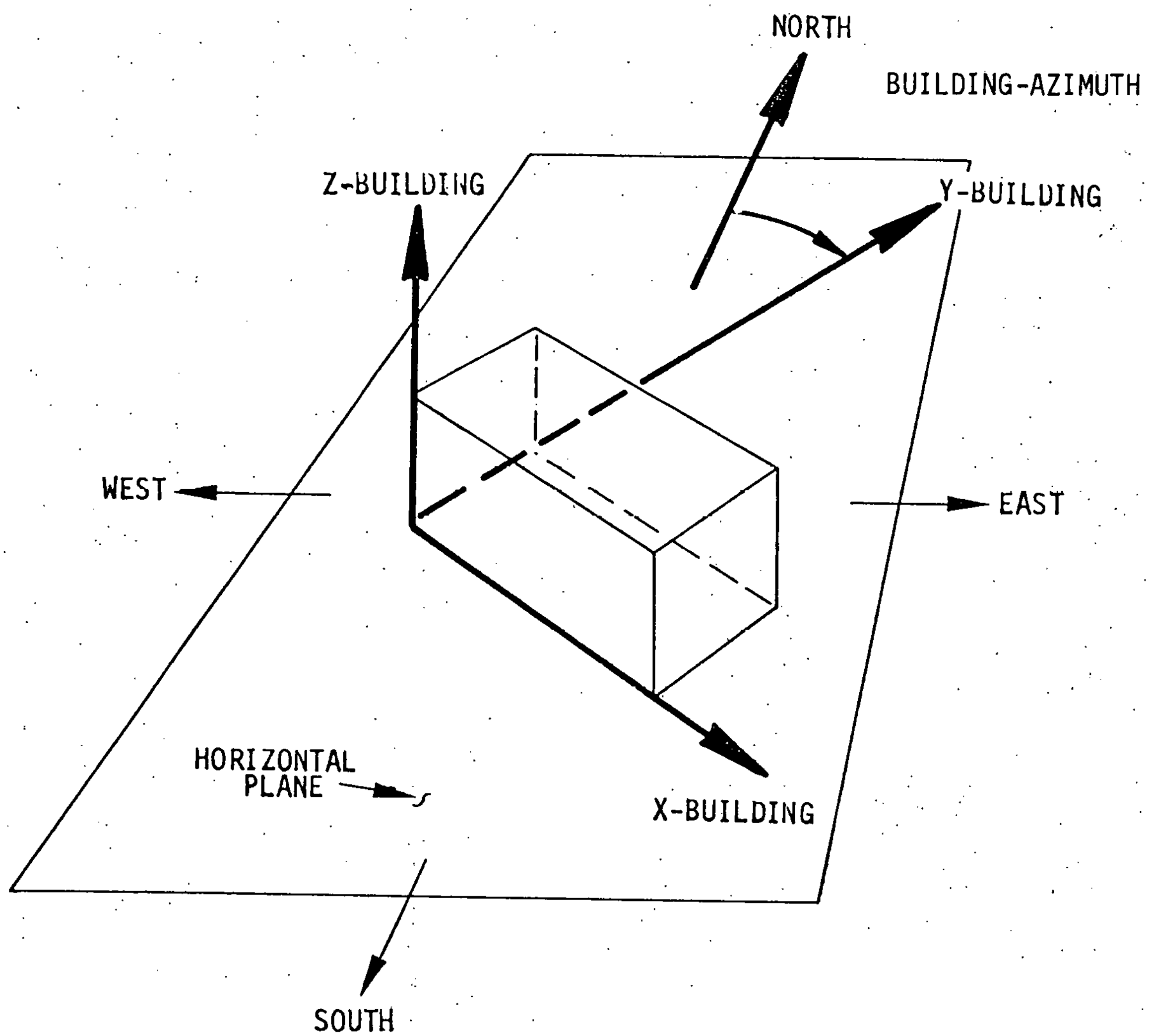
Examples of BUILDING-AZIMUTH Angle

Figure V-4

BUILDING-AZIMUTH The BUILDING-AZIMUTH angle is defined as the angle from the direction of true north to the positive Y-axis (Y-BUILDING) of the building coordinate system. The X-BUILDING Y-BUILDING plane is assumed to be a horizontal plane at the location specified for the building, and the positive Z axis (Z-BUILDING) is specified as its outward normal (i.e., up). The user should note that the building may be rotated in the clockwise (defined as positive) or in the counterclockwise (defined as negative) direction from true north by rotating the X-BUILDING Y-BUILDING plane about the Z-BUILDING axis. BAZ is specified as a decimal fraction in degrees and tenths of degrees. Minutes and seconds of arc must be converted to a decimal fraction. (e.g., 10 degrees and 15 minutes would be specified as 10.25 degrees).

Figure V-5 is an example of the BUILDING-AZIMUTH angle to illustrate how a building may be rotated (mathematically) about the Z-BUILDING axis by specifying various values for the BUILDING-AZIMUTH angle.

NOTE: The abbreviation BAZ is not allowed in the SOLAR Design Package for Cal-ERDA 1.3.

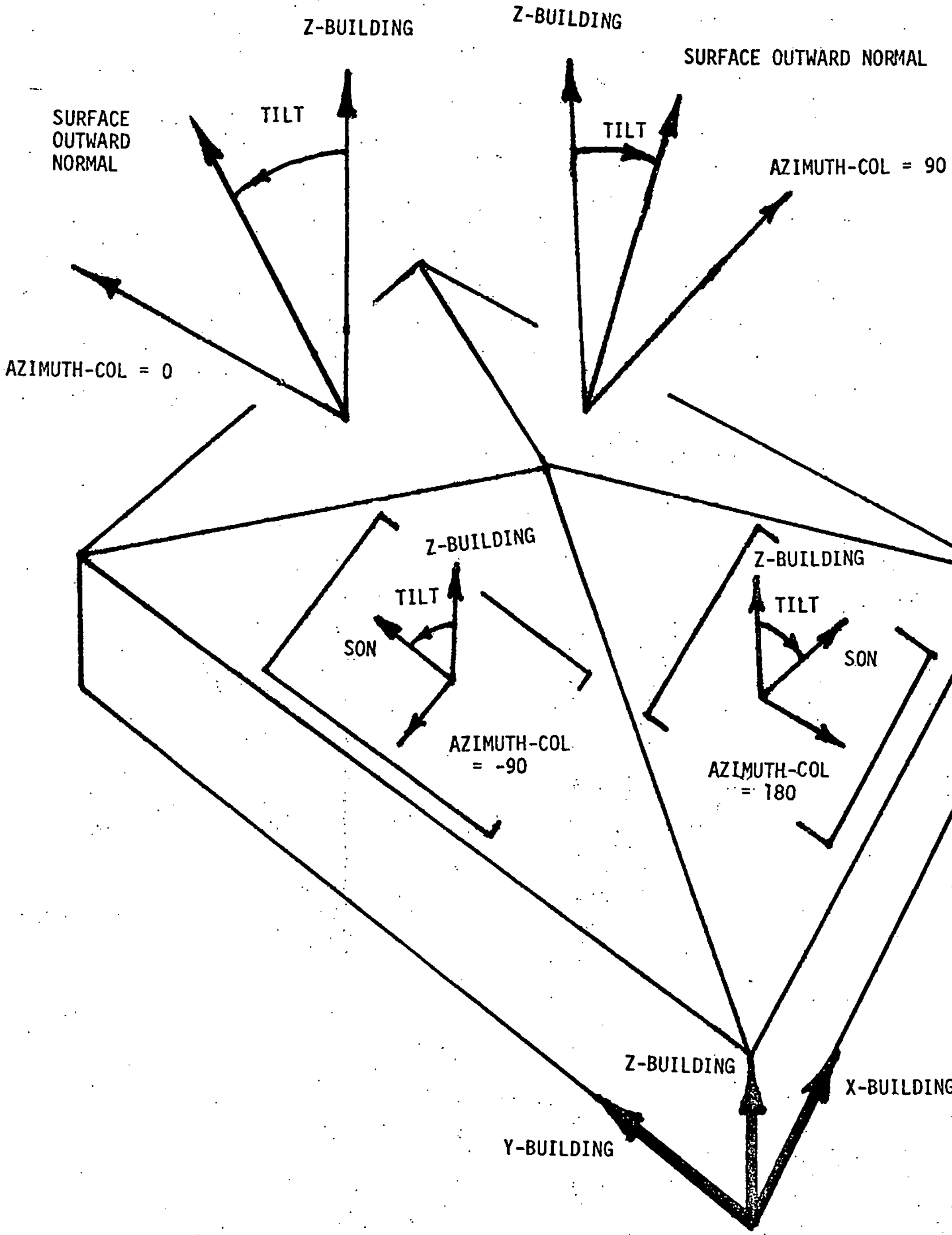


Example of BUILDING-AZIMUTH Keyword

Figure V-5

AZIMUTH-COL

The AZIMUTH-COL keyword specifies the angle from the positive Y axis (Y-BUILDING) of the building coordinate system to the horizontal projection of the surface outward normal of the collector, measured in degrees. This angle is defined as positive if measured in the clockwise direction, and as negative in the counter-clockwise direction, as viewed from above. The default value of 180.0 assumes the surface outward normal (SON) is parallel to the negative axis. Figure V-6 illustrates the definition of the AZIMUTH-COL keyword.



Example of AZIMUTH-COL Keyword

Figure V-6

GND-REFLECTANCE

The GND-REFLECTANCE keyword is used to specify a number which may be taken from the following table. (Ref. I-3)

Surface	GND-REFLECTANCE
Ocean	0.05
Bituminous Concrete	0.07
Wheat Field	0.07
Dark Soil	0.08
Green Field	0.12-0.25
Grass, Dry	0.20
Crushed Rock Surface	0.20
Concrete, Old	0.24
Concrete, Light Colored	0.30

Other numbers, besides those indicated in the table, may also be specified by the user. For example, if the ground facing the exterior wall surface were a paved asphalt parking lot, the user might specify: GND-REFLECTANCE = 0.18

CLEARNESS-SUMMER	The CLEARNESS-SUMMER keyword is used to specify a clearness number for May through October.
CLEARNESS-WINTER	The CLEARNESS-WINTER keyword is used to specify a clearness number for November through April.

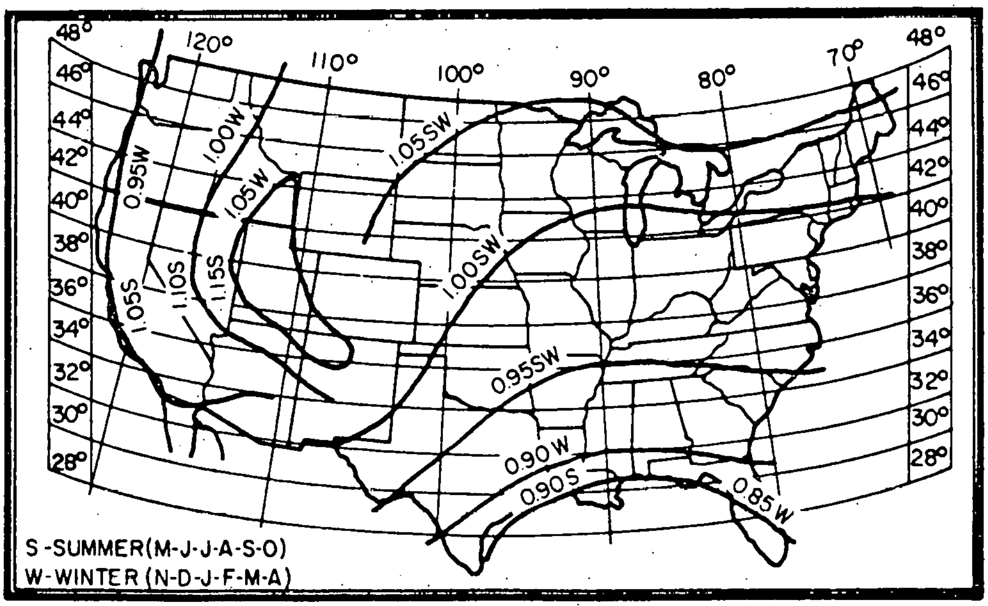


Figure 7 Clearness Numbers of Non-Industrial Atmosphere in United States

SUBSYSTEM-1

The SUBSYSTEM-1 component simulates the performance of a liquid collector, heat exchangers, tank and pumps as illustrated in Figure V-1.

Keyword	Default	Units
AREA	none	ft^2
FPRIME	0.90	number
SP-HT-COL-FLD	1.00	BTU/lb ^{o}F
TRANS-ABS-PROD	0.70	number
LOSS-COEF-COL	0.10	BTU/ft^2 hr ^{o}F
FLOW-COL-XCH	none	lb/hr
EFFECTIVENESS	0.8	number
VOL-TNK	none	ft^3
FLOW-TNK-XCH	none	lb/hr
SP-HT-TNK-FLD	1.0	BTU/lb ^{o}F
DENS-TNK-FLD	62.4	lb/ft^3
LOSS-COEF-TNK	0.1	BTU/ft^2 hr ^{o}F
TNK-HT-DIA-RATIO	1.0	number
T-TNK-INITIAL	130.0	^{o}F
T-ENV	65.0	^{o}F
T-BOIL	210.0	^{o}F

Rule: The user must specify the keywords AREA, FLOW-COL-XCH, VOL-TNK, and FLOW-TNK-XCH, in order to use this component.

AREA — The keyword AREA specifies the total active area of the collector(s) which are receiving insolation.

FPRIME — The keyword FPRIME specifies the collector geometry efficiency factor. For each particular collector FPRIME represents the ratio of (a) the heat transfer resistance from the absorber plate to the ambient air to (b) the heat transfer from the fluid to the ambient air. See reference I-8, Section 4.1 and reference I-9, Chapter 7 for derivations and equations used to model a flat plate solar collector.

SP-HT-COL-FLD — The keyword SP-HT-COL-FLD is used to specify the specific heat of the collector fluid; i.e. the ratio of the thermal capacity to that of water at 15^{o}.

TRANS-ABS-PROD	The keyword TRANS-ABS-PROD specifies the product of the transmittance of the glass cover plates multiplied by the absorptance of the absorber surface.
LOSS-COEF-COL	The LOSS-COEF-COL keyword is used to specify the overall collector heat loss coefficient (UL).
FLOW-COL-XCH	The FLOW-COL-XCH keyword is used to specify the total flow rate through the collector exchanger pump.
EFFECTIVENESS	The keyword EFFECTIVENESS specifies the effectiveness of the heat exchanger between the collector and the tank.
VOL-TNK	The VOL-TNK keyword specifies the volume of the tank.
T-ENV	The keyword T-ENV specifies the ambient temperature, or temperature of the environment surrounding the tank. If the user desires to use the outside hourly dry bulb temperatures rather than a constant volue (i.e. for a tank outdoors) specify T-ENV = 0.0. Any other value will instruct the program to compute the heat loss to a constant temperature.
T-BOIL	The keyword T-BOIL specifies the boiling temperature of the tank fluid.
FLOW-TNK-XCH	The FLOW-TNK-XCH keyword is used to specify the total flow rate through the tank exchanger pump.
SP-HT-TNK-FLD	The keyword SP-HT-TNK-FLD specifies the specific heat of the tank fluid.
DENS-TNK-FLD	The DENS-TNK-FLD keyword specifies the density of the tank fluid.
LOSS-COEF-TNK	The LOSS-COEF-TNK keyword specifies the overall heat loss coefficient for the tank.
TNK-HT-DIA-RATIO	The height to diameter ratio for a right cylindrical tank is given by the TNK-HT-DIA-RATIO keyword.
T-TNK-INITIAL	The initial tank temperature in ^{o}F is given by the keyword T-TNK-INITIAL.

LIQ-AUX-CNTRL-1

The LIQ-AUX-CNTRL-1 component simulates the performance of an auxiliary controller for the liquid solar heating system given in Figure V-1.

Keyword	Default	Units
SP-HT-COIL-FLD	1.0	BTU/lb ^{o}F
EFFECTIVENESS	0.80	number
FLOW-MAX-PHC	0.0	lb/hr
FLOW-MAX-HC	0.0	lb/hr
FLOW-MAX-RHC	0.0	lb/hr

SP-HT-COIL-FLD — The keyword SP-HT-COIL-FLD specifies the specific heat of the fluid in the heating coils.

EFFECTIVENESS — The EFFECTIVENESS keyword is used to specify a constant effectivnesss for the heating coils.

FLOW-MAX-PHC — The keyword FLOW-MAX-PHC specifies the design flow rate through the pre heat coil for the liquid system illustrated in Figure V-1.

FLOW-MAX-HC — The keyword FLOW-MAX-HC specifies the design flow rate through the heating coil for the liquid system illustrated in Figure V-1.

FLOW-MAX-RHC — The keyword FLOW-MAX-RHC specifies the design flow rate through the reheat coil for the liquid system illustrated in Figure V-1.

SUBSYSTEM-2

The SUBSYSTEM-2 component simulates the performance of an air collector, rock bed and fans as illustrated in Figure V-2.

Keyword	Default	Units
AREA	none	ft^2
FPRIME	0.90	number
SP-HT-AIR	0.245	BTU/lb °F
TRANS-ABS-PROD	0.70	number
LOSS-COEF-COL	0.20	BTU/ft^2 hr °F
FLOW-COL	none	lb/hr
DT-MIN	10.0	°F
VOL-BED	none	ft^3
EXT-AREA-BED	none	ft^2
EFF-DENS-BED	96.0	lb/ft^3
SP-HT-BED	0.21	BTU/lb °F
LOSS-COEF-BED	0.70	BTU/ft^2 hr °F
T-ENV	65.0	°F

Rule: The user must specify the keywords AREA, FLOW-COL, VOL-BED, and EXT-AREA-BED in order to use this component.

AREA — The keyword AREA specifies the total active area of the collector(s) which are receiving insolation.

FPRIME — The keyword FPRIME specifies the collector geometry efficiency factor. For each particular collector FPRIME represents the ratio of (a) the heat transfer resistance from the absorber plate to the ambient air to (b) the heat transfer resistance from the fluid to the ambient air. See reference I-8, Section 4.1 and reference I-9 Chapter 7 for derivations and equations used to model a flat plate solar collector.

SP-HT-AIR — The keyword SP-HT-AIR is used to specify the specific heat of the collector fluid; i.e. the ratio of the thermal capacity to that of water at 15°.

TRANS-ABS-PROD	The keyword TRANS-ABS-PROD specifies the product of the transmittance of the glass cover plates multiplied by the absorptance of the absorber surface.
LOSS-COEF-COL	The LOSS-COEF-COL keyword is used to specify the overall collector heat loss coefficient. (UL).
FLOW-COL	The FLOW-COL keyword is used to specify the total flow rate through the collector exchanger pump.
DT-MIN	The keyword DT-MIN specifies the minimum temperature difference (δT) in degrees Farenheit, that the outlet temperature (T), must be above the inlet temperature (T_2) for the collector.
VOL-BED	The keyword VOL-BED specifies the total interior volume of the rock bed.
EXT-AREA-BED	The keyword EXT-AREA-BED specifies the external area of the rock bed from which heat loss will occur. Normally the perimeter, around a cross sectional area perpendicular to the flow, will be multiplied by the length of the bed to obtain the value of this keyword.
EFF-DENS-BED	The EFF-DENS-BED keyword specifies the effective density of the rock bed. The value is calculated by dividing the weight of the rocks in pounds by the volume of the rock bed in cubic feet.
SP-HT-BED	The keyword SP-HT-BED specifies the specific heat of the rock bed.
LOSS-COEF-BED	The LOSS-COEF-BED keyword specifies the overall heat loss coefficient for the rock bed.
T-ENV	The T-ENV keyword specifies the ambient temperature, or temperatures of the environment surrounding the rock bed.
	If the user desires to use the outside hourly dry bulb temperatures rather than a constant value (ie.e for a tank outdoors) specify T-ENV= 0.0. Any other value will instruct the program to compute the heat loss to a constant temperature.

AIR-AUX-CNTRL-1

The AIR-AUX-CNTRL-1 component specifies the maximum flow rate for the AIR-SYSTEM-1 computational model.

Keyword	Default	Units
FLOW-MAX	none	lb/hr
SP-HT-AIR	0.245	BTU/lb ^{o}F

Rule: The user must enter the keyword FLOW-MAX and specify a value to use this component.

FLOW-MAX — The keyword FLOW-MAX specifies the maximum flow rate through the rock bed for the AIR-SYSTEM-1 computational model.

SP-HT-AIR — The specific heat of air is given by the SP-HT-AIR keyword.

LIQ-COLLECTOR-1

The LIQ-COLLECTOR-1 component models the performance of a solar collector using water as the transport fluid.

Keyword	Default	Units
AREA	none	ft^2
FPRIME	0.90	number
SP-HT-FLD	1.0	BTU/lb °F
ABSORPTANCE	0.98	number
GLAZINGS	2.0	number
EMITTANCE	0.89	number
LOSS-COEF-B-E	0.05	BTU/hr °F
TILT	45.0	degrees
K-L-PROD	0.02	number

Rule: The user is required to specify the keyword AREA and assign it a value, in order to use this component model.

AREA — The keyword AREA specifies the total active area of the collector (s) which are receiving insolation.

FPRIME — The keyword FPRIME specifies the collector geometry efficiency factor. For each particular collector FPRIME represents the ratio of (a) the heat transfer resistance from the absorber plate to the ambient air to (b) the heat transfer resistance from the fluid to the ambient air. See reference I-8, Section 4.1 and reference I-9, Chapter 7 for derivations and equations used to model a flat plate solar collector.

SP-HT-FLD — The keyword SP-HT-FLD is used to specify the specific heat of the transport fluids i.e. the ratio of the thermal capacity to that of water at 15°.

ABSORPTANCE — The ABSORPTANCE keyword specifies the ratio of absorbed energy to total incident energy at the absorber surface.

GLAZINGS — The number of glass cover plates is given by the GLAZINGS keyword.

EMITTANCE — The EMITTANCE keyword specifies the emittance of the absorber plate. The emittance of a surface is the ratio of the amount of energy emitted from a surface to the amount of energy a black body would emit.

LOSS-COEF-B-E — The LOSS-COEF-B-E keyword specifies the loss coefficient for the back and edges of the collector per unit collector area.

TILT — The TILT keyword specifies the angle from the collector to the horizontal plane. TILT, illustrated and defined in Chapter III, as the angle from the vertical to the surface outward normal is the same angle.

K-L-PROD — The keyword K-L-PROD specifies the product of the extinction coefficient (k) times the thickness (l) for a single glazing. Figure 3-23 illustrates the effect of transmittance at normal incidence as a function of extinction coefficient times thickness.

AIR-COLLECTOR-1

The AIR-COLLECTOR-1 component models the performance of a solar collector using air as the transport fluid.

Keyword	Default	Units
AREA	none	ft^2
FPRIME	0.90	number
SP-HT-FLD	0.245	BTU/lb ^{o}F
ABSORPTANCE	0.98	number
GLAZINGS	2.0	number
EMITTANCE	0.89	number
LOSS-COEF-B-E	0.05	BTU/hr ^{o}F
TILT	45.0	degrees
K-L-PROD	0.02	number

Rule — The user is required to specify the keyword AREA and assign a value to it, in order to use this component model.

AREA — The keyword AREA specifies the total active area of the collector (s) which are receiving insolation.

FPRIME — The keyword FPRIME specifies the collector geometry efficiency factor. For each particular collector, FPRIME represents the ratio of (a) the heat transfer resistance from the absorber plate to the ambient air to (b) the heat transfer resistance from the fluid to the ambient air. See reference I-8, Section 4.1 and reference I-9, Chapter 7 for derivations and equations used to model a flat plate solar collector.

SP-HT-FLD — The keyword SP-HT-FLD is used to specify the specific heat of the transport fluids i.e. the ratio of the thermal capacity to that of water at 15^{o}c.

ABSORPTANCE — The ABSORPTANCE keyword specifies the ratio of absorbed energy to total incident energy at the absorber surface.

GLAZINGS	The number of glass cover plates is given by the GLAZINGS keyword.
EMITTANCE	The EMITTANCE keyword specifies the emittance of the absorber plate. The emittance of a surface is the ratio of the amount of energy emitted from a surface to the amount of energy a black body would emit.
LOSS-COEF-B-E	The LOSS-COEF-B-E keyword specifies the heat loss coefficient for the back and edges of the collector per unit collector active area.
TILT	The TILT keyword specifies the angle from the collector to the horizontal plane. TILT was illustrated and defined in Chapter III as the angle from the vertical to the surface outward normal which is the same angle.
K-L-PROD	The keyword K-L-PROD specifies the product of the extinction coefficient (k) times the thickness (l) for a single glazing. Figure 3-23 illustrates the effect of transmittance at normal incidence as a function of extinction coefficient times thickness.

PUMP-1

The PUMP-1 component specifies the maximum flow rate for a pump or fan which moves the transport fluid.

Keyword	Default	Units
FLOW-MAX	none	lb/hr

Rule: The FLOW-MAX keyword must be specified to use this component.

FLOW-MAX The keyword FLOW-MAX specifies the maximum flow rate for a pump or fan.

DIF-TEMP-CNTRL-1

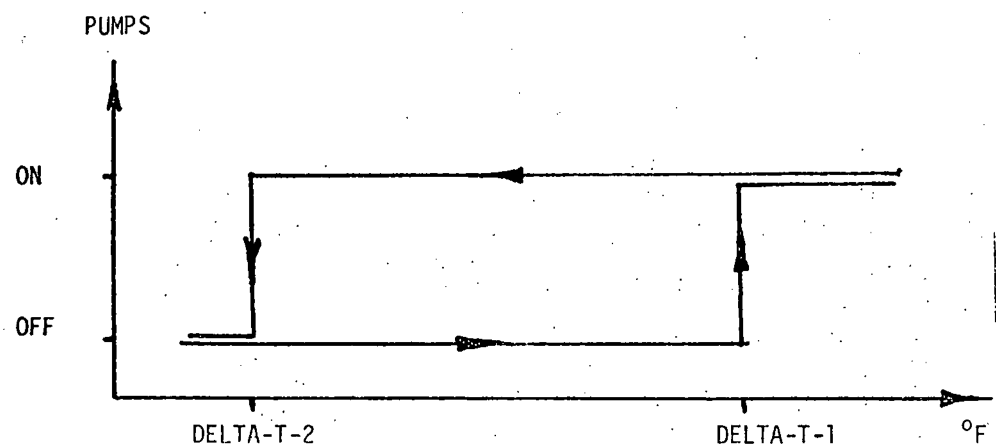
The DIF-TEMP-CNTRL-1 component specifies the settings for a differential temperature controller with hysteresis for the liquid system.

Keyword	Default	Units
DELTA-T-1	6.0	^oF
DELTA-T-2	6.0	^oF

DELTA-T-1 The DELTA-T-1 keyword specifies the (turn-on) temperature difference by which the collector outlet temperature (T. in Figure V-1) must exceed the tank temperature (T_2 in Figure V-1) before the pumps are turned on.

DELTA-T-2 The DELTA-T-2 keyword specifies the (turn-off) temperature difference by which the collector outlet temperature (T. in Figure V-1) exceeds the tank temperature (T_2 in Figure V-1) before the pumps are turned off.

Figure V-8 illustrates this controller function for DELTA-T = T. - T_2



Example of Differential Controller with Hysteresis

Figure V-8

Rule: The value specified for DELTA-T-1 must be greater than or equal to the value of DELTA-T-2.

DIF-TEMP-CNTRL-2

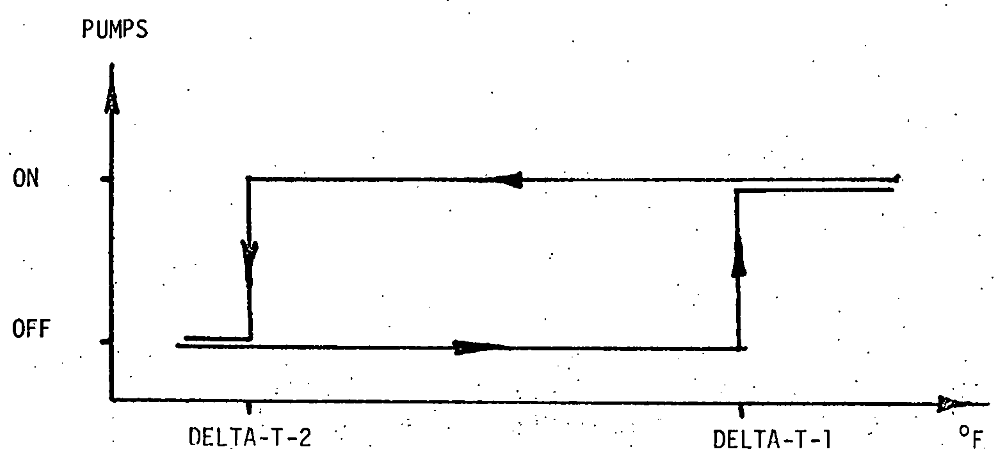
The DIF-TEMP-CNTRL-2 component specifies the settings for a differential temperature controller with hysteresis for the air system.

Keyword	Default	Units
DELTA-T-1	6.0	^{o}F
DELTA-T-2	6.0	^{o}F

DELTA-T-1 The DELTA-T-1 keyword specifies the (turn-on) temperature difference by which the collector outlet temperature (T. in Figure V-2) must exceed collector inlet temperature (T_2 in Figure V-2) before the fan is turned on.

DELTA-T-2 The DELTA-T-2 keyword specifies the (turn-off) temperature difference by which the collector outlet temperature (T. in Figure V-2) exceeds the collector inlet temperature (T_2 in Figure V-2) before the fan is turned off.

Figure V-9 illustrates this controller function for DELTA-T = T. - T_2.



Example of Differential Controller with Hysteresis
Figure V-9

Rule: The value specified for DELTA-T-1 must be greater than or equal to the value of DELTA-T-2.

EXCHANGER-1

The EXCHANGER-1 component specifies the parameters for a constant effectiveness heat exchanger.

Keyword	Default	Units
EFFECTIVENESS	0.8	number
SP-HT-HOT-FLD	1.0	BTU/lb °F
SP-HT-COLD-FLD	1.0	BTU/lb °F

EFFECTIVENESS — The EFFECTIVENESS keyword is used to specify a constant effectiveness for the heat exchanger.

SP-HT-HOT-FLD — The keyword SP-HT-HOT-FLD specifies the specific heat of the fluid on the hotter side of the heat exchanger.

SP-HT-COLD-FLD — The keyword SP-HT-COLD-FLD specifies the specific heat of the fluid on the colder side of the heat exchanger.

TANK-1

The TANK-1 component models the thermal performance of a heat storage tank where the fluid does not change phase but is allowed to stratify into thermal layers.

Keyword	Default	Units
VOLUME	none	ft^3
HEIGHT	none	ft
SP-HT-FLD	1.0	BTU/lb °F
DENS-FLD	62.4	lb/ft^3
LOSS-COEF	0.7	BTU/ft^2 hr °F
HEATER-CAP	0.0	BTU/hr
T-SET	32.0	°F
T-ENV	65.0	°F
T-INIT	130.0	°F

Rule: The user must specify the keywords VOLUME and HEIGHT in order to use this component.

VOLUME — The keyword VOLUME specifies the volume for a vertical right cylindrical tank.

HEIGHT — The HEIGHT keyword specifies the height for a vertical right cylindrical tank.

SP-HT-FLD — The SP-HT-FLD keyword specifies the specific heat for the fluid within the tank.

DENS-FLD — The DENS-FLD keyword is used to specify the density of the fluid within the tank.

LOSS-COEF — The LOSS-COEF keyword specifies a constant overall heat loss coefficient (u) between the fluid in the tank and the surrounding environment.

HEATER-CAP — The HEATER-CAP keyword specifies the maximum rate that energy may be added to the tank fluid by the heating element.

T-SET — The T-SET keyword specifies the temperature at which the auxiliary heater is set to turn on. In order to prevent freezing of water, the default is set to 0.0 ^{o}F; however, the user may also be using the tank for preheating or heating service hot water and may select another temperature.

T-ENV — The keyword T-ENV specifies the ambient temperature, or the temperature of the environment surrounding the tank. If the user desires to use the outside hourly dry bulb temperatures rather than a constant value (i.e. for a tank outdoors) specify T-ENV = 0.0. Any other value will instruct the program to compute the heat loss due to a constant temperature.

T-INIT — The keyword T-INIT specifies the tank temperature for the hour which precedes the first hour of the simulation.

ROCK-BED-1

The ROCK-BED-1 component models the thermal performance of a heat storage rock bed that is allowed to stratify into thermal layers.

Keyword	Default	Units
CROSS-SEC-AREA	none	ft^2
PERIMETER	none	ft
LENGTH	none	ft
SP-HT-AIR	0.245	BTU/lb ^oF
SP-HT-BED	0.210	BTU/lb ^oF
EFF-DENS-BED	96.0	lb/ft^3
LOSS-COEF	0.70	BTU/ft^2 hr ^oF
CONDUCTIVITY	0.0	BTU ft/hr ft^2 ^oF
T-ENV	65.0	^oF

Rule: The user must specify the keywords CROSS-SEC-AREA, PERIMETER, and LENGTH and assign values to them in order to use this component.

CROSS-SEC-AREA — The keyword CROSS-SEC-AREA specifies the internal cross sectional area through which air will flow in the rock bed. If a non uniform cross section exists along the axial direction, an "average" cross sectional area should be given.

PERIMETER — The PERIMETER keyword specifies the perimeter length of the cross sectional area.

LENGTH — The LENGTH keyword specifies the length of the rock bed in the direction of the air flow.

SP-HT-AIR — The SP-HT-AIR keyword specifies the specific heat of the air passing through the rock bed.

SP-HT-BED	The SP-HT-BED keyword specifies the specific heat of the rock in the bed.
EFF-DENS-BED	The EFF-DENS-BED keyword specifies the effective density of the rock bed. The value is calculated by dividing the weight of the rocks in pounds by the volume of the rock bed in cubic feet.
LOSS-COEF	The LOSS-COEF keyword specifies the overall heat loss coefficient for the rock bed.
CONDUCTIVITY	The CONDUCTIVITY keyword specifies the effective thermal conductivity in the direction of air flow through the rock bed.
T-ENV	The keyword T-ENV specifies the ambient temperature, or the temperature of the environment surrounding the rock bed. If the user desires to use the outside hourly dry bulb temperatures rather than a constant value (i.e. for a rock bed outdoors) specify T-ENV = 0.0. Any other value will instruct the program to compute the heat loss due to a constant temperature.

_______________ PLANT-EQUIPMENT
u-name EQUIPMENT
PE

Keyword or *Abbreviation*		User Input	Notes	Default	Range	
					Min.	Max.
TYPE		= ______________	code-word			
SIZE		= ______________	10^6Btu/hr	0.0	0.0	10000.0
INSTALLED-NUMBER	IN	= ______________	number	0.0	1.0	100.0
MAX-NUMBER-AVAIL	MNA	= ______________	number	0.0	1.0	100.0

_______________ PART-LOAD-RATIO
u-name PLR

Keyword or *Abbreviation*		User Input	Notes	Default	Range	
					Min.	Max.
TYPE		= ______________	code-word			
MIN-RATIO	MIN	= ______________	number	0.0	0.0	9.999
MAX-RATIO	MAX	= ______________	number	0.0	0.0	9.999
OPTIMUM-RATIO	OPT	= ______________	number	0.0	0.0	9.999
ELECTRIC-INPUT-RATIO	EIR	= ______________	number	0.0	0.0	9.999

_______________ PERFORMANCE
u-name PC

Keyword or *Abbreviation*		User Input	Notes	Default	Range	
					Min.	Max.
COEFFICIENT	C	= ______________	code-word			
CONSTANT-TERM	CT	= ______________	number	0.0	-99.9	999.9
LINEAR-TERM	LT	= ______________	number	0.0	-99.9	999.9
QUADRATIC-TERM	QT	= ______________	number	0.0	-99.9	999.9

EQUIPMENT-ASSIGNMENT
ASSIGNMENT
EA

u-name

Keyword or *Abbreviation*		User Input	Notes	Default	Range	
					Min.	Max.
TYPE	TY	= ______	code-word			
MAX-LOAD	ML	= ______	10^6Btu/hr	0.0	0.0	10000.0
SIZE 1	S1	= ______	u-name			
ASSIGN 1	A1	= ______	number	0.0	0.0	100.0
SIZE 2	S2	= ______	u-name			
ASSIGN 2	A2	= ______	number	0.0	0.0	100.0
SIZE 3	S3	= ______	u-name			
ASSIGN 3	A3	= ______	number	0.0	0.0	100.0
SIZE 4	S4	= ______	u-name			
ASSIGN 4	A4	= ______	number	0.0	0.0	100.0
SIZE 5	S5	= ______	u-name			
ASSIGN 5	A5	= ______	number	0.0	0.0	100.0
SIZE 6	S6	= ______	u-name			
ASSIGN 6	A6	= ______	number	0.0	0.0	100.0

PLANT-CONSTANTS
PC

____
u-name

Keyword or Abbreviation	User Input	Notes	Default	Range Min.	Range Max.
CPTYPE		code-word	1.0	1.0	2.0
HSTEAM		Btu/lb	1199.578	0.0	10^6
TSATUR		°F	369.635	212.0	10000.0
TLEAVE		°F	550.0	212.0	10^6
RFLASH			.071	0.0	10^5
PELCL			0.018	0.0	1.0
PELHT			0.006	0.0	1.0
SRATB			17.0	0.0	10^6
HFUELB		Btu/lb	20000.0	0.0	10^6
TWMAKE		°F	55.0	32.0	212.0
RHFLASH			0.50	0.0	10^6
PSTEAM		PSIG	150.0	-15.0	10^8
SR1A		10^6Btu/hr	18.7	0.0	10^6
SR2A		10^6Btu/hr	12.2	0.0	10^6
TCOOL		°F	44.0	32.0	212.0
DTCOOL		°F	15.0	0.0	10^6
RAVRHDB			0.95	0.0	1.0
TTOWR		°F	60.0	32.0	212.0
TCW		°F	110.0	32.0	212.0
PELTWR			0.013	0.0	1.0
RWCA		gpm/ton	3.0	0.0	10^6
RWCC		gpm/ton	3.0	0.0	10^6
RWCDB		gpm/ton	3.0	0.0	10^6

u-name

PLANT-CONSTANTS (continued)
PC

Keyword or *Abbreviation*	User Input	Notes	Default	Range	
				Min.	Max.
RMXKWD		cfm/kW	5.0	0.0	10^6
PSTMTUR		PSIG	150.0	-15.0	10^8
TSTMTUR		°F	494.635	212.0	10^8
PEXSTUR		PSIG	-12.7	-15.0	10^8
RPMNOM		rpm	10000.0	0.0	10^6
RWSTUR			0.97	0.0	1.0
TOTUEF			0.30	0.0	1.0
RMXKWG		cfm/kW	40.0	0.0	10^6
TMINH		°F	100.0	32.0	212.0
TMINC		°F	180.0	32.0	212.0

Keywords for LIQ-COLLECTOR-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
AREA		Ft^2	NONE	1.0	100,000
FPRIME		number	0.9	0.1	1.0
SP-HT-FLD		BTU/LB°F	1.0	0.01	10.0
ABSORPTANCE		number	0.98	0.0	1.0
GLAZINGS		number	2.0	1.0	3.0
EMITTANCE		number	0.89	0.01	1.0
LOSS-COEF-B-E		BTU/HR°F	0.05	0.0	10.0
TILT		Degrees	45.0	0.0	90.0
K-L-PROD		number	0.02	0.0	1.0

Keywords for AIR-COLLECTOR-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
AREA		Ft^2	NONE	1.0	10,000
FPRIME		number	0.9	0.1	1.0
SP-HT-FLD		BTU/LB °F	0.245	0.01	10.0
ABSORPTANCE		number	0.98	0.1	1.0
GLAZINGS		number	2.0	1.0	3.0
EMITTANCE		number	0.89	0.01	1.0
LOSS-COEF-B-E		BTU/HR °F	0.05	0.0	10.0
TILT		Degrees	45.0	0.0	90.0
K-L-PROD		number	0.02	0.0	1.0

Keywords for INSOLATION-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
LATITUDE		Degrees	NONE	0.0	90.0
LONGITUDE		Degrees	NONE	-180.0	180.0
TIME-ZONE		code-number	NONE	-12.0	12.0
TILT		Degrees	NONE	0.0	90.0
AZIMUTH-COL		Degrees	180.0	-360.0	360.0
BUILDING-AZIMUTH		Degrees	0.0	-360.0	360.0
GND-REFLECTANCE		number	0.2	0.0	1.0
CLEARNESS-SUMMER		number	1.0	0.5	1.2
CLEARNESS-WINTER		number	1.0	0.5	1.2

Keywords for AIR-AUX-CNTRL-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
FLOW-MAX		LB/HR	NONE	1.0	100,000.
SP-HT-AIR		BTU/LB °F	0.245	0.2	0.3

Keywords for EXCHANGER-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
EFFECTIVENESS		number	0.8	0.01	1.0
SP-HT-HOT-FLD		BTU/LB °F	1.0	0.01	10.0
SP-HT-COLD-FLD		BTU/LB °F	1.0	0.01	10.0

Keywords for LIQ-AUX-CNTRL-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
SP-HT-COIL-FLD		BTU/LB °F	1.0	0.01	10.0
EFFECTIVENESS		number	0.8	0.01	1.0
FLOW-MAX-PHC		LB/HR	0.0	0.0	100,000.
FLOW-MAX-HC		LB/HR	0.0	0.0	100,000.
FLOW-MAX-RHC		LB/HR	0.0	0.0	100,000.

Keywords for PUMP-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
FLOW-MAX		LB/HR	NONE	1.0	100,000

Keywords for ROCK-BED

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
SP-HT-AIR		BTU/LB°F	0.245	0.2	0.3
LENGTH		Ft	NONE	1.0	100.0
CROSS-SEC-AREA		Ft^2	NONE	1.0	1000.0
PERIMETER		Ft	NONE	1.0	1000.0
SP-HT-BED		BTU/LB °F	0.21	0.01	10.0
EFF-DENS-BED		LB/FT^3	96.0	1.0	1000.0
LOSS-COEF		BTU/HR FT^2 °F	0.0	0.0	100.0
CONDUCTIVITY		BTU/HR FT °F	0.0	0.0	100.0
T-ENV		°F	65.0	0.0	100.0

Keywords for SUBSYSTEM-1

Keyword	User Input	Notes	Default	Range	
				Min.	Max.
AREA		Ft^2	NONE	1.0	10,000.
FLOW-COL-XCH		LB/HR	NONE	1.0	100,000.
SP-HT-COL-FLD		BTU/LB°F	1.0	0.01	10.0
FLOW-TNK-XCH		LB/HR	NONE	1.0	100,000.
SP-HT-TNK-FLD		BTU/LB°F	1.0	0.01	10.0
FPRIME		number	0.9	0.1	1.0
TRANS-ABS-PROD		number	0.7	0.1	1.0
LOSS-COEF-COL		BTU/HR-Ft^2 °F	0.65	0.0001	10.0
T-BOIL		°F	210.0	0.0	300.0
EFFECTIVENESS		number	0.8	0.01	1.0
VOL-TNK		Ft^3	none	1.0	10,000.
DENS-TNK-FLD		LB/Ft^3	62.4	1.0	100.0

Keywords for SUBSYSTEM-1

(continued)

Keyword	*Abbreviation*	User Input	Notes	Default	Range Min.	Range Max.
LOSS-COEF-TNK			BTU/HR-Ft^2 °F	0.1	0.0	10.0
TNK-HT-DIA-RATIO			number	3.0	0.1	10.0
T-TNK-INITIAL			°F	65.0	0.0	300.0
T-ENV			°F	65.0	0.0	100.0
DT-MIN			°F	6.0	0.0	100.0

Keywords for SUBSYSTEM-2

Keyword	User Input	Notes	Default	Range Min.	Range Max.
AREA		Ft^2	NONE	1.0	10,000.
FLOW-COL		LB/HR	NONE	1.0	100,000.
SP-HT-AIR		BTU/LB °F	0.245	0.2	0.3
FPRIME		number	0.9	0.1	1.0
TRANS-ABS-PROD		number	0.7	0.1	1.0
LOSS-COEF-COL		BTU/HR Ft^2 °F	0.55	0.0001	10.0
DT-MIN		°F	25.0	0.0	100.0
VOL-BED		Ft^3	NONE	1.0	10,000.
EFF-DENS-BED		LB/FT^3	96.0	1.0	1000.
SP-HT-BED		BTU/LB°F	0.21	0.0001	10.0
LOSS-COEF-BED		BTU/HR FT^2 °F	0.15	0.0	10.0
EXT-AREA-BED		Ft^2	NONE	1.0	10,000.
T-ENV		°F	65.0	0.0	100.0

Keywords for TANK-1

Keyword	User Input	Notes	Default	Range Min.	Range Max.
VOLUME		Ft^3	NONE	1.0	10,000.
HEIGHT		Ft	NONE	1.0	100.0
SP-HT-FLD		BTU/LB°F	1.0	0.0001	10.0
DENS-FLD		LB/Ft^3	62.4	1.0	1000.
LOSS-COEF		BTU/HR FT^2°F	.1	0.0	10.0
HEATER-CAP		BTU/HR	0.0	0.0	10,000.
T-SET		°F	32.0	0.0	100.0
T-ENV		°F	65.0	0.0	100.0
T-INIT		°F	65.0	0.0	300.0

Keywords for DIF-TEMP-CNTRL-1

Keyword	User Input	Notes	Default	Range Min.	Range Max.
DELTA-T-1		°F	6.0	-100.0	100.0
DELTA-T-2		°F	6.0	-100.0	100.0

Keywords for DIF-TEMP-CNTRL-2

Keyword	User Input	Notes	Default	Range Min.	Range Max.
DELTA-T-1		°F	25.0	-100.0	100.0
DELTA-T-2		°F	25.0	-100.0	100.0

VI. ECONOMICS PROGRAM

† In PLANT Program for Cal-ERDA 1.3

* In Preparation

A. INTRODUCTION

1. Background

The economic evaluation methodology used by Cal-ERDA is based upon the guidelines described in ERDA Manual ERDA-76/130 "Life Cycle Costing Emphasizing Energy Conservation" (reference I-4). These guidelines were developed in response to rapidly rising energy costs and the consequent need to examine existing and proposed ERDA buildings with a view to possible modifications that would be both cost-effective and energy conserving. By the life-cycle costing method, a few numbers called "investment statistics," are calculated. These measure the cost effectiveness or "profitability" of each project as compared to a reference or "baseline" case defined by the user. Competing alternatives can then be ranked on the basis of these statistics to assess which choice will be the most cost-effective.

In Cal-ERDA 1.3 (10/77) economic calculations related to plant equipment are done by the PLANT program rather than the ECONOMICS program. However the user input instructions required for these calculations are discussed in this chapter (rather than in Chapter V) since these calculations will be incorporated into the ECONOMICS program in future versions and because their concern is with cost analysis.

The PLANT program presently calculates the life cycle costs for (1) purchasing, installing, and maintaining plant equipment and for (2) the fuel and electricity used by the facility. The user input data required for these calculations are entered using four BDL instructions (EQUIPMENT-COST, ENERGY-COST, LIFE-CYCLE-COSTS and PLANT-RATES). Note that even though these instructions and associated keywords are described in detail in Section B of this chapter, the keyword value relationships associated with these instructions must be entered with the PLANT program input data.

The costs calculated by the PLANT program are passed to the ECONOMICS program. The user then enters additional cost data necessary to perform trade-off studies, and the ECONOMICS program calculates the total life-cycle cost of alternative programs. In addition to calculating total cost, the ECONOMICS program also computes the following investment statistics which serve as a guide to the cost effectiveness of an energy conserving alternative.

- cost savings
- savings to investment ratio (SIR)
- fuel savings
- fuel savings to investment ratio
- discounted payback period

These statistics are calculated by comparing costs and fuel use for the project under consideration with those entered by the user for a baseline case (see BASELINE instruction Section B of this chapter).

2. Proposed Revisions

A number of revisions designed to bring the ECONOMICS program into better conformance with reference I-4 are currently under consideration.

- The current method of calculating discounted payback period does not correspond to the method used in reference I-4 in that the present value (PV) of savings are assumed to be uniform for each year of the project life (i.e. PV of yearly savings = PV of total savings/project life). This of course is true only when differential escalation equals discount rate. The calculation will be revised to account for year to year variation in the PV of savings.

- The program does not currently account for the residual value of equipment in the life cycle costing analysis.

- In Cal-ERDA 1.3, differential in operating cost (maintenance, consumables and overhauls) increases (or decreases) investment while reference I-4 uses this value to decrease (or increase) savings. For this reason the value of SIR calculated by Cal-ERDA will be exactly the same as that calculated by the method described in reference I-4 only when the differential operating cost is zero. Otherwise the SIR will be somewhat higher or lower depending on the magnitude and direction of this cost. This could be misleading (particularly when comparing SIR's calculated by the different methods.)

In addition a number of revisions that will improve the accuracy and increase the usefulness of the ECONOMICS program life cycle costing analysis are contemplated. These improvements are planned for incorporation into the program on or before the scheduled date for Cal-ERDA 2.0 (10/78).

- The existing ECONOMICS program uses a present value life-cycle cost analysis methodology based on ERDA 76/130 and as a result is most useful to government facilities. New economic routines that include such factors as taxes (federal, state and local) mortgage payments, insurance and effect on operating income will be added to meet the needs of the private sector.

- The existing program allows only one method of calculating electrical demand charges. Since the methods actually used to determine these charges are numerous and varied the program will be revised to permit simulation of alternate methods.

- Many utilities are charging differently for electricity used in prime time and in off-peak hours. The ability to simulate this charging scheme will be added.

3. Economics Description Language (EDL)

A general discussion of Building Design Language (BDL) including rules, syntax, notation, etc., can be found in Chapter II. The economics description language (EDL) is that portion of BDL that is solely applicable to the ECONOMICS program. Section B of this chapter contains a description of each EDL instruction (COMPONENT-COST, COMPONENT-RATES and BASELINE). Section B also contains a description of those plant description language (PDL) instructions whose concern is with costs and economics (EQUIPMENT-COST, ENERGY-COST and LIFE-CYCLE-COSTS and PLANT-RATES). As previously indicated these latter instructions are entered with the PLANT program data input.

4. Instruction Sequence

In general, the instructions for the ECONOMICS program may be arranged in any order the user desires. There are however some rules that must be followed. These are:

a. To begin the data entry to the ECONOMICS program the user must first enter the program control instruction

* INPUT ECONOMICS

b. The user then enters any EDL instructions he may have in any order he wishes. (Note the program will run even if no EDL instructions are entered).

c. The user must enter the program control instruction

END

to indicate that data entry is complete.

d. The program control instruction

* COMPUTE ECONOMICS

must be entered next to instruct the processor to perform the calculations.

e. Since the ECONOMICS program is the final module of the LSPE program sequence, the last instruction must be

* STOP.

* These instructions are not required for Cal-ERDA 1.3 (10/77) and can be neglected. See STATUS (10/77) Page xxxi

SECTION B

The BDL input instructions for the ECONOMICS program and those BDL input instructions for the PLANT program that are related to life cycle cost analysis are described in this section.

1. EQUIPMENT-COST

The function of the EQUIPMENT-COST instruction is to specify cost data for plant equipment (first cost, installation cost and the cost of consumables, maintenance and overhauls). Plant equipment is here defined as the primary energy conversion equipment simulated by the PLANT program (i.e. boilers, chillers, diesel generators, gas turbines, etc.).

A separate instruction is required for each type and size of equipment for which the user wishes to assign costs. If the user omits this instruction for any specified plant equipment item, the program will use default values. Table VI-B1 lists default values for one specific size of each type of plant equipment simulated by the PLANT program. The program will assign cost data to the actually specified size of each type of equipment using the cost data referenced in this table and the following scaling law:

$$C\text{-}P = C\text{-}P_{(ref)} \, X[SIZE/SIZE_{(ref)}]^{P}$$ where:

$C\text{-}P$ = one of the eight cost parameters listed in Table VI-B1 (excluding SIZE and INSTALLATION)

$C\text{-}P_{(ref)}$ = corresponding reference default value (see Table VI-B1)

SIZE = actual equipment size (user entered- see PLANT program, PLANT-EQUIPMENT instruction)

$SIZE_{(ref)}$ = reference equipment size (see Table VI-B1)

P = 0.67 for unit and maintenance costs

= 0.4 for consumables cost

= 0.2 for maintenance hours and overhaul intervals

= 0.1 for equipment life

TABLE VI-B1 EQUIPMENT COST REFERENCE DEFAULT VALUES

Equipment TYPE Code-word	SIZE $\frac{10^6 BTU}{HR}$	Unit COST (K$)	INSTALLATION cost factor	CONSUMABLES $\frac{\$}{HR}$	MAINTENANCE $\frac{HRS}{YR}$	Operating LIFE (HRS)	MINOR-OVHL- INVL Interval (HRS)	MINOR-OVHL- COST each ($)	MAJOR-OVHL- INVL Interval (HRS)	MAJOR-OVHL- COST each ($)
GTURB	8.50	600.0	1.20	1.20	380.0	60000.	0.	0.	30000.	12000.
DIESL	8.50	750.0	1.20	1.50	480.0	220000.	24000.	9000.	50000.	21000.
STMB	40.00	40.0	1.40	0.00	900.0	220000.	10000.	2000.	50000.	25000.
ABSI	12.00	110.0	1.20	0.00	400.0	100000.	20000.	8000.	50000.	15000.
ABS2	12.00	160.0	1.20	0.00	400.0	100000.	20000.	8000.	50000.	15000.
ABS2E	12.00	170.0	1.20	0.00	400.0	100000.	20000.	8000.	50000.	15000.
COMPH	12.00	120.0	1.20	0.00	500.0	100000.	20000.	5000.	50000.	15000.
COMPC	12.00	150.0	1.20	0.00	500.0	100000.	20000.	5000.	50000.	15000.
COMPR	12.00	100.0	1.20	0.00	500.0	100000.	20000.	5000.	50000.	15000.
DBUN	12.00	200.0	1.30	0.00	500.0	100000.	20000.	5000.	50000.	15000.
CTOWR	12.00	60.0	1.30	0.00	80.0	100000.	5000.	5000.	50000.	15000.
CTOWC	12.00	90.0	1.20	0.00	40.0	220000.	10000.	5000.	50000.	15000.
STURB	8.50	450.0	1.30	1.00	300.0	220000.	0.	0.	40000.	20000.
HTANK	10.00	10.0	1.20	0.00	16.0	250000.	0.	0.	0.	0.
CTANK	10.00	25.0	1.20	0.00	16.0	250000.	0.	0.	0.	0.

The user is forwarned to examine Table VI-B1 carefully before accepting default equipment costs since there can be considerable variation in cost within a generic type based 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 EQUIPMENT-COST instruction if used, must be entered with the PLANT program input data rather than with the ECONOMICS program input data (see Section A for discussion). Entry immediately following the related PLANT-EQUIPMENT instruction is suggested.

The User Worksheet for the EQUIPMENT-COST instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords. Note that the program will use default values as defined above if data entry for any keyword is omitted. The program will also print a warning message if the value of an entry is outside the indicated range unless instructed not to do so (see MESSAGE instruction - Chapter II).

______________ = EQUIPMENT-COST

u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range Min.	Range Max.
FOR	=	______	u-named	N/A	N/A	N/A
COST	=	______	$/1000	Note 3	0	10^5
INSTALLATION	=	______	number	1.0	1.0	100
CONSUMABLES	=	______	$/hr	Note 3	0.0	10^4
MAINTENANCE	=	______	hrs/yr	Note 3	0.0	8760
EQUIPMENT-LIFE	=	______	hrs	Note 3	0.0	10^6
MINOR-OVHL-INVL	=	______	hrs	Note 3	0.0	10^6
MINOR-OVHL-COST	=	______	$	Note 3	0.0	10^7
MAJOR-OVHL-INVL	=	______	hrs	Note 3	0.0	10^6
MAJOR-OVHL-COST	=	______	$	Note 3	0.0	10^7

See NOTES at end of this section

EQUIPMENT-COST The BDL command-word EQUIPMENT-COST informs the BDL processor that the data group to follow will define the costs associated with a particular plant equipment item. The user may, for his convenience, enter a unique user defined name (u-name) ahead of the command-word to identify the data group, but this is not required.

FOR The user input for the keyword FOR is the u-name, from the appropriate PLANT-EQUIPMENT instruction, of the particular item of equipment to which the costs defined by the keyword-value relationships that follow are to be attached.

COST The user input for the keyword COST is the first cost (in thousands of dollars) for one unit of the type and size referenced above, not including installation costs.

INSTALLATION The user input for the keyword INSTALLATION is the multiplier on equipment COST to estimate first cost per unit installed. For example if installation cost is 20% of first cost, then INSTALLATION = 1.2.

CONSUMABLES The user input for the keyword CONSUMABLES is 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 The user input for the keyword MAINTENANCE is the hours per year per unit of required on-site maintenance. The program will use this value along with the user input (or default) value for labor cost (see keyword LABOR in the LIFE-CYCLE-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 The user input for the keyword EQUIPMENT-LIFE is the expected number of total operating hours before the reference equipment must be replaced.

MINOR-OVHL-INVL — The user input for the keyword MINOR-OVHL-INVL is the expected number of operating hours between minor overhauls for the referenced item of equipment.

MINOR-OVHL-COST — The user input for the keyword MINOR-OVHL-COST is the cost (in dollars per unit) for a minor overhaul of the referenced item of equipment.

MAJOR-OVHL-INVL — The user input for the keyword MAJOR-OVHL-INVL is the expected number of operating hours between major overhauls for the referenced item of equipment.

MAJOR-OVHL-COST — The user input for the keyword MAJOR-OVHL-COST is the cost (in dollars per unit) for a major overhaul of the referenced item of equipment.

2. ENERGY-COST

The function of the ENERGY-COST instruction is to specify a cost, or a schedule of costs, for the energy used by the facility. For the purpose of specifying energy costs, energy resources are divided into four categories as follows: (1) electricity direct from a utility; (2) diesel oil for diesel engines; (3) natural gas for gas turbines; and (4) fuel for boilers. Unit energy costs may be uniform regardless of the quantity used, may vary in fixed sized blocks, or may vary in block sizes that are a function of the monthly peak loads.

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 on Table VI-B2. The user is forwarned that because there can be significant energy cost differences based on location and size of installation, the default values used by the program may not be realistic for his facility. Note that the ENERGY-COST instruction, if used, must for the reasons discussed in Section A, be entered with PLANT program input data rather than with the ECONOMICS program input data.

The User Worksheet for the ENERGY-COST instruction is reproduced below followed by definitions and instructions for use of the command-word and associated keywords. Note that the program will use default values from Table VI-B2 if data entry for any keyword is omitted.

______________ = ENERGY-COST
u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range Min.	Range Max.
RESOURCE	=	______	code-word	N/A	N/A	N/A
UNIT	=	______	Btu	Note 4	0.0	10^8
UNIFORM-COST	=	______	$/unit	Note 4	0.0	10^5
ESCALATION	=	______	percent	Note 4	0.0	100.0
MIN-MONTHLY-CHG	=	______	$/month	0.0	0.0	10^5
MIN-PEAK-LOAD	=	______	kw	0.0	0.0	10^5
PEAK-LOAD-CHG	=	______	$/kw	0.0	0.0	10^5
BLOCK1	=	______	No.of units	Note 4	0.0	10^7
MULTIPLIER1	=	______	Number	Note 4	0.0	745
COST1	=	______	$/unit	Note 4	0.0	10^5

(continued on next page)

ENERGY-COST (continued)

Keyword		User Input Note 2	Notes	Default	Range	
					Min.	Max.
BLOCK2	=		No.of units	Note 4	0.0	10^7
MULTIPLIER2	=		number	Note 4	0.0	745
COST2	=		$/unit	Note 4	0.0	10^5
BLOCK3	=		No.of units	Note 4	0.0	10^7
MULTIPLIER3	=		number	Note 4	0.0	745
COST3	=		$/unit	Note 4	0.0	10^5
BLOCK4	=		No.of units	Note 4	0.0	10^7
MULTIPLIER4	=		number	Note 4	0.0	745
COST4	=		$/unit	Note 4	0.0	10^5
BLOCK5	=		No.of units	Note 4	0.0	10^7
MULTIPLIER5	=		number	0.0	0.0	745
COST5	=		$/unit	0.0	0.0	10^5
BLOCK6	=		No.of units	0.0	0.0	10^7
MULTIPLIER6	=		number	0.0	0.0	745
COST6	=		$/unit	0.0	0.0	10^5
BLOCK7	=		NO.of units	0.0	0.0	10^7
MULTIPLIER7	=		number	0.0	0.0	10^7
COST7	=		$/unit	0.0	0.0	10^5
BLOCK8	=		No.of units	0.0	0.0	10^7
MULTIPLIER8	=		number	0.0	0.0	745
COST8	=		$/unit	0.0	0.0	10^5
BLOCK9	=		No.of units	0.0	0.0	10^7
MULTIPLIER9	=		number	0.0	0.0	745
COST9	=		$/unit	0.0	0.0	10^5

See NOTES at end of this section

TABLE VI-B2

ENERGY-COST Instruction
Reference Default Values

Keyword	Code-Word for RESOURCE ELECT	DIESEL	GASTUR	BOILER
UNIT (BTU)	3412	130,000	1,000,000	1,000,000
UNIFORM-COST ($/UNIT)	0	0.40	1.5	1.5
ESCALATION (Percent	5.0	5.0	5.0	5.0
MIN-MONTHLY-CHG ($/MONTH)	0	0	0	0
MIN-PEAK-LOAD (KW)	50	0	0	0
PEAK-LOAD-CHG ($/KW)	1.00	0	0	0
BLOCK1 (KWH)	20	0	0	0
BLOCK2	50	0	0	0
BLOCK3	80	0	0	0
BLOCK4	100	0	0	0
BLOCK5	250	0	0	0
BLOCK6 thru BLOCK9	0	0	0	0
COST1 ($/KWH)	0.020	0	0	0
COST2	0.015	0	0	0
COST3	0.013	0	0	0
COST4	0.010	0	0	0
COST5	0.008	0	0	0
COST6 thru COST9	0	0	0	0
MULTIPLIER1 thru MULTIPLIER9	0	0	0	0

ENERGY COST	The BDL command-word ENERGY-COST informs the BDL processor that the data group to follow will define the costs associated with a particular energy resource used by the facility. The user may, for his convenience, enter a unique user defined name (u-name) ahead of the command-word to identify the data group, but this is not required.
RESOURCE	The user input for the keyword RESOURCE is the code-word that identifies the energy resource category, for which cost data is being specified. The code-words are:

ELECT, for electric energy from a utility;

DIESEL, for diesel oil;

GASTUR, for gas turbine fuel, i.e. natural gas;

BOILER, for boiler fuel (oil, natural gas, coal, etc.)

UNIT	The user input for the keyword UNIT is the fuel content (in BTU) of a typical unit quantity of the fuel or energy source being specified. For example entry of UNIT = 100,000 would correspond to the typical fuel content of a 100 cubic-foot unit (one therm) of natural gas, or entry of UNIT = 138,700 would correspond to the typical fuel content of a gallon of oil, or entry of UNIT = 3412 would correspond to one kilowatt of electricity.
UNIFORM-COST	The user input for the keyword UNIFORM-COST is 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 alternate (generally more expensive fuel) must be used after the monthly allotment of primary fuel has been exhausted.

ESCALATION The user input for the keyword ESCALATION is the anticipated yearly percentage increase in cost for the RESOURCE being specified over and above the increase due to 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 a 5% per year increase (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 geographical region and on fuel type, and in general will vary from year to year. Since Cal-ERDA assumes the escalation rate per year to be constant, the user is advised to determine how sensitive his results are to the assumed rate by running the program with low, medium, and high values. Table VI-B3 lists the differential cost escalation rates recommended by ERDA for life cycle costing analysis of their facilities.

TABLE VI-B3

ERDA RECOMMENDED ANNUAL ENERGY DIFFERENTIAL ESCALATION RATES FOR LIFE-CYCLE COSTING

Coal	5%
Fuel Oil	8%
Gas (Natural or LPG)	10%

ELECTRICITY

Region	Region
New England - 6.9% Connecticut Maine Massachusetts New Hampshire Rhode Island Vermont	East North Central - 5.6% Illinois Indiana Michigan Ohio Wisconsin
Middle Atlantic - 5.9% New Jersey New York Pennsylvania	West North Central - 5.6% Iowa Kansas Minnesota Nebraska North Dakota South Dakota
South Atlantic - 5.6% District of Columbia Florida Georgia Maryland North Carolina South Carolina Virginia West Virginia	West South Central - 7.5% Arkansas Louisiana Oklahoma Texas
East South Central - 5.6% Alabama Kentucky Mississippi Tennessee	Mountain - 5.7% Arizona Colorado Idaho Montana Nevada New Mexico Utah Wyoming
Pacific - 7.3% California Oregon Washington	

MIN-MONTHLY-CHG — The user input for the keyword MIN-MONTHLY-CHG is the minimum cost (in dollars) each month, for the resource being specified, regardless of the amount of energy used. Data entry for this keyword is made only when a charging arrangement of this type 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 — The user input for the keyword MIN-PEAK-LOAD is the minimum peak load to be used for 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. For each month the PLANT program calculates a peak load, and the greatest value of this for the year is determined. Then for each month, that months peak load is averaged with the annual maximum. This value, or the user entry for MIN-PEAK-LOAD, whichever is greater, is then 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 — The user entry for the keyword PEAK-LOAD-CHG is the cost in dollars for each unit of demand. This cost is multiplied by the monthly demand factor (see keyword MIN-PEAK-LOAD above for discussion of how the program determines this factor) to obtain the monthly demand related surcharge.

BLOCK1 thru BLOCK9 — These keywords are applicable only if charges for the resource being specified are non-uniform. They provide a method for specifying up to nine charge blocks. The user input for the keyword BLOCK1 is the size, in energy units, (see keyword UNIT) of the first block of energy used by the facility. In current practice this block of energy will generally have the highest unit cost. The size of the ensuing energy charge blocks are similarly specified using as many of keywords BLOCK2 thru BLOCK9 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 respectively, data entry is:

BLOCK1 = 100

BLOCK2 = 1000

BLOCK3 = 10000

Once block sizes have been specified, the program uses these values along with the specified unit energy costs for each block to calculate monthly energy charge (see discussion for keywords COST1 thru COST9 below).

MULTIPLIER1 thru MULTIPLIER9

These keywords provide an alternate method for specifying up to nine charge blocks.

The user input for the keyword MULTIPLIER1 is a number by which the program will multiply the monthly peak load in order to determine the size, in energy units, of the first block of energy used by the facility. The size of the ensuing energy charge blocks are similarly specified using as many of keywords MULTIPLIER2 through MULTIPLIER9 as there are different unit rates in the cost schedule. For example if the user enters

MULTIPLIER1 = 1

MULTIPLIER2 = 10

MULTIPLIER3 = 100

and the PLANT program calculates a peak load for the month in question of 100 KW, then the program will calculate block sizes as follows:

size of first block = 1 x 100 = 100 KWH

size of second block = 10 x 100 - 1000 KWH

size of third block = 100 x 100 = 10,000 KWH

Once block sizes have been calculated the program uses these values along with the specified unit energy costs for each block to calculate the monthly energy charge (see discussion for keywords COST1 through COST9 below).

COST1 thru COST9

These keywords provide a means of specifying unit costs for up to nine charge blocks. The user input for the keyword COST1 is the cost per unit, in dollars, of the first block of energy used by the facility. In current practice this block of energy will generally have the highest cost. The unit costs for the ensuing energy charge blocks are similarly specified using as many of keywords COST1 through COST9 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 respectively, data entry is:

```
COST1 = 0.03

COST2 = 0.02

COST3 = 0.01
```

The monthly energy cost will be the sum of the products of each block size times the assigned cost for that block. If the total energy used for 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.

Example:

```
ELECT1 = ENERGY-COST     RESOURCE=ELECT, UNIT=3412,
                         ESCALATION=5
                         BLOCK1=20, COST1=0.02,
                         BLOCK2=50, COST2=0.015,
                         BLOCK3=80, COST3=0.010..
```

In this example, it is specified that the price of electric energy from the utility is given in units of 3412 BTU (1 KWH); there is no uniform cost, minimum monthly cost, or peak cost; the cost escalation rate is 5%; 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 higher.

3. LIFE-CYCLE-COSTS

The function of the LIFE-CYCLE-COSTS instruction is to specify a number of the parameters used by the PLANT program for life-cycle costing analyses of plant equipment (additional parameters are entered using the PLANT-RATES instruction). Additional information required for life-cycle costing is entered via the EQUIPMENT-COST instruction and also generated by the PLANT program (operating hours).

Note that the LIFE-CYCLE-COSTS instruction, if used, must, be entered with the PLANT program input data rather than with the ECONOMICS program input data (see Section A for discussion). The data in this instruction (with the exception of the SITE-FACTOR) must be entered again via the COMPONENT-RATES instruction for use by the ECONOMICS program for calculation of non-plant life-cycle costs.

The User Worksheet for the LIFE-CYCLE-COSTS instruction is reproduced below followed by definitions and instructions for use of the command-word and associated keywords. Note that the program will use the default values indicated if data entry for any keyword is omitted (or if the instruction is ommitted). The program will also print a warning message if the value of any entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction - Chapter II).

________________ = LIFE-CYCLE-COSTS

u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range	
					Min.	Max.
PROJECT-LIFE	=	________________	years	25.0	1.0	100
LABOR	=	________________	$/hr	25.0	2.0	50
SITE-FACTOR	=	________________	number	1.0	0.5	2.0

See NOTES at end of this section

LIFE-CYCLE-COSTS — The BDL command-word LIFE-CYCLE-COSTS informs the BDL Processor that the data group to follow will define certain specific parameters used by the program for life cycle costing analysis. The user may, for his convenience, enter a unique user defined name (u-name) ahead of the command-word to identify the data group, but this is not required.

PROJECT-LIFE — The user input for the keyword PROJECT-LIFE is the anticipated lifetime of the project being evaluated. Life cycle costs are accumulated over this period.

LABOR — The user input for the keyword LABOR is the cost, in dollars, per hour of maintenance labor. The plant program multiplies this value by the annual maintenance hours (entered via keyword MAINTENANCE in the EQUIPMENT-COST instruction) to obtain annual maintenance costs.

SITE-FACTOR — The user input for the keyword SITE-FACTOR is a number that can be used to adjust annual equipment 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 via the EQUIPMENT-COST instruction (or obtained from default values) by the adjustment factor entered with this keyword.

4. PLANT-RATES

The function of the PLANT-RATES instruction is to specify a number of the parameters used by the PLANT program for calculation of plant equipment life-cycle costs (additional parameters are entered using the LIFE-CYCLE-COSTS instruction). Additional information required for life-cycle costing is entered via the EQUIPMENT-COST instruction and also generated by the PLANT program (operating hours).

Note that the PLANT-RATES instruction, if used, must be entered with the PLANT program input data rather than with the ECONOMICS program input data (see Section A for discussion). The data in this instruction (with the exception of LABOR) must be entered again via the COMPONENT-RATES instruction for use by the ECONOMICS program for calculation of non-plant life-cycle costs.

The User Worksheet for the LIFE-CYCLE-RATES instruction is reproduced below followed by definitions and instructions for use of the command-word and associated keywords.

_______________ = PLANT-RATES

u-name Note 1

Keyword	User Input (Note 2)	Notes	Default	Range Min.	Range Max.
DISCOUNT-RATE	= ______________	%/year	10.0	5.0	15.0
LABOR-INFLTN	= ______________	%/year	0.0	0.0	10.0
MATERIALS-INFLTN	= ______________	%/year	0.0	0.0	10.0

See NOTES at end of this section

PLANT-RATES The BDL command-word PLANT-RATES informs the BDL Processor that the data group to follow will define certain specific parameters used by the program for life cycle costing analyses. The user may, for his convenience, enter a unique user defined name (u-name) ahead of the command-word to identify the data group, but this is not required.

DISCOUNT-RATE The user input for the keyword DISCOUNT-RATE is the value, in percent, to be used for this parameter in the life cycle costing calculations made by the PLANT program. The discount rate is the factor used in the "present value method" of economic evaluation, to account for the time value of money. It represents the "cost of capital" or alternatively "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.

The following two paragraphs extracted from reference I-4 provide additional explanation of the discounting concept:

The purpose of analyzing investment opportunities is to measure the productivity of current dollar expenditures against future benefits derived from project implementation. The decision-maker cannot be indifferent between otherwise exactly comparable alternatives in which the timing of benefits varies widely. More immediate benefits are preferable to benefits obtained farther out in time, even if risk and uncertainty are comparable. If ERDA has to wait to obtain a sum of money in benefits derived from an investment, then the Agency is losing the opportunity to invest the funds elsewhere during the interim period. Stated another way, money has value distinctly related to the timing of its receipt and disbursement, and this value is determined by the <u>opportunity</u> to earn from normal investment activity. This opportunity cost is referred to as the interest rate or the discount rate.

Without attempting to justify the procedures used to determine the interest rate or opportunity cost of funds used by the United States Treasury, the Office of Management and Budget (OMB) in Circular A-94 has specified that a 10 percent annual interest rate be used to discount investment decisions. Unless otherwise specified the current ERDA Guidelines require use of the 10 percent factor in energy conservation evaluations.

LABOR-INFLTN The user input for the keyword LABOR-INFLTN is the anticipated yearly percentage increase in the cost of labor, over and above the increase due to general inflation (i.e. this is a differential or relative cost escalation).

The current version (10/77) of the PLANT program applies the labor inflation rate only to the calculation of maintenance costs while applying the materials inflation rate (see below) to the calculation of overhead costs and replacement costs (including installation of the replacement unit). A program revision that will result in use of the labor inflation rate for both overhead costs and replacement installation costs is currently under consideration but plans to implement this revision have not yet been formalized.

MATERIALS-INFLTN The user input for the keyword MATERIALS-INFLTN is the anticipated yearly percentage increase in the cost of materials, over and above the increase due to 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 currently also applied to overhaul costs and replacement installation costs but this will be revised as noted above (see keyword LABOR-INFLTN).

5. COMPONENT-COST

The function of the COMPONENT-COST instruction is to specify cost data for non-plant components (first cost, installation cost and the cost of consumables, maintenance and overhauls). Non-plant components are here defined as everything except the primary energy conversion equipment such as boilers, chillers, diesel generators, gas turbines storage tanks, etc.; (see Chapter V). A non-plant component can be anything from roof insulation, to a HVAC system, to an entire building. Costs for plant equipment are specified using the EQUIPMENT-COST instruction.

Costs for up to fifteen different non-plant 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 these components and combines these with the present value of the plant equipment life cycle costs (calculated by the PLANT program). The combined cost is then used, along with calculated life cycle energy usage and costs for economic comparison of the energy conservation project under consideration with a baseline condition or project (baseline costs and energy usage are specified using the BASELINE instruction). From this comparison, the program computes the investment cost effectiveness statistics described in Section A of this chapter.

The User Worksheet for the COMPONENT-COST instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords.

______________ = COMPONENT-COST

u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range Min.	Range Max.
UNIT-NAME	=	______	Note 5	N/A	N/A	N/A
NUMBER-OF-UNITS	=	______	Number	1.0	0.0	10^5
FIRST-COST	=	______	$	0.0	0.0	10^7
FC-PER-UNIT	=	______	$	0.0	0.0	10^6
INSTALL-COST	=	______	$	0.0	0.0	10^6
IC-PER-UNIT	=	______	$	0.0	0.0	10^5
ANNUAL-COST	=	______	$	0.0	0.0	10^5
AC-PER-UNIT	=	______	$	0.0	0.0	$5x^4$
MAINT-COST	=	______	$	0.0	0.0	$7x10^4$
MC-PER-UNIT	=	______	$	0.0	0.0	$2x10^4$
CONSUM-COST	=	______	$	0.0	0.0	$3x10^4$
CONSC-PER-UNIT	=	______	$	0.0	0.0	10^4
CYCLICAL-COST	=	______	$	0.0	0.0	10^5
CC-PER-UNIT	=	______	$	0.0	0.0	$5x10^4$
COMPONENT-LIFE	=	______	years	999.	0.1	100
MIN-OVERH-INT	=	______	years	999.	0.1	50
MIN-OVERH-COST	=	______	$	0.	0.0	10^5
MINOC-PER-UNIT	=	______	$	0.	0.0	$5x10^4$
MAJ-OVERH-INT	=	______	years	999.	0.1	50
MAJ-OVERH-COST	=	______	$	0.	0.0	$2x10^5$
MAJOC-PER-UNIT	=	______	$	0.	0.0	10^5

See NOTES at end of this section

COMPONENT-COST — The BDL command word COMPONENT-COST informs the BDL processor that the data group to follow will define the costs of a particular non-plant component. The user input for this data entry is a unique user defined name (u-name) that precedes the command-word. Entry of the u-name is not required but is recommended in user convenience in identifying and validating data input particularly if a number of different components are being costed.

UNIT-NAME — Cost factors may be specified as a single lump sum or on a cost per unit basis. Data entry for the keyword UNIT-NAME is required only if the cost per unit option is used. The user input for this data entry is any word of sixteen characters or less that describes the size or type of unit that the subsequently specified unit costs are referenced to. For example, SQFT, TONS, LBS, FEET, etc.: The purpose of this data entry is for user convenience in data input identification and verification.

NUMBER-OF-UNITS — The user input for the keyword NUMBER-OF-UNITS is the number of units, of the type or size described above (see keyword UNIT-NAME) that are to be costed. The program multiplies the subsequently entered unit costs by this value to obtain the total cost of the component being specified. This data entry may be omitted if the component specified is a single unit or if costs are subsequently specified as a single sum.

FIRST-COST — The user input for the keyword FIRST-COST is the initial cost, in dollars, excluding installation, for the component whose cost is being specified. Data entry for this keyword is omitted (and data entry is made instead for keyword FC-PER-UNIT) if the option to specify costs on a per unit basis is used.

FC-PER-UNIT — The user input for the keyword FC-PER-UNIT is the initial cost, in dollars, excluding installation, for <u>one unit</u> of the component whose cost is being specified. The program multiplies this value by the number of units (see keyword NUMBER-OF-UNITS) to obtain total procurement cost. Data entry for this keyword is omitted if data entry is made for keyword FIRST-COST.

INSTALL-COST — The user input for the keyword INSTALL-COST is the installation cost, in dollars, for the component being specified. Data entry for this keyword is omitted (and data entry is made instead for keyword IC-PER-UNIT) if the option to specify costs on a per unit basis is used.

IC-PER-UNIT — The user input for the keyword IC-PER-UNIT is the installation cost, in dollars, for one unit of the component whose cost is being specified. Data entry for this keyword is omitted if data entry is made for keyword INSTALL-COST.

ANNUAL-COST — The user entry for the keyword ANNUAL-COST is the cost per year for maintenance (labor) and consumables (materials) for the component whose cost is being specified. The differential labor inflation rate is applied to annual cost (if data entry is made for keyword LABOR-INFLTN in the COMPONENT-RATES instruction). Alternatively these costs may be specified separately by using keywords MAINT-COST and CONSUM-COST, or they may be specified on a per unit basis using keyword AC-PER-UNIT.

AC-PER-UNIT — The user entry for the keyword AC-PER-UNIT is the cost per year for maintenance (labor) and consumables (materials) for one unit of the component whose cost is being specified. The differential labor rate is applied to the annual unit cost (if data entry is made for keyword LABOR-INFLTN in the COMPONENT-RATES instruction). Alternatively these costs may be specified separately by using keywords MC-PER-UNIT and CONSC-PER-UNIT or they may be specified on a single (rather than per unit) cost basis using keyword ANNUAL-COST.

MAINT-COST — The user input for the keyword MAINT-COST is the annual cost of maintenance (labor), in dollars, for the component whose cost is being specified. The differential labor inflation rate is applied to this cost (if data entry is made for keyword LABOR-INFLTN in the COMPONENT-RATES instruction. Data entry for this keyword is omitted if ANNUAL-COST is specified or if the option to specify costs on a per unit basis is used (see MC-PER-UNIT below).

MC-PER-UNIT — The user input for the keyword MC-PER-UNIT is the annual maintenance cost, in dollars, for one unit of the component whose costs are being specified. The differential labor inflation rate is applied to the annual maintenance cost (if data entry is made for keyword LABOR-INFLTN in the COMPONENT-RATES instruction). Data entry for this keyword is omitted if data entry is made for keyword AC-PER-UNIT or keyword MAINT-COST.

CONSUM-COST — The user input for the keyword CONSUM-COST is the annual cost, in dollars, for the consumables (materials), used by the component whose cost is being specified. The differential materials inflation rate is applied to this cost (if data entry is made for keyword MATERIALS-INFLTN in the COMPONENT-RATES instruction). This data entry is omitted if ANNUAL-COST is specified or if the option to specify costs on a per unit basis is used (see keyword CONSC-PER-UNIT below).

CONSC-PER-UNIT — The user input for the keyword CONSC-PER-UNIT is the annual cost in dollars for the consumables (materials) used by <u>one unit</u> of the component whose cost is being specified. The differential materials inflation rate is applied to this cost (if data entry is made for keyword MATERIALS-INFLTN in the COMPONENT-RATES instruction). Data entry for this keyword is omitted if data entry is made for keyword AC-PER-UNIT or keyword CONSUM-COST.

CYCLICAL-COSTS — The user input for the keyword CYCLICAL-COSTS is the cost per year, in dollars, for minor and major overhauls of the component whose costs are being specified. Alternatively, these costs may be specified separately by using keywords MIN-OVERH-INT, MIN-OVERH-COST, MAJ-OVERH-INT and MAJ-OVERH-COST. Note that the life cycle costs calculated from these alternative methods of specifying cyclical costs will be different, even if the summed costs are the same, because of the difference in discounting. Several additional alternative methods of specifying these costs are available if the option to specify costs on a per unit basis is used (see keywords CC-PER-UNIT, MINOC-PER-UNIT and MAJOR-PER-UNIT).

CC-PER-UNIT — The user input for the keyword CC-PER-UNIT is the cost per year, in dollars, for minor and major overhauls of <u>one unit</u> of the component whose cost is being specified. Alternative ways of specifying these costs are discussed for keyword CYCLICAL-COSTS above.

COMPONENT-LIFE — The user input for the keyword COMPONENT-LIFE is the useful life, in years, of the component whose cost is being specified. The program uses this value to calculate life cycle replacement costs. For example if LIFE=n is specified, replacement and installation cost are calculated every year, up to the life of the project.

MIN-OVERH-INT — The user input for the keyword MIN-OVERH-INT is the anticipated time period, in years, between minor overhauls of the component whose cost is being specified. This data entry is omitted if one of the alternative methods of specifying cyclical costs is used. (see CYCLICAL-COST, and CC-PER-UNIT).

MIN-OVERH-COST — The user input for the keyword MIN-OVERH-COST is the cost in dollars of a minor overhaul of the component whose cost is being specified. This data entry is omitted if one of the alternative methods of specifying cyclical cost is used (see keywords CYCLICAL-COST, CC-PER-UNIT and MINOC-PER-UNIT).

MINOC-PER-UNIT — The user input for the keyword MINOC-PER-UNIT is the cost in dollars of a minor overhaul of one unit of the component whose cost is being specified. This data entry is omitted if one of the alternative methods of specifying minor overhaul cost is used (see keywords CYCLICAL-COST, CC-PER-UNIT, and MIN-OVERH-COST).

MAJ-OVERH-INT — The user input for the keyword MAJ-OVERH-INT is the anticipated time period, in years, between major overhauls for the component whose cost is being specified. This data entry is omitted if one of the alternative methods of specifying cyclical cost is used (see keywords CYCLICAL-COST-and CC-PER-UNIT)

MAJ-OVERH-COST — The user input for the keyword MAJ-OVERH-COST is the cost, in dollars, of a major overhaul of the component whose cost is being specified. This data entry is omitted if one of the alternative methods of specifying cyclical cost is used (see keywords CYCLICAL-COST, CC-PER-UNIT and MAJOC-PER-UNIT)

MAJOC-PER-UNIT — The user input for the keyword MAJOC-PER-UNIT is the cost, in dollars, for a major overhaul of one unit of the component whose cost is being specified. This data entry is omitted if one of the alternative methods of specifying cyclical cost is used (see keywords CYCLICAL-COST, CC-PER-UNIT and MAJ-OVERH-COST)

6. COMPONENT-RATES

The function of the COMPONENT-RATES instruction is to specify a number of parameters used by the ECONOMICS program for calculation of non-plant component life-cycle costs. Additional information required for these calculations is entered via the COMPONENT-COST instruction.

Note that the parameters specified by this instruction were previously entered via the LIFE-CYCLE-COSTS and PLANT-RATES instructions for use by the PLANT program for calculation of plant equipment life-cycle costs.

The User Worksheet for the COMPONENT-RATES instruction is reproduced below followed by definitions and instructions for use of the command-word and associated keywords. Note that the program will use the default values indicated if data entry for any keyword is omitted (or if the instruction is omitted). The program will also print a warning message if the value of any entry is outside the indicated range, unless instructed not to do so (see MESSAGE instruction - Chapter II).

______________ = COMPONENT-RATES

u-name Note 1

Keyword	User Input Note 2	Notes	Default	Range	
				Min.	Max.
DISCOUNT-RATE	= ______________	%/year	10.0	5.0	15.0
LABOR-INFLTN	= ______________	%/year	0.0	0.0	10.0
MATERIALS-INFLTN	= ______________	%/year	0.0	0.0	10.0
PROJECT-LIFE	= ______________	years	25.0	1.0	100.

See NOTES at end of this section

COMPONENT-RATES The BDL command-word COMPONENT-RATES informs the BDL processor that the data group to follow will define parameters used by the program for life-cycle costing analysis. The user may for his convenience, enter a unique user defined name (u-name) ahead of the command-word to identify the data group, but this is not required.

DISCOUNT-RATE The user input for the keyword DISCOUNT-RATE is the value, in percent, to be used for this parameter in the life-cycle costing calculations made by the ECONOMICS program. This keyword serves the same function for the ECONOMICS program as the keyword of the same name in the PLANT-RATES instruction does for the PLANT program. See the PLANT-RATES instruction for a discussion of discount rate and discounting.

LABOR-INFLTN The user input for the keyword LABOR-INFLTN is the anticipated yearly percentage increase in the cost of labor, over and above the increase due to general inflation (i.e. this is a differential or relative cost escalation). The ECONOMICS Program applies the labor inflation rate in the calculation of costs for maintenance and overhauls and, for the installation of replacement units.

The labor inflation rate is supplied to the PLANT program via data entry for an identically named keyword in the PLANT-RATES instruction but is used somewhat differently by that program (see PLANT-RATES instruction for discussion).

MATERIALS-INFLTN The user input for the keyword MATERIALS-INFLTN is the anticipated yearly percentage increase in the cost of materials, over and above the increase due to general inflation (i.e. this is a differential or relative cost escalation). The ECONOMICS program applies the material inflation rate to the cost of consumables and the procurement cost of replacement units.

The materials inflation rate is supplied to the PLANT program via data entry for an identically named keyword in the PLANT-RATES instruction but is used somewhat differently by that program (see PLANT-RATES instruction for discussion).

PROJECT-LIFE The user input for the keyword PROJECT-LIFE is the anticipated lifetime of the project being evaluated. This period must be the same as that entered for an identically named keyword in the LIFE-CYCLE-COSTS instructions.

7. BASELINE

The function of the BASELINE instruction is to specify the baseline condition of investment cost, fuel cost and fuel usage against which an alternative energy conservation project can be evaluated. The baseline figures may have been obtained from a previous CAL-ERDA run or they may be based on actual operating data for the building under consideration. In any 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 with respect to the baseline case. From this comparison the program calculates the statistics, described in Section A, that provide a measure of the investment cost effectiveness of the energy conversation alternative under consideration.

The user Worksheet for the BASELINE instruction is reproduced below followed by definitions and instructions for use of the command-word and the associated keywords.

______________ = BASELINE
u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range Min.	Range Max.
PLANT-COST	=	______	\$/1000	0.0	0.0	$5x10^4$
FUEL-COST	=	______	\$/1000	0.0	0.0	$2x10^4$
FUEL-USE	=	______	$Btu/10^9$	0.0	0.0	10^5

See Notes at end of this section

BASELINE

The BDL command-word BASELINE informs the BDL processor that the data group to follow will define the costs and fuel usage associated with a baseline condition or project to be used for purposes of economic evaluation comparison with the project under consideration. The user may, for his convenience, enter a unique user defined name (u-name) ahead of the command-word to identify the data group but this is not required.

PLANT-COST

The user input for the keyword PLANT-COST is the present value, in thousands of dollars, of the life-cycle investment cost, for the baseline case (excluding fuel and electricity).

If the Project under consideration is a retrofit, PLANT-COST for the baseline condition would exclude initial construction cost and consider only operational costs (excluding energy) and replacement costs. As indicated in Section A, the current program does not account for residual value but planned program revisions will take this factor into consideration. Once this revision is implemented, residual value if any should also be incorporated into the base-line PLANT-COST.

If the baseline condition is a project proposed as an alternate to the one under consideration, PLANT-COST figures could be obtained from a CAL-ERDA run of the baseline project.

FUEL-COST

The user input for the keyword FUEL-COST is the present value, in thousands of dollars, of the life-cycle cost of fuel and electricity for the baseline case.

If the project under consideration is a retrofit, baseline FUEL-COST could be based on actual fuel and electricity usage (for the same weather year used by Cal-ERDA to calculate energy usage by the alternative project). The present value of the life-cycle energy cost associated with this usage could then be obtained using current fuel prices and the PVF factor from the appropriate table in reference I-4. Alternatively a Cal-ERDA run of the baseline building will yield the value to be used for FUEL-COST.

FUEL-USE

The user input for the keyword FUEL-USE is the total fuel and electricity consumed (in 10^9Btu) for the baseline case over the lifetime of the alternative project. The program compares this to the calculated life-cycle energy usage of the alternative energy conservation project to determine fuel savings and uses the savings in its calculations of the fuel savings into investment ratio.

If the project under consideration is a retrofit, baseline FUEL-USE could be based on actual energy usage (for the same weather year used by Cal-ERDA to calculate the energy usage of the alternative project). The energy usage in the referenced year multiplied by the project life will yield the baseline FUEL-USE. Alternatively a Cal-ERDA run of the baseline building, multiplied by project life, will yield the value to be used for FUEL-USE. Note that the program uses the net value for utility supplied electricity (3412 BTU/KWH) rather than the source value (11,600 BTU/KWH). This could be somewhat misleading when comparing the fuel saving to investment ratio for energy conservation alternatives that save a different mix of fuel and utility electricity.

8. ECONOMICS-REPORT

The Cal-ERDA 1.3 (10/77) BDL vocabulary does not include an ECONOMICS-REPORT instruction. Instead the three output reports produced by the ECONOMICS Program, and described below, are automatically printed. Future versions of the program, particularly after the enhancements described in Section A have been completed, will include an ECONOMICS-REPORT instruction to permit the user to select from an expanded list of available reports.

The existing ECONOMICS program produces three reports, labeled E01, E02 and E03 with the following information:

1. E01, "Economics Verification", echoes the data input via the COMPONENT-COST, COMPONENT-RATES and BASELINE instructions.

2. E02, "Life-Cycle Costs Summary" produces two outputs

   a) the life cycle cost for each item entered via a COMPONENT-COST instruction, and

   b) the overall life-cycle cost for each of the following: all non-plant items, plant equipment, fuel (including electricity), and the sum of all of these.

3. E03, "Life-Cycle Savings/Investment Statistics", compares present-run vs. baseline costs and energy use, and gives the following quantities.

   a) Investment (10^3\$) The sum of the life-cycle values of all of the plant cost items (entered via EQUIPMENT-COST instruction) and the non plant cost items (entered via COMPONENT-COST instruction) minus the baseline cost (entered for keyword PLANT-COST in the BASELINE instruction)

   b) Cost Savings(10^3\$) The life-cycle dollar savings produced by the investment. It is calculated as the baseline fuel-cost minus the fuel cost of the present case.

   c) Savings-to-investment ratio. Cost-savings divided by investment. The larger this ratio, the higher the cost-effectiveness of the "energy conserving option." The "energy-conserving option" is not cost-effective if this ratio is less than 1.0.

d) <u>Fuel Savings (10^6Btu)</u>. Baseline fuel-use minus fuel-use of present case.

e) <u>Fuel-Savings-to-investment ratio (10^9Btu/$.)</u> Fuel savings, in 10^9Btu, divided by investment, in dollars.

f) <u>Disounted Payback Period (years)</u>. The number of years it takes the accumulated annual cost savings to add up to the investment. The "annual cost saving" is the present value of the life cycle cost saving divided by the project life-time. The smaller the payback period, the faster the investment pays for itself in terms of plant and fuel cost savings. (Note the discrepancy indicated in Section A of this chapter, between the Cal-ERDA 1.3 (10/77) method of calculating this statistic and the method described in reference I-4).

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______________ = EQUIPMENT-COST
u-name Note 1

Keyword	User Input Note 2	Notes	Default	Range Min.	Range Max.
FOR	= ______________	u-named	N/A	N/A	N/A
COST	= ______________	$/1000	Note 3	0	10^5
INSTALLATION	= ______________	number	1.0	1.0	100
CONSUMABLES	= ______________	$/hr	Note 3	0.0	10^4
MAINTENANCE	= ______________	hrs/yr	Note 3	0.0	8760
EQUIPMENT-LIFE	= ______________	hrs	Note 3	0.0	10^6
MINOR-OVHL-INVL	= ______________	hrs	Note 3	0.0	10^6
MINOR-OVHL-COST	= ______________	$	Note 3	0.0	10^7
MAJOR-OVHL-INVL	= ______________	hrs	Note 3	0.0	10^6
MAJOR-OVHL-COST	= ______________	$	Note 3	0.0	10^7

See NOTES at end of this section

______________ = ENERGY-COST
u-name Note 1

Keyword	User Input Note 2	Notes	Default	Range Min.	Range Max.
RESOURCE	= ______________	code-word	N/A	N/A	N/A
UNIT	= ______________	Btu	Note 4	0.0	10^8
UNIFORM-COST	= ______________	$/unit	Note 4	0.0	10^5
ESCALATION	= ______________	percent	Note 4	0.0	100.0
MIN-MONTHLY-CHG	= ______________	$/month	0.0	0.0	10^5
MIN-PEAK-LOAD	= ______________	kw	0.0	0.0	10^5
PEAK-LOAD-CHG	= ______________	$/kw	0.0	0.0	10^5
BLOCK1	= ______________	No.of units	Note 4	0.0	10^7
MULTIPLIER1	= ______________	Number	Note 4	0.0	745
COST1	= ______________	$/unit	Note 4	0.0	10^5

(continued on next page)

Keyword	User Input Note 2	Notes	Default	Range Min.	Range Max.
BLOCK2	= ________	No.of units	Note 4	0.0	10^7
MULTIPLIER2	= ________	number	Note 4	0.0	745
COST2	= ________	$/unit	Note 4	0.0	10^5
BLOCK3	= ________	No.of units	Note 4	0.0	10^7
MULTIPLIER3	= ________	number	Note 4	0.0	745
COST3	= ________	$/unit	Note 4	0.0	10^5
BLOCK4	= ________	No.of units	Note 4	0.0	10^7
MULTIPLIER4	= ________	number	Note 4	0.0	745
COST4	= ________	$/unit	Note 4	0.0	10^5
BLOCK5	= ________	No.of units	Note 4	0.0	10^7
MULTIPLIER5	= ________	number	0.0	0.0	745
COST5	= ________	$/unit	0.0	0.0	10^5
BLOCK6	= ________	No.of units	0.0	0.0	10^7
MULTIPLIER6	= ________	number	0.0	0.0	745
COST6	= ________	$/unit	0.0	0.0	10^5
BLOCK7	= ________	NO.of units	0.0	0.0	10^7
MULTIPLIER7	= ________	number	0.0	0.0	10^7
COST7	= ________	$/unit	0.0	0.0	10^5
BLOCK8	= ________	No.of units	0.0	0.0	10^7
MULTIPLIER8	= ________	number	0.0	0.0	745
COST8	= ________	$/unit	0.0	0.0	10^5
BLOCK9	= ________	No.of units	0.0	0.0	10^7
MULTIPLIER9	= ________	number	0.0	0.0	745
COST9	= ________	$/unit	0.0	0.0	10^5

See NOTES at end of this section

_______________ = LIFE-CYCLE-COSTS

u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range	
					Min.	Max.
PROJECT-LIFE	=	______	years	25.0	1.0	100
LABOR	=	______	$/hr	25.0	2.0	50
SITE-FACTOR	=	______	number	1.0	0.5	2.0

See NOTES at end of this section

_______________ = PLANT-RATES

u-name Note 1

Keyword		User Input Note 2	Notes	Default	Range	
					Min.	Max.
DISCOUNT-RATE	=	______	%/year	10.0	5.0	15.0
LABOR-INFLTN	=	______	%/year	0.0	0.0	10.0
MATERIALS-INFLTN	=	______	%/year	0.0	0.0	10.0

See NOTES at end of this section

_______________ = COMPONENT-COST

u-name Note 1

Keyword	User Input Note 2	Notes	Default	Range Min.	Range Max.
UNIT-NAME	= ______	Note 5	N/A	N/A	N/A
NUMBER-OF-UNITS	= ______	Number	1.0	0.0	10^5
FIRST-COST	= ______	$	0.0	0.0	10^7
FC-PER-UNIT	= ______	$	0.0	0.0	10^6
INSTALL-COST	= ______	$	0.0	0.0	10^6
IC-PER-UNIT	= ______	$	0.0	0.0	10^5
ANNUAL-COST	= ______	$	0.0	0.0	10^5
AC-PER-UNIT	= ______	$	0.0	0.0	$5x^4$
MAINT-COST	= ______	$	0.0	0.0	$7x10^4$
MC-PER-UNIT	= ______	$	0.0	0.0	$2x10^4$
CONSUM-COST	= ______	$	0.0	0.0	$3x10^4$
CONSC-PER-UNIT	= ______	$	0.0	0.0	10^4
CYCLICAL-COST	= ______	$	0.0	0.0	10^5
CC-PER-UNIT	= ______	$	0.0	0.0	$5x10^4$
COMPONENT-LIFE	= ______	years	999.	0.1	100
MIN-OVERH-INT	= ______	years	999.	0.1	50
MIN-OVERH-COST	= ______	$	0.	0.0	10^5
MINOC-PER-UNIT	= ______	$	0.	0.0	$5x10^4$
MAJ-OVERH-INT	= ______	years	999.	0.1	50
MAJ-OVERH-COST	= ______	$	0.	0.0	$2x10^5$
MAJOC-PER-UNIT	= ______	$	0.	0.0	10^5

See NOTES at end of this section

________________ = COMPONENT-RATES

u-name　　　　Note 1

Keyword	User Input Note 2	Notes	Default	Range	
				Min.	Max.
DISCOUNT-RATE =	________	%/year	10.0	5.0	15.0
LABOR-INFLTN =	________	%/year	0.0	0.0	10.0
MATERIALS-INFLTN =	________	%/year	0.0	0.0	10.0
PROJECT-LIFE =	________	years	25.0	1.0	100.

See NOTES at end of this section

________________ = BASELINE

u-name　　　　Note 1

Keyword	User Input Note 2	Notes	Default	Range	
				Min.	Max.
PLANT-COST =	________	$/1000	0.0	0.0	$5x10^4$
FUEL-COST =	________	$/1000	0.0	0.0	$2x10^4$
FUEL-USE =	________	Btu/10^9	0.0	0.0	10^5

See Notes at end of this section

NOTES to ECONOMICS Program and (PLANT Economics Program) User Worksheets

NOTE 1 Data entry may consist of a unique user defined (u-name) followed by the command-word or the command-word only (user option). If a u-name is entered an equal sign must be inserted between it and the command-word. See Chapter II for discussion of BDL rules, notation, syntax, etc.

NOTE 2 Data entry consists of the keyword or its abbreviation followed by a u-name, code-word or value as indicated. A separator (equal sign, comma or blank) must be inserted between the keyword and the user input and a terminator (double period) must be used following the last data entry in the instruction.

NOTE 3 Default value for this keyword depends on the size and type of equipment being specified. See Table VI-B1 and scaling formula discussed in text for EQUIPMENT-COST instruction - Section B.

NOTE 4 Default value for this keyword depends on the type of RESOURCE being specified (i.e. ELECT, DIESEL, GASTUR or BOILER). See Table VI-B2, Section B.

NOTE 5 The user input for this data entry is any word of sixteen characters or less that describes the size or type of unit that subsequently specified unit costs are referenced to. For example SOFT, TONS, LBS, FEET, FANS, etc. The purpose of this data entry is for user convenience in data input identification and verification.

VII. REPORT AND GRAPHICS PROGRAMS

* In Preparation

VII. REPORT and GRAPHICS Programs

A. Diagnostic Messages

The following messages will be printed by the BDL Processor if an error is detected.

SAME LABEL WAS DEFINED PREVIOUSLY

COMMAND MISSING

BAD COMMAND

ALPHANUMERIC CHARACTER IN NUMBER FIELD

DATA OUT OF RANGE

NUMBER MISSING

UNRECOGNIZIBLE KEYWORD

MORE DATA THAN REQUIRED

FOUND SYMBOL INSTEAD OF NUMBER

SYMBOL TABLE CAPACITY EXCEEDED

MEMORY CAPACITY EXCEEDED

CAN NOT ACCEPT MORE THAN FIVE TITLES

FOUND ·· INSTEAD OF SYMBOL

PREVIOUSLY UNDEFINED SYMBOL USED

KEYWORD DOES NOT APPLY TO THIS COMMAND

FOUND KEYWORD INSTEAD OF VALUE

KEYWORD PREVIOUSLY GIVEN A VALUE

INSUFFICIENT DATA

NAME IS REQUIRED FOR THIS DATA TYPE

NUMBER FOUND INSTEAD OF A SYMBOL

WRONG DATA TYPE IN LIKE FIELD

SYMBOL DOESN'T MATCH KEYWORD TYPE

FOUND SYMBOL WITH NON-NUMERIC VALUE

FOUND NUMBER INSTEAD OF A NAME

GLASS DEFINITION OUT OF SEQUENCE

UNLOCATED GLASS ASSUMED

SHADE DEFINITION OUT OF SEQUENCE

UNLOCATED SHADE ASSUMED

NO SPACE LEVEL DATA FOUND IN INPUT DECK

KEYWORD NAME USED AS PARAMETER NAME

KEYWORD NAME USED AS PARAMETER VALUE

INCORRECT REPORT CODE-WORD

Each message should be self explanatory. As new messages, or frequent errors are identified they will be added to this list. Additional descriptive text will be added if requested by the users.

B. REPORT Program

1. Introduction

The REPORT Program collects all the input instructions, and all the results of the calculations from the LOADS, SYSTEMS, PLANT and ECONOMICS programs. These data are then arranged into tables and lists so the user may easily recognize the results he desires to examine. A user may select one of the standard output reports using one of the following instructions:

LOADS-REPORT

SYSTEMS-REPORT

* PLANT-REPORT

* ECONOMICS-REPORT

* USER-REPORT

Each of these instructions is described in the chapter to which they apply. An example of the outline used for the standard reports is given in this section, and an example of each report.

Cal-ERDA 1.3 uses the REPORT program to generate verification reports for the LOADS program only. The other reports are produced within each of the computational programs.

* In Preparation

2. Standard Reports

A standard report is considered to be any of the reports available to users of the system when referred to by the report identification code-word in one of the report instructions. The format and general content of such reports have been predefined, and the only options open to the user are then limited ones pertaining to the inclusion or suppression of certain notations.

The overall layout of all standard reports is similar, and each page of a report contains some or all of the elements as shown in Figure VII-1. The Image Width has been assumed to be 131 positions, and Image Length has been set to 62 lines.

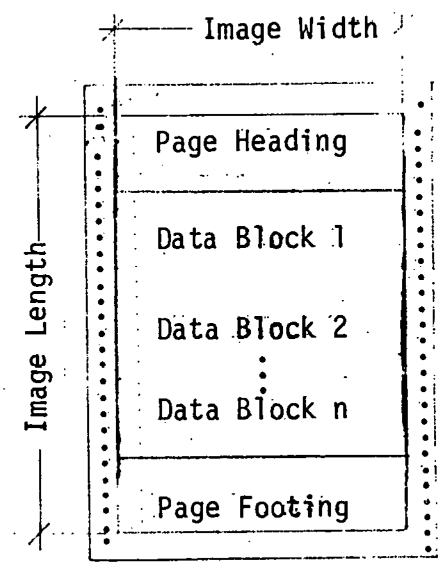


Figure VII-1 Major Divisions of a Standard Report

a. Page Heading

PROJECT NAME	USER NAME	DATE	TIME
REPORT I.D.	TITLE FIELD	CONTINUATION	

Details of Page Heading

Figure VII-2

In Figure VII-2, the details of the standard page heading are shown, and are as follows:

PROJECT NAME — PROJECT NAME consists of 40 characters, input via the first TITLE instruction, and is used to identify the building being processed.

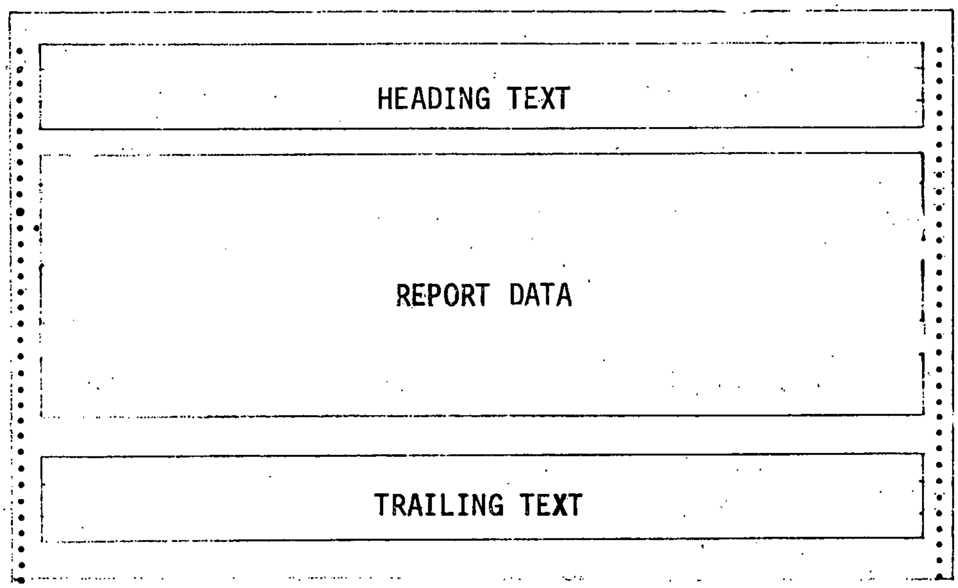
USER NAME — USER NAME consists of 40 characters, input via the second TITLE instruction, and is used to identify the system user.

DATE — DATE consists of 11 characters, generated by the computer system in the sequence MONTH DAY YEAR corresponding to the day on which the report is generated.

TIME — TIME consists of 8 characters, generated by the computer system in the form HOUR, MINUTE, SECOND corresponding to the time at which computation of this report began execution.

REPORT I.D.	REPORT I.D. identifies the code-word for a specific standard report selected by the user.
TITLE FIELD	The TITLE FIELD consists of 120 characters which identify the subject matter of a specific standard report. These 120 characters may be entered by the user on the third, fourth, and fifth TITLE instructions, each having 40 characters. The TITLE fields for the LOADS verification reports have been assigned a name for each report.
CONTINUATION	The CONTINUATION field consists of 11 print positions; if the page being printed is a continuation of a report which began on a previous page, the word (CONTINUED) is printed, otherwise blanks are printed.

b. Data Block



Details of Data Block

Figure VII-3

In Figure VIII-3, the details of the standard data are shown, and are as follows:

HEADING TEXT	HEADING TEXT consists of one or more lines of 131 characters which appear as the first lines of a data block; these will normally be column headings and other words to identify the data items to be printed in the following block.
REPORT DATA	REPORT DATA consist of one or more lines of numeric and/or alphabetic data produced as output by a routine; this data is the subject matter of the report.
TRAILING TEXT	TRAILING TEXT consists of one or more lines of 131 characters which appear after the completion of the group of REPORT DATA lines and any data total lines.

c. <u>Page Footing</u>

DASHED LINE		CONTINUED
REPORT I.D.	TITLE FIELD	PAGE NO.

Details of Page Footing

Figure VII-4

In Figure VII-4, the details of the page footing are shown, and are as follows:

DASHED LINE	The DASHED LINE consists of 106 dashes which provide a visual break across the page.
CONTINUED	CONTINUED consists of 25 print positions. If the page being printed is the last page of the report, the dashed line continues, but if the report is to continue onto another page, the words (CONTINUED TO NEXT PAGE) appear.
REPORT I.D.	REPORT I.D. identifies the code-word for a specific standard report selected by the user.
TITLE FIELD	The TITLE FIELD consists of 120 characters which identify the subject matter of a specific standard report. These 120 characters may be entered by the user on the third, fourth, and fifth TITLE instructions, each having 40 characters. This field has been preassigned for the LOAD verification reports.
PAGE NO.	This field gives the page number of the report.

PROJECT-CAL-ERDA SAMPLE 31-STORY OFFICE USER-DUAL-DUCT CONS.VOL./CHICAGO 1974 T-R-YR CAL-ERDA 1.3 27 SEP 1977 13.31.54
REPORT- V01 GENERAL PROJECT AND BUILDING INPUT

PERIOD OF STUDY

STARTING DATE	ENDING DATE	NUMBER OF DAYS
1 JAN 1974	3 JAN 1974	3

SITE CHARACTERISTIC DATA

STATION NAME	LATITUDE (DEG)	LONGITUDE (DEG)	ALTITUDE (FT)	TIME ZONE	BUILDING AZIMUTH (DEG)
CHICAGO	42.0	88.0	0.	6 CST	0.0

REPORT- V01 GENERAL PROJECT AND BUILDING INPUT PAGE 1

PROJECT-CAL-ERDA SAMPLE 31-STORY OFFICE USER-DUAL-DUCT CONS.VOL./CHICAGO 1974 T-R-YR CAL-ERDA 1.3 27 SEP 1977 13.31.54
REPORT- V02 SUMMARY OF SPACES OCCURRING IN THE PROJECT

NUMBER OF SPACES 11 EXTERIOR 9 INTERIOR 2

SPACE	SPACE MULTIPLIER	SPACE TYPE	HEIGHT (FT)	AREA (SQ FT)	VOLUME (CU FT)
A-STORAGE	1	INT	8.0	20000.	400000.
TOP-FLOOR-1	1	EXT	13.0	11900.	154700.
TOP-FLOOR-WEST	1	EXT	13.0	3000.	39000.
*TOP-FLOOR-SOUTH	1	EXT	13.0	1500.	19500.
TOP-FLOOR-EAST	1	EXT	13.0	3000.	39000.
*TOP-FLOOR-NORTH	1	EXT	13.0	1500.	19500.
MID-FLOOR-1	30	INT	13.0	11900.	154700.
MID-FLOOR-WEST	30	EXT	13.0	3000.	39000.
*MID-FLOOR-SOUTH	30	EXT	13.0	1500.	19500.
MID-FLOOR-EAST	30	EXT	13.0	3000.	39000.
*MID-FLOOR-NORTH	30	EXT	13.0	1500.	19500.

REPORT- V02 SUMMARY OF SPACES OCCURRING IN THE PROJECT PAGE 2

DATA FOR SPACE   *A-STORAGE*

LOCATION OF ORIGIN
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	0.0	0.0	1	8.	20000.	400000.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
2	0	0	2

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
0	0	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
150.0	75.0

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	PERCENT OF LOAD TO SPACE
LIGHTS	RCFLR-NV	2.00	0.	70.0

UNDERGROUND SURFACES

SURFACE NAME	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION NAME	U-VALUE (BTU/SQ FT/ HR/DEG F)
	1	12000.	GARAGE-WALL	.60
	1	20000.	GARAGE-WALL	.60

DATA FOR SPACE *TOP-FLOOR-EAST*

LOCATION OF ORIGIN
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	0.0	0.0	1	13.	3000.	39000.

TOTAL NUMBER OF SURFACES	NUMBER OF EXTERIOR SURFACES	NUMBER OF INTERIOR SURFACES	NUMBER OF UNDERGROUND SURFACES
2	2	0	0

NUMBER OF SUBSURFACES

TOTAL	WINDOWS	DOORS
1	1	0

FLOOR WEIGHT (LBS/SQ FT)	CALCULATION TEMPERATURE (DEG F)
70.0	75.0

INFILTRATION

SCHEDULE	INFILTRATION CALCULATION METHOD	CFM PER SQ FT	AIR CHANGES PER HOUR	HEIGHT TO NEUTRAL ZONE (FT)
INFILTRATION	1	0.00	.50	0.0

PEOPLE

SCHEDULE	NUMBER	ACTIVITY LEVEL (BTU/HR)	AREA PER PERSON (SQ FT)
OCCUPANCY	28.0	450.0	107.1

(CONTINUED TO NEXT PAGE)

REPORT- V03 DETAILS OF SPACE *TOP-FLOOR (CONTINUED)

LIGHTING

SCHEDULE	LIGHTING TYPE	LOAD (WATTS/ SQ FT)	LOAD (KW)	PERCENT OF LOAD TO SPACE
LIGHTS	RCFLR-NV	3.00	0.	80.0

ELECTRICAL EQUIPMENT

SCHEDULE	ELEC LOAD (WATTS/ SQ FT)	ELEC LOAD (KW)	PERCENT LOAD TO SPACE SENSIBLE	LATENT
EQUIPMENT	.18	0.	0.0	0.0

EXTERIOR SURFACES

SURFACE NAME	MULTIPLIER	AREA (SQ FT)	WIDTH (FT)	HEIGHT (FT)	CONSTRUCTION NAME	U-FACTOR (BTU/SQ FT/ HR/DEG F)	SURFACE TYPE
EAST-WALL	1	2600.	200.00	13.00	WALL-1	.28	DELAYED
	1	3000.	15.00	200.00	ROOF	.23	DELAYED

SURFACE NAME	AZIMUTH (DEG)	TILT (DEG)	LOCATION OF ORIGIN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN SPACE COORDINATES X (FT)	Y (FT)	Z (FT)
EAST-WALL	90.0	90.0	15.00	0.00	0.00	15.00	0.00	0.00
	180.0	0.0	0.00	0.00	13.00	0.00	0.00	13.00

RECTANGULAR WINDOWS

WINDOW NAME	MULTIPLIER	AREA (SQ FT)	SHADING COEFF	NUMBER OF PANES	GLASS TYPE INDEX	REVEAL (FT)	WIDTH (FT)	HEIGHT (FT)	SKY FORM FACTOR	GROUND FORM FACTOR
	1	650.	.86	2	1	0.00	6.50	100.00	.50	.50

(CONTINUED TO NEXT PAGE)

REPORT- V03 DETAILS OF SPACE *TOP-FLOOR (CONTINUED)

WINDOW NAME	LOCATED IN SURFACE	LOCATION OF ORIGIN BUILDING COORDINATES XB (FT)	YB (FT)	ZB (FT)	LOCATION OF ORIGIN SURFACE COORDINATES J (FT)	K (FT)
	EAST-WALL	15.00	0.00	0.00	0.00	0.00

REPORT- V04 DETAILS OF EXTERIOR SURFACES OCCURRING IN THE PROJECT.

NUMBER OF EXTERIOR SURFACES 13 RECTANGULAR 13 OTHER 0

RECTANGULAR SURFACES

SURFACE NAME	MULTIPLIER	HEIGHT (FT)	WIDTH (FT)	AZIMUTH (DEG)	TILT (DEG)	GROUND REFLEC-TANCE	X-DIVISIONS	LOCATION OF ORIGIN SPACE COORDINATES X (FT)	Y (FT)	Z (FT)
	1	170.00	70.00	180.	0.	.20	20	0.00	0.00	13.00
WEST-WALL	1	13.00	200.00	270.	90.	.20	20	0.00	200.00	0.00
	1	200.00	15.00	180.	0.	.20	20	0.00	0.00	13.00
SOUTH-WALL	1	13.00	100.00	180.	90.	.20	20	0.00	0.00	0.00
	1	15.00	100.00	180.	0.	.20	20	0.00	0.00	13.00
EAST-WALL	1	13.00	200.00	90.	90.	.20	20	15.00	0.00	0.00
	1	200.00	15.00	180.	0.	.20	20	0.00	0.00	13.00
NORTH-WALL	1	13.00	100.00	0.	90.	.20	20	100.00	15.00	0.00
	1	15.00	100.00	180.	0.	.20	20	0.00	0.00	13.00
MID-WALL-WEST	1	13.00	200.00	270.	90.	.20	20	0.00	200.00	0.00
MID-WALL-SOUTH	1	13.00	100.00	180.	90.	.20	20	0.00	0.00	0.00
MID-WALL-EAST	1	13.00	200.00	90.	90.	.20	20	15.00	0.00	0.00
MID-WALL-NORTH	1	13.00	100.00	0.	90.	.20	20	100.00	15.00	0.00

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
	ROOF	.23	.70	3	0.00	DELAYED	4
WEST-WALL	WALL-1	.28	.70	3	0.00	DELAYED	4
	ROOF	.23	.70	3	0.00	DELAYED	4
SOUTH-WALL	WALL-1	.28	.70	3	0.00	DELAYED	4
	ROOF	.23	.70	3	0.00	DELAYED	4
EAST-WALL	WALL-1	.28	.70	3	0.00	DELAYED	4
	ROOF	.23	.70	3	0.00	DELAYED	4
NORTH-WALL	WALL-1	.28	.70	3	0.00	DELAYED	4
	ROOF	.23	.70	3	0.00	DELAYED	4
MID-WALL-WEST	WALL-1	.28	.70	3	0.00	DELAYED	4
MID-WALL-SOUTH	WALL-1	.28	.70	3	0.00	DELAYED	4
MID-WALL-EAST	WALL-1	.28	.70	3	0.00	DELAYED	4
MID-WALL-NORTH	WALL-1	.28	.70	3	0.00	DELAYED	4

REPORT- V05 DETAILS OF UNDERGROUND SURFACES OCCURRING IN THE PROJECT

NUMBER OF UNDERGROUND SURFACES 2

SURFACE NAME	MULTIPLIER	AREA (SQ FT)	CONSTRUCTION NAME	U-VALUE (BTU/SQ FT/ HR/DEG F)
	1	12000.	GARAGE-WALL	.60
	1	20000.	GARAGE-WALL	.60

REPORT- V06 DETAILS OF INTERIOR SURFACES OCCURRING IN THE PROJECT

NUMBER OF INTERIOR SURFACES 0

REPORT- V07 DETAILS OF SCHEDULES OCCURRING IN THE PROJECT

NUMBER OF SCHEDULES 4

SCHEDULE *OCCUPANCY*

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR DAYS MON TUE WED THU FRI

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	.60	.40	.80	1.00	1.00	1.00	.30	.10	.10	.10	0.00	0.00	0.00	0.00

SCHEDULE *LIGHTS*

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR DAYS MON TUE WED THU FRI

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	.60	.40	.80	1.00	1.00	1.00	.30	.10	.10	.10	0.00	0.00	0.00	0.00

SCHEDULE *EQUIPMENT*

(CONTINUED TO NEXT PAGE)

REPORT- V07 CETAILS CF SCHEDULES OCCURRING IN THE PROJECT (CONTINUED)

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR DAYS MON TUE WED THU FRI

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	.80	.40	.80	1.00	1.00	1.00	.30	.10	.10	.10	0.00	0.00	0.00	0.00

SCHEDULE *INFILTRATION*

THROUGH 31 12

FOR DAYS SUN SAT HOL

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

FOR DAYS MON TUE WED THU FRI

HOUR	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	.80	.40	.80	1.00	1.00	1.00	.30	.10	.10	.10	0.00	0.00	0.00	0.00

REPORT- V09 CETAILS OF WINDOWS OCCURRING IN THE PROJECT

NUMBER OF WINDOWS 8 RECTANGULAR 8 OTHER 0

RECTANGULAR WINDOWS

WINDOW NAME	MULTIPLIER	HEIGHT (FT)	WIDTH (FT)	LOCATION OF ORIGIN SURFACE COORDINATES J (FT)	K (FT)
LONG-WINDOW	1	6.50	100.00	0.00	0.00
SHORT-WINDOW	1	6.50	200.00	0.00	0.00
	1	6.50	100.00	0.00	0.00
	1	6.50	200.00	0.00	0.00
	1	6.50	100.00	0.00	0.00
	1	6.50	200.00	0.00	0.00
	1	6.50	100.00	0.00	0.00
	1	6.50	200.00	0.00	0.00

WINDOW NAME	SETBACK (FT)	SKY FORM FACTOR	GROUND FORM FACTOR	X-DIVISIONS	SHADING COEFF	NUMBER OF PANES	GLASS TYPE CODE	INFILTRATION FLOW COEFF
LONG-WINDOW	0.00	.50	.50	20	.86	2	1	0.00
SHORT-WINDOW	0.00	.50	.50	20	.86	2	1	0.00
	0.00	.50	.50	20	.86	2	1	0.00
	0.00	.50	.50	20	.86	2	1	0.00
	0.00	.50	.50	20	.86	2	1	0.00
	0.00	.50	.50	20	.86	2	1	0.00
	0.00	.50	.50	20	.86	2	1	0.00
	0.00	.50	.50	20	.86	2	1	0.00

REPORT- V12 CETAILS OF CONSTRUCTIONS OCCURRING IN THE PROJECT

NUMBER OF CONSTRUCTIONS 4 DELAYED 2 QUICK 2

CONSTRUCTION NAME	U-VALUE (BTU/SQ FT/ HR/DEG F)	SURFACE ABSORPTANCE	SURFACE ROUGHNESS INDEX	INFILTRATION FLOW COEFFICIENT	SURFACE TYPE	NUMBER OF RESPONSE FACTORS
ROOF	.23	.70	3	0.00	DELAYED	4
WALL-1	.28	.70	3	0.00	DELAYED	4
GARAGE-WALL	.60	.70	3	0.00	QUICK	0
FLOOR-CEILING	.28	.70	3	0.00	QUICK	0

VIII. WEATHER DATA

* In Preparation

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 Cal-ERDA library are given.

Ordinarily, the user only needs to use the WEATHER-STATION command followed by the code-name for the desired weather station. This command is described in Chapter III.

A list of weather stations available in the Cal-ERDA library is given in Table VIII-1, 2, and 3, including location data.

If the required weather data are not in the Cal-ERDA library, the user can create his own weather file using the Weather Processor Programs at LBL.

B. Weather Variables

The weather variables used by Cal-ERDA 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

This file also contains the latitude, longitude, and time zone of the station which may be overridden by using the BUILDING-LOCATION command described in Chapter III.

C. Weather Files

Three groups of weather files are available in the Cal-ERDA library.

1. TRY

The Cal-ERDA library has one year of data for each of 60 different U.S. weather stations selected according to the ASHRAE Test Reference Year (TRY) procedure. Table VIII-1 lists the TRY cities presently available.

A manual for the TRY data, published by the National Climatic Center in Asheville, N. C., is reproduced in Appendix VIII.1.

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

One year of data for each of 15 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 Figure VIII-1. Table VIII-2 gives the Cal-ERDA file name and the major cities for each of the 15 zones.

3. DOE Laboratories

One year of data is available for several of the Department of Energy (DOE) laboratories, as listed in Table VIII-3.

TABLE VIII-1

Weather Data

Data for additional cities will be added if it becomes available.

STATE AND CITY	YEAR	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
ALABAMA					
BIRMINGHAM	1965	33.57	86.85	6	610
MOBILE					
HUNTSVILLE					
ALASKA					
ANCHORAGE					
FAIRBANKS					
JUNEAU					
ARIZONA					
FLAGSTAFF					
PHOENIX	1951	33.43	112.02	7	1117
ARKANSAS					
LITTLE-ROCK					
CALIFORNIA					
FRESNO	1951	36.77	119.72	8	326
LOS-ANGELES	1973	33.93	118.40	8	99
LOS-ANGELES , airport					
SACRAMENTO	1962	38.52	121.50	8	17
SAN-DIEGO	1974	32.43	117.17	8	19
SAN-FRANCISCO	1974	37.62	122.38	8	8
SAN-FRANCISCO , airport					
SAN-JOSE					
COLORADO					
DENVER					
GRAND-JUNCTION					
CONNECTICUT					
HARTFORD					
DELAWARE					
WILMINGTON					
DISTRICT OF COLUMBIA					
WASHINGTON-DC	1957	38.85	77.03	5	14

STATE AND CITY	YEAR	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
FLORIDA					
APPACACOLA					
JACKSONVILLE	1965	30.50	81.70	5	24
MIAMI	1964	25.80	80.27	5	7
ORLANDO					
TAMPA	1953	27.97	82.53	5	19
GEORGIA					
ATLANTA	1975	33.65	84.43	5	1005
HAWAII					
HONOLULU					
IDAHO					
BOISE	1966	43.54	116.22	7	2842
ILLINOIS					
ARGONNE					
CHICAGO, downtown	1974	41.78	87.75	6	610
CHICAGO					
PEORIA					
SPRINGFIELD					
INDIANA					
FORT-WAYNE					
INDIANAPOLIS	1972	39.93	86.28	5	793
IOWA					
DES-MOINES					
KANSAS					
DODGE-CITY	1971	37.47	99.97	6	2594
WITCHITA					
KENTUCKY					
LEXINGTON					
LOUISVILLE	1972	38.18	85.73	5	979
LOUISIANA					
LAKE-CHARLES	1966	30.12	93.22	6	14
NEW-ORLEANS	1958	29.98	90.25	6	3

STATE AND CITY	YEAR	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
MAINE					
CARIBOU					
PORTLAND-MAINE	1965	43.65	70.32	5	6]
MARYLAND					
BALTIMORE					
MASSACHUSETTS					
BLUE-HILL					
BOSTON	1969	42.37	71.03	5	15
PITTSFIELD					
MICHIGAN					
DETROIT	1968	42.23	83.33	5	633
MACKINAW-CITY					
MINNESOTA					
DULUTH					
MINNEAPOLIS	1970	44.88	93.22	6	822
MISSISSIPPI					
JACKSON	1964	32.32	90.08	6	330
MISSOURI					
COLUMBIA	1968	38.97	92.32	6	778
KANSAS-CITY	1968	39.12	94.60	6	742
ST -LOUIS	1972	38.45	90.38	6	535
SPRINGFIELD					
MONTANA					
GREAT-FALLS	1956	47.48	111.37	7	3664
HELENA					
NEBRASKA					
OMAHA	1966	41.30	95.90	6	978
NEVADA					
LAS-VEGAS					
RENO					
NEW HAMPSHIRE					
CONCORD					

STATE AND CITY	YEAR	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
NEW JERSEY					
ATLANTIC-CITY					
NEW MEXICO					
ALBUQUERQUE	1959	35.05	106.62	7	5310
LOS-ALAMOS					
NEW YORK					
ALBANY	1969	42.75	73.80	5	277
BUFFALO	1974	42.77	78.73	5	705
NEW-YORK-CITY	1951	40.77	73.90	5	
NORTH CAROLINA					
RALEIGH	1965	35.82	78.78	5	19
NORTH DAKOTA					
BISMARCK	1970	46.77	100.75	6	
OHIO					
CINCINNATI	1957	39.07	84.67	5	1647
CLEVELAND	1969	41.40	81.85	5	777
COLUMBUS					
TOLEDO					
OKLAHOMA					
OKLAHOMA-CITY	1951	35.40	97.60	6	1280
TULSA	1973	36.20	95.90	6	650
OREGON					
MEDFORD	1966	42.37	122.87	8	1298
PORTLAND-OREGON	1960	45.60	122.60	8	21
PENNSYLVANIA					
HARRISBURG					
PHILADELPHIA	1969	39.88	75.25	5	7
PITTSBURGH	1957	40.50	80.72	5	1137
RHODE ISLAND					
PROVIDENCE					

STATE AND CITY	YEAR	LATITUDE (degrees)	LONGITUDE (degrees)	TIME ZONE (numeric)	ALTITUDE (feet)
SOUTH CAROLINA					
CHARLESTON	1955	32.90	80.03	5	41
COLUMBIA					
SOUTH DAKOTA					
PIERRE					
TENNESSEE					
OAK-RIDGE					
KNOXVILLE					
MEMPHIS	1964	35.05	89.98	6	263
NASHVILLE	1972	36.12	86.68	6	577
TEXAS					
AMARILLO	1968	35.23	101.70	6	3607
AUSTIN					
BROWNSVILLE	1955	25.90	97.43	6	16
DALLAS					
EL-PASO	1967	31.80	106.40	7	3918
FORT-WORTH	1975	32.90	97.03	6	544
HOUSTON	1966	29.65	95.28	6	50
LUBBOCK	1955	33.65	101.82	6	3243
SAN-ANTONIO	1960	29.53	98.47	6	792
UTAH					
SALT-LAKE-CITY	1948	40.77	111.97	7	4220
VERMONT					
BURLINGTON	1966	44.47	73.15	5	331
VIRGINIA					
NORFOLK	1969	36.90	76.20	5	26
RICHMOND	1969	37.50	77.33	5	162
WASHINGTON					
RICHLAND					
SEATTLE	1960	47.45	122.30	8	386
SPOKANE					
WISCONSIN					
MADISON	1974	43.13	89.33	6	858
MILWAUKEE					
WYOMING					
CHEYENNE	1974	41.15	104.82	7	6126

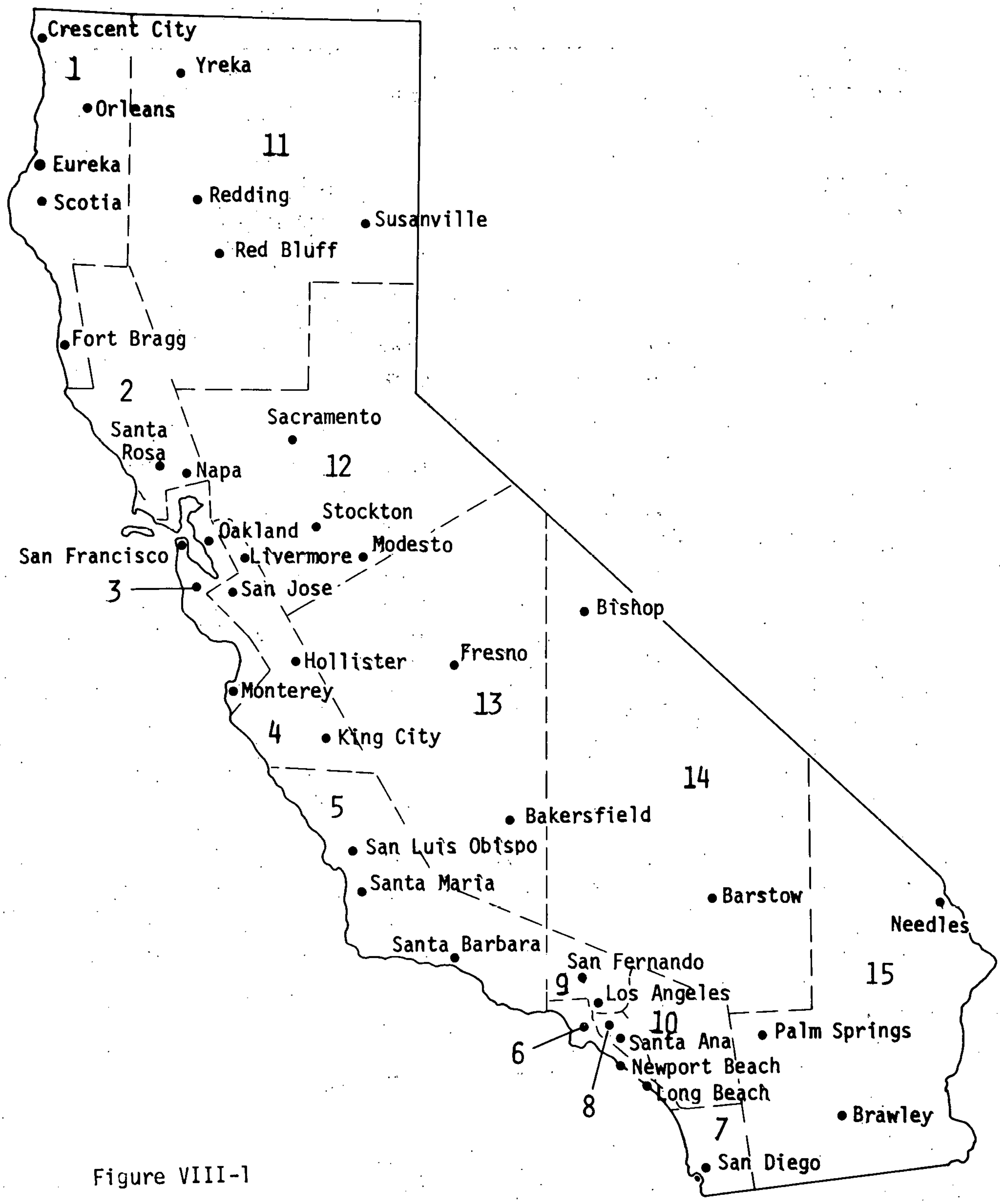


Figure VIII-1

Map of California Climate Zones

Table VIII-2

California Climate Zone Weather File Inventory

Zone	Representative Cities	Cal-ERDA Filename
1. North Coast	Crescent City Eureka Fort Bragg Orleans Scotia	CTZ1
2. North Coast Valley	Healdsburg Napa Petaluma Santa Rosa St. Helena Ukiah	CTZ2
3. San Francisco Bay Area	Berkeley Hamilton AFB Oakland Redwood City San Mateo San Rafael San Francisco	CTZ3
4. Upper Coast Range Valley	Hollister King City Livermore Los Gatos Monterey Salinas San Jose Santa Clara Santa Cruz Watsonville	CTZ4
5. Lower Coast Range Valley	Lompoc Ojai Oxnard Paso Robles San Luis Obispo Santa Barbara Santa Paula Santa Maria	CTZ5
6. Los Angeles Beach	Culver City Laguna Beach Los Angeles Airport Newport Beach Santa Monica Torrance	CTZ6

Zone	Representative Cities	Cal-ERDA Filename
7. San Diego	Chula Vista Escondido San Diego	CTZ7
8. Santa Ana	El Toro Long Beach Santa Ana Yorba Linda	CTZ8
9. Los Angeles City	Burbank Los Angeles Civic Center Pasadena San Fernando San Gabriel	CTZ9
10. San Bernadino	Beaumont Corona Redlands Riverside San Bernadino San Jacinto Upland	CTZ10
11. Northern Zone	Alturas Chico Colusa Marysville McCloud Oroville Orland Red Bluff Redding Susanville Willows Yreka	CTZ11
12. Central Zone	Antioch Auburn Davis Lodi Modesto Nevada City Placerville Sacramento Stockton Tahoe City Vacaville Woodland	CTZ12

Zone	Representative Cities	Cal-ERDA 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

Table VIII-3

ERDA Lab Weather File Inventory

	Laboratory	Location	Year	Cal-ERDA Filename
	Argonne National Lab	Argonne, IL	1968	ARGN68
	Brookhaven National Lab	Upton, NY	1975	BNL
	Fermilab	Batavia, IL	1968	ARGN68
	Lawrence Berkeley Lab	Berkeley, CA	a	CO3
	Los Alamos Scientific Lab	Los Alamos, NM	1974	LASL74
b	Oak Ridge National Lab	Oak Ridge, TN		ORNL
b	Pacific Northwest Lab	Richland, WA		RICHLAND
	Sandia Laboratories	Albuquerque, NM	1958	ALBUQUERQUE
	Stanford Linear Accelerator	Stanford, CA	a	CO4

[a] Weather year does not apply since the data in the California climate zone library is a compilation from many years to date.

[b] Currently unavailable.

D. Solar Radiation Data

None of the present TRY or California weather files contains measured solar radiation data. The program, therefore, calculates hourly values of solar radiation for the station in question on the basis of cloud cover data, using algorithms described in the Program Manual.

For files which do have measured solar radiation, such as BNL and LASL74 (Table VIII-3), the user may specify that the program use measured solar radiation values throughout or use only calcualted values.

SOLMET

One year of solar data for each of 35 U. S. weather stations will be included in the weather data library at a future date. The SOLMET format and a map showing the location of the solar monitoring weather stations are included as Figures 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 Chapter III. When the design day instruction is used, a weather file must also be specified for Cal-ERDA 1.3.

F. Weather Data Processing Programs

Cal-ERDA weather data processing programs are available which can be used to construct packed binary files of weather data for the LOADS, SYSTEMS, and PLANT programs for weather stations which are not in the Cal-ERDA weahter library. They include routines for decoding weather tapes, selecting a benchmark year, the compressing data into a compact form.

The programs in the weather package are as follows:

a. A weather tape decoder and a statistical routine to analyze the data. The packed weather file is first written by this code and may contain up to 10 years' data. (Starting year and number of years run are control card arguments.) Tables are printed for use in selecting a year from the file.

b. An extraction routine which writes the selected year to a separate file and inserts information in the record headers.

c. An editor for replacing missing or incorrect data.

d. A listing program.

e. A five-variable plotting program.

For Cal-ERDA 1.3 these weather processing programs are dependent on the CDC 6600/7600 operating system at LBL.

SOLMET

ID								SOLAR											
DECK =	WBAN STN =	SOLAR TIME					LST TIME	ETR KJ/m²	RADIATION VALUES KJ/m²										SUNSHINE MIN
		YR	MO	DY	HR	MN			DIRECT	DIFFUSE	NET	TILTED	GLOBAL			A	B		
													OBS	ENG COR'ED	MODEL COR'ED	*	*		
9724	XXXXX	XX	XX	XX	XX	XX	XXXX	XXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX	XXXXX		XX

|←—23—→|←—51—→|

SURFACE METEOROLOGY

OB TIME LST	CEIL-ING dam	SKY COND.	VSBY hm	WEATHER	PRESSURE KPa		TEMP °C		WIND		CLOUDS																SNOW COVER
					SEA LEVEL	STATION	DRY BULB	DEW POINT	DIR 36 PTS	SPEED Km/hr	TOTAL	LOWEST			SECOND				THIRD				FOURTH			OPAQUE.	
												AMOUNT	TYPE	HEIGHT dam	AMOUNT	TYPE	HEIGHT dam	SUM AMT	AMOUNT	TYPE	HEIGHT dam	SUM AMT	AMOUNT	TYPE	HEIGHT dam		
XX	XXXX	XXXXX	XXXX	XXXXXXXX	XXXXX	XXXXX	XXXX	XXXX	XX	XXX	XX	XX	XX	XXXX	XX	XX	XXXX	XX	XX	XX	XXXX	XX	XX	XX	XXXX	XX	X

|←—87—→|

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

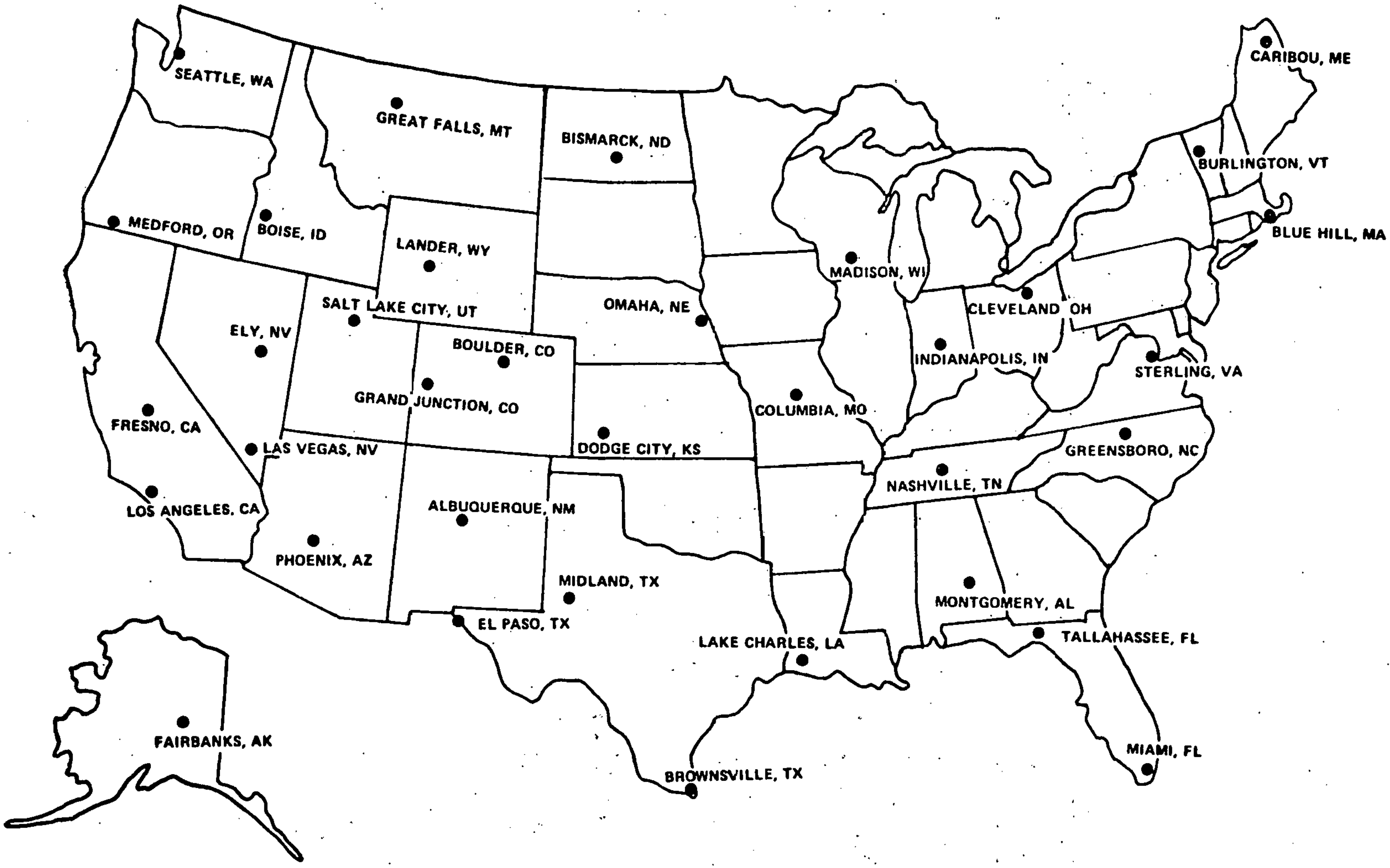
* 'A' AND 'B' ARE SUPPLEMENTAL FIELDS FOR ADDITIONAL RADIATION MEASUREMENTS; I.E., ULTRAVIOLET, TILTED, ETC.

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 10^1)
hm	HECTOMETERS (M x 10^2)
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

Figure VIII - 2



NEW NOAA NATIONAL WEATHER SERVICE NETWORK

FIGURE 3

APPENDIX VIII.1

NOAA TEST REFERENCE YEAR

WEATHER DATA MANUAL

Available From:

National Climatic Center

Federal Building

Asheville, North Carolina 28801

(704) 254-0961

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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 a 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 Test Reference Year, 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 Test Reference Year. 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 Test Reference Year.

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.

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 practises. These led to the development of Card Deck-144. Although the usual beginning date of digital information in this form is June 1948 the changeover 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.

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 practises, for internal consistency, for serial, 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, wind speeds 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 re-subjected 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.

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 practises.

MANUAL AND TAPE NOTATIONS

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.

MANUAL AND TAPE

x = any numeric or alphanumeric character

- = an "11" or zone punch

Δ = blank

NOTE: Missing fields are 9 filled.

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. Enen at that time, however, only a small percentage of the stations will have the Solar Radiation data available.

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 DIR	WIND SPD	STAT PRES	WX	TOT AMT	CLOUDS LAYER 1 AMT	LAYER 1 TYP	LAYER 1 HGT	LAYER 2 AMT	LAYER 2 TYP	LAYER 2 HGT	SUM	LAYER 3 AMT	LAYER 3 TYP	LAYER 3 HGT	SUM	LAYER 4 AMT	LAYER 4 TYP	LAYER 4 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 WMO 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°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	26 - 27	TOTAL SKY COVER	00 - 10 99	Amount of the celestial dome covered by clouds or obscuring phenomena in tenths. 00-10 = 0-10 tenths 99 = Missing
010	28 - 29	AMOUNT OF LOWEST CLOUD LAYER		
013	34 - 35	AMOUNT OF SECOND CLOUD LAYER		
016	40 - 41	SUMMATION OF FIRST TWO LAYERS		
017	42 - 43	AMOUNT OF THIRD CLOUD LAYER		
020	48 - 49	SUMMATION OF FIRST THREE LAYERS		
021	50 - 51	AMOUNT OF FOURTH CLOUD LAYER		

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TAPE FORMAT DOCUMENTATION

TAPE DECK		PAGE NO.
9706	TEST REFERENCE YEAR (TRY)	4

TAPE FIELD NUMBER	TAPE POSITIONS	ELEMENT	TAPE CONFIGURATION	CODE DEFINITIONS AND REMARKS
011	30	TYPE OF LOWEST CLOUD OR OBSCURING PHENOMENA	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
014	36	TYPE OF CLOUD - SECOND LAYER		
018	44	TYPE OF CLOUD - THIRD LAYER		
022	52	TYPE OF CLOUD - FOURTH LAYER		
012	31 - 33	HEIGHT OF BASE OF LOWEST LAYER	000 - 760 777 888 999	Height of base of clouds or obscurring phenomena in hundreds of feet. 000-760 = 0-76,000 feet 777 = Unlimited - clear 888 = Cirroform clouds of unknown height 999 = Missing
015	37 - 39	HEIGHT OF BASE OF SECOND LAYER		
019	45 - 47	HEIGHT OF BASE OF THIRD LAYER		
023	53 - 55	HEIGHT OF BASE OF FOURTH LAYER		
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.

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IX. UTILITY PROGRAMS

*In Preparation

IX. UTILITY PROGRAMS

A. *EXECUTIVE Program

The EXECUTIVE Program is used by the computer operating system to control the processing of the Cal-ERDA Programs. It provides the control card instructions of Job Control Language (JCL) statements necessary to run a job. This program is necessarily somewhat on the current operating system and other site specific details. A CDC 6600/7600 version will be developed as will an IBM 360/370 version.

B. Response Factor Program

1. Introduction

The program PONSFAC calculates Response Factors for walls and roofs based on the details of their construction. The response factor method for calculating the transient effect of heat flow through materials was introduced in Chapter III and is described in more detail in Reference I-1. A detailed flow chart and a description of the algorithms used to calculate the response factors appears in the Program Manual. A description of the input data needed to run the program PONSFAC and an example of the output from the Program are given to illustrate its use.

2. Input to PONSFAC

The input deck to PONSFAC consists of layer-by layer descriptions of constructions for which one wants the response factors. Input deck structure is as shown below:

Card No.	Columns	Variable name	Format	Meaning
1	1-10	FNOC	F	Number of constructions in the input deck
2	1-6	CODENM(1)	A	First six characters of the construction code name
	11-50	CNAME	A	Description of construction
3	1-3	CODENM(2)	A	Last three characters of the construction code name. **
4	7-9	FNOL	F	Number of layers in this construction

The above four cards are to be followed by a layer card for each layer.

** This card is used if code name exceeds 6 characters. If not, card 3 is a blank card.

* In Preparation

The layer card must be repeated FNOL times, and contains the following data.

Card No.	Columns	Variable name	Format	Meaning
5	1-40	DEFC(I,J)	A	Layer Description
	41-48	XL(I)	F	Thickness ft.
	49-56	XK(I)	F	Conductivity Btu/hr-ft^2-^{0}F-ft
	57-64	D(I)	F	Density lb/ft^3
	65-72	SH(I)	F	Specific Heat Btu/lb-^{0}F
	73-80	RES(I)	F	Resistance hr-ft^2-^{0}F/Btu

These cards are to be arranged in the order that the layers exist as seen from the outside of the building toward the inside. The outside air film coefficient is not used in the calculation of the response factors; it is calculated separately in the LOADS program.

For example, if there are 5 layers in a wall then the number 5 appears in columns 7-9 of card 4, (FNOL=5) and card 4 must be followed by five layer data cards (cards 5 through 9). Cards 2 through the last layer data card are to be repeated for each construction in the input deck.

In the description of a layer, the value of resistance (incolumns (73-80) is required only if the values of thickness, conductivity etc., are not given. if these values are given, the entry in columns 73-80 is ignored.

3. Output of Program PONSFAC

The output of the program PONSFAC consists of punched cards and printout of the layer descriptions and the resulting response factors for each construction. An example of the printed output is shown in Figure IX-2.

WALL,LIGHT CONSTRUCTION,WOOD FRAME, UNINSULATED

DESCRIPTION OF CONSTRUCTION

LAYER NUMBER	THICKNESS FT	CONDUCTIVITY BTU PER (HR)(FT)(F)	DENSITY LB PER CU FT	SPECIFIC HEAT BTU PER (LB)(F)	RESISTANCE (HR)(SQ FT)(F) PER BTU		
1	.0729	.417	116.0	.20	0.00	MSTC	MASONRY STUCCO 7/8IN
2	.0417	.093	50.0	.20	0.00	GYPC	GYPSUM OR PLASTER BOARD 1/2 IN
3	0.0000	0.000	0.0	0.00	.92	ALOS	AIR GAP, CEILING OR WALL SPACE
4	.0521	.093	50.0	.20	0.00	GYPU	GYPSUM OR PLASTER BOARD 5/8 IN
5	0.0000	0.000	0.0	0.00	.68	ALL1	AIR LAYER, INTERNAL WALL SURFAC

THERMAL CONDUCTANCE = .3204198815 BTU PER (HR)(SQ FT)(F)

RESPONSE FACTORS

HOUR	X	Y	Z
0	2.2922871931	.1561565746	.5863500878
1	-1.9103181069	.1805891732	-.2185005695
2	-.0223058960	.0133262190	-.0086599470
3	-.0009282845	.0005930326	-.0003798201

NUMBER OF HOURS REQUIRED TO REACH COMMON RATIO = 3
NUMBER OF RESPONCE FACTORS PER SET = 4
COMMON RATIO = .0439657259

Example of PONSFAC Output

Figure IX-1

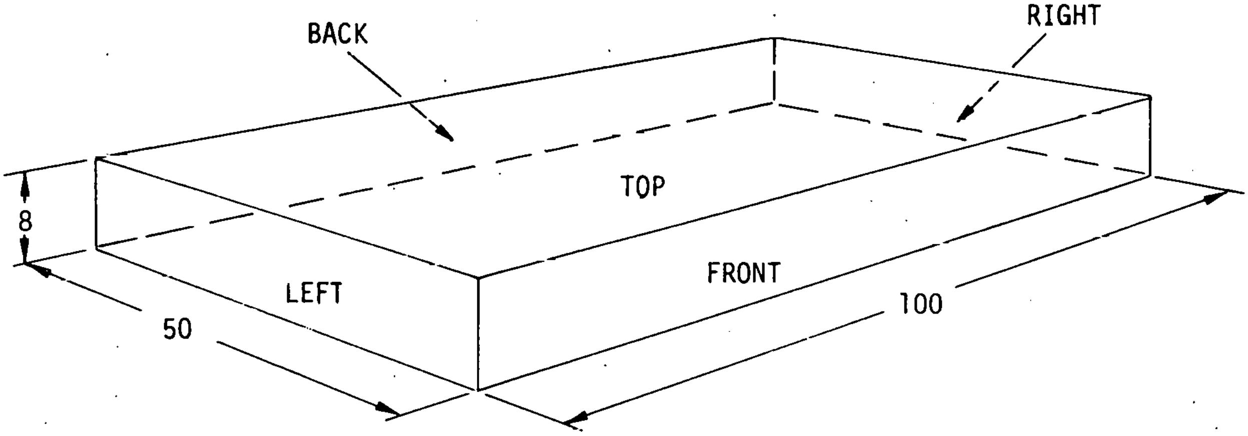
```
*
 OFFICE FLOOR SLAB1
O-FLS1              3  .124775404272
     FL 4 INCH CONCRETE                               .3334 1.0000140.000   .200 0.0000
     FL 2 INCH INSULATION BOARD                       .1667  .0250  2.000   .200 0.0000
     FL INSIDE AIR FILM                              0.0000 0.0000  0.000  0.000  .6800
             4     .4416118149     .4759908336     .1196064325
               5.912257034058  .018132610981  .152461739374
              -4.008216952052  .057824483191 -.020617631883
               -.990800170094  .030273971881 -.000926769503
               -.437249078334  .013375366418 -.000409151348
*
 OFFICE ROOF CONSTRUCTION
O-RFC1              4  .063269675857
     RF BUILT-UP ROOF                                 .0313  .0950 70.000   .330 0.0000
     RF 3 INCH INSULATION BOARD                       .2500  .0250  2.000   .200 0.0000
     RF 8 INCH CONCRETE                               .6667 1.0000140.000   .200 0.0000
     RF INSIDE AIR FILM                              0.0000 0.0000  0.000  0.000  .6800
             5     .9371496908     .0929728788     .0122007100
                .827755451819  .000008297351 1.211714453782
               -.732645112120  .000709953711 -.168721695859
               -.000979598382  .002835613831 -.089550674385
               -.000627701094  .004143780482 -.065724727118
               -.000530161387  .004503064624 -.054743676152
*
 OFFICE WALL CONSTRUCTION
EO-WC1              4  .062440067896
     WL 8 INCH CONCRETE                               .6667 1.0000140.000   .200 0.0000
     WL 3 INCH INSULATION BOARD                       .2500  .0250  2.000   .200 0.0000
     WL GYPSUM BOARD                                  .0417  .0926100.000   .200 0.0000
     WL INSIDE AIR FILM                              0.0000 0.0000  0.000  0.000  .6800
             6     .8131868751    1.0242942889     .0422276394
               5.970819668122  .000018708861  .658962220064
              -3.499754375840  .001912180582 -.444072084810
               -.600016323041  .008162956875 -.098310440439
               -.359108247051  .011473493034 -.022547218463
               -.270909763489  .011109360519 -.005461264201
               -.216736689825  .009550939484 -.001549527613
*
 OFFICE WALLS BLDG90
B-90WL              4  .197223839666
     ASBESTOS CEMENT                                  .0210  .4000120.000   .200 0.0000
     INSULATION                                       .0830  .0210  9.000   .190 0.0000
     ASBESTOS CEMENT                                  .0210  .4000120.000   .200 0.0000
     INSIDE AIR FILM                                 0.0000 0.0000  0.000  0.000  .6800
             4     .0489694055     .2110898639     .2110760110
                .774148675273  .122727948690  .590808509764
               -.561908377655  .083735498932 -.361183275730
               -.001096727618  .004397233494 -.017630334005
               -.000053706069  .000215329915 -.000863346974
*
 ROOF BLDG90
B-90RF              4  .142369945358
     BUILT-UP ROOFING                                 .0310  .6700 70.000   .350 0.0000
     STEEL                                           0.0000 0.0000  0.000  0.000  .0004
     INSULATION                                       .1670  .0280 16.000   .250 0.0000
     INSIDE AIR FILM                                 0.0000 0.0000  0.000  0.000  .6800
             4     .1379764339     .1498252832     .1491154563
               1.125509693944  .046279233103  .311516416504
               -.956614316247  .085325889608 -.145625529880
               -.016759890605  .015385811220 -.014166873439


               -.002310203867  .002124522393 -.001953779271
*
 BASEMENT WALLS BLDG90
B-90BB              2  .542593597396
     CONCRETE                                         .8300 1.0000 65.000   .160 0.0000
     INSIDE AIR FILM                                 0.0000 0.0000  0.000  0.000  .6800
             4     .5410627089     .8985064802     .5434521031
               3.638667314722  .038273477119 1.085631409657
              -2.148284885448  .223207508022 -.218072700461
               -.390834396795  .181358326326 -.094839052109
               -.201041552256  .100612791615 -.050717912833
*
```

```
 SINGLE-FAMILY DWELLING,RUOF
SF1-RF               7  .044361025551
      SLATE                                           .0417  .8300 55.000   .400 0.0000
      FELT                                            .0313  .1100 70.000   .400 0.0000
      WOOD                                            .0833  .0700 37.000   .600 0.0000
      AIR SPACE                                      0.0000 0.0000  0.000  0.000 1.0000
      INSULATION                                      .4750  .0250  2.000   .200 0.0000
      GYPSUM                                          .0313  .4200100.000   .200 0.0000
      INAR                                           0.0000 0.0000  0.000  0.000  .6100
              5     .5131835391     .1133681515     .0380516625
               2.523792516723  .000164114323  .625190051257
              -1.964630713993  .006290033488 -.513956607536
               -.253870893424  .014139106046 -.055635491277
               -.127011824802  .011081723944 -.008082980550
               -.064910933027  .006376684724 -.001613839631
*
 SINGLE-FAMILY DWELLING, WALL
SF1-SW               5  .075300867305
      STUCCO.0                                        .0833  .4000116.000   .200 0.0000
      AIR SPACE                                      0.0000 0.0000  0.000  0.000  .9100
      INSULATION                                      .2750  .0250  2.000   .200 0.0000
      GYPBOARDON                                      .0625  .4200100.000   .200 0.0000
      INAR                                           0.0000 0.0000  0.000  0.000  .6800
              5     .3256749890     .0773339942     .0763240579
               2.007197054138  .011522178063  .849616564987
              -1.922483127749  .039380197050 -.521707922437
               -.006550167273  .017722816991 -.169034808301
               -.000630121668  .005807428281 -.055049348169
               -.000199623242  .001891477528 -.017928192089
*
 USERS MAN.
WA01-2               5  .067610626634
     WS01        SHINGLES                             .0583  .0667 32.000   .300 0.0000
     PW03        PLYWOOD                              .0417  .0667 34.000   .290 0.0000
     IN02        INSULATION                           .2957  .0250  6.000   .200 0.0000
     GP01        GYPSUM                               .0417  .0926 50.000   .200 0.0000
     AL01        INSIDE AIR FILM                     0.0000 0.0000  0.000  0.000  .6800
              5     .3214146464     .0730140463     .0670543253
                .852743203098  .001557489671  .474767082822
               -.645642957926  .022754925841 -.347755939603
               -.098516117844  .026405183336 -.044009505374
               -.027271093163  .012041131707 -.009854998496
               -.008299007910  .004295596700 -.002750431006
*
 USERS MAN.
RB01-1               5  .192677058517
     RG01        ROOF GRAVEL                          .0417  .8340 55.000   .400 0.0000
     BR01        BUILT UP ROOF                        .0313  .0939 70.000   .350 0.0000
     IN72        ROOF INSULATION                      .0833  .0300  5.700   .200 0.0000
     WO01        WOOD SHEATHING                       .0625  .0667 32.000   .330 0.0000


     AL03        INSIDE AIR FILM                     0.0000 0.0000  0.000  0.000  .7600
              4     .1606967617     .2063108633     .2051454714
               1.879212954998  .060920135174  .533485750807
              -1.656368193413  .116277978339 -.277342230793
               -.014320118376  .024074061345 -.042180647969
               -.002213779904  .003873296511 -.006778043728
```

X. EXAMPLES



Example 1, Simple One Space Building

L D L   P R O C E S S O R   I N P U T   D A T A

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/*THE ILLUSTRATION BEGINS WITH A SIMPLE, SINGLE ZONE BUILDING CONSISTING OF
FOUR WALLS, A ROOF, AND A FLOOR. THIS IS CALLED EXAMPLE BUILDING 1*/

/*THE FIRST INSTRUCTIONS IDENTIFY THE PROJECT, WEATHER INPUT, DIAGNOSTIC
ANNOTATIONS TO THE INPUT LISTING, TYPE OF OUTPUT REPORT, AND GEOGRAPHIC
LOCATION.*/

/*COMMENTS WHICH INCLUDE THE PARENTHETICAL STATEMENT (WILL GO HERE)
REPRESENT COMMANDS WHICH WILL SOON BE OPERATIONAL.*/

                 /*INPUT               LOADS    (WILL GO HERE)*/

TITLE   EXAMPLE BUILDING 1
TITLE   USER NAME

                              /*PROGRAM CONTROL INSTRUCTIONS*/

                 /*WEATHER-STATION     CHICAGO  (WILL GO HERE)*/
                   RUN-PERIOD          JAN 1 1974  THRU  DEC 31 1974
                   LIST                ABORT ERROR
                   DIAGNOSTIC          WARNING
                   LOADS-REPORT        L02
                   BUILDING-LOCATION   LATITUDE = 42.0 LONGITUDE = 88.0
                                       TIME-ZONE=6.0  BUILDING-AZIMUTH=30.0

/*BUILDING-AZIMUTH FIXES THE ORIENTATION OF THE BUILDING.  IT IS THE ANGLE
MEASURED FROM NORTH (POSITIVE IN THE CLOCKWISE DIRECTION) TO THE Y-AXIS OF THE
BUILDING COORDINATE SYSTEM.  THIS IS NORMALLY ALONG THE LEFT WALL AT GRADE
LEVEL.*/

/*THE NEXT INSTRUCTIONS ADDRESS THE THERMAL CHARACTERISTICS OF WALLS AND ROOF.
EACH OF THE MATERIALS IN THE WALL IS INDIVIDUALLY DEFINED, THEN THE LAYERS
COMMAND CAUSES THE COMPOSITE RESPONSE FACTORS TO BE COMPUTED.
LIKEWISE FOR THE ROOF.*/

                              /*COMPUTE RESPONSE FACTORS*/

/* THE U-NAMES, WS01 ETC., ARE LIBRARY NAMES ( SEE TABLE XI-C-1, USERS
MANUAL) FOR SPECIFIC MATERIALS.  IF THEY HAD BEEN CALLED FROM THE LIBRARY, IT
WOULD NOT HAVE BEEN NECESSARY TO ENTER THICKNESS, CONDUCTIVITY, DENSTIY, AND
SPECIFIC HEAT AS SHOWN HERE.  IFR IS INSIDE FILM RESISTANCE.  MATERIALS ARE
LISTED FROM OUTSIDE LAYER TO IFR.*/

WS01=MATERIAL      TH=.0583  CON=.0667 DE=32.    SPH=.3 /*WOOD SHINGLES*/
PW03=MATERIAL      TH=.0417  CON=.0667  DE=34.   SPH=.29 /*PLYWOOD SHEATH*/
IN02=MATERIAL      TH=.2957  CON=.025  DE=6.     SPH=.2 /*FIBERGLASS INS*/
GP01=MATERIAL      TH=.0417  CON=.0926 DE=50.    SPH=.2 /*GYPSUM BOARD*/
WA01-2=LAYERS      M1=WS01 M2=PW03 M3=IN02 M4=GP01 IFR=.68

RG01=MATERIAL      TH=.0417  CON=.834  DE=55.    SPH=.4 /*ROOF GRAVEL*/
BR01=MATERIAL      TH=.0313  CON=.0939 DE=70.    SPH=.35 /*BUILT UP ROOF*/
IN72=MATERIAL      TH=.0833  CON=.03   DE=5.7    SPH=.2 /*FIBERGLASS INS*/
WD01=MATERIAL      TH=.0625  CON=.0667 DE=32.    SPH=.33 /*WOOD SHEATH*/
RB01-1=LAYERS      M1=RG01 M2=BR01 M3=IN72 M4=WD01 IFR=.76

/*THE COMMAND WORD CONSTRUCTION IS ASSIGNED A USER NAME AND CONSTRUCTION TYPE
FOR EACH SURFACE. NOTE THAT THE WALL AND ROOF USE RESPONSE FACTORS. THE FLOOR IS
ASSIGNED A U-VALUE BECAUSE IT IS EXPERIENCING STEADY-STATE HEAT TRANSFER.*/

                              /*CONSTRUCTION*/

WALL-1         =CONSTRUCTION       WALL-TYPE=WA01-2
ROOF-1         =CONSTRUCTION       ROOF-TYPE=RB01-1
FLOOR-1        =CONSTRUCTION       U = 0.45
```

```
/*THE CHARACTERISTICS OF THE SPACE(ZONE) ARE DEFINED NEXT. THESE HAVE TO DO WITH
THE GEOMETRY AND LOCATION OF THE SPACE, THE SOURCES OF INTERNAL LOADS,
AND THE NATURE OF THE INFILTRATION. SINCE THIS FIRST EXAMPLE IS A SIMPLE
BOX, ONLY THE  GEOMETRY AND LOCATION ARE PERTINENT.*/

                                   /*GENERAL SPACE DEFINITIONS*/

ROOM-1           =SPACE                    AREA  =  5000,
                                           VOLUME=40000,
                                           X=0 Y=0 Z=0                                  ..

/* WE NEXT CONSIDER THE EXTERIOR SURFACES OF THE SPACE. THE GEOMETRY,
ORIENTATION, AND LOCATION WITH RESPECT TO THE  PARENT SPACE  ARE DEFINED
FOR EACH OF THE BOUNDING SURFACES OF THE SPACE. THE PREVIOUSLY DEFINED THERMAL
CHARACTERISTICS ARE RECALLED WITH THE CONSTRUCTION COMMAND.*/

/* THE KEYWORD TEMPERATURE HAS BEEN ALLOWED TO DEFAULT AT 70F. PEAK LOADS WILL
BE COMPUTED BASED ON THIS FIXED TEMPERATURE. VARIABLE TEMPERATURE WILL NOT COME
INTO PLAY UNTIL LOADS ARE RECALCULATED BY SYSTEMS.*/

/*THE X-AXIS IS ALONG THE FRONT OF THE BUILDING AT GRADE LEVEL. THE Y-AXIS IS
ALONG THE LEFT SIDE OF THE BUILDING AT GRADE LEVEL. THE Z-AXIS IS STRAIGHT UP
FROM GRADE AT THE INTERSECTION OF THE FRONT AND LEFT WALLS. THE AZIMUTH OF
FRONT-1, 180, IS THE NUMBER OF DEGREES MEASURED CLOCKWISE FROM THE Y-AXIS TO
THE OUTWARD NORMAL OF FRONT-1. THE LOWER LEFT CORNER OF FRONT-1 AS VIEWED
FROM THE OUTSIDE (LOOKING INTO THE OUTWARD NORMAL) IS AT X=0, Y=0, Z=0. THE
LOWER LEFT HAND CORNER OF ALL EXTERIOR SURFACES AS SEEN BY AN OBSERVER
LOOKING INTO THE OUTWARD NORMAL IS ALWAYS AT THE SURFACE ORIGIN.  THE
TILT KEYWORD IS ALLOWED TO DEFAULT TO 90 FOR THE VERTICAL WALLS. TILT IS DEFINED
AS THE NUMBER OF DEGREES BETWEEN THE OUTWARD NORMAL AND VERTICAL.*/


/* U-NAMES SUCH AS FRONT-1 ARE ARBITRARY.  ALSO THEY DON'T HAVE TO BE ASSIGNED
TO SURFACES UNLESS YOU ARE GOING TO REFERENCE THEM LATER.*/

    FRONT-1     =EXTERIOR-WALL        HEIGHT = 8               WIDTH = 100
                                      X=0    Y=0    Z=0        AZIMUTH = 180
                                      CONSTRUCTION = WALL-1                      ..

    RIGHT-1     =EXTERIOR-WALL        HEIGHT = 8               WIDTH =  50
                                      X=100 Y=0     Z=0        AZIMUTH =  90
                                      CONSTRUCTION = WALL-1                      ..

    BACK-1      =EXTERIOR-WALL        HEIGHT = 8               WIDTH = 100
                                      X=100 Y=50   Z=0         AZIMUTH =   0
                                      CONSTRUCTION = WALL-1                      ..

    LEFT-1      =EXTERIOR-WALL        HEIGHT = 8               WIDTH = 50
                                      X=0    Y=50  Z=0         AZIMUTH = -90
                                      CONSTRUCTION = WALL-1                      ..

/*BOTTOM-1 IS A GRADE LEVEL FLOOR AND IS CONSIDERED AN INTERIOR SURFACE. TILT
AND AZIMUTH DO NOT APPLY TO INTERIOR SURFACES. HEAT TRANSFER WILL BE STEADY-
STATE BETWEEN GROUND TEMPERATURE AND SPACE TEMPERATURE.*/

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

/*CONSIDER THE ROOF INITIALLY AS A VERTICAL WALL WITH THE LOWER LEFT CORNER AT
X=0, Y=0, Z=8, AND AZIMUTH=180. IT WILL APPEAR AS A FALSE FRONT ON TOP OF
FRONT-1. THE COMMAND TILT=0 WILL ROTATE THIS SURFACE ABOUT THE X-AXIS UNTIL THE
OUTWARD NORMAL IS POINTING STRAIGHT UP. THE ROOF IS NOW IN PLACE.*/

    TOP-1       =ROOF                 LENGTH = 100             WIDTH = 50
                                      X=0    Y=0    Z=8        AZIMUTH = 180
                                      TILT = 0
                                      CONSTRUCTION = ROOF-1                      ..

/*ALL NECESSARY INPUTS HAVE NOW BEEN MADE TO PERFORM A LOADS ANALYSIS ON
EXAMPLE BUILDING 1.*/

END  /*LOADS*/                                                                   ..
```

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
ROOM-1	1.	65.877	JUL 7 4 PM	88F	73F	-102.218	JAN 12 9 AM	-8F	-8F
SUM		65.877				-102.218			
BUILDING PEAK		65.877	JUL 7 4 PM	88F	73F	-102.218	JAN 12 9 AM	-8F	-8F

SPACE ROOM-1

MULTIPLIER 1

FLOOR AREA 5000 SQFT 464 SQMT
VOLUME 40000 CUFT 1132 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 9 AM	
DRY-BULB TEMP	88F	31C	-8F	-22C
WET-BULB TEMP	73F	23C	-8F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	5.047	5.32	0.000	0.00	-11.928	-12.59
CEILINGS	56.330	59.43	0.000	0.00	-76.790	-81.02
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	4.500	4.75	0.000	0.00	-13.500	-14.24
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	65.877	69.50	0.000	0.00	-102.218	-107.85

	COOLING		HEATING	
TOTAL LOAD	65.877 KBTU/H	69.50 MJ/H	-102.218 KBTU/H	-107.85 MJ/H
TOTAL LOAD / AREA	13.18 BTUH/SQFT	.14979 MJ/H/SQMT	20.44 BTUH/SQFT	.23243 MJ/H/SQMT

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

*** BUILDING ***

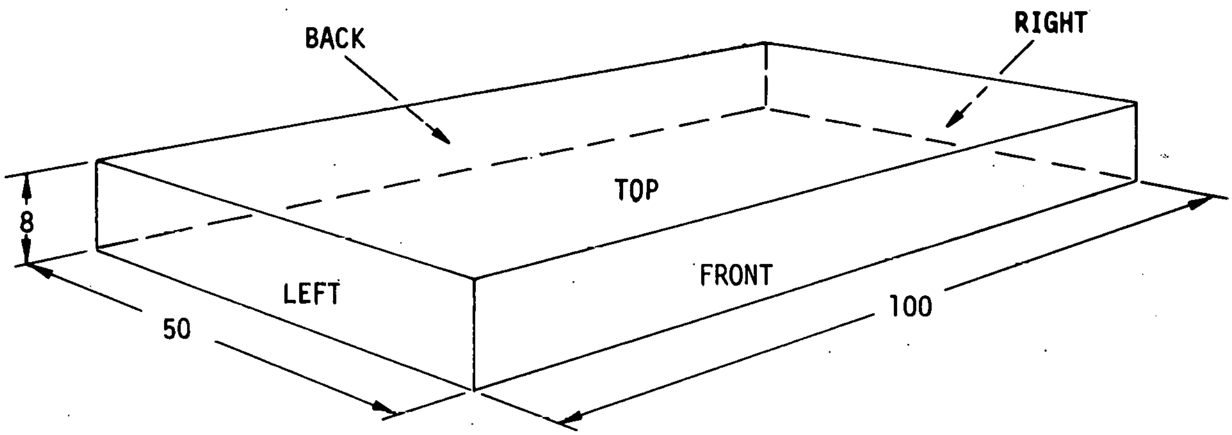
FLOOR AREA	5000	SQFT	464	SQMT
VOLUME	40000	CUFT	1132	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 9 AM	
DRY-BULB TEMP	88F	31C	-8F	-22C
WET-BULB TEMP	73F	23C	-8F	-22C

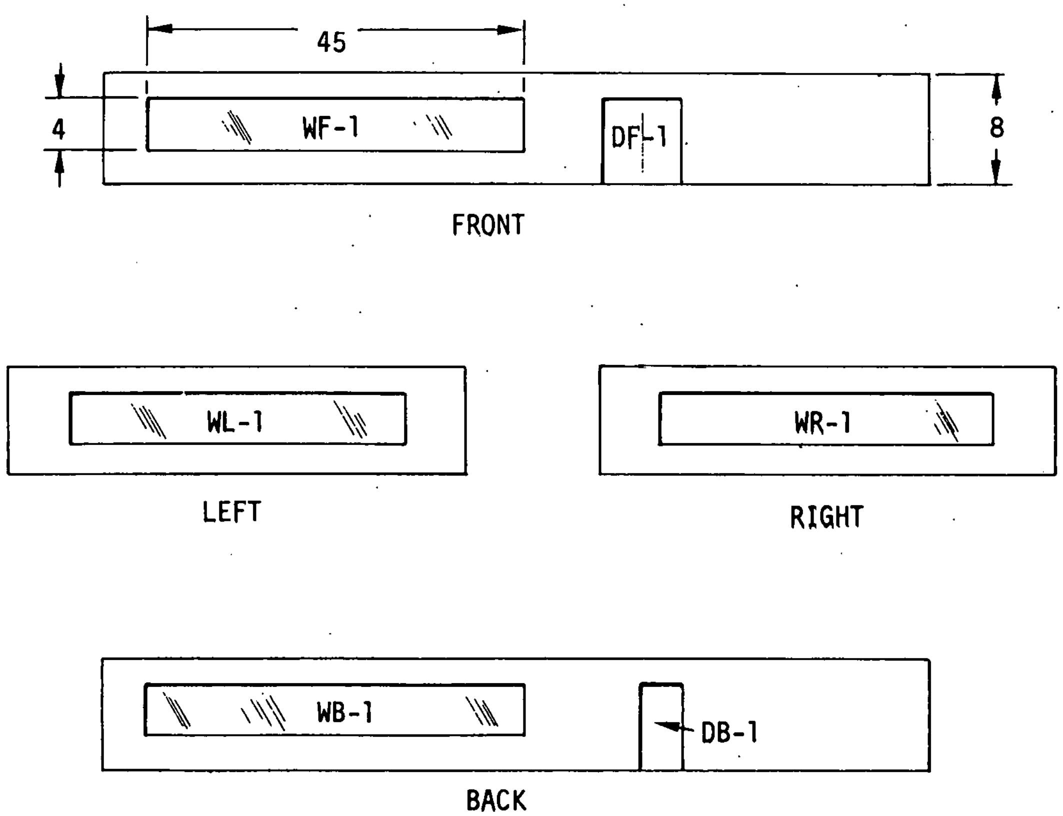
	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (MJ/H)	COOLING LATENT (KBTU/H)	COOLING LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	5.047	5.32	0.000	0.00	-11.928	-12.59
CEILINGS	56.330	59.43	0.000	0.00	-76.790	-81.02
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	4.500	4.75	0.000	0.00	-13.500	-14.24
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	65.877	69.50	0.000	0.00	-102.218	-107.85

	COOLING		HEATING	
TOTAL LOAD	65.877 KBTU/H	69.50 MJ/H	-102.218 KBTU/H	-107.85 MJ/H
TOTAL LOAD / AREA	13.18 BTUH/SQFT	.14979 MJ/H/SQMT	20.44 BTUH/SQFT	.23243 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 1, Simple One Space Building



Example 2, Add Doors, Windows, People, Lighting and Equipment

LDL PROCESSOR INPUT DATA

```
                1              2              3              4              5              6              7              8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
/*THE SECOND EXAMPLE WILL USE THE SAME BUILDING AS IN EXAMPLE 1, BUT WILL ADD
WINDOWS, DOORS, AND INTERNAL LOADS DUE TO PEOPLE, LIGHTS, AND EQUIPMENT.*/
                  /*INPUT                  LOADS    (WILL GO HERE)*/                  ..
TITLE    EXAMPLE BUILDING 2                                                           ..
TITLE    USER NAME                                                                    ..
                                 /*PROGRAM CONTROL INSTRUCTIONS*/
                  /*WEATHER-STATION        CHICAGO  (WILL GO HERE)*/                  ..
                    RUN-PERIOD             JAN 1 1974  THRU  DEC 31 1974              ..
                    LIST                   ABORT ERROR                                ..
                    DIAGNOSTIC             WARNING                                    ..
                    LOADS-REPORT           L02                                        ..
                    BUILDING-LOCATION      LATITUDE = 42.0 LONGITUDE = 88.0
                                           TIME-ZONE=6.0  BUILDING-AZIMUTH=30.0       ..
/*THE NEXT INSTRUCTION ILLUSTRATES THE USE OF THE DEFINE COMMAND. THE U-NAME FOR
WALL-TYPE, WOO-1, IS EQUIVALENCED TO WA01-2, A LIBRARY NAME FOR A PREDETERMINED
WALL. THIS WALL IS IDENTICAL TO WALL-TYPE WA01-2 WHICH WAS BUILT UP FROM
SCRATCH USING MATERIAL AND LAYERS COMMANDS IN EXAMPLE 1. IN THIS CASE THE WALL
IS CONVENIENTLY CALLED OUT FROM THE LIBRARY. ONLY THE DEFINE CARD NEED BE
CHANGED IF YOU WANT  TO ANALYSE THE EFFECT OF A DIFFERENT WALL. THE SAME
APPLIES TO ROOF-TYPE.*/
/* WEEK-SCHEDULE IS EQUIVALENCED TO SCHEDULE-BLOCK USING THE DEFINE COMMAND
BECAUSE, ALTHO WEEK-SCHEDULE IS A LEGAL COMMAND, THE EXPERIMANTAL FILE USED IN
THIS RUN DID NOT CONTAIN WEEK-SCHEDULE.  THIS ILLUSTRATES HOW YOU CAN GENERATE
NEW COMMAND WORDS FOR AN EXISTING FUNCTION.*/
                                 /*DEFINE USER VARIABLES*/
                  DEFINE                   WOO-1=WA01-2                               ..
                  DEFINE                   ROO-1=RB01-1                               ..
                  DEFINE                   WEEK-SCHEDULE=SCHEDULE-BLOCK               ..
/*GLASS WINDOWS AND GLASS DOORS HAVE NOW BEEN ADDED. NOTE THAT THE SUBCOMMAND
WORD GLASS-TYPE SERVES IN A SIMILAR CAPACITY FOR GLASS AS CONSTRUCTION DOES
FOR WALLS. GLASS-TYPE KEYWORDS FOR NUMBER OF PANES, SHADING COEFFICIENT, AND
INFILTRATION HAVE BEEN ALLOWED TO DEFAULT. ALSO DEFAULTED ARE CONSTRUCTION
KEYWORDS FOR ABSORPTANCE, ROUGHNESS, AND INFILTRATION.*/
                                 /*CONSTRUCTION AND GLASS-TYPES*/
WALL-1          =CONSTRUCTION          WALL-TYPE=WOO-1                                ..
ROOF-1          =CONSTRUCTION          ROOF-TYPE=ROO-1                                ..
FLOOR-1         =CONSTRUCTION          U = 0.3                                        ..
WINDOW-1        =GLASS-TYPE            GLASS-TYPE-CODE = 1                            ..
FRONT-DOOR-1    =GLASS-TYPE            GLASS-TYPE-CODE = 1                            ..
BACK-DOOR-1     =GLASS-TYPE            GLASS-TYPE-CODE = 1                            ..
```

```
/*SCHEDULES FOR INTERNAL LOADS ARE NOW DEFINED. THE FIRST SCHEDULE IS FOR PEOPLE
OCCUPANCY. THE FIRST ELEMENT OF THIS SCHEDULE IS THE DAY-SCHEDULE. (1,8) 0.0
MEANS THAT FROM MIDNIGHT THRU 8AM THERE ARE NO PEOPLE PRESENT. (12,14) 0.8,0.4,
0.8 MEANS .8 OF MAXIMUM OCCUPANCY IS PRESENT AT NOON, .4 PRESENT AT 1PM, AND .8
PRESENT AT 2PM. ETC. THE NEXT ELEMENT IS WEEK-SCHEDULE. THIS STATES THAT DAY-
SCHEDULE OC-2 APPLIES TO SAT, SUN, AND HOL, WHILE OC-1 APPLIES TO WEEKDAYS.
THE LAST ELEMENT IS SCHEDULE. THIS STATES THAT WEEK-SCHEDULE OC-WEEK APPLIES
TO EACH WEEK OF THE YEAR.*/

                                   /*SCHEDULES*/

OC-1              =DAY-SCHEDULE        (1,8) 0.0
                                       (9,11) 1.0
                                       (12,14) 0.8,0.4,0.8
                                       (15,18) 1.0
                                       (19,21) 0.5,0.1,0.1
                                       (22,24) 0.0

OC-2              =DAY-SCHEDULE        (1,24) 0.0

OC-WEEK           =WEEK-SCHEDULE       (SUN)     OC-2
                                       (MON,FRI) OC-1
                                       (SAT,HOL) OC-2

OCCUPY-1          =SCHEDULE            THRU DEC 31 OC-WEEK

/* LIGHT SCHEDULE */

LT-1              =DAY-SCHEDULE        (1,8) 0.05
                                       (9,14) 0.9,0.95,1.0,0.95,0.8,0.9
                                       (15,18) 1.0
                                       (19,21) 0.6,0.2,0.2
                                       (22,24) 0.05

LT-2              =DAY-SCHEDULE        (1,24) 0.05

LT-WEEK           =WEEK-SCHEDULE       (SUN)     LT-2
                                       (MON,FRI) LT-1
                                       (SAT,HOL) LT-2

LIGHTS-1          =SCHEDULE            THRU DEC 31 LT-WEEK

/* EQUIPMENT SCHEDULE */

EQ-1              =DAY-SCHEDULE        (1,8) 0.02
                                       (9,14) 0.4,0.9,0.9,0.9,0.9,0.9
                                       (15,20) 0.8,0.7,0.5,0.5,0.3,0.3
                                       (21,24) 0.02

EQ-2              =DAY-SCHEDULE        (1,24) 0.2

EQ-WEEK           =WEEK-SCHEDULE       (SUN)     EQ-2
                                       (MON,FRI) EQ-1
                                       (SAT,HOL) EQ-2

EQUIP-1           =SCHEDULE            THRU DEC 31 EQ-WEEK

/*THE NEXT INSTRUCTION ILLUSTRATES THE USE OF THE SET-DEFAULT COMMAND. THIS
COMMAND ESTABLISHES A NEW SET OF DEFAULT VALUES FOR THE KEYWORDS LISTED.*/
                                   /*SET-DEFAULT VALUES*/

                   SET-DEFAULT         FLOOR-WEIGHT = 70.0
                                       GLASS-HEIGHT = 4.0
                                       GLASS-WIDTH = 5.0
                                       GLASS-TYPE = WINDOW-1

/* SET-DEFAULT DEFINES FLOOR-WEIGHT=70 LBS/CU. FT. THE DEFAULT VALUE IS 50.
FLOOR-WEIGHT IS A MEASURE OF THE COMPOSITE HEAT CAPACITY THAT CAN BE EXPECTED
FROM THE FLOOR, FURNISHINGS AND/OR EQUIPMENT, AND OTHER STRUCTURES OR WALLS IN
THE SPACE. IT IS USED IN DETERMINING WEIGHTING FACTORS FOR THE COOLING LOAD
```

```
COMPUTATION.*/

/*EXAMPLE 1 NEEDED ONLY GEOMETRY AND LOCATION FOR SPACE DEFINITION. WE
NOW MUST ALSO INCLUDE THE SCHEDULES AND VALUES FOR DETERMINATION OF INTERNAL
LOADS.*/

/* LIGHT-TO-SPACE IS A KEYWORD WHICH ASSIGNS THE PERCENT OF LIGHT ENERGY THAT
MATERIALIZES AS HEAT INTO THE SPACE. */
                         /*GENERAL SPACE DEFINITIONS*/

/* IN THIS CASE IT IS NOT NECESSARY TO POSITION THE WINDOW AND THE DOOR AT
SPECIFIC PLACES IN THE WALL, USING SURFACE COORDINATES K AND J. THE WINDOW AND
THE DOOR WILL ACQUIRE AZIMUTH FROM THE ASSIGNED WALL-AZIMUTH, AND THAT IS
SUFFICIENT UNLESS SHADING IS INVOLVED. */

ROOM-1          =SPACE                   AREA  =  5000,
                                         VOLUME = 40000
                                         PEOPLE-SCHEDULE =      OCCUPY-1
                                         LIGHTING-SCHEDULE =    LIGHTS-1
                                         EQUIPMENT-SCHEDULE =   EQUIP-1
                                         LIGHTING-TYPE =        2
                                         LIGHTING-W/SQFT =      3
                                         LIGHT-TO-SPACE =       80
                                         EQUIPMENT-W/SQFT =     1
                                         NUMBER-OF-PEOPLE =     50

/*NOTE THAT WF-1 (FRONT WINDOW) AND DF-1 (FRONT DOOR) FOLLOW IMMEDIATELY THE
WALL TO WHICH THEY BELONG, FRONT-1. THIS SEQUENCE WILL CUT A HOLE IN THE WALL
FOR THE WINDOW AND THE GLASS DOOR, AND WILL THEN FILL EACH HOLE WITH THE
APPROPRIATE GLASS-TYPE.*/

/*NOTE BELOW THE USE OF THE KEYWORD MULTIPLIER. THE BACK DOOR IS A DOUBLE GLASS
DOOR. A SINGLE DOOR IS DEFINED, THEN MULTIPLIER=2 PROVIDES FOR THE FULL DOUBLE
DOOR.*/

/* NOTE THAT NO WINDOW HEIGHT IS SPECIFIED FOR WF-1.  THAT HEIGHT IS AUTOMATIC
FROM THE SET-DEFAULT COMMAND FOR WINDOW HEIGHT. */

    FRONT-1     =EXTERIOR-WALL       HEIGHT = 8              WIDTH = 100
                                     X=0    Y=0    Z=0       AZIMUTH = 180
                                     CONSTRUCTION = WALL-1
      WF-1      =WINDOW              GLASS-WIDTH = 45
      DF-1      =WINDOW              GLASS-WIDTH = 4         GLASS-HEIGHT = 8
                                     GLASS-TYPE=FRONT-DOOR-1
                                     MULTIPLIER=2

    RIGHT-1     =EXTERIOR-WALL       HEIGHT = 8              WIDTH =  50
                                     X=100 Y=0    Z=0        AZIMUTH =  90
                                     CONSTRUCTION = WALL-1
      WR-1      =WINDOW              GLASS-WIDTH = 25

    BACK-1      =EXTERIOR-WALL       HEIGHT = 8              WIDTH = 100
                                     X=100 Y=50   Z=0        AZIMUTH =   0
                                     CONSTRUCTION = WALL-1
     WB-1       =WINDOW              GLASS-WIDTH = 45
      DB-1      =WINDOW              GLASS-WIDTH = 3.6       GLASS-HEIGHT = 7
                                     GLASS-TYPE=BACK-DOOR-1
                                     MULTIPLIER = 2

    LEFT-1      =EXTERIOR-WALL       HEIGHT = 8              WIDTH =  50
                                     X=0    Y=50   Z=0       AZIMUTH = -90
                                     CONSTRUCTION = WALL-1
      WL-1=      WINDOW              GLASS-WIDTH = 25

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

    TOP-1       =ROOF                LENGTH = 100            WIDTH = 50
                                     X=0    Y=0    Z=8       AZIMUTH = 180
                                     TILT = 0
                                     CONSTRUCTION = ROOF-1

                END /*LOADS*/
```

PROJECT- EXAMPLE BUILDING 2 USER NAME CAL-ERDA 1.3 17 OCT 1977 23.02.23

REPORT- L01 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
ROOM-1	1.	160.210	JUL 9 5 PM	97F	73F	-134.036	JAN 12 8 AM	-7F	-7F
SUM		160.210				-134.036			
BUILDING PEAK		160.210	JUL 9 5 PM	97F	73F	-134.036	JAN 12 8 AM	-7F	-7F

REPORT- L01 SPACE PEAK LOADS SUMMARY

PROJECT- EXAMPLE BUILDING 2 USER NAME CAL-ERDA 1.3 17 OCT 1977 23.02.23

REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE ROOM-1

MULTIPLIER 1

FLOOR AREA 5000 SQFT 464 SQMT
VOLUME 40000 CUFT 1132 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	3.754	3.96	0.000	0.00	-8.290	-8.75
CEILINGS	45.748	48.27	0.000	0.00	-74.567	-78.67
GLASS CONDUCTION	17.066	18.01	0.000	0.00	-52.043	-54.91
GLASS SOLAR	34.666	36.57	0.000	0.00	2.106	2.22
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	3.000	3.17	0.000	0.00	-9.000	-9.50
OCCUPANTS TO SPACE	13.313	14.05	4.638	4.89	.642	.68
LIGHT TO SPACE	29.121	30.72	0.000	0.00	3.512	3.71
EQUIPMENT TO SPACE	8.904	9.39	0.000	0.00	3.604	3.80
PROCESS TO SPACE	0.000	C.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	155.572	164.14	4.638	4.89	-134.036	-141.42
TOTAL LOAD	160.210 KBTU/H		169.03 MJ/H		-134.036 KBTU/H	-141.42 MJ/H
TOTAL LOAD / AREA	32.04 BTUH/SQFT		.36429 MJ/H/SQMT		26.81 BTUH/SQFT	.30478 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- L02 SPACE PEAK LOAD COMPONENTS SPACE ROOM-1

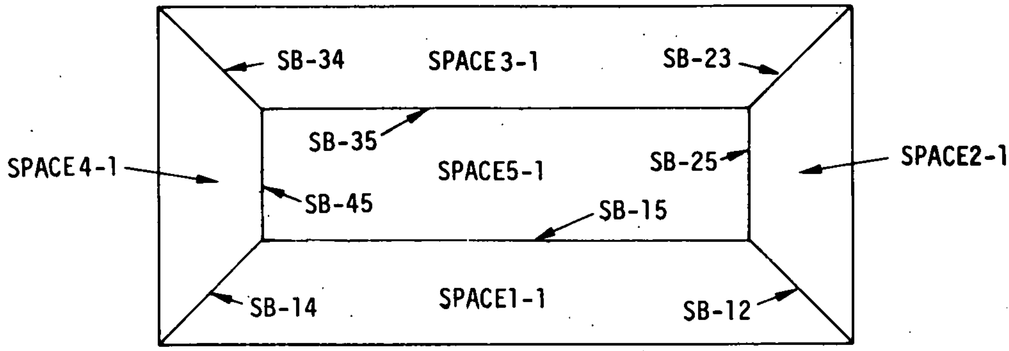
*** BUILDING ***

FLOOR AREA	5000	SQFT	464	SQMT
VOLUME	40000	CUFT	1132	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

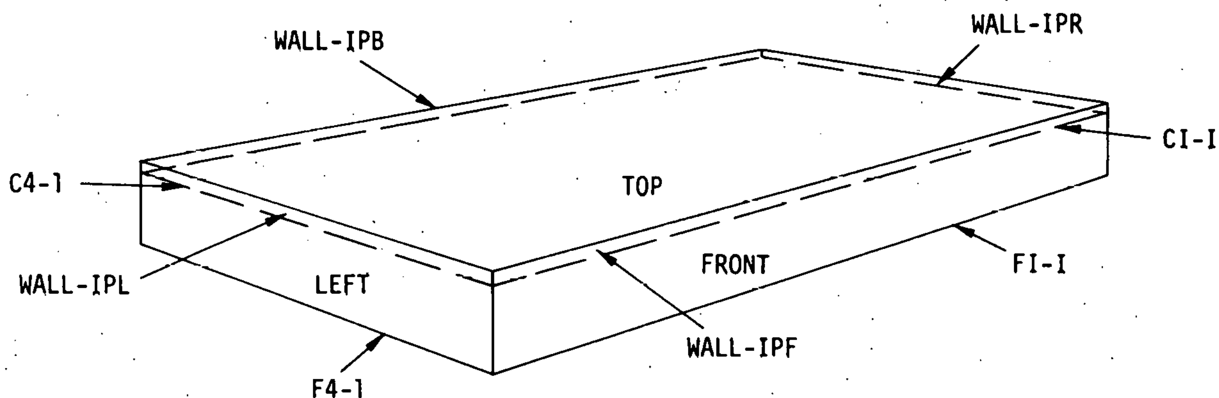
	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (MJ/H)	COOLING LATENT (KBTU/H)	COOLING LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	3.754	3.96	0.000	0.00	-8.290	-8.75
CEILINGS	45.748	48.27	0.000	0.00	-74.567	-78.67
GLASS CONDUCTION	17.066	18.01	0.000	0.00	-52.043	-54.91
GLASS SOLAR	34.666	36.57	0.000	0.00	2.106	2.22
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	3.000	3.17	0.000	0.00	-9.000	-9.50
OCCUPANTS TO SPACE	13.313	14.05	4.638	4.89	.642	.68
LIGHT TO SPACE	29.121	30.72	0.000	0.00	3.512	3.71
EQUIPMENT TO SPACE	8.904	9.39	0.000	0.00	3.604	3.80
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	155.572	164.14	4.638	4.89	-134.036	-141.42
TOTAL LOAD	160.210 KBTU/H		169.03 MJ/H		-134.036 KBTU/H	-141.42 MJ/H
TOTAL LOAD / AREA	32.04 BTUH/SQFT		.36429 MJ/H/SQMT		26.81 BTUH/SQFT	.30478 MJ/H/SQMT

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



SPACE _ - _
SPACE NAME
LEVEL(STORY)

SB- _ _
SPACE-BOUNDRY
BETWEEN THESE
TWO ZONES



DOORS AND
WINDOWS SAME
AS FOR SIMPLE
BUILDING

<u>2' HIGH PLENUM ADDED</u>

(PLENUM-1 = SPACE)

Example 3, Divide Example 2 Building Into Five Spaces and add Plenum and HVAC System

L D L   P R O C E S S O R   I N P U T   D A T A

```
          1         2         3         4         5         6         7         8
1234567890123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890

/* THE THIRD EXAMPLE WILL START WITH BUILDING 2, DIVIDE IT INTO FOUR EXTERNAL
ZONES AND ONE INTERNAL ZONE, AND ADD A TWO FOOT HIGH PLENUM.*/

                 /*INPUT               LOADS    (WILL GO HERE)*/                   ..

TITLE   EXAMPLE BUILDING 3                                                           ..
TITLE   USER NAME                                                                    ..

                             /*PROGRAM CONTROL INSTRUCTIONS*/                        ..

                 /*WEATHER-STATION     CHICAGO  (WILL GO HERE)*/                     ..
                   RUN-PERIOD          JAN 1 1974  THRU  DEC 31 1974                 ..
                   DIAGNOSTIC          WARNING                                       ..
                   LIST                ABORT ERROR                                   ..
                   LOADS-REPORT        L02                                           ..
                   BUILDING-LOCATION   LATITUDE = 42.0 LONGITUDE = 88.0
                                       TIME-ZONE=6.0  BUILDING-AZIMUTH=30.0          ..

                             /*DEFINE USER VARIABLES*/

                   DEFINE              W00-1=WA01-2                                  ..
                   DEFINE              R00-1=RB01-1                                  ..
                   DEFINE              WEEK-SCHEDULE=SCHEDULE-BLOCK                  ..

                             /*CONSTRUCTION AND GLASS-TYPES*/

/* CONSTRUCTION COMMANDS ARE ADDED FOR INTERNAL PARTITIONS AND CEILING.*/

/* INFILTRATION WILL BE COMPUTED IN THIS EXAMPLE. CONSEQUENTLY INFILTRATION
COEFFICIENTS ARE PROVIDED TO THE GLASS-TYPE COMMANDS.*/

WALL-1          =CONSTRUCTION          WALL-TYPE=W00-1                               ..
ROOF-1          =CONSTRUCTION          ROOF-TYPE=R00-1                               ..
CLNG-1          =CONSTRUCTION          U = 0.27                 /*CEILING*/          ..
SB-U            =CONSTRUCTION          U = 2.0                  /*PARTITION*/        ..
FLOOR-1         =CONSTRUCTION          U = 0.3                                       ..
W-1             =GLASS-TYPE            GLASS-TYPE-CODE = 1
                                       GLASS-INFILTRATION = 1                        ..
FRNTDR          =GLASS-TYPE            GLASS-TYPE-CODE = 1
                                       GLASS-INFILTRATION = 18                       ..
BCKDR           =GLASS-TYPE            GLASS-TYPE-CODE = 1
                                       GLASS-INFILTRATION = 18                       ..

                             /*SCHEDULES*/                                           ..

OC-1            =DAY-SCHEDULE          (1,8) 0.0
                                       (9,11) 1.0
                                       (12,14) 0.8,0.4,0.8
                                       (15,18) 1.0
                                       (19,21) 0.5,0.1,0.1
                                       (22,24) 0.0                                   ..

OC-2            =DAY-SCHEDULE          (1,24) 0.0                                    ..

OC-WEEK         =WEEK-SCHEDULE         (SUN)     OC-2
                                       (MON,FRI) OC-1
```

```
                                              (SAT,HOL) OC 2

OCCUPY-1         =SCHEDULE                    THRU DEC 31 OC-WEEK

LT-1             =DAY-SCHEDULE                (1,8) 0.05
                                              (9,14) 0.9,0.95,1.0,0.95,0.8,0.9
                                              (15,18) 1.0
                                              (19,21) 0.6,0.2,0.2
                                              (22,24) 0.05

LT-2             =DAY-SCHEDULE                (1,24) 0.05

LT-WEEK          =WEEK-SCHEDULE               (SUN)       LT-2
                                              (MON,FRI) LT-1
                                              (SAT,HOL) LT-2

LIGHTS-1         =SCHEDULE                    THRU DEC 31 LT-WEEK

EQ-1             =DAY-SCHEDULE                (1,8) 0.02
                                              (9,14) 0.4,0.9,0.9,0.9,0.9,0.9
                                              (15,20) 0.8,0.7,0.5,0.5,0.3,0.3
                                              (21,24) 0.02

EQ-2             =DAY-SCHEDULE                (1,24) 0.2

EQ-WEEK          =WEEK-SCHEDULE               (SUN)       EQ-2
                                              (MON,FRI) EQ-1
                                              (SAT,HOL) EQ-2

EQUIP-1          =SCHEDULE                    THRU DEC 31 EQ-WEEK

/* AN INFILTRATION SCHEDULE HAS BEEN ADDED. NOTE THAT INFILTRATION WILL OCCUR
ONLY DURING NON-OCCUPIED PERIODS. DURING OCCUPIED PERIODS, THE FANS PRESSURIZE
THE BUILDING.*/

INF-1            =DAY-SCHEDULE                (1,8) 1.0
                                              (9,18) 0.0
                                              (19,24) 1.0

INF-2            =DAY-SCHEDULE                (1,24) 1.0

INF-WEEK         =SCHEDULE-BLOCK              (SUN)       INF-2
                                              (MON,FRI)   INF-1
                                              (SAT,HOL)   INF-2

INFIL-SCH        =SCHEDULE                    THRU DEC 31 INF-WEEK

                                /*SET-DEFAULT VALUES*/

                  SET-DEFAULT                 FLOOR-WEIGHT = 70.0
                                              GLASS-HEIGHT = 4.0
                                              GLASS-WIDTH = 5.0
                                              GLASS-TYPE = W-1

                                /*GENERAL SPACE DEFINITIONS*/

/* NOTE THE OVERRIDE OF THE SET-DEFAULT VALUE FOR FLOOR-WEIGHT. ALSO THE ASSIGN-
MENT OF TEMP=70 IS UNNECESSARY SINCE 70 IS THE DEFAULT VALUE.*/

PLENUM           =SPACE-CONDITIONS   FLOOR-WEIGHT = 5       TEMP = 70

SPACE-1          =SPACE-CONDITIONS   FLOOR-WEIGHT          =70
```

```
                                              TEMP                     =70
                                              PEOPLE-SCHEDULE          =OCCUPY-1
                                              NUMBER-OF-PEOPLE         =50
                                              PEOPLE-ACTIVITY          =400.0
                                              LIGHTING-SCHEDULE        =LIGHTS-1
                                              LIGHTING-TYPE            =2
                                              LIGHT-TO-SPACE           =80
                                              LIGHTING-W/SQFT          =3
                                              EQUIPMENT-SCHEDULE       =EQUIP-1
                                              EQUIPMENT-W/SQFT         =1
                                              INF-METHOD               =2
                                              NEUTRAL-ZONE-HEIGHT      =6
                                              INF-SCHEDULE             =INFIL-SCH           ..

/* INF-METHOD=2 CALLS FOR INFILTRATION COMPUTATION USING THE CRACK METHOD. INF-
METHOD=1 WOULD USE AIR CHANGES.  KEYWORD NEUTRAL-ZONE-HEIGHT MUST BE
ASSIGNED A NON-ZERO VALUE WHEN USING INF-METHOD=2. */

                          /*SPECIFIC SPACE DETAILS*/

/* ALTHOUGH THE PLENUM IS AN UNCONDITIONED SPACE, LOADS WILL STILL BE CALCULATED
AT CONSTANT TEMP, THE SAME AS WITH CONDITIONED SPACES. NOTE THAT CONSTANT SPACE
TEMP PRECLUDES HEAT TRANSFER ACROSS INTERIOR SURFACES. INTERIOR HEAT TRANSFER
WILL NOT OCCUR UNTIL SYSTEMS RECALCULATES LOADS UNDER VARIABLE TEMP CONDITIONS.
*/

PLENUM-1          =SPACE                      SPACE-CONDITIONS=PLENUM
                                              VOLUME=10000             SPACE-HEIGHT=2       ..

    WALL-1PF      =EXTERIOR-WALL              HEIGHT = 2               WIDTH = 100
                                              AZIMUTH = 180
                                              CONSTRUCTION = WALL-1                         ..

    WALL-1PR      =EXTERIOR-WALL              HEIGHT = 2               WIDTH =  50
                                              AZIMUTH =  90
                                              CONSTRUCTION = WALL-1                         ..

    WALL-1PB      =EXTERIOR-WALL              HEIGHT = 2               WIDTH = 100
                                              AZIMUTH =   0
                                              CONSTRUCTION = WALL-1                         ..

    WALL-1PL      =EXTERIOR-WALL              HEIGHT = 2               WIDTH =  50
                                              AZIMUTH = 270
                                              CONSTRUCTION = WALL-1                         ..

    TOP-1         =ROOF                       LENGTH = 100             WIDTH = 50
                                              X=0    Y=0    Z=10       AZIMUTH = 180
                                              TILT=0                   GND-REFLECTANCE=0
                                              CONSTRUCTION = ROOF-1                         ..

/* GROUND-REFLECTIVITY=0 BECAUSE GROUND REFLECTED SOLAR ENERGY CANNOT IMPACT A
FLAT ROOF. THE DEFAULT VALUE IS 0.2.*/

/* WE ARE NOW DEALING WITH MULTIPLE SPACES. THIS IS SPACE NO. 1 OF FLOOR NO. 1.
BELOW SPACE1-1 ARE ITS BOUNDING SURFACES, INCLUDING DOOR AND WINDOW.*/

/* U-NAME SB12 INDICATES AN INTERIOR SURFACE BETWEEN SPACE1 AND SPACE2. NOTE
THAT AN INTERIOR SURFACE NEEDS ONLY AREA, CONSTRUCTION, AND THE SPACE IT IS NEXT
TO FOR COMPLETE DEFINITION.*/

/* U-NAME C1-1 IS A CEILING, ALTHOUGH IT USES THE SAME COMMAND WORD AS A VER-
TICAL PARTITION.*/
```

```

/* SB14 ILLUSTRATES THE USE OF THE EQUIVALENCE COMMAND LIKE. SB14 IS IDENTICAL
TO SB12 EXCEPT THAT IT IS NEXT-TO SPACE4-1 INSTEAD OF SPACE2-1.*/

/* THE FIRST FOUR SPACES ARE ALL EXTERNAL SPACES. THIS MEANS THAT EACH HAS AT
LEAST ONE EXTERIOR SURFACE. IN THIS EXAMPLE, EACH EXTERIOR WALL ALSO HAS AT
LEAST A WINDOW, AND SOMETIMES A GLASS DOOR AS WELL. THIS MEANS THAT THESE SPACES
ARE SUBJECT TO HIGH SOLAR HEAT GAIN DURING THE DAY, AND HIGH CONDUCTION LOSS AT
NIGHT.*/

/* INTERNAL PARTITIONS ARE COMMON TO ADJACENT SPACES.  BE SURE YOU DEFINE THE
PARTITION FOR ONLY ONE SPACE.  FOR EXAMPLE, SB12 IS DEFINED UNDER SPACE1-1,
CONSEQUENTLY IT DOES NOT APPEAR UNDER SPACE 2-1, EVEN THOUGH IT IS COMMON
TO BOTH SPACES. */

SPACE1-1        =SPACE               SPACE-CONDITIONS      =SPACE-1
                                     AREA  =    1056        VOLUME = 8448
                                     NUMBER-OF-PEOPLE   =   10.56              ..

     FRONT-1    =EXTERIOR-WALL       HEIGHT = 8             WIDTH = 100
                                     X=0    Y=0    Z=0      AZIMUTH = 180
                                     CONSTRUCTION = WALL-1                     ..
        WF-1    =WINDOW              GLASS-WIDTH = 45                          ..
        DF-1    =WINDOW              GLASS-WIDTH = 4        GLASS-HEIGHT = 8
                                     MULTIPLIER = 2         GLASS-TYPE = FRNTDR ..
     C1-1       =INTERIOR-WALL       AREA = 1056            NEXT-TO  PLENUM-1
                                     CONSTRUCTION = CLNG-1                     ..
     F1-1       =UNDERGROUND-FLOOR   AREA = 1056
                                     CONSTRUCTION = FLOOR-1                    ..
     SB12       =INTERIOR-WALL       AREA 135.76            NEXT-TO  SPACE2-1
                                     CONSTRUCTION = SB-U                       ..
     SB14       =INTERIOR-WALL       LIKE SB12              NEXT-TO  SPACE4-1  ..
     SB15       =INTERIOR-WALL       AREA 608               NEXT-TO  SPACE5-1
                                     CONSTRUCTION = SB-U                       ..

SPACE2-1        =SPACE               SPACE-CONDITIONS      =SPACE-1
                                     AREA  =     456        VOLUME = 3648
                                     NUMBER-OF-PEOPLE   =   4.56               ..
     RIGHT-1    =EXTERIOR-WALL       HEIGHT = 8             WIDTH =  50
                                     X=100  Y=0    Z=0      AZIMUTH =  90
                                     CONSTRUCTION = WALL-1                     ..
       WR-1     =WINDOW              GLASS-WIDTH = 25                          ..
     C2-1       =INTERIOR-WALL       AREA =  456            NEXT-TO  PLENUM-1
                                     CONSTRUCTION = CLNG-1                     ..
     F2-1       =UNDERGROUND-FLOOR   AREA =  456
                                     CONSTRUCTION = FLOOR-1                    ..
     SB23       =INTERIOR-WALL       AREA 135.76            NEXT-TO  SPACE3-1
                                     CONSTRUCTION = SB-U                       ..
     SB25       =INTERIOR-WALL       AREA 208               NEXT-TO  SPACE5-1
                                     CONSTRUCTION = SB-U                       ..

SPACE3-1        =SPACE               SPACE-CONDITIONS      =SPACE-1
                                     AREA  =    1056        VOLUME = 8448
                                     NUMBER-OF-PEOPLE   =   10.56              ..
     BACK-1     =EXTERIOR-WALL       HEIGHT = 8             WIDTH = 100
                                     X=100  Y=50   Z=0      AZIMUTH =   0
                                     CONSTRUCTION = WALL-1                     ..
       WB-1     =WINDOW              GLASS-WIDTH = 45                          ..
        DB-1    =WINDOW              GLASS-WIDTH = 3.6      GLASS-HEIGHT = 7
                                     GLASS-TYPE=BCKDR
                                     MULTIPLIER = 2                            ..
     C3-1       =INTERIOR-WALL       AREA = 1056            NEXT-TO  PLENUM-1
```

```
                                            CONSTRUCTION = CLNG-1
      F3-1            =UNDERGROUND-FLOOR    AREA = 1056
                                            CONSTRUCTION = FLOOR-1
      SB34            =INTERIOR-WALL        AREA 135.8            NEXT-TO   SPACE4-1
                                            CONSTRUCTION = SB-U
      SB35            =INTERIOR-WALL        AREA 608              NEXT-TO   SPACE5-1
                                            CONSTRUCTION = SB-U

  SPACE4-1            =SPACE                SPACE-CONDITIONS      =SPACE-1
                                            AREA  =     456        VOLUME = 3648
                                            NUMBER-OF-PEOPLE   =   4.56
      LEFT-1          =EXTERIOR-WALL        HEIGHT = 8            WIDTH =   50
                                            X=0    Y=50   Z=0      AZIMUTH = 270
                                            CONSTRUCTION = WAL-1
        WL-1          =WINDOW               GLASS-WIDTH = 25
      C4-1            =INTERIOR-WALL        AREA =   456          NEXT-TO   PLENUM-1
                                            CONSTRUCTION = CLNG-1
      F4-1            =UNDERGROUND-FLOOR    AREA =   456
                                            CONSTRUCTION = FLOOR-1
      SB45            =INTERIOR-WALL        AREA 208              NEXT-TO   SPACE5-1
                                            CONSTRUCTION = SB-U

  /* SPACE 5-1 IS AN INTERNAL ZONE.  ALL HEAT TRANSFER IS STEADY-STATE.  HEATING
  LOADS ARE NORMALLY SO SMALL THAT ONLY COOLING NEED BE SUPPLIED.*/

  SPACE5-1            =SPACE                SPACE-CONDITIONS      =SPACE-1
                                            AREA  =     1976       VOLUME =15808
                                            NUMBER-OF-PEOPLE   =   19.76
      C5-1            =INTERIOR-WALL        AREA = 1976           NEXT-TO   PLENUM-1
                                            CONSTRUCTION = CLNG-1
      F5-1            =UNDERGROUND-FLOOR    AREA = 1976
                                            CONSTRUCTION = FLOOR-1

                       END /*LOADS*/
```

PROJECT- EXAMPLE BUILDING 3   USER NAME   CAL-ERDA 1.3 18 OCT 1977 19.05.08

REPORT- L01 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.	57.592	JUL 7 4 PM	88F	73F	-79.772	JAN 12 9 AM	-8F	-8F
SPACE1-1	1.	42.386	SEP 26 5 PM	81F	61F	-32.355	MAR 24 5 AM	9F	8F
SPACE2-1	1.	15.623	JUL 3 11 AM	87F	74F	-9.211	JAN 12 8 AM	-7F	-7F
SPACE3-1	1.	28.022	JUL 3 3 PM	92F	74F	-34.023	APR 8 7 AM	31F	28F
SPACE4-1	1.	14.552	JUL 9 5 PM	97F	73F	-10.155	JAN 12 8 AM	-7F	-7F
SPACE5-1	1.	24.154	AUG 30 3 PM	82F	64F	-2.628	JAN 2 8 AM	4F	3F
SUM		182.329				-168.144			
BUILDING PEAK		163.385	JUL 9 5 PM	97F	73F	-152.176	JAN 12 8 AM	-7F	-7F

REPORT- L01 SPACE PEAK LOADS SUMMARY

SPACE PLENUM-1

MULTIPLIER	1			
FLOOR AREA	0	SQFT	0	SQMT
VOLUME	10000	CUFT	283	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 9 AM	
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	1.262	1.33	0.000	0.00	-2.982	-3.15
CEILINGS	56.330	59.43	0.000	0.00	-76.790	-81.02
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	57.592	60.76	0.000	0.00	-79.772	-84.16
TOTAL LOAD	57.592 KBTU/H	60.76 MJ/H			-79.772 KBTU/H	-84.16 MJ/H

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

SPACE SPACE1-1

MULTIPLIER	1			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	SEP 26 5 PM		MAR 24 5 AM	
DRY-BULB TEMP	81F	27C	9F	-13C
WET-BULB TEMP	61F	16C	8F	-13C

	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	.829	.87	0.000	0.00	-2.102	-2.22
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	2.076	2.19	0.000	0.00	-16.158	-17.05
GLASS SOLAR	27.021	28.51	0.000	0.00	2.465	2.60
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	.634	.67	0.000	0.00	-1.584	-1.67
OCCUPANTS TO SPACE	2.813	2.97	.980	1.03	.007	.01
LIGHT TO SPACE	6.154	6.49	0.000	0.00	.367	.39
EQUIPMENT TO SPACE	1.881	1.98	0.000	0.00	.723	.76
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-16.074	-16.96
TOTAL	41.406	43.69	.980	1.03	-32.355	-34.14
TOTAL LOAD	42.386 KBTU/H	44.72 MJ/H			-32.355 KBTU/H	-34.14 MJ/H
TOTAL LOAD / AREA	40.14 BTUH/SQFT	.45632 MJ/H/SQMT			30.64 BTUH/SQFT	.34833 MJ/H/SQMT

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

SPACE SPACE2-1

MULTIPLIER 1

FLOOR AREA 456 SQFT 42 SQMT
VOLUME 3648 CUFT 103 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 11 AM		JAN 12 8 AM	
DRY-BULB TEMP	87F	31C	-7F	-22C
WET-BULB TEMP	74F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.568	.60	0.000	0.00	-1.439	-1.52
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.724	1.82	0.000	0.00	-7.717	-8.14
GLASS SOLAR	8.469	8.93	0.000	0.00	.405	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	.274	.29	0.000	0.00	-.821	-.87
OCCUPANTS TO SPACE	.920	.97	.338	.36	.059	.06
LIGHT TO SPACE	2.212	2.33	0.000	0.00	.320	.34
EQUIPMENT TO SPACE	1.118	1.18	0.000	0.00	.329	.35
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.347	-.37
TOTAL	15.285	16.13	.338	.36	-9.211	-9.72

TOTAL LOAD 15.623 KBTU/H 16.48 MJ/H -9.211 KBTU/H -9.72 MJ/H

TOTAL LOAD / AREA 34.26 BTUH/SQFT .39246 MJ/H/SQMT 20.20 BTUH/SQFT .23138 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE2-1

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.08
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE3-1

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 8448 CUFT 239 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 3 PM		APR 8 7 AM	
DRY-BULB TEMP	92F	33C	31F	-1C
WET-BULB TEMP	74F	23C	28F	-2C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.886	.94	0.000	0.00	-1.419	-1.50
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	5.222	5.51	0.000	0.00	-10.380	-10.95
GLASS SOLAR	9.323	9.84	0.000	0.00	1.117	1.18
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	.634	.67	0.000	0.00	-1.584	-1.67
OCCUPANTS TO SPACE	2.708	2.86	.980	1.03	.000	.00
LIGHT TO SPACE	5.908	6.23	0.000	0.00	.347	.37
EQUIPMENT TO SPACE	2.363	2.49	0.000	0.00	.162	.17
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-22.266	-23.49
TOTAL	27.042	28.53	.980	1.03	-34.023	-35.90

TOTAL LOAD 28.022 KBTU/H 29.56 MJ/H -34.023 KBTU/H -35.90 MJ/H

TOTAL LOAD / AREA 26.54 BTUH/SQFT .30168 MJ/H/SQMT 32.22 BTUH/SQFT .36629 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE3-1

SPACE SPACE4-1

MULTIPLIER 1

FLOOR AREA 456 SQFT 42 SQMT
VOLUME 3648 CUFT 103 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.679	.72	0.000	0.00	-1.446	-1.53
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	2.531	2.67	0.000	0.00	-7.717	-8.14
GLASS SOLAR	5.964	6.29	0.000	0.00	.080	.08
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	.274	.29	0.000	0.00	-.821	-.87
OCCUPANTS TO SPACE	1.214	1.28	.423	.45	.059	.06
LIGHT TO SPACE	2.656	2.80	0.000	0.00	.320	.34
EQUIPMENT TO SPACE	.812	.86	0.000	0.00	.329	.35
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.958	-1.01
TOTAL	14.129	14.91	.423	.45	-10.155	-10.71

TOTAL LOAD 14.552 KBTU/H 15.35 MJ/H -10.155 KBTU/H -10.71 MJ/H

TOTAL LOAD / AREA 31.91 BTUH/SQFT .36555 MJ/H/SQMT 22.27 BTUH/SQFT .25509 MJ/H/SQMT

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

SPACE SPACE5-1

MULTIPLIER 1

FLOOR AREA 1976 SQFT 183 SQMT
VOLUME 15808 CUFT 447 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 3 PM		JAN 2 8 AM	
DRY-BULB TEMP	82F	28C	4F	-16C
WET-BULB TEMP	64F	18C	3F	-16C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	1.778	1.88	0.000	0.00	-3.557	-3.75
OCCUPANTS TO SPACE	5.067	5.35	1.833	1.93	0.000	0.00
LIGHT TO SPACE	11.055	11.66	0.000	0.00	.647	.68
EQUIPMENT TO SPACE	4.421	4.66	0.000	0.00	.281	.30
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	22.321	23.55	1.833	1.93	-2.628	-2.77

TOTAL LOAD 24.154 KBTU/H 25.48 MJ/H -2.628 KBTU/H -2.77 MJ/H

TOTAL LOAD / AREA 12.22 BTUH/SQFT .13925 MJ/H/SQMT 1.33 BTUH/SQFT .01515 MJ/H/SQMT

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

*** BUILDING ***

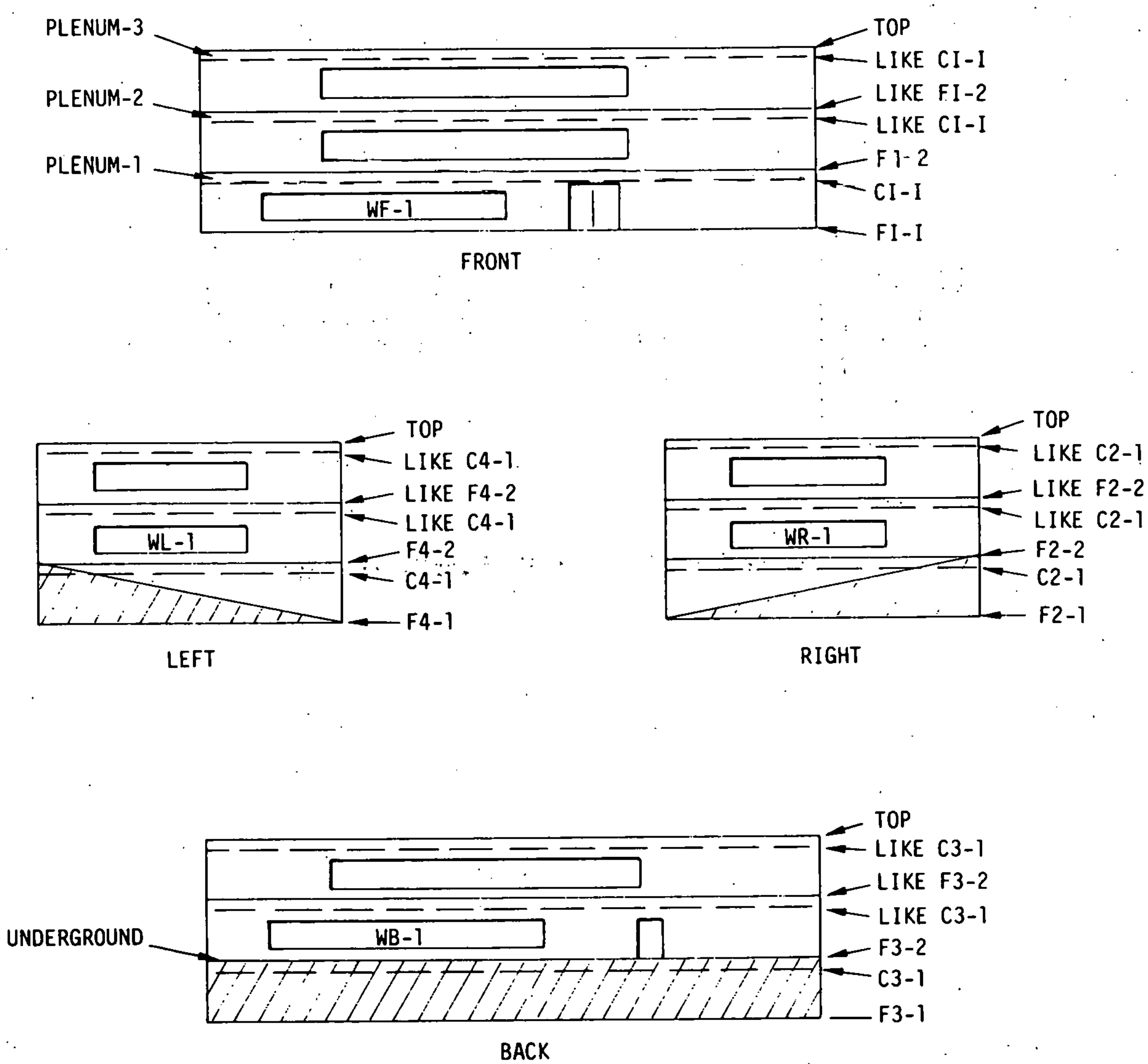
FLOOR AREA	5000	SQFT	464	SQMT
VOLUME	50000	CUFT	1416	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	5.100	5.38	0.000	0.00	-11.220	-11.84
CEILINGS	47.576	50.19	0.000	0.00	-75.878	-80.06
GLASS CONDUCTION	17.066	18.01	0.000	0.00	-52.043	-54.91
GLASS SOLAR	34.667	36.58	0.000	0.00	2.106	2.22
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	3.000	3.17	0.000	0.00	-9.000	-9.50
OCCUPANTS TO SPACE	13.313	14.05	4.638	4.89	.642	.68
LIGHT TO SPACE	29.121	30.72	0.000	0.00	3.512	3.71
EQUIPMENT TO SPACE	8.904	9.39	0.000	0.00	3.604	3.80
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-13.899	-14.66
TOTAL	158.747	167.49	4.638	4.89	-152.176	-160.55

	COOLING		HEATING	
TOTAL LOAD	163.385 KBTU/H	172.38 MJ/H	-152.176 KBTU/H	-160.55 MJ/H
TOTAL LOAD / AREA	32.68 BTUH/SQFT	.37151 MJ/H/SQMT	30.44 BTUH/SQFT	.34602 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 4, Expand Example 3 to Three Stories

L D L   P R O C E S S O R   I N P U T   D A T A

```
                 1         2         3         4         5         6         7         8
        12345678901234567890123456789012345678901234567890123456789012345678901234567890

        /* THE FOURTH EXAMPLE TURNS BUILDING 3 INTO A THREE STORY BUILDING, AND PLACES
        EARTH BURM AGAINST THREE OF THE FIRST FLOOR WALLS.  THERE IS A SIGNIFICANT
        REDUCTION IN LOADS FOR THE AFFECTED SPACES BECAUSE OF THIS BURM. */

                          /*INPUT               LOADS     (WILL GO HERE)*/

        TITLE    EXAMPLE BUILDING 4
        TITLE    USER NAME

                                      /*PROGRAM CONTROL INSTRUCTIONS*/

                          /*WEATHER-STATION     CHICAGO  (WILL GO HERE)*/
                            RUN-PERIOD          JAN 1 1974  THRU  DEC 31 1974
                            DIAGNOSTIC          WARNING
                            LOADS-REPORT        L02
                            BUILDING-LOCATION   LATITUDE = 42.0 LONGITUDE = 88.0
                                                TIME-ZONE=6.0  BUILDING-AZIMUTH=30.0

                                      /*DEFINE USER VARIABLES*/

                            DEFINE              W00-1=WA01-2
                            DEFINE              R00-1=RB01-1
                            DEFINE              WEEK-SCHEDULE=SCHEDULE-BLOCK

                                      /*CONSTRUCTION AND GLASS-TYPES*/

        WALL-1            =CONSTRUCTION         WALL-TYPE=W00-1
        WALL-2            =CONSTRUCTION         U=0.4
        ROOF-1            =CONSTRUCTION         ROOF-TYPE=R00-1
        CLNG-1            =CONSTRUCTION         U = 0.27                /*CEILING*/
        SB-U              =CONSTRUCTION         U = 2.0                 /*PARTITION*/
        FLOOR-1           =CONSTRUCTION         U = 0.3
        FLOOR-2           =CONSTRUCTION         U=0.9
        W-1               =GLASS-TYPE           GLASS-TYPE-CODE = 1
                                                GLASS-INFILTRATION = 1
        FRNTDR            =GLASS-TYPE           GLASS-TYPE-CODE = 1
                                                GLASS-INFILTRATION = 18
        BCKDR             =GLASS-TYPE           GLASS-TYPE-CODE = 1
                                                GLASS-INFILTRATION = 18

                                      /*SCHEDULES*/

        OC-1              =DAY-SCHEDULE         (1,8) 0.0
                                                (9,11) 1.0
                                                (12,14) 0.8,0.4,0.8
                                                (15,18) 1.0
                                                (19,21) 0.5,0.1,0.1
                                                (22,24) 0.0

        OC-2              =DAY-SCHEDULE         (1,24) 0.0

        OC-WEEK           =WEEK-SCHEDULE        (SUN)      OC-2
                                                (MON,FRI) OC-1
                                                (SAT,HOL) OC-2

        OCCUPY-1          =SCHEDULE             THRU DEC 31 OC-WEEK
```

```
LT-1          =DAY-SCHEDULE        (1,8) 0.05
                                   (9,14) 0.9,0.95,1.0,0.95,0.8,0.9
                                   (15,18) 1.0
                                   (19,21) 0.6,0.2,0.2
                                   (22,24) 0.05

LT-2          =DAY-SCHEDULE        (1,24) 0.05

LT-WEEK       =WEEK-SCHEDULE       (SUN)      LT-2
                                   (MON,FRI) LT-1
                                   (SAT,HOL) LT-2

LIGHTS-1      =SCHEDULE            THRU DEC 31 LT-WEEK

EQ-1          =DAY-SCHEDULE        (1,8) 0.02
                                   (9,14) 0.4,0.9,0.9,0.9,0.9,0.9
                                   (15,20) 0.8,0.7,0.5,0.5,0.3,0.3
                                   (21,24) 0.02

EQ-2          =DAY-SCHEDULE        (1,24) 0.2

EQ-WEEK       =WEEK-SCHEDULE       (SUN)      EQ-2
                                   (MON,FRI) EQ-1
                                   (SAT,HOL) EQ-2

EQUIP-1       =SCHEDULE            THRU DEC 31 EQ-WEEK

INF-1         =DAY-SCHEDULE        (1,8) 1.0
                                   (9,18) 0.0
                                   (19,24) 1.0

INF-2         =DAY-SCHEDULE        (1,24) 1.0

INF-WEEK      =SCHEDULE-BLOCK      (SUN)       INF-2
                                   (MON,FRI)   INF-1
                                   (SAT,HOL)   INF-2

INFIL-SCH     =SCHEDULE            THRU DEC 31 INF-WEEK


                        /*SET-DEFAULT VALUES*/

               SET-DEFAULT         FLOOR-WEIGHT = 70.0
                                   GLASS-HEIGHT = 4.0
                                   GLASS-WIDTH = 5.0
                                   GLASS-TYPE = W-1

                        /*GENERAL SPACE DEFINITIONS*/

PLENUM        =SPACE-CONDITIONS    FLOOR-WEIGHT = 5        TEMP = 70

SPACE-1       =SPACE-CONDITIONS    FLOOR-WEIGHT            =70
                                   TEMP                    =70
                                   PEOPLE-SCHEDULE         =OCCUPY-1
                                   NUMBER-OF-PEOPLE        =50
                                   PEOPLE-ACTIVITY         =400.0
                                   LIGHTING-SCHEDULE       =LIGHTS-1
                                   LIGHTING-TYPE           =2
                                   LIGHT-TO-SPACE          =80
                                   LIGHTING-W/SQFT         =3
                                   EQUIPMENT-SCHEDULE      =EQUIP-1
                                   EQUIPMENT-W/SQFT        =1
```

```
                                                  INF-METHOD              =2
                                                  NEUTRAL-ZONE-HEIGHT     =6
                                                  INF-SCHEDULE            =INFIL-SCH     ..

                                       /*SPECIFIC SPACE DETAILS*/

   PLENUM-1         =SPACE                        SPACE-CONDITIONS=PLENUM
                                                  VOLUME=10000             SPACE-HEIGHT=2 ..

        WALL-1PF    =EXTERIOR-WALL                HEIGHT = 2               WIDTH = 100
                                                  AZIMUTH = 180
                                                  CONSTRUCTION = WALL-1                   ..

        WALL-1PR    =EXTERIOR-WALL                HEIGHT = 2               WIDTH =  50
                                                  AZIMUTH =  90
                                                  CONSTRUCTION = WALL-1                   ..

        WALL-1PB    =EXTERIOR-WALL                HEIGHT = 2               WIDTH = 100
                                                  AZIMUTH =   0
                                                  CONSTRUCTION = WALL-1                   ..

        WALL-1PL    =EXTERIOR-WALL                HEIGHT = 2               WIDTH =  50
                                                  AZIMUTH = 270
                                                  CONSTRUCTION = WALL-1                   ..

   PLENUM-2   =   SPACE                           LIKE PLENUM-1                           ..
                      EXTERIOR-WALL               LIKE WALL-1PF                           ..
                      EXTERIOR-WALL               LIKE WALL-1PR                           ..
                      EXTERIOR-WALL               LIKE WALL-1PB                           ..
                      EXTERIOR-WALL               LIKE WALL-1PL                           ..

   PLENUM-3   =   SPACE                           LIKE PLENUM-1                           ..
                      EXTERIOR-WALL               LIKE WALL-1PF                           ..
                      EXTERIOR-WALL               LIKE WALL-1PR                           ..
                      EXTERIOR-WALL               LIKE WALL-1PB                           ..
                      EXTERIOR-WALL               LIKE WALL-1PL                           ..

        TOP-1       =ROOF                         LENGTH = 100             WIDTH = 50
                                                  X=0   Y=0    Z=10        AZIMUTH = 180
                                                  TILT=0                   GND-REFLECTANCE=0
                                                  CONSTRUCTION = ROOF-1                   ..

   SPACE1-1         =SPACE                        SPACE-CONDITIONS        =SPACE-1
                                                  AREA   =    1056         VOLUME = 8448
                                                  NUMBER-OF-PEOPLE    =    10.56          ..

        FRONT-1     =EXTERIOR-WALL                HEIGHT = 8               WIDTH = 100
                                                  X=0    Y=0    Z=0        AZIMUTH = 180
                                                  CONSTRUCTION = WALL-1                   ..
           WF-1     =WINDOW                       GLASS-WIDTH = 45                        ..
           DF-1     =WINDOW                       GLASS-WIDTH = 4          GLASS-HEIGHT = 8
                                                  MULTIPLIER = 2           GLASS-TYPE = FRNTDR ..
        C1-1        =INTERIOR-WALL                AREA = 1056              NEXT-TO  PLENUM-1
                                                  CONSTRUCTION = CLNG-1                   ..
        F1-1        =UNDERGROUND-FLOOR            AREA = 1056
                                                  CONSTRUCTION = FLOOR-1                  ..
        SB12        =INTERIOR-WALL                AREA 135.76              NEXT-TO  SPACE2-1
                                                  CONSTRUCTION = SB-U                     ..
        SB14        =INTERIOR-WALL                LIKE SB12                NEXT-TO  SPACE4-1  ..
        SB15        =INTERIOR-WALL                AREA 608                 NEXT-TO  SPACE5-1
                                                  CONSTRUCTION = SB-U                     ..
```

```
SPACE2-1         =SPACE                SPACE-CONDITIONS      =SPACE-1
                                       AREA  =     456        VOLUME = 3648
                                       NUMBER-OF-PEOPLE   =   4.56              ..
                  UNDERGROUND-WALL     AREA 400               CONSTRUCTION WALL-2 ..
        C2-1     =INTERIOR-WALL        AREA =  456            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
        F2-1     =UNDERGROUND-FLOOR    AREA =  456
                                       CONSTRUCTION = FLOOR-1                   ..
        SB23     =INTERIOR-WALL        AREA 135.76            NEXT-TO  SPACE3-1
                                       CONSTRUCTION = SB-U                      ..
        SB25     =INTERIOR-WALL        AREA 208               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

SPACE3-1         =SPACE                SPACE-CONDITIONS      =SPACE-1
                                       AREA  =    1056        VOLUME = 8448
                                       NUMBER-OF-PEOPLE   =   10.56             ..
                  UNDERGROUND-WALL     AREA 800               CONSTRUCTION WALL-2 ..
        C3-1     =INTERIOR-WALL        AREA = 1056            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
        F3-1     =UNDERGROUND-FLOOR    AREA = 1056
                                       CONSTRUCTION = FLOOR-1                   ..
        SB34     =INTERIOR-WALL        AREA 135.8             NEXT-TO  SPACE4-1
                                       CONSTRUCTION = SB-U                      ..
        SB35     =INTERIOR-WALL        AREA 608               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

SPACE4-1         =SPACE                SPACE-CONDITIONS      =SPACE-1
                                       AREA  =     456        VOLUME = 3648
                                       NUMBER-OF-PEOPLE   =   4.56              ..
                  UNDERGROUND-WALL     AREA 400               CONSTRUCTION WALL-2 ..
        C4-1     =INTERIOR-WALL        AREA =  456            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
        F4-1     =UNDERGROUND-FLOOR    AREA =  456
                                       CONSTRUCTION = FLOOR-1                   ..
        SB45     =INTERIOR-WALL        AREA 208               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

SPACE5-1         =SPACE                SPACE-CONDITIONS      =SPACE-1
                                       AREA  =    1976        VOLUME =15808
                                       NUMBER-OF-PEOPLE   =   19.76             ..
       C5-1      =INTERIOR-WALL      AREA = 1976            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
        F5-1     =UNDERGROUND-FLOOR    AREA = 1976
                                       CONSTRUCTION = FLOOR-1                   ..

/* USE OF THE EQUIVALENCE COMMAND LIKE GREATLY REDUCES THE AMOUNT OF INPUT
CODING NEEDED FOR FLOORS 2 AND 3.  ALSO NOTE THAT U-NAMES ARE GENERALLY
NOT NEEDED FOR 2ND AND 3RD FLOOR WALLS. */

SPACE1-2=      SPACE                   LIKE SPACE1-1                            ..
                 EXTERIOR-WALL         LIKE FRONT-1           Z = 10            ..
                 WINDOW                GLASS-WIDTH = 50                         ..
                 INTERIOR-WALL         LIKE C1-1              NEXT-TO PLENUM-2  ..
      F1-2  =    INTERIOR-WALL         AREA 1056              NEXT-TO PLENUM-1
                                       CONSTRUCTION FLOOR-2                     ..
                 INTERIOR-WALL         LIKE SB12              NEXT-TO SPACE2-2  ..
                 INTERIOR-WALL         LIKE SB14              NEXT-TO SPACE4-2  ..
                 INTERIOR-WALL         LIKE SB15              NEXT-TO SPACE5-2  ..

SPACE2-2=      SPACE                   LIKE SPACE2-1                            ..
      RIGHT-1   =EXTERIOR-WALL         HEIGHT = 8             WIDTH =  50
                                       X=100 Y = 0 Z = 10     AZIMUTH =  90
```

```
                                        CONSTRUCTION = WALL-1
         WR-1      =WINDOW              GLASS-WIDTH = 25
                     INTERIOR-WALL      LIKE C2-1              NEXT-TO PLENUM-2
       F2-2   =      INTERIOR-WALL      AREA 456               NEXT-TO PLENUM-1
                                        CONSTRUCTION FLOOR-2
                     INTERIOR-WALL      LIKE SB23              NEXT-TO SPACE3-2
                     INTERIOR-WALL      LIKE SB25              NEXT-TO SPACE5-2

  SPACE3-2=      SPACE                  LIKE SPACE3-1
       BACK-1      =EXTERIOR-WALL       HEIGHT = 8             WIDTH = 100
                                        X=100 Y =50 Z = 10     AZIMUTH =   0
                                        CONSTRUCTION = WALL-1
         WB-1 =      WINDOW             GLASS-WIDTH = 45
          DB-1     =WINDOW              GLASS-WIDTH = 3.6      GLASS-HEIGHT = 7
                                        GLASS-TYPE=BCKDR
                                        MULTIPLIER = 2
                     INTERIOR-WALL      LIKE C3-1              NEXT-TO PLENUM-2
       F3-2   =      INTERIOR-WALL      AREA 1056              NEXT-TO PLENUM-1
                                        CONSTRUCTION FLOOR-2
                     INTERIOR-WALL      LIKE SB34              NEXT-TO SPACE4-2
                     INTERIOR-WALL      LIKE SB35              NEXT-TO SPACE5-2
  SPACE4-2=      SPACE                  LIKE SPACE4-1
       LEFT-1      =EXTERIOR-WALL       HEIGHT = 8             WIDTH =  50
                                        X = 0 Y =50 Z = 10     AZIMUTH = 270
                                        CONSTRUCTION = WALL-1
         WL-1=       WINDOW             GLASS-WIDTH = 25
                     INTERIOR-WALL      LIKE C4-1              NEXT-TO PLENUM-2
       F4-2   =      INTERIOR-WALL      AREA 456               NEXT-TO PLENUM-1
                                        CONSTRUCTION FLOOR-2
                     INTERIOR-WALL      LIKE SB45              NEXT-TO SPACE5-2
  SPACE5-2=      SPACE                  LIKE SPACE5-1
                     INTERIOR-WALL      LIKE C5-1              NEXT-TO PLENUM-2
       F5-2   =      INTERIOR-WALL      AREA 1976              NEXT-TO PLENUM-1
                                        CONSTRUCTION FLOOR-2
  SPACE1-3=      SPACE                  LIKE SPACE1-1
                     EXTERIOR-WALL      LIKE FRONT-1           Z = 20
                     WINDOW             GLASS-WIDTH = 50
                     INTERIOR-WALL      LIKE C1-1              NEXT-TO PLENUM-3
                     INTERIOR-WALL      LIKE F1-2              NEXT-TO PLENUM-2
                     INTERIOR-WALL      LIKE SB12              NEXT-TO SPACE2-3
                     INTERIOR-WALL      LIKE SB14              NEXT-TO SPACE4-3
                     INTERIOR-WALL      LIKE SB15              NEXT-TO SPACE5-3
  SPACE2-3=      SPACE                  LIKE SPACE2-1
                     EXTERIOR-WALL      LIKE RIGHT-1           Z = 20
                     WINDOW             LIKE WR-1
                     INTERIOR-WALL      LIKE C2-1              NEXT-TO PLENUM-3
                     INTERIOR-WALL      LIKE F2-2              NEXT-TO PLENUM-2
                     INTERIOR-WALL      LIKE SB23              NEXT-TO SPACE3-3
                     INTERIOR-WALL      LIKE SB23              NEXT-TO SPACE5-3
  SPACE3-3=      SPACE                  LIKE SPACE3-1
                   EXTERIOR-WALL        LIKE BACK-1            Z = 20
         WB-3=       WINDOW             GLASS-WIDTH = 50
                     INTERIOR-WALL      LIKE C3-1              NEXT-TO PLENUM-3
                     INTERIOR-WALL      LIKE F3-2              NEXT-TO PLENUM-2
                     INTERIOR-WALL      LIKE SB34              NEXT-TO SPACE4-3
                     INTERIOR-WALL      LIKE SB35              NEXT-TO SPACE5-3
  SPACE4-3=      SPACE                  LIKE SPACE4-1
                     EXTERIOR-WALL      LIKE LEFT-1            Z = 20
                     WINDOW             LIKE WL-1
                     INTERIOR-WALL      LIKE C4-1              NEXT-TO PLENUM-3
                     INTERIOR-WALL      LIKE F4-2              NEXT-TO PLENUM-2
                     INTERIOR-WALL      LIKE SB45              NEXT-TO SPACE5-3
  SPACE5-3=      SPACE                  LIKE SPACE5-1
                     INTERIOR-WALL      LIKE C5-1              NEXT-TO PLENUM-3
                     INTERIOR-WALL      LIKE F5-2              NEXT-TO PLENUM-2

                     END /*LOADS*/
```

REPORT- L01 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.	1.393	JUL 9 6 PM	96F	73F	-2.996	JAN 12 10 AM	-7F	-7F
PLENUM-2	1.	1.393	JUL 9 6 PM	96F	73F	-2.996	JAN 12 10 AM	-7F	-7F
PLENUM-3	1.	57.592	JUL 7 4 PM	88F	73F	-79.772	JAN 12 9 AM	-8F	-8F
SPACE1-1	1.	42.386	SEP 26 5 PM	81F	61F	-32.355	MAR 24 5 AM	9F	8F
SPACE2-1	1.	6.054	AUG 30 3 PM	82F	64F	-1.567	JAN 2 8 AM	4F	3F
SPACE3-1	1.	11.990	APR 26 3 PM	78F	61F	0.000		0F	0F
SPACE4-1	1.	5.177	APR 26 3 PM	78F	61F	0.000		0F	0F
SPACE5-1	1.	22.435	APR 26 3 PM	78F	61F	0.000		0F	0F
SPACE1-2	1.	36.571	SEP 26 5 PM	81F	61F	-16.274	JAN 12 8 AM	-7F	-7F
SPACE2-2	1.	15.350	JUL 3 11 AM	87F	74F	-8.390	JAN 12 8 AM	-7F	-7F
SPACE3-2	1.	27.388	JUL 3 3 PM	92F	74F	-32.439	APR 8 7 AM	31F	28F
SPACE4-2	1.	14.278	JUL 9 5 PM	97F	73F	-9.334	JAN 12 8 AM	-7F	-7F
SPACE5-2	1.	22.435	APR 26 3 PM	78F	61F	0.000		0F	0F
SPACE1-3	1.	36.571	SEP 26 5 PM	81F	61F	-16.274	JAN 12 8 AM	-7F	-7F
SPACE2-3	1.	15.350	JUL 3 11 AM	87F	74F	-8.390	JAN 12 8 AM	-7F	-7F
SPACE3-3	1.	25.517	JUL 3 3 PM	92F	74F	-17.226	JAN 12 8 AM	-7F	-7F
SPACE4-3	1.	14.278	JUL 9 5 PM	97F	73F	-9.334	JAN 12 8 AM	-7F	-7F
SPACE5-3	1.	22.435	APR 26 3 PM	78F	61F	0.000		0F	0F
SUM		378.593				-237.346			
BUILDING PEAK		345.257	JUL 9 5 PM	97F	73F	-222.574	JAN 12 8 AM	-7F	-7F

REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE PLENUM-1

MULTIPLIER 1

FLOOR AREA	0	SQFT	0	SQMT
VOLUME	10000	CUFT	283	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 6 PM		JAN 12 10 AM	
DRY-BULB TEMP	96F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	1.393	1.47	0.000	0.00	-2.996	-3.16
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	1.393	1.47	0.000	0.00	-2.996	-3.16
TOTAL LOAD	1.393 KBTU/H	1.47 MJ/H			-2.996 KBTU/H	-3.16 MJ/H

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

SPACE PLENUM-2

MULTIPLIER	1			
FLOOR AREA	0	SQFT	0	SQMT
VOLUME	10000	CUFT	283	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 6 PM		JAN 12 10 AM	
DRY-BULB TEMP	96F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	1.393	1.47	0.000	0.00	-2.996	-3.16
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	1.393	1.47	0.000	0.00	-2.996	-3.16
TOTAL LOAD	1.393 KBTU/H		1.47 MJ/H		-2.996 KBTU/H	-3.16 MJ/H

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

REPORT- L02 SPACE PEAK LOAD COMPONENTS SPACE PLENUM-2

PROJECT- EXAMPLE BUILDING 4 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.44

REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE PLENUM-3

MULTIPLIER	1			
FLOOR AREA	0	SQFT	0	SQMT
VOLUME	10000	CUFT	283	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 9 AM	
DRY-BULB TEMP	88F	31C	-8F	-22C
WET-BULB TEMP	73F	23C	-8F	-22C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	1.262	1.33	0.000	0.00	-2.982	-3.15
CEILINGS	56.330	59.43	0.000	0.00	-76.790	-81.02
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	57.592	60.76	0.000	0.00	-79.772	-84.16
TOTAL LOAD	57.592 KBTU/H		60.76 MJ/H		-79.772 KBTU/H	-84.16 MJ/H

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

REPORT- L02 SPACE PEAK LOAD COMPONENTS SPACE PLENUM-3

SPACE SPACE2-1

MULTIPLIER 1

FLOOR AREA 456 SQFT 42 SQMT
VOLUME 3648 CUFT 103 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30	3 PM	JAN 2	8 AM
DRY-BULB TEMP	82F	28C	4F	-16C
WET-BULB TEMP	64F	18C	3F	-16C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	.890	.94	0.000	0.00	-1.781	-1.88
OCCUPANTS TO SPACE	1.169	1.23	.423	.45	0.000	0.00
LIGHT TO SPACE	2.551	2.69	0.000	0.00	.149	.16
EQUIPMENT TO SPACE	1.020	1.08	0.000	0.00	.065	.07
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	5.631	5.94	.423	.45	-1.567	-1.65

	COOLING		HEATING	
TOTAL LOAD	6.054 KBTU/H	6.39 MJ/H	-1.567 KBTU/H	-1.65 MJ/H
TOTAL LOAD / AREA	13.28 BTUH/SQFT	.15208 MJ/H/SQMT	3.44 BTUH/SQFT	.03935 MJ/H/SQMT

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

SPACE SPACE3-1

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 8448 CUFT 239 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	APR 26	3 PM		
DRY-BULB TEMP	78F	26C		
WET-BULB TEMP	61F	16C		

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	2.714	2.86	.980	1.03	0.000	0.00
LIGHT TO SPACE	5.927	6.25	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	2.368	2.50	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	11.010	11.62	.980	1.03	0.000	0.00

	COOLING	
TOTAL LOAD	11.990 KBTU/H	12.65 MJ/H
TOTAL LOAD / AREA	11.35 BTUH/SQFT	.12908 MJ/H/SQMT

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

SPACE SPACE4-1

MULTIPLIER 1

FLOOR AREA 456 SQFT 42 SQMT
VOLUME 3648 CUFT 103 CUMT

	COOLING LOAD		HEATING LOAD
TIME	APR 26 3 PM		
DRY-BULB TEMP	78F	26C	
WET-BULB TEMP	61F	16C	

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	1.172	1.24	.423	.45	0.000	0.00
LIGHT TO SPACE	2.559	2.70	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	1.023	1.08	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	4.759	5.02	.423	.45	0.000	0.00

TOTAL LOAD 5.177 KBTU/H 5.46 MJ/H

TOTAL LOAD / AREA 11.35 BTUH/SQFT .13006 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE4-1

SPACE SPACE5-1

MULTIPLIER 1

FLOOR AREA 1976 SQFT 183 SQMT
VOLUME 15808 CUFT 447 CUMT

	COOLING LOAD		HEATING LOAD
TIME	APR 26 3 PM		
DRY-BULB TEMP	78F	26C	
WET-BULB TEMP	61F	16C	

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	5.079	5.36	1.833	1.93	0.000	0.00
LIGHT TO SPACE	11.091	11.70	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	4.432	4.68	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	20.602	21.74	1.833	1.93	0.000	0.00

TOTAL LOAD 22.435 KBTU/H 23.67 MJ/H

TOTAL LOAD / AREA 11.35 BTUH/SQFT .12935 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE5-1

PROJECT- EXAMPLE BUILDING 4 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.44

REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE1-2

MULTIPLIER	1			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	SEP 26 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	81F	27C	-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	.895	.94	0.000	0.00	-2.868	-3.03
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.701	1.79	0.000	0.00	-15.434	-16.28
GLASS SOLAR	22.148	23.37	0.000	0.00	1.225	1.29
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	2.813	2.97	.980	1.03	.136	.14
LIGHT TO SPACE	6.154	6.49	0.000	0.00	.742	.78
EQUIPMENT TO SPACE	1.881	1.98	0.000	0.00	.761	.80
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.836	-.88
TOTAL	35.591	37.55	.980	1.03	-16.274	-17.17
TOTAL LOAD	36.571 KBTU/H		38.58 MJ/H		-16.274 KBTU/H	-17.17 MJ/H
TOTAL LOAD / AREA	34.63 BTUH/SQFT		.39372 MJ/H/SQMT		15.41 BTUH/SQFT	.17521 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE1-2

PROJECT- EXAMPLE BUILDING 4 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.44

REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE2-2

MULTIPLIER	1			
FLOOR AREA	456	SQFT	42	SQMT
VOLUME	3648	CUFT	103	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 11 AM		JAN 12 8 AM	
DRY-BULB TEMP	87F	31C	-7F	-22C
WET-BULB TEMP	74F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.568	.60	0.000	0.00	-1.439	-1.52
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.724	1.82	0.000	0.00	-7.717	-8.14
GLASS SOLAR	8.469	8.93	0.000	0.00	.405	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	.920	.97	.338	.36	.059	.06
LIGHT TO SPACE	2.212	2.33	0.000	0.00	.320	.34
EQUIPMENT TO SPACE	1.118	1.18	0.000	0.00	.329	.35
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.347	-.37
TOTAL	15.011	15.84	.338	.36	-8.390	-8.85
TOTAL LOAD	15.350 KBTU/H		16.19 MJ/H		-8.390 KBTU/H	-8.85 MJ/H
TOTAL LOAD / AREA	33.66 BTUH/SQFT		.38559 MJ/H/SQMT		18.40 BTUH/SQFT	.21076 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE2-2

SPACE SPACE3-2

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 8448 CUFT 239 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 3 PM		APR 8 7 AM	
DRY-BULB TEMP	92F	33C	31F	-1C
WET-BULB TEMP	74F	23C	28F	-2C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.886	.94	0.000	0.00	-1.419	-1.50
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	5.222	5.51	0.000	0.00	-10.380	-10.95
GLASS SOLAR	9.323	9.84	0.000	0.00	1.117	1.18
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	2.708	2.86	.980	1.03	.000	.00
LIGHT TO SPACE	5.908	6.23	0.000	0.00	.347	.37
EQUIPMENT TO SPACE	2.363	2.49	0.000	0.00	.162	.17
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-22.266	-23.49
TOTAL	26.409	27.86	.980	1.03	-32.439	-34.23

TOTAL LOAD	27.388 KBTU/H	28.90 MJ/H	-32.439 KBTU/H	-34.23 MJ/H
TOTAL LOAD / AREA	25.94 BTUH/SQFT	.29486 MJ/H/SQMT	30.72 BTUH/SQFT	.34924 MJ/H/SQMT

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

SPACE SPACE4-2

MULTIPLIER 1

FLOOR AREA 456 SQFT 42 SQMT
VOLUME 3648 CUFT 103 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.679	.72	0.000	0.00	-1.446	-1.53
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	2.531	2.67	0.000	0.00	-7.717	-8.14
GLASS SOLAR	5.964	6.29	0.000	0.00	.080	.08
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	1.214	1.28	.423	.45	.059	.06
LIGHT TO SPACE	2.656	2.80	0.000	0.00	.320	.34
EQUIPMENT TO SPACE	.812	.86	0.000	0.00	.329	.35
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.958	-1.01
TOTAL	13.855	14.62	.423	.45	-9.334	-9.85

TOTAL LOAD	14.278 KBTU/H	15.06 MJ/H	-9.334 KBTU/H	-9.85 MJ/H
TOTAL LOAD / AREA	31.31 BTUH/SQFT	.35868 MJ/H/SQMT	20.47 BTUH/SQFT	.23447 MJ/H/SQMT

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

SPACE SPACE5-2

MULTIPLIER 1

FLOOR AREA	1976	SQFT	183	SQMT
VOLUME	15808	CUFT	447	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	APR 26	3 PM		
DRY-BULB TEMP	78F	26C		
WET-BULB TEMP	61F	16C		

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	5.079	5.36	1.833	1.93	0.000	0.00
LIGHT TO SPACE	11.091	11.70	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	4.432	4.68	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	20.602	21.74	1.833	1.93	0.000	0.00

TOTAL LOAD 22.435 KBTU/H 23.67 MJ/H

TOTAL LOAD / AREA 11.35 BTUH/SQFT .12935 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE5-2

PROJECT- EXAMPLE BUILDING 4 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.44
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE1-3

MULTIPLIER 1

FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	SEP 26	5 PM	JAN 12	8 AM
DRY-BULB TEMP	81F	27C	-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	.895	.94	0.000	0.00	-2.868	-3.03
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.701	1.79	0.000	0.00	-15.434	-16.28
GLASS SOLAR	22.148	23.37	0.000	0.00	1.225	1.29
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	2.813	2.97	.980	1.03	.136	.14
LIGHT TO SPACE	6.154	6.49	0.000	0.00	.742	.78
EQUIPMENT TO SPACE	1.881	1.98	0.000	0.00	.761	.80
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.836	-.88
TOTAL	35.591	37.55	.980	1.03	-16.274	-17.17

TOTAL LOAD 36.571 KBTU/H 38.58 MJ/H -16.274 KBTU/H -17.17 MJ/H

TOTAL LOAD / AREA 34.63 BTUH/SQFT .39372 MJ/H/SQMT 15.41 BTUH/SQFT .17521 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE1-3

SPACE SPACE2-3

MULTIPLIER	1			
FLOOR AREA	456	SQFT	42	SQMT
VOLUME	3648	CUFT	103	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 11 AM		JAN 12 8 AM	
DRY-BULB TEMP	87F	31C	-7F	-22C
WET-BULB TEMP	74F	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	.568	.60	0.000	0.00	-1.439	-1.52
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.724	1.82	0.000	0.00	-7.717	-8.14
GLASS SOLAR	8.469	8.93	0.000	0.00	.405	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	.920	.97	.338	.36	.059	.06
LIGHT TO SPACE	2.212	2.33	0.000	0.00	.320	.34
EQUIPMENT TO SPACE	1.118	1.18	0.000	0.00	.329	.35
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.347	-.37
TOTAL	15.011	15.84	.338	.36	-8.390	-8.85

	COOLING		HEATING	
TOTAL LOAD	15.350 KBTU/H	16.19 MJ/H	-8.390 KBTU/H	-8.85 MJ/H
TOTAL LOAD / AREA	33.66 BTUH/SQFT	.38559 MJ/H/SQMT	18.40 BTUH/SQFT	.21076 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE2-3

PROJECT- EXAMPLE BUILDING 4 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.44
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE3-3

MULTIPLIER	1			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 3 PM		JAN 12 8 AM	
DRY-BULB TEMP	92F	33C	-7F	-22C
WET-BULB TEMP	74F	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	.934	.98	0.000	0.00	-2.894	-3.05
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	4.533	4.78	0.000	0.00	-15.434	-16.28
GLASS SOLAR	8.093	8.54	0.000	0.00	.109	.12
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	2.708	2.86	.980	1.03	.136	.14
LIGHT TO SPACE	5.908	6.23	0.000	0.00	.742	.78
EQUIPMENT TO SPACE	2.363	2.49	0.000	0.00	.761	.80
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.645	-.68
TOTAL	24.537	25.89	.980	1.03	-17.226	-18.17

	COOLING		HEATING	
TOTAL LOAD	25.517 KBTU/H	26.92 MJ/H	-17.226 KBTU/H	-18.17 MJ/H
TOTAL LOAD / AREA	24.16 BTUH/SQFT	.27471 MJ/H/SQMT	16.31 BTUH/SQFT	.18545 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE3-3

SPACE SPACE4-3

MULTIPLIER 1

FLOOR AREA	456	SQFT	42	SQMT
VOLUME	3648	CUFT	103	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	.679	.72	0.000	0.00	-1.446	-1.53
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	2.531	2.67	0.000	0.00	-7.717	-8.14
GLASS SOLAR	5.964	6.29	0.000	0.00	.080	.08
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	1.214	1.28	.423	.45	.059	.06
LIGHT TO SPACE	2.656	2.80	0.000	0.00	.320	.34
EQUIPMENT TO SPACE	.812	.86	0.000	0.00	.329	.35
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-.958	-1.01
TOTAL	13.855	14.62	.423	.45	-9.334	-9.85
TOTAL LOAD	14.278 KBTU/H		15.06 MJ/H		-9.334 KBTU/H	-9.85 MJ/H
TOTAL LOAD / AREA	31.31 BTUH/SQFT		.35868 MJ/H/SQMT		20.47 BTUH/SQFT	.23447 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE4-3

PROJECT- EXAMPLE BUILDING 4 USER NAME CAL-ERDA 1.3 18 OCT 1977 19.05.44
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE5-3

MULTIPLIER 1

FLOOR AREA	1976	SQFT	183	SQMT
VOLUME	15808	CUFT	447	CUMT

	COOLING LOAD		HEATING LOAD
TIME	APR 26 3 PM		
DRY-BULB TEMP	78F	26C	
WET-BULB TEMP	61F	16C	

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	5.079	5.36	1.833	1.93	0.000	0.00
LIGHT TO SPACE	11.091	11.70	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	4.432	4.68	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	20.602	21.74	1.833	1.93	0.000	0.00
TOTAL LOAD	22.435 KBTU/H		23.67 MJ/H			
TOTAL LOAD / AREA	11.35 BTUH/SQFT		.12935 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- L02 SPACE PEAK LOAD COMPONENTS SPACE SPACE5-3

*** BUILDING ***

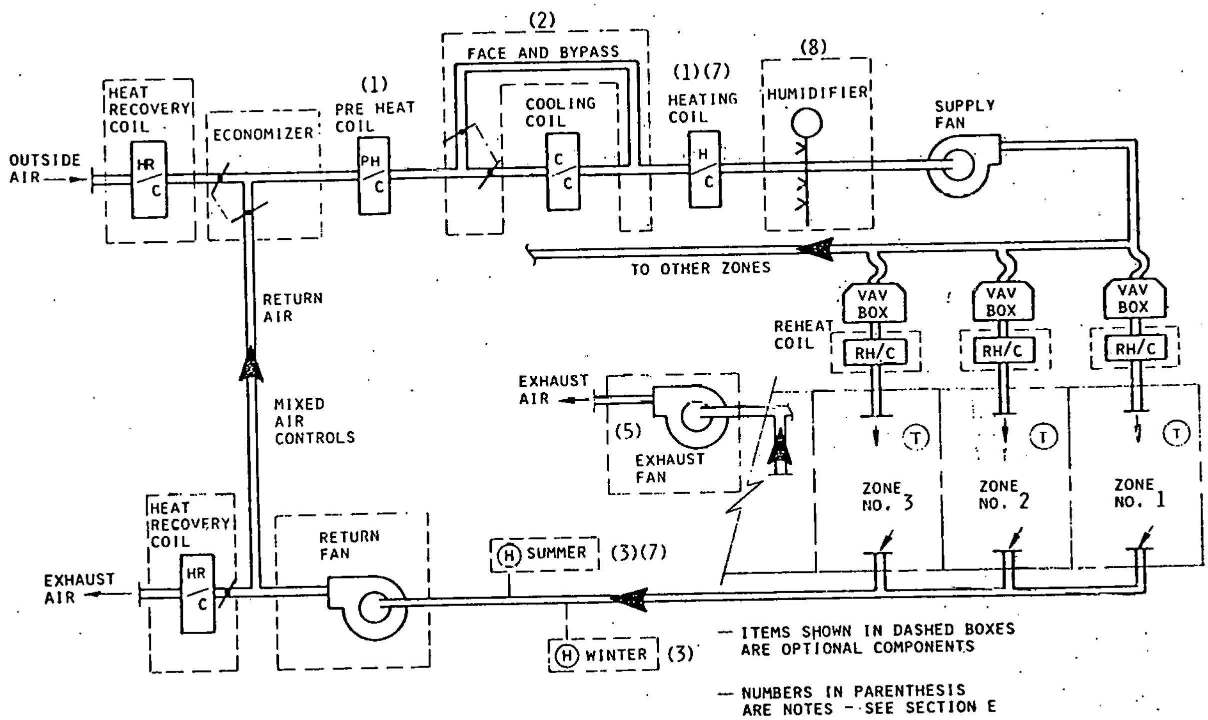
FLOOR AREA	15000	SQFT	1393	SQMT
VOLUME	150000	CUFT	4248	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 12 8 AM	
DRY-BULB TEMP	97F	36C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	13.249	13.98	0.000	0.00	-28.594	-30.17
CEILINGS	47.576	50.19	0.000	0.00	-75.878	-80.06
GLASS CONDUCTION	37.310	39.36	0.000	0.00	-113.779	-120.04
GLASS SOLAR	77.967	82.26	0.000	0.00	5.150	5.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	1.227	1.29	0.000	0.00	-3.682	-3.88
OCCUPANTS TO SPACE	39.939	42.14	13.914	14.68	.971	1.02
LIGHT TO SPACE	87.363	92.17	0.000	0.00	5.310	5.60
EQUIPMENT TO SPACE	26.713	28.18	0.000	0.00	5.449	5.75
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-17.522	-18.49
TOTAL	331.343	349.59	13.914	14.68	-222.574	-234.83

	COOLING		HEATING	
TOTAL LOAD	345.257 KBTU/H	364.27 MJ/H	-222.574 KBTU/H	-234.83 MJ/H
TOTAL LOAD / AREA	23.02 BTUH/SQFT	.26150 MJ/H/SQMT	14.84 BTUH/SQFT	.16858 MJ/H/SQMT

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



SYSTEM NO. 12 Variable Volume Fan System (VAVS)

<u>Example 5, Add Variable Volume fan system, Plant, and Economics to Example 4.</u>

L D L   P R O C E S S O R   I N P U T   D A T A

```
          1         2         3         4         5         6         7         8
 12345678901234567890123456789012345678901234567890123456789012345678901234567890

 /* INPUT LOADS */

 TITLE    EXAMPLE BUILDING 3                                                      ••
 TITLE    USER NAME                                                               ••

                             /*PROGRAM CONTROL INSTRUCTIONS*/                     ••

                    RUN-PERIOD          JAN  1 1974  THRU  DEC 31 1974            ••
                    DIAGNOSTIC          WARNING                                   ••
                    LIST                ABORT ERROR                               ••
                    LOADS-REPORT        L02                                       ••
                    BUILDING-LOCATION   LATITUDE = 42.0 LONGITUDE = 88.0
                                        TIME-ZONE=6.0  BUILDING-AZIMUTH=30.0      ••

                             /*DEFINE USER VARIABLES*/

                    DEFINE              WOO-1=WA01-2                              ••
                    DEFINE              ROO-1=SF1-RF                              ••
                    DEFINE              WEEK-SCHEDULE=SCHEDULE-BLOCK              ••

                             /*CONSTRUCTION AND GLASS-TYPES*/

 WALL-1             =CONSTRUCTION       WALL-TYPE=WOO-1                           ••
 ROOF-1             =CONSTRUCTION       ROOF-TYPE=ROO-1                           ••
 CLNG-1             =CONSTRUCTION       U = 0.27             /*CEILING*/          ••
 SB-U               =CONSTRUCTION       U = 2.0              /*PARTITION*/        ••
 FLOOR-1            =CONSTRUCTION       U = 0.3                                   ••
 W-1                =GLASS-TYPE         SHADING-COEFF=0.86
                                        PANES=2                                   ••
 FRNTDR             =GLASS-TYPE         GLASS-TYPE-CODE = 1
                                        GLASS-INFILTRATION = 18                   ••
 BCKDR              =GLASS-TYPE         GLASS-TYPE-CODE = 1
                                        GLASS-INFILTRATION = 18                   ••

                             /*SCHEDULES*/                                        ••

 OC-1               =DAY-SCHEDULE       (1,8) 0.0
                                        (9,11) 1.0
                                        (12,14) 0.8,0.4,0.8
                                        (15,18) 1.0
                                        (19,21) 0.5,0.1,0.1
                                        (22,24) 0.0                               ••

 OC-2               =DAY-SCHEDULE       (1,24) 0.0                                ••

 OC-WEEK            =WEEK-SCHEDULE      (SUN)      OC-2
                                        (MON,FRI) OC-1
                                        (SAT,HOL) OC-2                            ••

 OCCUPY-1           =SCHEDULE           THRU DEC 31 OC-WEEK                       ••

 LT-1               =DAY-SCHEDULE       (1,8) 0.05
                                        (9,14) 0.9,0.95,1.0,0.95,0.8,0.9
                                        (15,18) 1.0
                                        (19,21) 0.6,0.2,0.2
                                        (22,24) 0.05                              ••


 LT-2               =DAY-SCHEDULE       (1,24) 0.05                               ••

 LT-WEEK            =WEEK-SCHEDULE      (SUN)      LT-2
                                        (MON,FRI) LT-1
                                        (SAT,HOL) LT-2                            ••

 LIGHTS-1           =SCHEDULE           THRU DEC 31 LT-WEEK                       ••

 EQ-1               =DAY-SCHEDULE       (1,8) 0.02
                                        (9,14) 0.4,0.9,0.9,0.9,0.9,0.9
                                        (15,20) 0.8,0.7,0.5,0.5,0.3,0.3
                                        (21,24) 0.02                              ••

 EQ-2               =DAY-SCHEDULE       (1,24) 0.2                                ••
```

```
EQ-WEEK          =WEEK-SCHEDULE       (SUN)       EQ-2
                                      (MON,FRI) EQ-1
                                      (SAT,HOL) EQ-2

EQUIP-1          =SCHEDULE            THRU DEC 31 EQ-WEEK

INF-1            =DAY-SCHEDULE        (1,8) 1.0
                                      (9,18) 0.0
                                      (19,24) 1.0

INF-2            =DAY-SCHEDULE        (1,24) 1.0

INF-WEEK         =SCHEDULE-BLOCK      (SUN)       INF-2
                                      (MON,FRI)  INF-1
                                      (SAT,HOL)  INF-2

INFIL-SCH        =SCHEDULE            THRU DEC 31 INF-WEEK

                           /*SET-DEFAULT VALUES*/

                  SET-DEFAULT         FLOOR-HEIGHT = 70.0
                                      GLASS-HEIGHT = 4.0
                                      GLASS-WIDTH = 5.0
                                      GLASS-TYPE = W-1

                           /*GENERAL SPACE DEFINITIONS*/

PLENUM           =SPACE-CONDITIONS    FLOOR-WEIGHT = 5         TEMP = 70

SPACE-1          =SPACE-CONDITIONS    FLOOR-WEIGHT             =70
                                      TEMP                     =70
                                      PEOPLE-SCHEDULE          =OCCUPY-1
                                      NUMBER-OF-PEOPLE         =50
                                      PEOPLE-ACTIVITY          =400.0
                                      LIGHTING-SCHEDULE        =LIGHTS-1
                                      LIGHTING-TYPE            =2
                                      LIGHT-TO-SPACE           =80
                                      LIGHTING-W/SQFT          =3
                                      EQUIPMENT-SCHEDULE       =EQUIP-1
                                      EQUIPMENT-W/SQFT         =1
                                      INF-METHOD               =2
                                      NEUTRAL-ZONE-HEIGHT      =6
                                      INF-SCHEDULE             =INFIL-SCH

                           /*SPECIFIC SPACE DETAILS*/

PLENUM-1         =SPACE               SPACE-CONDITIONS=PLENUM
                                      VOLUME=10000             SPACE-HEIGHT=2

     WALL-1PF    =EXTERIOR-WALL       HEIGHT = 2               WIDTH = 100
                                      AZIMUTH = 180
                                      CONSTRUCTION = WALL-1

     WALL-1PR    =EXTERIOR-WALL       HEIGHT = 2               WIDTH =  50
                                      AZIMUTH =  90
                                      CONSTRUCTION = WALL-1

     WALL-1PB    =EXTERIOR-WALL       HEIGHT = 2               WIDTH = 100
                                      AZIMUTH =   0
                                      CONSTRUCTION = WALL-1

     WALL-1PL    =EXTERIOR-WALL       HEIGHT = 2               WIDTH =  50
                                      AZIMUTH = 270
                                      CONSTRUCTION = WALL-1

     TOP-1       =ROOF                LENGTH = 100             WIDTH = 50
                                      X=0   Y=0   Z=10         AZIMUTH = 180
                                      TILT=0                   GND-REFLECTANCE=0
                                      CONSTRUCTION = ROOF-1

SPACE1-1         =SPACE               SPACE-CONDITIONS         =SPACE-1
                                      AREA  =   1056           VOLUME = 8448
                                      NUMBER-OF-PEOPLE    =    10.56
```

```

     FRCNT-1      =EXTERIOR-WALL       HEIGHT = 8             WIDTH = 100
                                       X=0   Y=0   Z=0        AZIMUTH = 180
                                       CONSTRUCTION = WALL-1                    ..
       WF-1       =WINDOW              GLASS-WIDTH = 45                         ..
       DF-1       =WINDOW              GLASS-WIDTH = 4        GLASS-HEIGHT = 8
                                       MULTIPLIER = 2         GLASS-TYPE = FRNTDR ..
     C1-1         =INTERIOR-WALL       AREA = 1056            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
     F1-1         =UNDERGROUND-FLOOR   AREA = 1056
                                       CONSTRUCTION = FLOOR-1                   ..
     SB12         =INTERIOR-WALL       AREA 135.76            NEXT-TO  SPACE2-1
                                       CONSTRUCTION = SB-U                      ..
     SB14         =INTERIOR-WALL       LIKE SB12              NEXT-TO  SPACE4-1 ..
     SB15         =INTERIOR-WALL       AREA 608               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

 SPACE2-1         =SPACE               SPACE-CONDITIONS       =SPACE-1
                                       AREA =      456        VOLUME = 3648
                                       NUMBER-OF-PEOPLE   =   4.56              ..
     RIGHT-1      =EXTERIOR-WALL       HEIGHT = 8             WIDTH =   50
                                       X=100  Y=0   Z=0       AZIMUTH =   90
                                       CONSTRUCTION = WALL-1                    ..
       WR-1       =WINDOW              GLASS-WIDTH = 25                         ..
     C2-1         =INTERIOR-WALL       AREA =  456            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
     F2-1         =UNDERGROUND-FLOOR   AREA =  456
                                       CONSTRUCTION = FLOOR-1                   ..
     SB23         =INTERIOR-WALL       AREA 135.76            NEXT-TO  SPACE3-1
                                       CONSTRUCTION = SB-U                      ..
     SB25         =INTERIOR-WALL       AREA 208               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

 SPACE3-1         =SPACE               SPACE-CONDITIONS     =SPACE-1
                                       AREA =    1056         VOLUME = 8448
                                       NUMBER-OF-PEOPLE   =   10.56             ..
     BACK-1       =EXTERIOR-WALL       HEIGHT = 8             WIDTH = 100
                                       X=100  Y=50  Z=0       AZIMUTH =    0
                                       CONSTRUCTION = WALL-1                    ..
       WB-1       =WINDOW              GLASS-WIDTH = 45                         ..
       DB-1       =WINDOW              GLASS-WIDTH = 3.6      GLASS-HEIGHT = 7
                                       GLASS-TYPE=BCKDR
                                       MULTIPLIER = 2                           ..
     C3-1         =INTERIOR-WALL       AREA = 1056            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
     F3-1         =UNDERGROUND-FLOOR   AREA = 1056
                                       CONSTRUCTION = FLOOR-1                   ..
     SB34         =INTERIOR-WALL       AREA 135.8             NEXT-TO  SPACE4-1
                                       CONSTRUCTION = SB-U                      ..
     SB35         =INTERIOR-WALL       AREA 608               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

 SPACE4-1         =SPACE               SPACE-CONDITIONS       =SPACE-1
                                       AREA =      456        VOLUME = 3648
                                       NUMBER-OF-PEOPLE   =   4.56              ..
     LEFT-1       =EXTERIOR-WALL       HEIGHT = 8             WIDTH =   50
                                       X=0    Y=50  Z=0       AZIMUTH = 270
                                       CONSTRUCTION = WALL-1                    ..
       WL-1       =WINDOW              GLASS-WIDTH = 25                         ..
     C4-1         =INTERIOR-WALL       AREA =  456            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
     F4-1         =UNDERGROUND-FLOOR   AREA =  456
                                       CONSTRUCTION = FLOOR-1                   ..
     SB45         =INTERIOR-WALL       AREA 208               NEXT-TO  SPACE5-1
                                       CONSTRUCTION = SB-U                      ..

 SPACE5-1         =SPACE               SPACE-CONDITIONS       =SPACE-1
                                       AREA =     1976        VOLUME =15808
                                       NUMBER-OF-PEOPLE   =   19.76             ..
     C5-1         =INTERIOR-WALL       AREA = 1976            NEXT-TO  PLENUM-1
                                       CONSTRUCTION = CLNG-1                    ..
     F5-1         =UNDERGROUND-FLOOR   AREA = 1976
                                       CONSTRUCTION = FLOOR-1                   ..

 END /*LOADS*/                                                                  ..
```

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 12 NOV 1977 14.26.17

REPORT- L01 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.	20.757	JUL 7 3 PM	90F	72F	-20.576	JAN 12 9 AM	-8F	-8F
SPACE1-1	1.	33.416	SEP 26 5 PM	81F	61F	-32.275	MAR 25 8 AM	14F	12F
SPACE2-1	1.	11.815	AUG 19 1 PM	87F	70F	-7.637	FEB 4 7 AM	6F	5F
SPACE3-1	1.	20.583	JUL 9 5 PM	97F	73F	-33.057	APR 8 7 AM	31F	28F
SPACE4-1	1.	9.514	JUL 9 5 PM	97F	73F	-7.678	FEB 4 7 AM	6F	5F
SPACE5-1	1.	18.226	AUG 30 3 PM	82F	64F	-18.041	FEB 25 8 AM	10F	9F
SUM		114.311				-119.264			
BUILDING PEAK		96.385	AUG 19 5 PM	90F	71F	-101.819	JAN 7 6 AM	1F	1F

REPORT- L01 SPACE PEAK LOADS SUMMARY

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 12 NOV 1977 14.26.17

REPORT- L02 SPACE PEAK LOAD COMPONENTS

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 12 NOV 1977 14.26.17
REPORT- LO2 SPACE PEAK LOAD COMPONENTS

SPACE PLENUM-1

MULTIPLIER 1

FLOOR AREA 0 SQFT 0 SQMT
VOLUME 10000 CUFT 283 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 3 PM		JAN 12 9 AM	
DRY-BULB TEMP	90F	32C	-8F	-22C
WET-BULB TEMP	72F	22C	-8F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	1.664	1.76	0.000	0.00	-3.023	-3.19
CEILINGS	19.093	20.14	0.000	0.00	-17.553	-18.52
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
OCCUPANTS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
LIGHT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
EQUIPMENT TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	20.757	21.90	0.000	0.00	-20.576	-21.71

TOTAL LOAD 20.757 KBTU/H 21.90 MJ/H -20.576 KBTU/H -21.71 MJ/H

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

SPACE SPACE1-1

MULTIPLIER	1			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	SEP 26 5 PM		MAR 25 8 AM	
DRY-BULB TEMP	81F	27C	14F	-10C
WET-BULB TEMP	61F	16C	12F	-11C

	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	.891	.94	0.000	0.00	-2.078	-2.19
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.089	1.15	0.000	0.00	-8.049	-8.49
GLASS SOLAR	22.144	23.36	0.000	0.00	2.602	2.75
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-2.534	-2.67	0.000	0.00	-9.821	-10.36
OCCUPANTS TO SPACE	2.813	2.97	.980	1.03	.000	.00
LIGHT TO SPACE	6.154	6.49	0.000	0.00	.346	.37
EQUIPMENT TO SPACE	1.881	1.98	0.000	0.00	.150	.16
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-15.427	-16.28
TOTAL	32.436	34.22	.980	1.03	-32.275	-34.05

	COOLING		HEATING	
TOTAL LOAD	33.416 KBTU/H	35.26 MJ/H	-32.275 KBTU/H	-34.05 MJ/H
TOTAL LOAD / AREA	31.64 BTUH/SQFT	.35975 MJ/H/SQMT	30.56 BTUH/SQFT	.34747 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- LO2 SPACE PEAK LOAD COMPONENTS SPACE SPACE1-1

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 12 NOV 1977 14.26.17

REPORT- LO2 SPACE PEAK LOAD COMPONENTS

SPACE SPACE2-1

MULTIPLIER 1

FLOOR AREA	456	SQFT	42	SQMT
VOLUME	3648	CUFT	103	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 19 1 PM		FEB 4 7 AM	
DRY-BULB TEMP	87F	31C	6F	-14C
WET-BULB TEMP	70F	21C	5F	-15C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.694	.73	0.000	0.00	-1.234	-1.30
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.507	.53	0.000	0.00	-2.447	-2.58
GLASS SOLAR	6.961	7.34	0.000	0.00	.202	.21
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.958	-1.01	0.000	0.00	-4.378	-4.62
OCCUPANTS TO SPACE	.912	.96	.338	.36	.000	.00
LIGHT TO SPACE	2.179	2.30	0.000	0.00	.150	.16
EQUIPMENT TO SPACE	1.181	1.25	0.000	0.00	.070	.07
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	11.477	12.11	.338	.36	-7.637	-8.06

	COOLING		HEATING	
TOTAL LOAD	11.815 KBTU/H	12.47 MJ/H	-7.637 KBTU/H	-8.06 MJ/H
TOTAL LOAD / AREA	25.91 BTUH/SQFT	.29680 MJ/H/SQMT	16.75 BTUH/SQFT	.19184 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- LO2 SPACE PEAK LOAD COMPONENTS

SPACE SPACE3-1

MULTIPLIER	1			
FLOOR AREA	1056	SQFT	98	SQMT
VOLUME	8448	CUFT	239	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		APR 8 7 AM	
DRY-BULB TEMP	97F	36C	31F	-1C
WET-BULB TEMP	73F	23C	28F	-2C

	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	1.120	1.18	0.000	0.00	-1.438	-1.52
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	2.966	3.13	0.000	0.00	-5.052	-5.33
GLASS SOLAR	7.526	7.94	0.000	0.00	.733	.77
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-2.851	-3.01	0.000	0.00	-8.554	-9.02
OCCUPANTS TO SPACE	2.812	2.97	.980	1.03	.000	.00
LIGHT TO SPACE	6.150	6.49	0.000	0.00	.347	.37
EQUIPMENT TO SPACE	1.881	1.98	0.000	0.00	.162	.17
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-19.254	-20.31
TOTAL	19.604	20.68	.980	1.03	-33.057	-34.88

	COOLING		HEATING	
TOTAL LOAD	20.583 KBTU/H	21.72 MJ/H	-33.057 KBTU/H	-34.88 MJ/H
TOTAL LOAD / AREA	19.49 BTUH/SQFT	.22160 MJ/H/SQMT	31.30 BTUH/SQFT	.35589 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- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE4-1

```
MULTIPLIER          1

FLOOR  AREA       456  SQFT        42  SQMT
VOLUME           3648  CUFT       103  CUMT
```

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		FEB 4 7 AM	
DRY-BULB TEMP	97F	36C	6F	-14C
WET-BULB TEMP	73F	23C	5F	-15C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	.750	.79	0.000	0.00	-1.234	-1.30
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.936	.99	0.000	0.00	-2.447	-2.58
GLASS SOLAR	3.955	4.17	0.000	0.00	.162	.17
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-1.231	-1.30	0.000	0.00	-4.378	-4.62
OCCUPANTS TO SPACE	1.214	1.28	.423	.45	.000	.00
LIGHT TO SPACE	2.656	2.80	0.000	0.00	.150	.16
EQUIPMENT TO SPACE	.812	.86	0.000	0.00	.070	.07
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	9.091	9.59	.423	.45	-7.678	-8.10

```
TOTAL LOAD            9.514 KBTU/H       10.04 MJ/H               -7.678 KBTU/H        -8.10 MJ/H

TOTAL LOAD / AREA     20.87 BTUH/SQFT    .23901 MJ/H/SQMT         16.84 BTUH/SQFT      .19286 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- LO2 SPACE PEAK LOAD COMPONENTS

SPACE SPACE5-1

MULTIPLIER 1

FLOOR AREA	1976	SQFT	183	SQMT
VOLUME	15808	CUFT	447	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 3 PM		FEB 25 8 AM	
DRY-BULB TEMP	82F	28C	10F	-12C
WET-BULB TEMP	64F	18C	9F	-13C

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)	(KBTU/H)	(MJ/H)
WALLS	0.000	0.00	0.000	0.00	0.000	0.00
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	0.000	0.00	0.000	0.00	0.000	0.00
GLASS SOLAR	0.000	0.00	0.000	0.00	0.000	0.00
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-4.150	-4.38	0.000	0.00	-18.970	-20.01
OCCUPANTS TO SPACE	5.067	5.35	1.833	1.93	.000	.00
LIGHT TO SPACE	11.055	11.66	0.000	0.00	.647	.68
EQUIPMENT TO SPACE	4.421	4.66	0.000	0.00	.281	.30
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	0.000	0.00
TOTAL	16.393	17.30	1.833	1.93	-18.041	-19.03

TOTAL LOAD	18.226 KBTU/H	19.23 MJ/H	-18.041 KBTU/H	-19.03 MJ/H
TOTAL LOAD / AREA	9.22 BTUH/SQFT	.10508 MJ/H/SQMT	9.13 BTUH/SQFT	.10401 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- LO3 BUILDING PEAK LOAD COMPONENTS

*** BUILDING ***

FLOOR AREA	5000	SQFT	464	SQMT
VOLUME	50000	CUFT	1416	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 19 5 PM		JAN 1 6 AM	
DRY-BULB TEMP	90F	32C	1F	-17C
WET-BULB TEMP	71F	22C	1F	-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	4.648	4.90	0.000	0.00	-10.376	-10.95
CEILINGS	8.810	9.30	0.000	0.00	-15.632	-16.49
GLASS CONDUCTION	5.800	6.12	0.000	0.00	-22.447	-23.68
GLASS SOLAR	32.286	34.06	0.000	0.00	1.712	1.81
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-10.500	-11.08	0.000	0.00	-43.500	-45.89
OCCUPANTS TO SPACE	13.159	13.88	4.638	4.89	.001	.00
LIGHT TO SPACE	28.672	30.25	0.000	0.00	1.641	1.73
EQUIPMENT TO SPACE	8.872	9.36	0.000	0.00	.830	.88
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-14.048	-14.82
TOTAL	91.747	96.80	4.638	4.89	-101.819	-107.42
TOTAL LOAD	96.385 KBTU/H		101.69 MJ/H		-101.819 KBTU/H	-107.42 MJ/H
TOTAL LOAD / AREA	19.28 BTUH/SQFT		.21916 MJ/H/SQMT		20.36 BTUH/SQFT	.23152 MJ/H/SQMT

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

S D L   P R O C E S S O R   I N P U T   D A T A

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         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
/* INPUT SYSTEMS */

SYSTEMS-REPORT       DETAIL-LEVEL=ZONE  VERIFICATION=SV01
*FAN-1*       =DAY-SCHEDULE     (1,8) 0  (9,18) 1  (19,24) 0
*FAN-2*       =DAY-SCHEDULE     (1,24) 0
*FAN-WEEK*    =WEEK-SCHEDULE    (MON,FRI) *FAN-1*  (WEH)  *FAN-2*
*FAN-SCHED*   =SCHEDULE         THRU DEC 31 *FAN-WEEK*
*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*
*AIR*         =ZONE-AIR       OUTSIDE-CFM/PER=7.
*CONTROL*     =ZONE-CONTROL   DESIGN-HEAT-TEMP=69  DESIGN-COOL-TEMP=71
                              HEAT-TEMP-SCHED=*HEAT-SCHED*
                              COOL-TEMP-SCHED=*COOL-SCHED*
                              THROTTLING-RANGE=2
                              THERMOSTAT-TYPE=DUAL-SET-POINT
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
PLENUM-1      =ZONE           ZONE-TYPE=PLENUM
*S-CONT*      =SYSTEM-CONTROL   COOLING-SCHEDULE=*FAN-SCHED*
                                HEATING-SCHEDULE=*FAN-SCHED*
                                COOL-SET-TEMP=55
                                MAX-SUPPLY-TEMP=105
                                MIN-SUPPLY-TEMP=55
                                COOL-CONTROL=CONSTANT
                                MAX-HUMIDITY=0.01
                                MIN-HUMIDITY=0.008
*S-AIR*       =SYSTEM-AIR       OUTSIDE-CONTROL=ENTHALPY
*S-FANS*      =SYSTEM-FANS      FAN-SCHEDULE=*FAN-SCHED*
                                FAN-CONTROL=INLET
                                SUPPLY-STATIC=3.5
                                SUPPLY-EFF=0.8
                                RETURN-STATIC=1.0
                                RETURN-EFF=0.8
*S-TERM*      =SYSTEM-TERMINAL  REHEAT-DELTA-T=45
                                MIN-CFM-RATIO=0.15
*VAR-VOL*     =SYSTEM           SYSTEM-TYPE=VAVS
                                SYSTEM-CONTROL=*S-CONT*
                                SYSTEM-FANS=*S-FANS*
                                SYSTEM-AIR=*S-AIR*
                                SYSTEM-TERMINAL=*S-TERM*
                                VARIABLE-TEMP=ON
                                SIZING-RATIO=1
                                RETURN-AIR-PATH=PLENUM-ZONE
                                PLENUM-NAMES=PLENUM-1


                                 ZONE-NAMES=SPACE1-1 SPACE2-1 SPACE3-1
                                           SPACE4-1 SPACE5-1 PLENUM-1
*WONDER*      =PLANT-ASSIGNMENT SYSTEM-NAMES = *VAR-VOL*
END /* SYSTEMS */
```

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 12 NOV 1977 14.26.55

REPORT SV01 SYSTEM DESIGN PARAMETERS PAGE 1

SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
VAR-VOL	5309.	.15	.07	2.73	.78	1.00

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE1-1	1880.	80.	-32.28	32.44	10.6	1.0
SPACE2-1	660.	40.	-7.64	11.48	4.6	1.0
SPACE3-1	1130.	80.	-33.06	19.60	10.6	1.0
SPACE4-1	530.	40.	-7.68	9.09	4.6	1.0
SPACE5-1	950.	140.	-18.04	16.39	19.8	1.0
PLENUM-1	0.	0.	0.00	0.00	0.0	1.0

PLANT SIZING INFORMATION

HEATING MAXIMUM = -148315. COOLING MAXIMUM = 125863. ELECTRICAL MAXIMUM = 22.

PROJECT- EXAMPLE BUILDING 3 USER NAME CAL-ERDA 1.3 12 NOV 1977 14.26.55

REPORT S01 SYSTEM LOAD SUMMARY

SYSTEM *VAR-VOL* TYPE VAVS

MONTH	HEATING ENERGY (MBTU)	TIME OF MAXIMUM DAY	TIME OF MAXIMUM HOUR	MAXIMUM LOAD (KBTU/HR)	COOLING ENERGY (MBTU)	TIME OF MAXIMUM DAY	TIME OF MAXIMUM HOUR	MAXIMUM LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM LOAD (KW)
JAN	-21.029	2	9	-148.315	.013	14	18	.562	5267.	21.
FEB	-18.570	4	9	-140.557	.010	28	11	1.057	4602.	21.
MAR	-15.987	18	14	-134.040	.034	6	18	5.009	5080.	21.
APR	-9.717	22	9	-133.419	1.012	26	17	43.528	5207.	21.
MAY	-4.080	13	8	-131.693	2.867	22	16	63.111	5247.	21.
JUN	-.482	24	8	-68.607	9.115	20	17	107.344	4880.	21.
JUL	0.000	31	24	0.000	19.654	8	17	125.863	5403.	22.
AUG	0.000	31	24	0.000	18.597	19	17	124.343	5384.	22.
SEP	-.317	23	8	-84.635	7.535	11	15	108.978	4915.	21.
OCT	-1.954	21	8	-132.550	2.628	4	17	71.944	5441.	21.
NOV	-8.728	29	10	-133.704	.333	1	16	48.888	4848.	21.
DEC	-15.349	17	10	-133.923	.011	2	13	.777	4721.	21.
TOTAL	-96.214				61.811				60995.963	
MAX				-148.315				125.863		21.992

P D L   P R O C E S S O R   I N P U T   D A T A

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/* INPUT PLANT */

          /*EQUIPMENT DESCRIPTION*/


                     /* BOILER */

SBOIL1=   EQUIPMENT
          TYPE=STMB              /*CODE NAME IS STMB FOR BOILER*/
          SIZE = 0.2             /*CAPACITY IS 0.2 MBTU/HR*/
          AVAILABLE=1            /*ONE UNIT IS AVAILABLE FOR OPERATION*/
          NUMBER=1               /*ONE UNIT IS PRESENT ON SITE*/
          ..

          /*BOILER COSTS ARE DEFAULTED*/

                     /* CHILLERS */

CBLB1=    EQUIPMENT
          TYPE=DBUN      SIZE=.18
          AVAILABLE=1    NUMBER=1
          ..

          /*CHILLER COSTS ARE DEFAULTED*/

                     /* COOLING TOWER */

CTOW1=    EQUIPMENT
          TYPE=CTOWR     SIZE=.22
          AVAILABLE=1    NUMBER=1
          ..

          /*TOWER COSTS ARE DEFAULTED*/

                     /* ENERGY COSTS */

          ENERGY-COST            /*SPECIFY COST FOR BOILER FUEL*/
          RESOURCE=BOILER
          UNIT=100000            /*100000 BTU PER ENERGY UNIT (THERM)*/
          COST=0.22              /*COST PER THERM IS UNIFORM AT $0.22*/
          ESCALATION=10          /*RATE OF ESCALATION OF FUEL COST (RELATIVE TO*/
                                 /*GENERAL INFLATION) IS 10 PCT PER YEAR*/
          ..
          ENERGY-COST            /*SPECIFY COST OF PURCHASED ELECTRICITY*/
          RESOURCE=ELECT
          UNIT=3413              /*3413 BTU PER ENERGY UNIT (KWH)*/
          COST=0.045             /*COST PER KWH IS UNIFORM AT $0.045*/
          ESCALATION=6           /*RELATIVE RATE OF ESCALATION OF ELECTRICITY*/
                                 /*COST IS 6 PCT PER YEAR*/
          ..

                     /* LIFE-CYCLE COST PARAMETERS */

          LIFE-CYCLE-RATES
          DISCOUNT-RATE=8        /*RELATIVE DISCOUNT (INTEREST) RATE IS 8 PCT*/


          LABOR-INFLTN=0         /*RELATIVE LABOR-COST INFLATION RATE IS ZERO*/
          MATERIALS-INFLTN=0     /*RELATIVE MATERIAL-COST INFLATION IS ZERO*/
          ..

          LIFE-CYCLE-COSTS
          PROJECT-LIFE=25        /*LIFETIME OF PROJECT IS 25 YEARS*/
          LABOR=25               /*LABOR COSTS $25 PER HOUR*/
          SITE-FACTOR=1          /*ADJUSTMENT FACTOR WHICH MULTIPLIES   */
                                 /*EQUIPMENT MAINTENANCE AND CONSUMABLES COSTS*/
          ..
END   /*DOUBLE BUNDLE COMPRESSOR AND BOILER PLANT*/                          ..
```

EQUIPMENT SIZE , AVAILABILITY (ES) DATA

CODE	E Q U I P M E N T	SIZE (MBTU)	NUMBER INSTD	AVAIL	SIZE (MBTU)	NUMBER INSTD	AVAIL	SIZE (MBTU)	NUMBER INSTD	AVAIL	SIZE (MBTU)	NUMBER INSTD	AVAIL	SIZE (MBTU)	NUMBER INSTD	AVAIL	SIZE (MBTU)	NUMBER INSTD	AVAIL
STMB	STEAM BOILER	.200	1	1															
DBUN	DOUBLE BUNDLE CHILLER	.180	1	1															
CTOWR	COOLING TOWER	.220	1	1															

EQUIPMENT LOAD RATIOS (ER) DATA

CODE	E Q U I P M E N T	PART LOAD RATIOS MINIMUM	MAXIMUM	OPTIMUM	ELECTRIC INPUT TO NOMINAL CAPACITY RATIO (BTU/BTU)
STMB	STEAM BOILER	.0100	1.0000	.8700	0.0000
DBUN	DOUBLE BUNDLE CHILLER	.1000	1.0500	.6500	.2275
CTOWR	COOLING TOWER	0.0000	0.0000	.4365	.0120

EQUIPMENT PERFORMANCE COEFFS (EP) DATA

CODE	NAME	COEFF 1	COEFF 2	COEFF 3
CAVL1A	AVAILABLE CAPACITY (1-STG ABS CHILR)	1.00000000	0.00000000	0.00000000
CAVL2A	AVAILABLE CAPACITY (2-STG ABS CHILR)	1.00000000	0.00000000	0.00000000
REN1A	ENERGY I/O COEF (1-STG ABS CHILR)	.08375000	.63170000	.26705000
REN2A	ENERGY I/O COEF (2-STG ABS CHILR)	.11467000	.67212000	.21212000
REN2AE	ENERGY I/O COEF (2-STG ABS CHILR W ECON)	.12917000	.36902000	.51136000
TCON1A	CONDST TEMP COEFF (1-STG ABS CHILR)	1.00000000	0.00000000	0.00000000
RPWR1C	ENERGY I/O COEFF (HERMETIC COMPR CHILR)	.16017000	.31644000	.51894000
RPWR2C	ENERGY I/O COEFF (OPEN CENT COMPR CHILR)	.04864000	.54542000	.38885000
RPWR3C	ENERGY I/O COEFF (RECIPROC COMPR CHILR)	-.01200000	.44727000	.56061000
RCAVDB	AVAILABLE CAPACITY RATIO (DBL BUNDLE)	1.00000000	-.03300000	-.00560000
RPWRDB	ENERGY I/O COEFF (DBL BUNDLE)	.16017000	.31644000	.51894000
ADJTDB	CONDENST COOLNG WTR TEMP ADJ(DBL BUNDLE)	95.00000000	2.50000000	44.00000000
ADJEDB	ENERGY RATIO ADJSMNT FACTOR (DBL BUNDLE)	1.61000000	-.61000000	0.00000000
RELD	POWER OUT / FUEL INPUT COEFF (DIESEL)	.09755000	.63180000	-.41650000
RJACD	JACKET HEAT/ FUEL INPUT COEFF (DIESEL)	.39220000	-.43670000	.27796000
RLUBD	LUBE HEAT / FUEL INPUT COEFF (DIESEL)	.08830000	-.13710000	.08030000
REXD	EXHAUST HEAT/FUEL INPUT COEFF (DIESEL)	.31440000	-.13530000	.09726000
TEXD	EXHAUST TEMP COEFF (DIESEL)	720.00000000	60.00000000	0.00000000
FUEL1G	FUEL I/O COEFF 1-3 (GAS TURBINE)	7.68300000	-13.48000000	8.00000000
FUEL2G	FUEL I/O COEFF 4-6 (GAS TURBINE)	1.88220000	-.00433000	.00001400
FEXG	EXHAUST FLOW COEFF (GAS TURBINE)	.01822600	.00002900	0.00000000
TEX1G	EXHAUST TEMP COEFF 1-3 (GAS TURBINE)	1.00000000	.38450000	.02815000
TEX2G	EXHAUST TEMP COEFF 4-6 (GAS TURBINE)	406.96000000	.63170000	.00022400
ELUBG	LUBE OIL COEFF (GAS TURBINE)	.22300000	-.40000000	.22860000
RF1	RATING FACTOR TEMP COEFF 1- 3 (TOWER)	7.66800000	-.12796000	.00059400
RF2	RATING FACTOR TEMP COEFF 4- 6 (TOWER)	7.47850000	-.14145000	.00074900
RF3	RATING FACTOR TEMP COEFF 7- 9 (TOWER)	4.69600000	-.08080000	.00040000
RF4	RATING FACTOR TEMP COEFF 10-12 (TOWER)	4.20850000	-.07881000	.00043200
RF5	RATING FACTOR TEMP COEFF 13-15 (TOWER)	3.18760000	-.05461000	.00027700
RF6	RATING FACTOR TEMP COEFF 16-18 (TOWER)	2.63970000	-.04440000	.00022400
RFUELB	ENERGY I/O COEFF (STEAM BOILER)	.60000000	.88888889	-.49382716
SR1DTA	STEAM RATE COEFF (1-STG ABS CHILR)	1.00000000	0.00000000	0.00000000
SR2DTA	STEAM RATE COEFF (2-STG ABS CHILR)	1.00000000	0.00000000	0.00000000
TCON2A	CONDST TEMP COEFF (2-STG ABS CHILR)	1.00000000	0.00000000	0.00000000
RFSTUR	STEAM FLOW COEFF (STEAM TURBINE)	1.00000000	0.00000000	0.00000000
UACD	STACK U-FACTOR * AREA COEFF (DIESEL)	.01902575	.90000000	0.00000000
UACG	STACK U-FACTOR * AREA COEFF (GAS TURB)	.03805149	.90000000	0.00000000
RFR	RATING FACTOR RANGE COEFF (TOWER)	0.00000000	.10000000	0.00000000

SPECIAL PARAMETERS (S) DATA

CODE	NAME	VALUE
HSTEAM	STEAM ENTHALPY	1171.74914093
TSATUR	STEAM SATURATION TEMP	253.71178594
RFLASH	BOILER FLASH WATER/STEAM FEED (HEATREC)	.07100000
PELCL	ELECT INP. TO CIRC. PUMP/COOLING LOAD	.01800000
PELHT	ELECT INP. TO CIRC. PUMP/HEATING LOAD	.00600000
PELTWR	ELEC INP TO TOWER/TOWER COOL LOAD(TOWER)	.01300000
TOWLPR	TOWER OPERATION TYPE (TOWER)	2.00000000
TWMAKE	MAKE UP WATER TEMP (HEATREC)	55.00000000
TCCOL	CHILLED WATER TEMP	44.00000000
DTCOCL	CHILLED WATER TEMP RISE	15.00000000
TTOWR	ENTERING TOWER WATER TEMP	60.00000000
TCW	LEAVING CONDENSER WATER TEMP	110.00000000
TMINH	MIN TANK TEMP FOR HEATING (SOLUSE)	100.00000000
TMINC	MIN TANK TEMP FOR COOLING (SOLUSE)	180.00000000
CPTYPE	TEPS TYPE. 1.=UTILITY ONLY, 2.=MIXED TEP	1.00000000
TLEAVE	BOILER STACK LEAVING TEMP (BOILER)	450.00000000
SR2A	FULL LOAD STM RATE (2-STG ABSORP CHILR)	12.20000000
SR1A	FULL LOAD STM RATE (1-STG ABSORP CHILR)	18.70000000
RAVRHDB	AVAILBL RECVRBL HT RATIO (DBUNDLE)	.95000000
RMXKWD	MAX EXH FLOW / KW OUTPUT (DIESEL)	15.00000000
RMXKWG	MAX EXH FLOW / KW OUTPUT (GASTURB)	40.00000000
RWCA	TOWER WATER/ABSOR CHILR CAPAC (TOWER)	3.00000000
RWCC	TOWER WATER/COMPR CHILR CAPAC (TOWER)	3.00000000
RWCDB	TOWER WATER/DBUND CHILR CAPAC (TOWER)	3.00000000
SRATB	AIR/FUEL STOICH RATIO (BOILER)	17.00000000
HFUELB	HEAT CONTENT OF FUEL (BOILER)	20000.00000000
RHFLASH	RECOVD HEAT/FLASH STEAM ENERGY (HEATREC)	.50000000
PSTEAM	STEAM PRESSURE, PSIG	15.00000000
PSTMTUR	ENTERING STEAM PRESS,PSIG(STEAM TURBINE)	150.00000000
TSTMTUR	ENTERING STEAM TEMP (STEAM TURBINE)	378.71178594
PEXSTUR	NOM EXH STEAM PRESS ,PSIG(STEAM TURBINE)	-12.70000000
RPMNOM	NOM SPEED , RPM (STEAM TURBINE)	10000.00000000
RWSTUR	CONDENSATE/ENTERING STEAM(STEAM TURBINE)	.97000000
TOTUEF	TOT EFFIC OF UTIL ELEC GENERATION(EFFIC)	.33330000

COST OF EQUIPMENT (CE) DATA

CODE	EQUIPMENT	SIZE (MBTUH)	UNIT COST (K$)	INSTALD COST FACTOR	CONSUMABLES ($/HR)	MAINTENANCE (HRS/YR)	EQPMT LIFE (HRS)	HRS TO MINOR OVHAUL	MINOR OVHAUL COST ($)	HRS TO MAJOR OVHAUL	MAJOR OVHAUL COST ($)
STMB	STEAM BOILER	.200	8.618	1.400	0.000	311.9	129518.	3466.	57.	17329.	718.
DBUN	DOUBLE BUNDLE CHILLER	.180	10.796	1.300	0.000	215.9	65707.	8635.	300.	21587.	900.
CTOWR	COOLING TOWER	.220	4.116	1.300	0.000	36.0	67038.	2247.	343.	22471.	1029.

COST REFERENCE FOR EQUIPMENT (CR) DATA

(USED TO CALCULATE DEFAULTS)

CODE	E Q U I P M E N T	SIZE (MBTUH)	UNIT COST (K$)	INSTALD COST FACTOR	CONSUM-ABLES ($/HR)	MAINTA-NANCE (HRS/YR)	EQPMT LIFE (HRS)	HRS TO MINOR OVHAUL	MINOR OVHAUL COST ($)	HRS TO MAJOR OVHAUL	MAJOR OVHAUL COST ($)
STMB	STEAM BOILER	40.000	300.000	1.400	0.000	900.0	220000.	10000.	2000.	50000.	25000.
DBUN	DOUBLE BUNDLE CHILLER	12.000	180.000	1.300	0.000	500.0	100000.	20000.	5000.	50000.	15000.
CTOWR	COOLING TOWER	12.000	60.000	1.300	0.000	80.0	100000.	5000.	5000.	50000.	15000.

COST OF UTILITY, ENERGY (CU) DATA

ENERGY SOURCE	ENERGY /UNIT (BTU)	UNIFRM COST /UNIT ($)	COST ESCAL-ATION FACTOR	MIN PK LOAD CHARGE ($)	MIN PK LOAD	PK LOAD UNIT COST ($/UNIT)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)	BLOCK MULT	COST/ UNIT ($)
ELECT	3413.	.045	6.000	0.000	50.	1.50										
DIESEL	130000.	.400	5.000	0.000	0.	0.00										
GASTUR	1000000.	1.500	5.000	0.000	0.	0.00										
BOILER	100000.	.220	10.000	0.000	0.	0.00										

LIFE CYCLE PARAMETERS (L) DATA

DISCOUNT RATE (PCT)	INFLATION RATES (PCT) LABOR	INFLATION RATES (PCT) MATERIAL	PROJECT LIFE (YEARS)	LABOR COST ($/HR)	SITE COST FACTOR
8.00	0.00	0.00	25.	25.00	1.000

C E N T R A L   P L A N T   E N E R G Y   U T I L I Z A T I O N   S U M M A R Y

MONTH	TOTAL HEAT ENERGY (GBTU)	TOTAL ELECTR ENERGY (GBTU)	COOLING ENERGY (GBTU)	RCVRED ENERGY (GBTU)	WASTED RCVRABL ENERGY (GBTU)	HEAT EN INPUT COOLING (GBTU)	ELEC EN INPUT COOLING (GBTU)	ENERGY INPUT HEATING (GBTU)	ENERGY INPUT ELECTRC (GBTU)	TOTAL FUEL INPUT (GBTU)	TOTAL ENERGY INPUT (GBTU)	AVERAGE PLANT EFFIC (PERCT)
1	.021	.019	.000	.002	.000	0.000	.002	.030	.056	.028	.084	47.
2	.019	.016	.000	.001	0.000	0.000	.001	.027	.049	.025	.074	47.
3	.016	.018	.000	.002	.000	0.000	.002	.023	.055	.021	.076	45.
4	.010	.019	.001	.002	.001	0.000	.004	.015	.058	.011	.070	42.
5	.004	.020	.003	.002	.002	0.000	.005	.008	.061	.004	.065	38.
6	.000	.020	.009	.000	.001	0.000	.007	.001	.060	.000	.060	34.
7	0.000	.024	.020	0.000	0.000	0.000	.012	0.000	.072	0.000	.072	33.
8	0.000	.024	.019	0.000	0.000	0.000	.012	0.000	.071	0.000	.071	33.
9	.000	.020	.008	.000	.000	0.000	.006	.001	.059	.000	.060	34.
10	.002	.021	.003	.001	.001	0.000	.005	.004	.062	.002	.064	35.
11	.009	.017	.003	.001	.000	0.000	.002	.014	.052	.013	.065	40.
12	.015	.017	.000	.001	.000	0.000	.001	.023	.050	.021	.071	45.
	.096	.235	.062	.012	.006	0.000	.059	.146	.705	.127	.832	39.

E Q U I P M E N T   U S E   S T A T I S T I C S

E Q U I P M E N T	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
STEAM BOILER	.324	.148	1	2	9	.200	1304								
DOUBLE BUNDLE CHILLER	.223	.126	7	8	17	.180	1537								
COOLING TOWER	.299	.152	7	8	17	.220	1231								

CENTRAL PLANT LIFE CYCLE EQUIPMENT COST SUMMARY

EQUIPMENT TOTALS

STEAM BOILER	95.8		
NOMINAL SIZE (MBTU)			.200
NUMBER INSTALLED			1
FIRST COST (K$)		12.1	12.1
ANNUAL COST (K$)		83.2	83.2
CYCLICAL COST (K$)		.5	.5
-----TOTAL----(K$)			95.8
DOUBLE BUNDLE CHILLER	72.4		
NOMINAL SIZE (MBTU)			.180
NUMBER INSTALLED			1
FIRST COST (K$)		14.0	14.0
ANNUAL COST (K$)		57.6	57.6
CYCLICAL COST (K$)		.8	.8
-----TOTAL----(K$)			72.4
COOLING TOWER	17.1		
NOMINAL SIZE (MBTU)			.220
NUMBER INSTALLED			1
FIRST COST (K$)		5.4	5.4
ANNUAL COST (K$)		9.6	9.6
CYCLICAL COST (K$)		2.2	2.2
-----TOTAL----(K$)			17.1
EQUIPMENT TOTAL	185.3		

MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY

UTILITY, ENERGY	MO 1 USE/PK (MBTU)	MO 2 USE/PK (MBTU)	MO 3 USE/PK (MBTU)	MO 4 USE/PK (MBTU)	MO 5 USE/PK (MBTU)	MO 6 USE/PK (MBTU)	MO 7 USE/PK (MBTU)	MO 8 USE/PK (MBTU)	MO 9 USE/PK (MBTU)	MO 10 USE/PK (MBTU)	MO 11 USE/PK (MBTU)	MO 12 USE/PK (MBTU)	ONE-YEAR USE/PEAK (MBTU)	YEAR COST (K$)	COST ESCLTN (PCT)
ELECT	18.673	16.215	18.203	19.430	20.308	20.068	23.965	23.669	19.752	20.662	17.254	16.695	234.895	3.2	6.0
PEAK	.083	.083	.083	.087	.090	.097	.106	.105	.101	.090	.086	.083	.106		
DY/HR	15/ 11	7/ 11	12/ 11	26/ 15	21/ 11	20/ 15	8/ 14	19/ 14	11/ 14	31/ 15	1/ 15	16/ 11			
BOILER	28.369	25.350	21.136	11.473	3.989	.221	0.000	0.000	.354	2.289	12.793	21.121	127.075	.4	10.0
PEAK	.200	.191	.182	.181	.164	.097	0.000	0.000	.126	.181	.182	.182	.200		
DY/HR	2/ 9	4/ 9	4/ 11	22/ 9	20/ 8	17/ 8	31/ 24	31/ 24	23/ 8	21/ 8	29/ 10	31/ 10			
TOTAL													361.970	3.5	

NOTES TO ABOVE TABLE
(1) ALL ENERGY USE VALUES ARE NET, I.E., AT BUILDING BOUNDARY
(2) PEAK VALUES ARE IN MBTJH
(3) YEAR COST IS LIFE-CYCLE COST DIVIDED BY PROJECT LIFETIME

LIFE-CYCLE PLANT COST SUMMARY

	ANNUAL	LIFETIME(25 YRS)
PLANT EQUIPMENT COST	7.4	185.3 K$
ENERGY COST	3.5	88.0 K$
ENERGY USE (NET)	.4	9.0 GBTU

```
------------------------------------------
- PLANT EQUIPMENT PLUS ENERGY            -
- LIFE CYCLE COST FOR 25 YEARS =   .2733 (M$) -
-                                        -
------------------------------------------
```

NOTES TO ABOVE TABLE
(1) ANNUAL QUANTITIES ARE LIFE-CYCLE VALUES DIVIDED BY PROJECT LIFETIME
(2) ENERGY USE IS NET, I.E., AT BUILDING BOUNDARY

EDL PROCESSOR INPUT DATA

```
         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

/* INPUT ECONOMICS */

    /*ECONOMICS-- BASELINE AND NON-PLANT COSTS DESCRIPTION*/

         /*DEFINE LIFE-CYCLE COST PARAMETERS*/

         LIFE-CYCLE-RATES
         DISCOUNT-RATE=8       /*RELATIVE DISCOUNT RATE IS 8 PCT PER YEAR*/
         LABOR-INFLTN=0        /*RELATIVE LABOR-COST INFLATION IS ZERO*/
         MATERIALS-INFLTN=0    /*RELATIVE MATERIALS COST INFLATION IS ZERO*/
         PROJECT-LIFE=25       /*LIFETIME OF PROJECT IS 25 YEARS*/
         LABOR=25              /*LABOR COSTS $25 PER HOUR*/
         ..


         /*SPECIFY BASELINE DATA (FROM PREVICUS RUN)*/
         /*BASELINE CASE HAS U=0.19 ROOF AND SINGLE-GLAZING*/
         /*PRESENT CASE HAS U=0.04 ROOF AND DOUBLE-GLAZING*/

         BASELINE
         PLANT-COST=185.2      /*BASELINE LIFE-CYCLE PLANT EQUIPMENT COST IN $K*/
         FUEL-COST=94.4        /*BASELINE LIFE-CYCLE FUEL COST IN $K*/
         FUEL-USE=10.7         /*BASELINE LIFE-CYCLE FUEL USE IN GBTU*/
         ..

         /*SPECIFY COST OF ADDITIONAL ROOF INSULATION*/

         ROOF-INSUL-1=  COST
         UNIT-NAME=SQFT
         NUMBER-OF-UNITS=5000  /*ROOF AREA IS 5000 SQFT*/
         FC-PER-UNIT=0.30      /*INCREMENTAL FIRST COST IS $0.30 PER SQFT*/
         ..

         /*SPECIFY COST OF DOUBLE-PANE EXTERIOR GLASS VS SINGLE PANE*/

         DOUBLE-PANE-2= COST
         UNIT-NAME=SQFT
         NUMBER-OF-UNITS=560    /*EXTERIOR GLASS AREA IS 560 SQFT*/
         FC-PER-UNIT=3.00       /*INCREMENTAL FIRST COST IS $3.00 PER SQFT*/
         ..

END /*ECONOMICS*/                                                              ..
```

REPORT- E01 ECONOMICS VERIFICATION (NON-PLANT COST ITEMS) CAL-ERDA 1.3 12 NOV 1977 14.29.00

DISCOUNT RATE (PCT)	LABOR INFL-RATE (PCT)	MATERIALS INFL-RATE (PCT)	PROJECT LIFETIME (YRS)
8.0	0.0	0.0	25.0

COST-NAME ROOF-INSUL-1 NO. OF UNITS 5000.0 UNIT-NAME SQFT LIFE(YRS) 999.0

FIRST COST	UNIT FIRST COST	INSTALL COST	UNIT INSTALL COST	ANNUAL COST	UNIT ANNUAL COST	MAINT COST	UNIT MAINT COST	CONSUM COST	UNIT CONSUM COST
1500.	.30	0.	0.00	0.	0.00	0.	0.00	0.	0.00

CYCLICAL COST	UNIT CYCLICAL COST	MINOR OVHL-INT (YRS)	MIN-OVHL COST	UNIT MIN-OVHL COST	MAJOR OVHL-INT (YRS)	MAJ-OVHL COST	UNIT MAJ-OVHL COST	REPLACE COST
0.	0.00	0.00	0.	0.00	0.00	0.	0.00	0.

COST-NAME DOUBLE-PANE-2 NO. OF UNITS 560.0 UNIT-NAME SQFT LIFE(YRS) 999.0

FIRST COST	UNIT FIRST COST	INSTALL COST	UNIT INSTALL COST	ANNUAL COST	UNIT ANNUAL COST	MAINT COST	UNIT MAINT COST	CONSUM COST	UNIT CONSUM COST
1680.	3.00	0.	0.00	0.	0.00	0.	0.00	0.	0.00

CYCLICAL COST	UNIT CYCLICAL COST	MINOR OVHL-INT (YRS)	MIN-OVHL COST	UNIT MIN-OVHL COST	MAJOR OVHL-INT (YRS)	MAJ-OVHL COST	UNIT MAJ-OVHL COST	REPLACE COST
0.	0.00	0.00	0.	0.00	0.00	0.	0.00	0.

REPORT- E02 LIFE-CYCLE COSTS SUMMARY CAL-ERDA 1.3 12 NOV 1977 14.29.00

PRESENT-VALUE OF NON-PLANT LIFE-CYCLE COSTS (K$)

COST-NAME	NO. OF UNITS	UNIT-NAME	FIRST COST	INSTALL -ATION	TOTAL ANNUAL	TOTAL MAINT	TOTAL CONSUM	TOTAL CYCLIC	MINOR OVHLS	MAJOR OVHLS	REPLACE -MENTS	TOTAL
ROOF-INSUL-1	5000.	SQFT	1.50	0.00	0.00 (	0.00	0.00)	0.00 (	0.00	0.00)	0.00	1.50
DOUBLE-PANE-2	560.	SQFT	1.68	0.00	0.00 (	0.00	0.00)	0.00 (	0.00	0.00)	0.00	1.68
		TOTAL	3.18	0.00	0.00 (	0.00	0.00)	0.00 (	0.00	0.00)	0.00	3.18

OVERALL LIFE-CYCLE COSTS (K$)

NON-PLANT	PLANT	FUEL	T O T A L
3.2	185.3	88.0	276.5

LIFE-CYCLE COMPARISON-- THIS RUN VS BASELINE

	INVEST-MENT(K$)	PLANT-EQUIP COST(K$)	ENERGY COST(K$)	PLANT-EQUIP + ENERGY COST(K$)	ENERGY USE(GBTU)
BASELINE		185.20	94.40	279.60	10.70
THIS RUN	3.18	185.29	88.03	273.32	9.05
SAVINGS		-.09	6.37	6.28	1.65

SAVINGS/INVESTMENT STATISTICS

COST SAVINGS (K$)	INVESTMENT (K$)	SAVINGS-TO-INVESTMENT RATIO	FUEL SAVINGS (MBTU)	FUEL-SAVINGS-TO-INVESTMENT RATIO(MBTU/$)	PAYBACK PERIOD (YRS)
6.3	3.2	2.0	1650.8	.52	12.7

XI. LIBRARY DATA

* In Preparation

B. Schedule Library

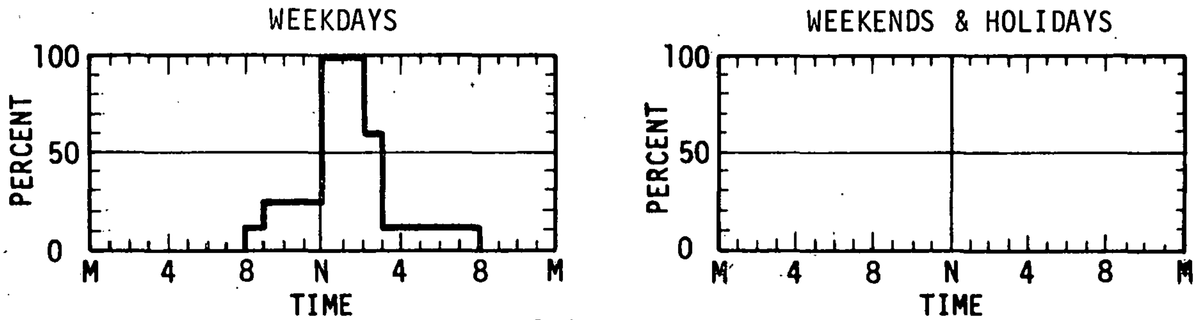
The schedule library is in preparation.

When a representative set of operation schedules for occupancy, lighting, electrical equipment, and processes can be assembled it will be inserted. In the meantime several representative schedules have been included here to aid the user. Until a rather complete set of schedules is prepared and given code names, the user will have to enter each schedule by using the DAY-SCHEDULE, WEEK-SCHEDULE, and SCHEDULE instructions given in Chapter II. A set of blank schedule forms have also been included.

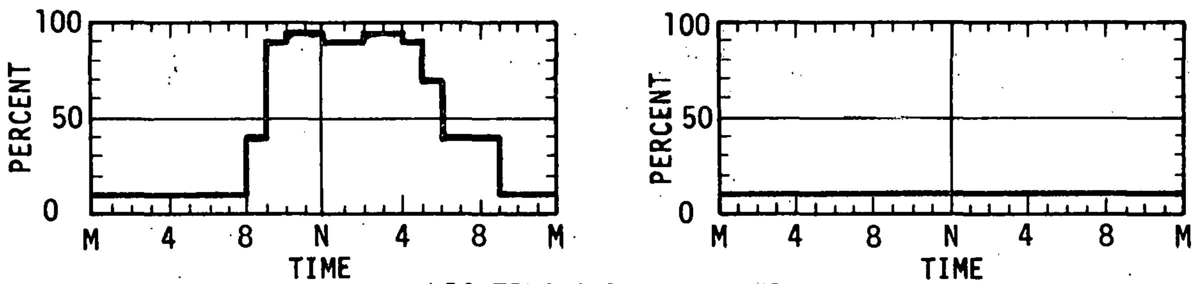
A limited schedule library will be prepared as soon as possible. The representative schedules were taken from;

"Cal-ERDA Testing in the User Environment", Ayres Associates, Report on Contract L47-35609-1, August 15, 1977.

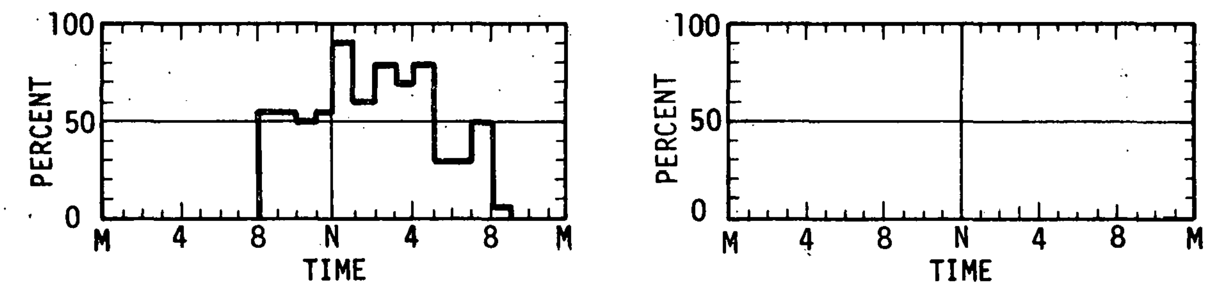
BANKS AND BANK OFFICES



OCCUPANCY



LIGHTING & RECEPTACLES



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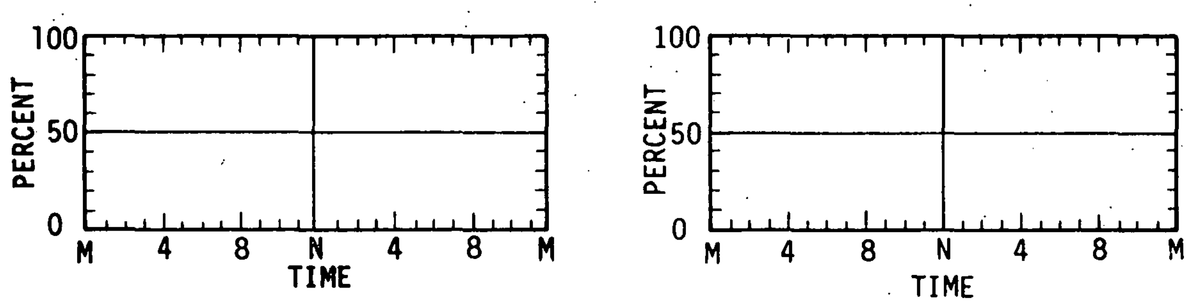
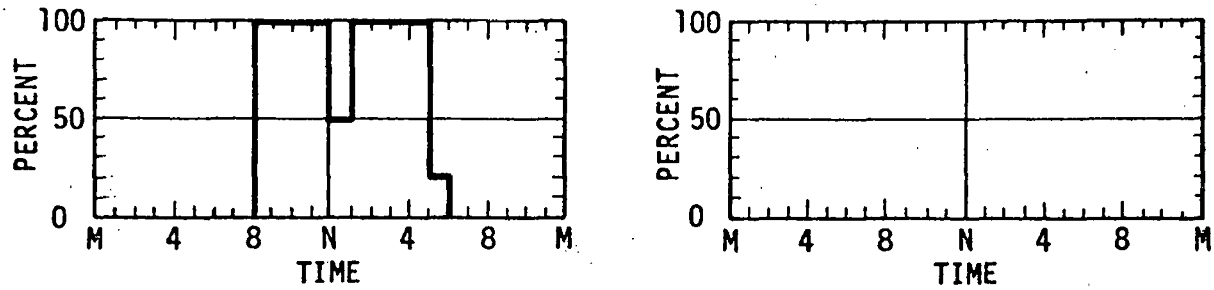


WEEKDAYS WEEKENDS & HOLIDAYS



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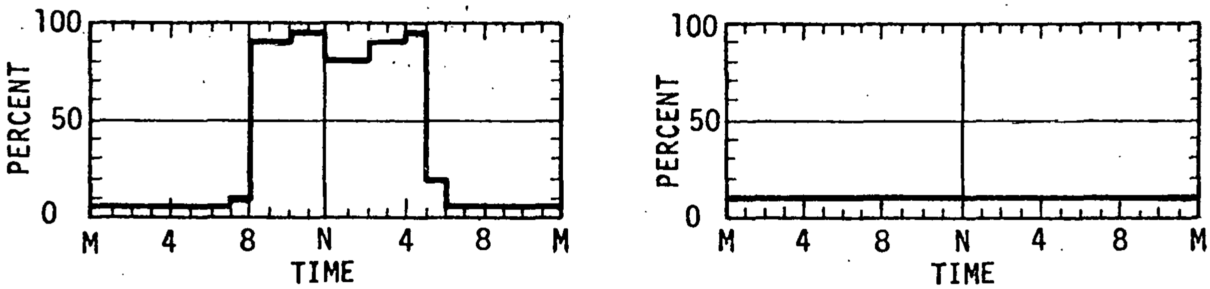

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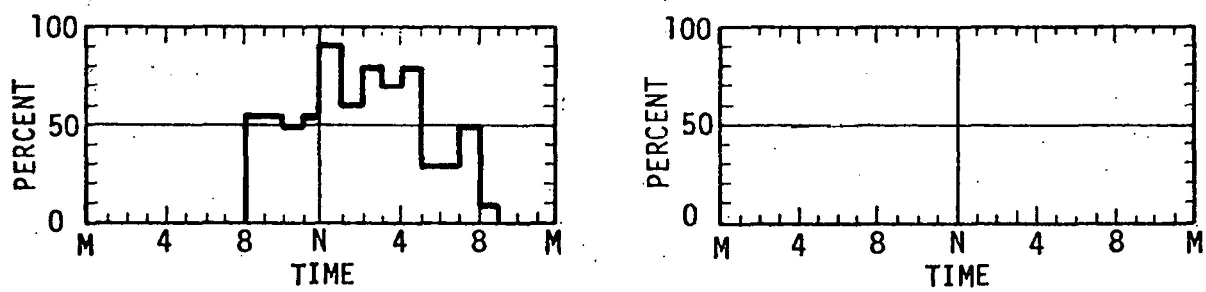

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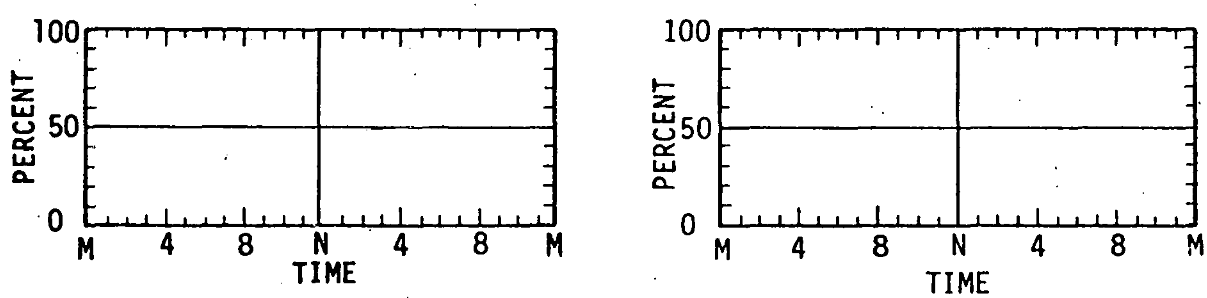
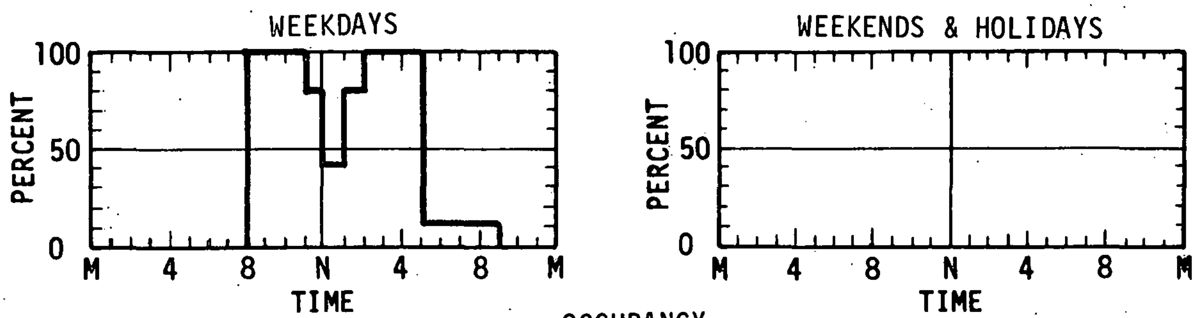


SMALL OFFICE BUILDING



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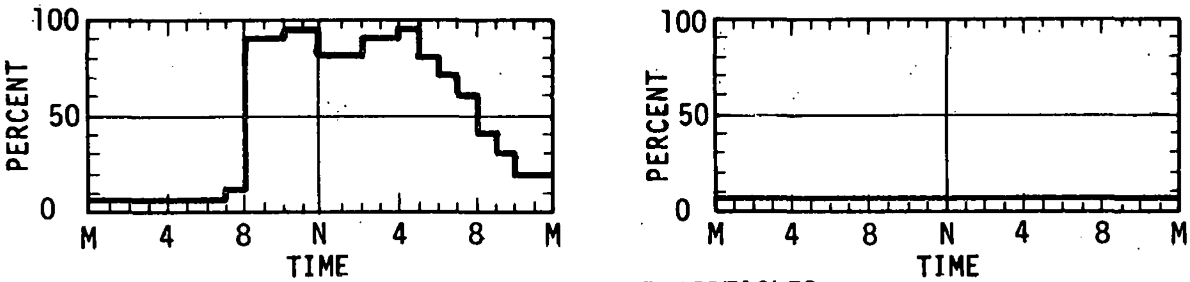
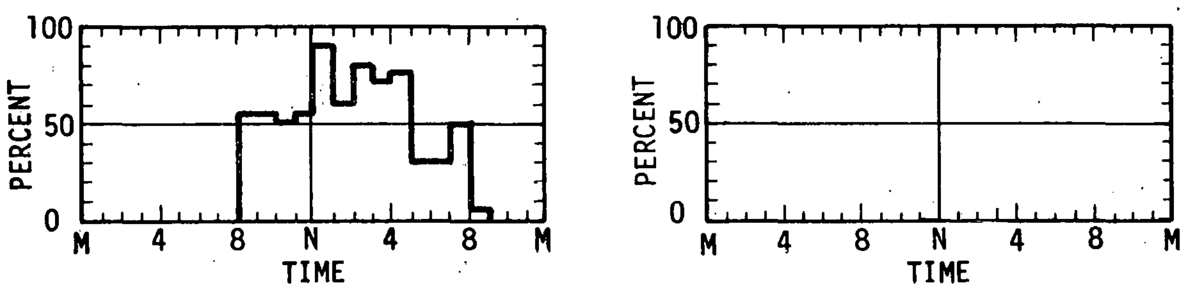
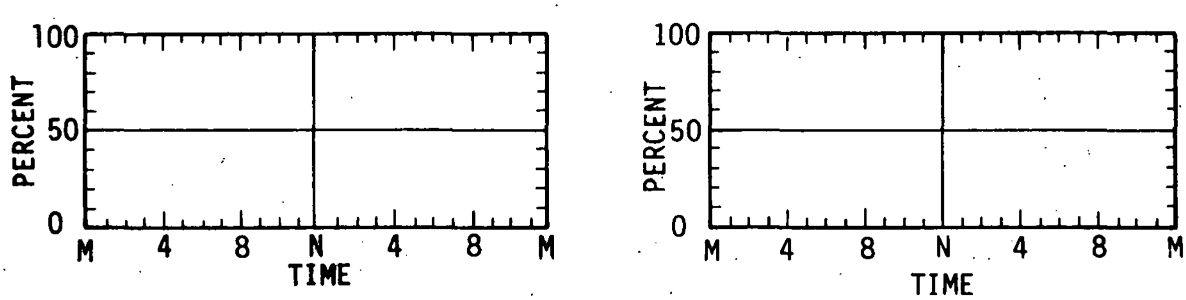


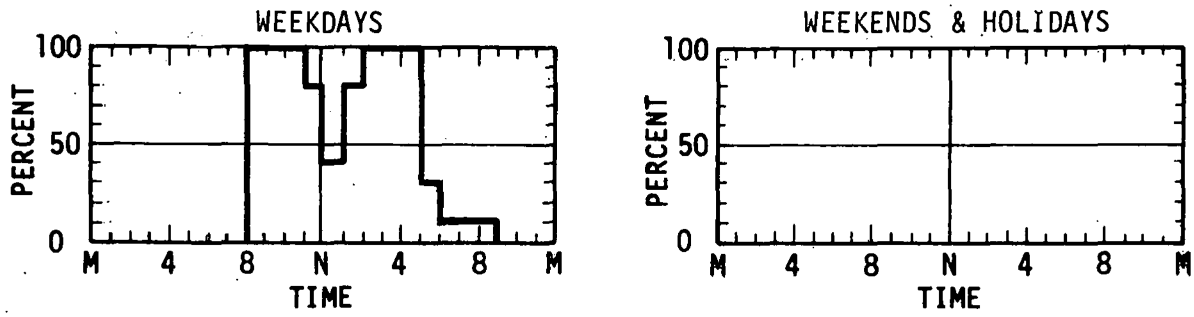
LIGHTING & RECEPTACLES



HOT WATER



OFFICES



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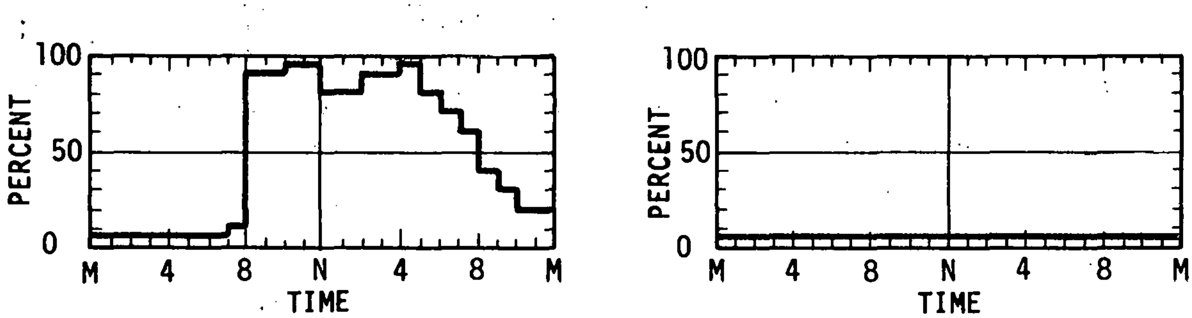

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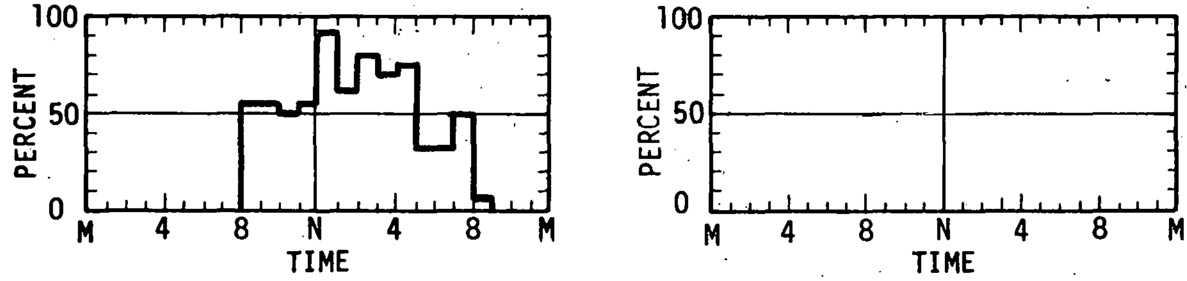
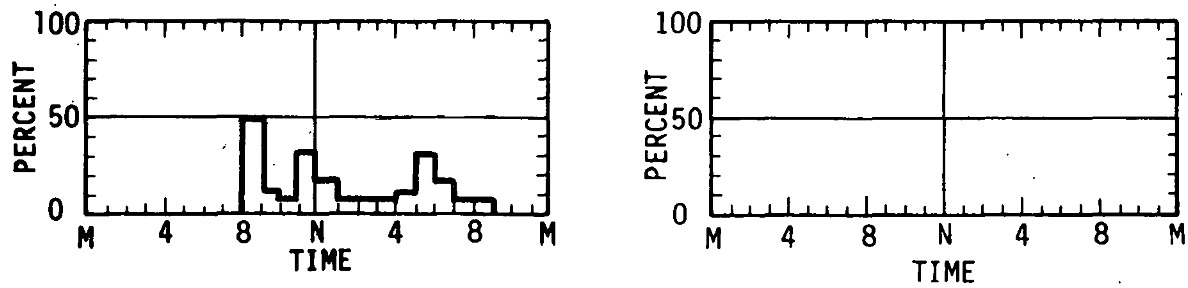


HOT WATER, HOT AND COLD WATER PUMPS

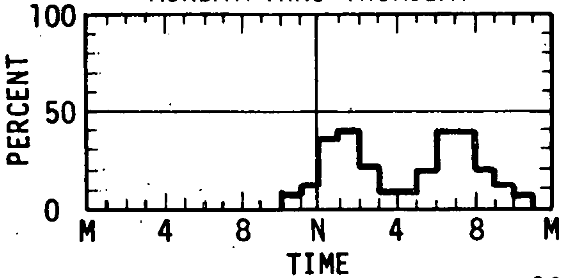


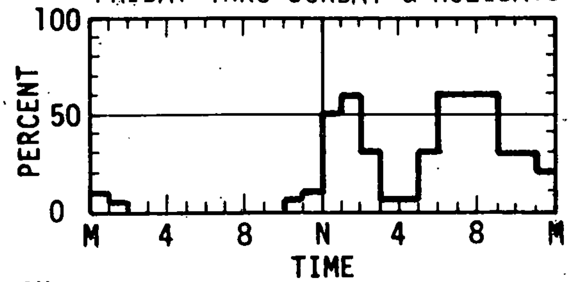
ELEVATORS

RESTAURANT

MONDAY THRU THURSDAY

FRIDAY THRU SUNDAY & HOLIDAYS





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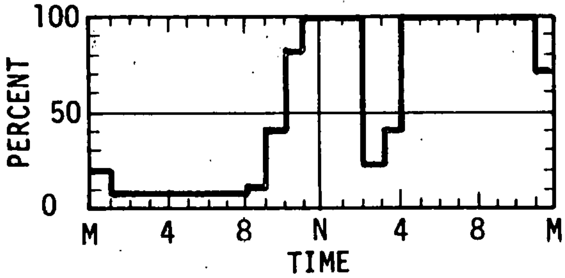

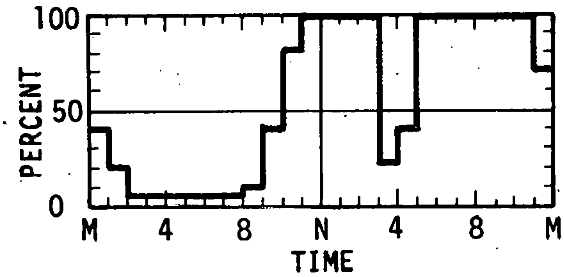

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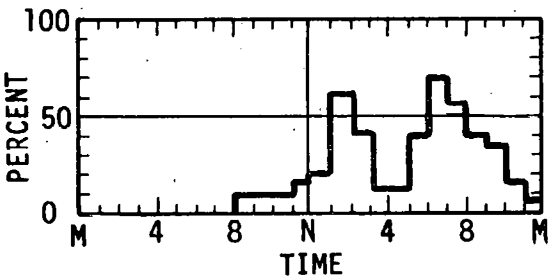

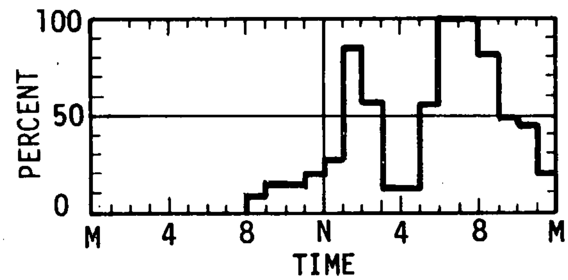

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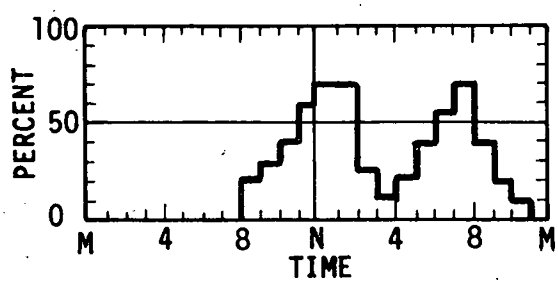
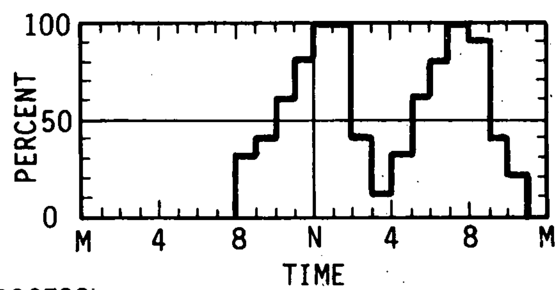
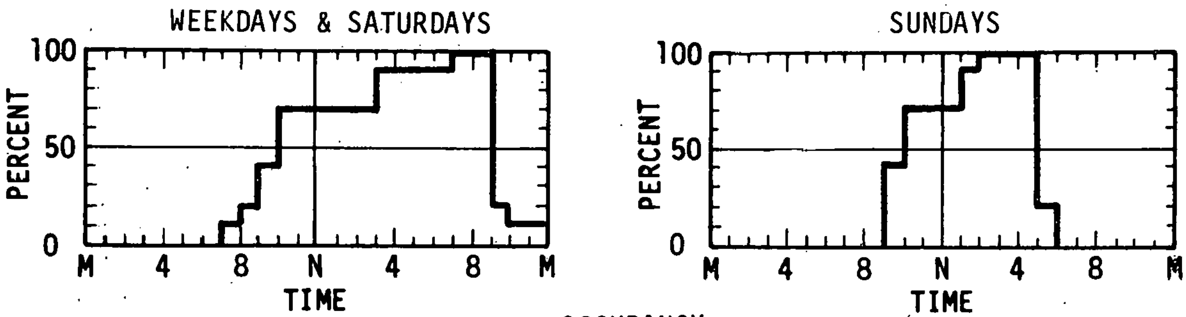




KITCHEN PROCESS

SMALL RETAIL STORE



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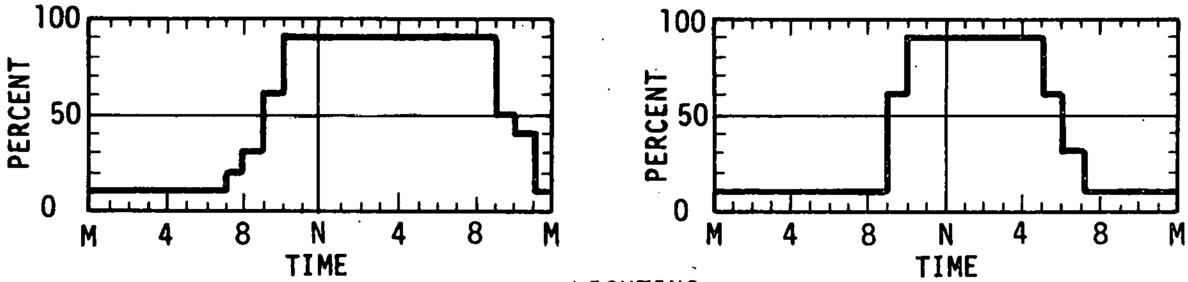
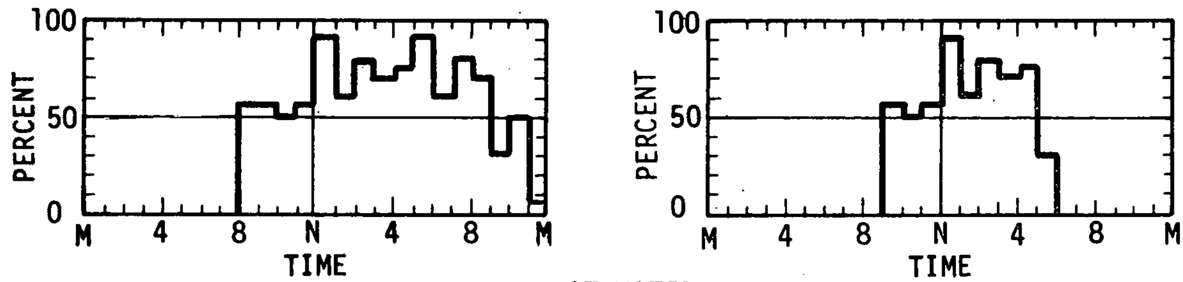
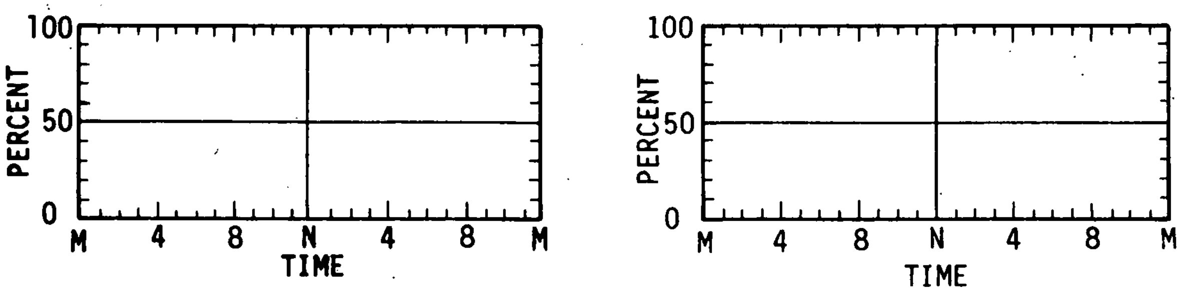


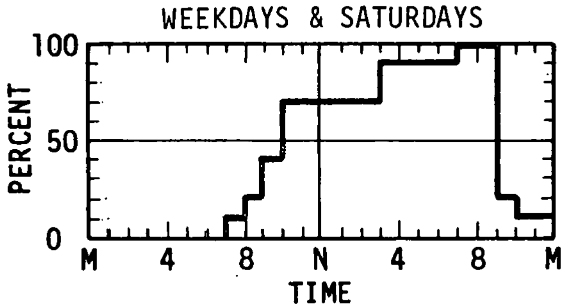
LIGHTING

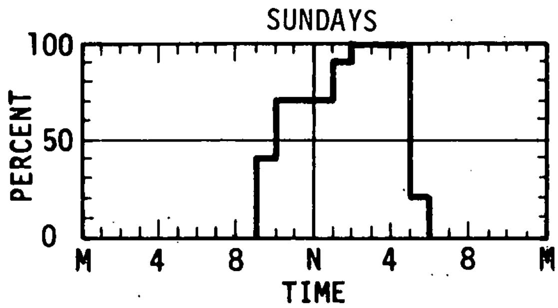


HOT WATER



LARGE RETAIL STORE





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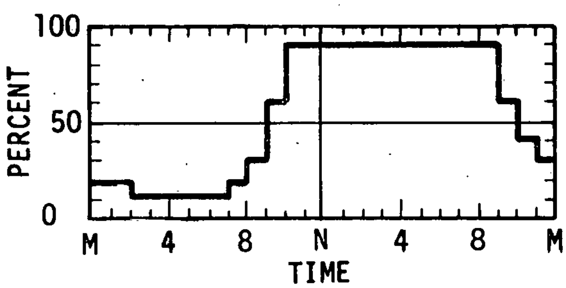
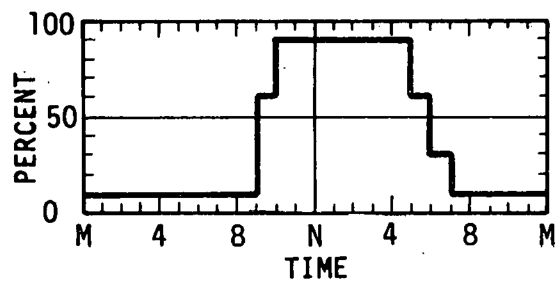
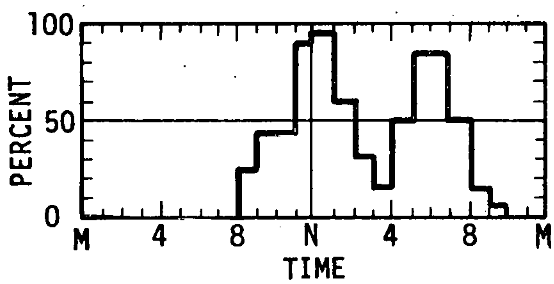
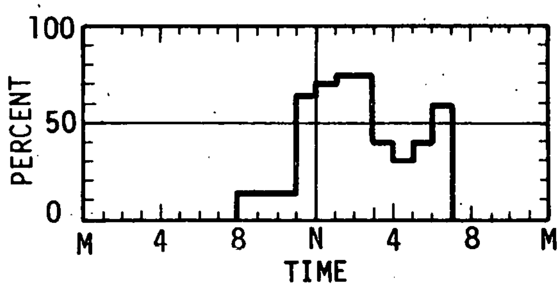




LIGHTING AND RECEPTACLE





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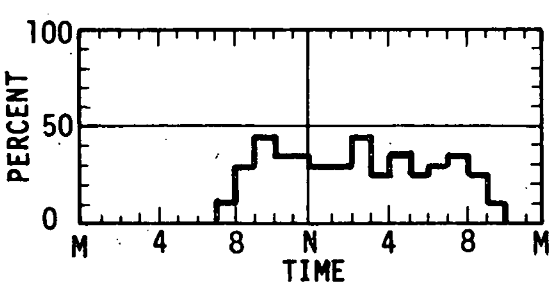
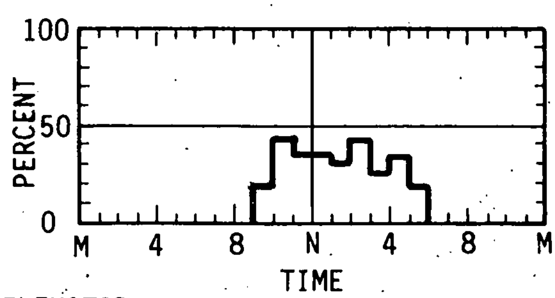


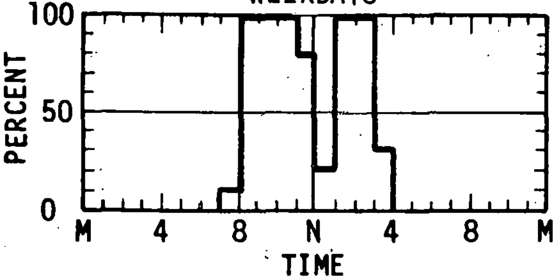


ESCALATOR & ELEVATOR

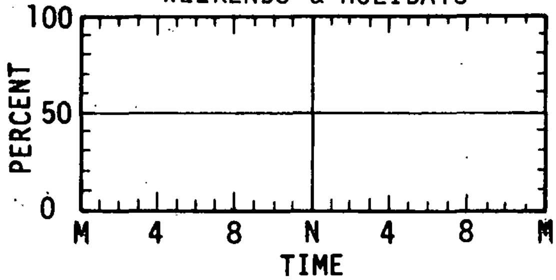
SCHOOL/CLASSROOM

REGULAR SCHOOL

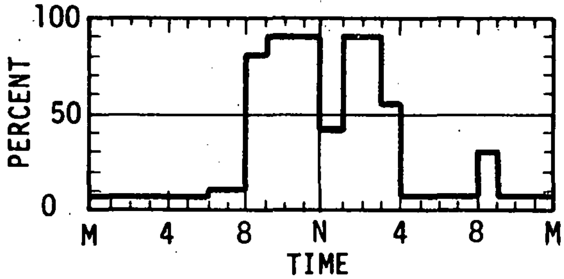
WEEKDAYS

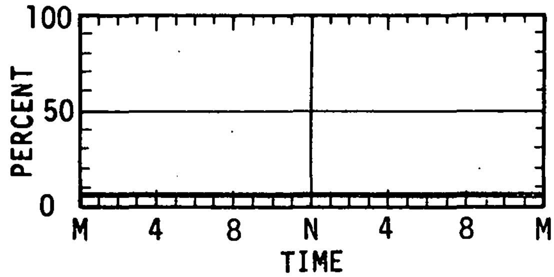


WEEKENDS & HOLIDAYS



OCCUPANCY

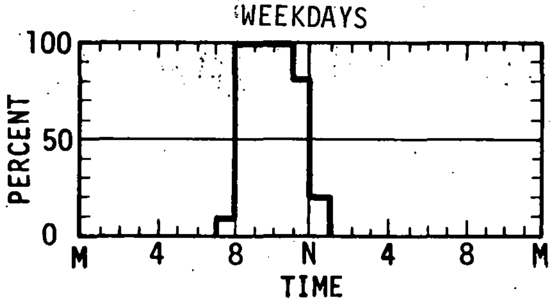




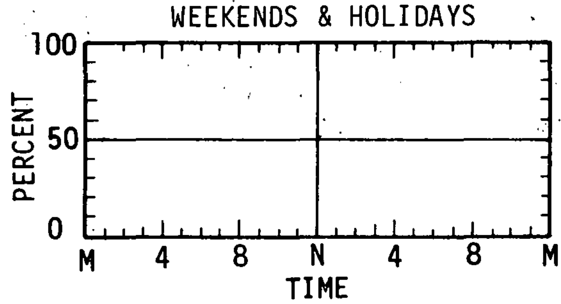
LIGHTING & RECEPTACLE

SUMMER SCHOOL

WEEKDAYS



WEEKENDS & HOLIDAYS



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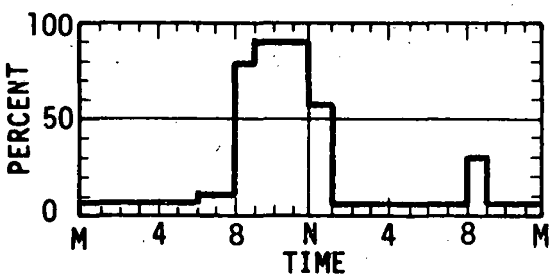
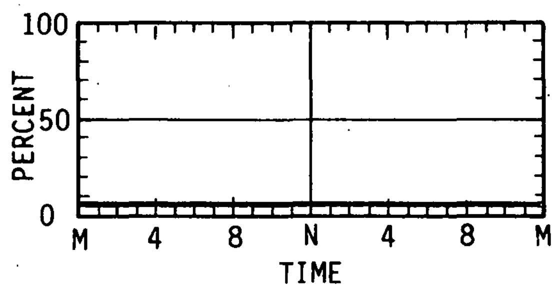
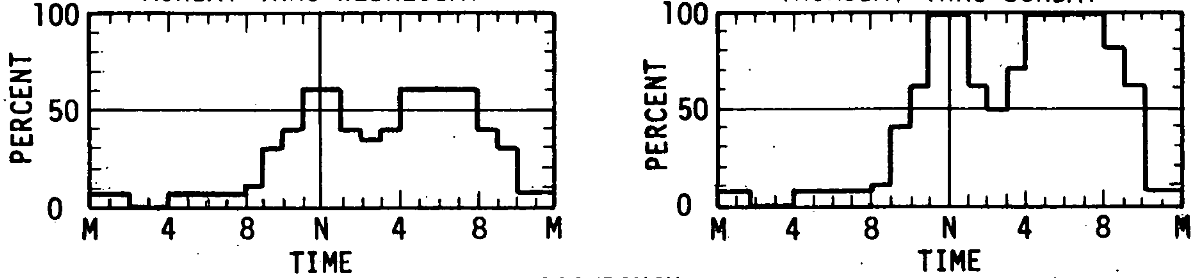




LIGHTING AND RECEPTACLES

SUPERMARKET

MONDAY THRU WEDNESDAY | THURSDAY THRU SUNDAY



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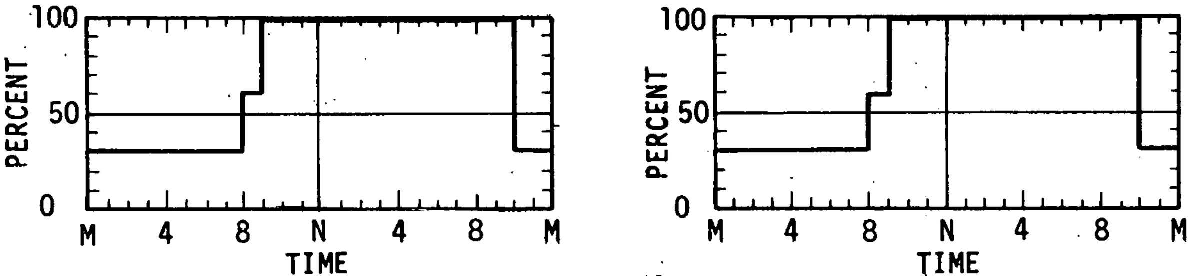

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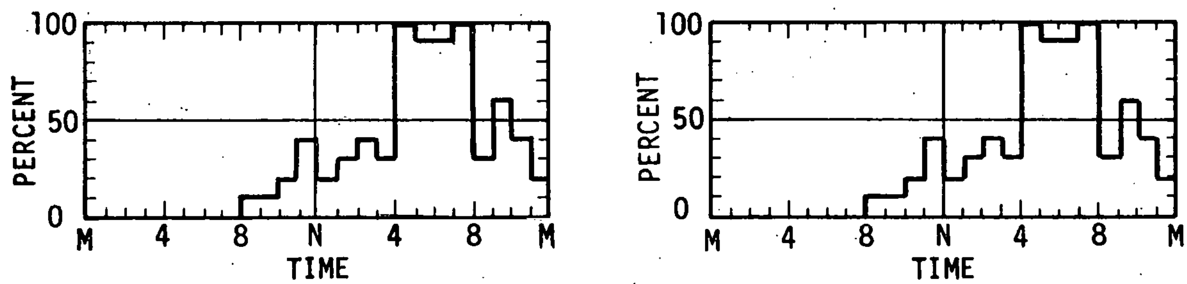

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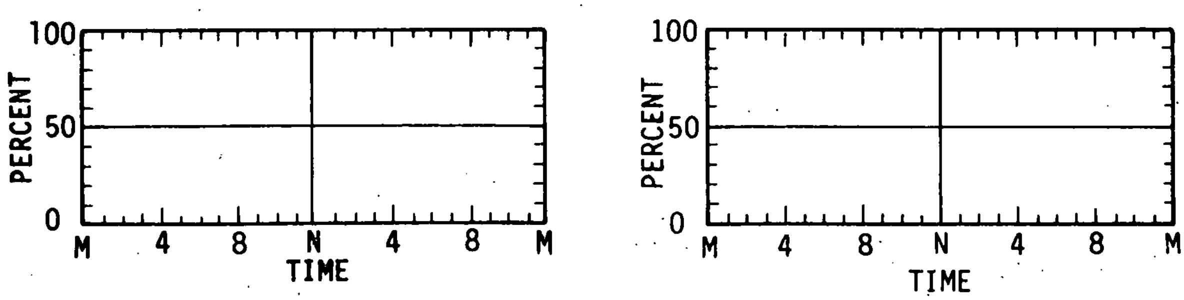

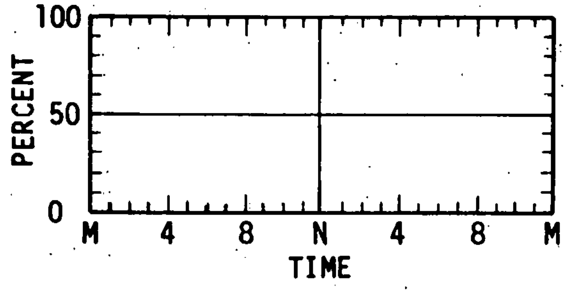
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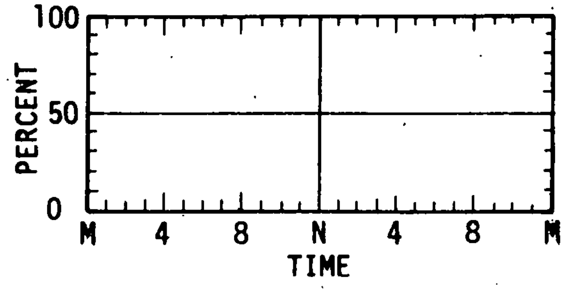
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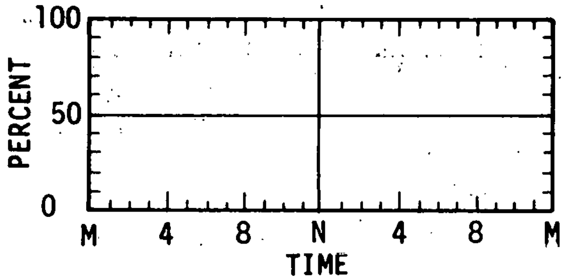
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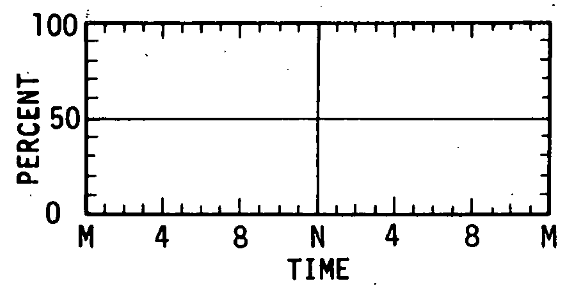
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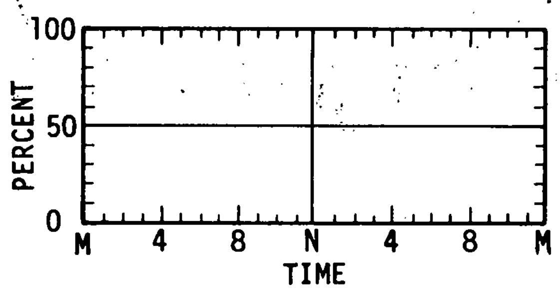
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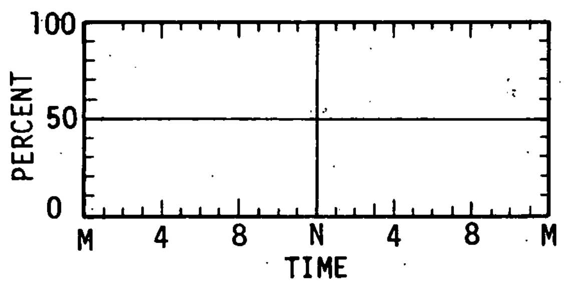
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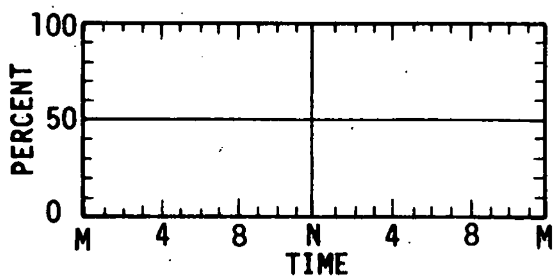
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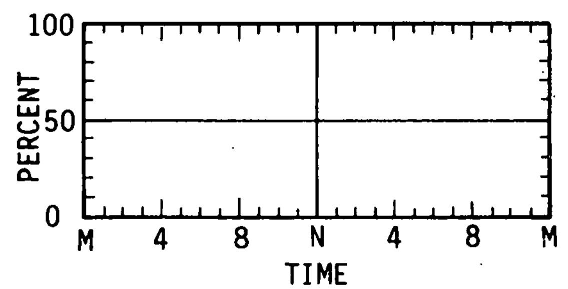
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TABLE NO. XI-C-1

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^oF}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^oF}$	$\frac{Hr \cdot Ft^2 \cdot {}^oF}{Btu}$
	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

TABLE NO. XI-C-1

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu•Ft / Hr•Ft^2•°F	Lb / Ft^3	Btu / Lb•°F	Hr•Ft^2•°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

TABLE NO. XI-C-1

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^oF}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^oF}$	$\frac{Hr \cdot Ft^2 \cdot {}^oF}{Btu}$
	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.

TABLE NO. XI-C-1

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	Btu·Ft / Hr·Ft^2·^{o}F	Lb / Ft^3	Btu / Lb·^{o}F	Hr·Ft^2·^{o}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.

TABLE NO.XI-C-1

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^oF}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^oF}$	$\frac{Hr \cdot Ft^2 \cdot {}^oF}{Btu}$
	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.

TABLE NO. XI-C-1

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

TABLE NO. XI-C-1

Thermal Properties of Building Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^oF}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^oF}$	$\frac{Hr \cdot Ft^2 \cdot {}^oF}{Btu}$
	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

TABLE NO. XI-C-2

Thermal Properties of Insulating Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^oF}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^oF}$	$\frac{Hr \cdot Ft^2 \cdot {}^oF}{Btu}$
	Mineral Wool/Fiber					
IN01	Batt, R-7(3)	0.1882	0.0250	6.0	0.2	7.53
IN02	Batt, R-11	0.2957	0.0250	6.0	0.2	11.83
IN03	Batt, R-19	0.5108	0.0250	6.0	0.2	20.43
IN04	Batt, R-24	0.6969	0.0250	6.0	0.2	27.88
IN05	Batt, R-30	0.8065	0.0250	6.0	0.2	32.26
IN11	Fill, 3.5 inch, R-11	0.2917	0.0270	6.0	0.2	10.80
IN12	Fill, 5.5 inch, R-19	0.4583	0.0270	6.3	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.

TABLE NO. XI-C-2

Thermal Properties of Insulating Materials

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^\circ F}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^\circ F}$	$\frac{Hr \cdot Ft^2 \cdot {}^\circ F}{Btu}$
	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

TABLE NO. XI-C-3

Thermal Properties of Air Films and Air Spaces (4)

code-word	Description	Thickness	Thermal Properties			
			Conductivity	Density	Specific Heat	Resistance
		Feet	$\frac{Btu \cdot Ft}{Hr \cdot Ft^2 \cdot {}^\circ F}$	$\frac{Lb}{Ft^3}$	$\frac{Btu}{Lb \cdot {}^\circ F}$	$\frac{Hr \cdot Ft^2 \cdot {}^\circ F}{Btu}$
	Inside Surface Air Film					
AL01	Vertical Walls					0.68
AL02	Slope 45 degrees					0.69
AL03	Horizontal Roofs					0.76
	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

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.

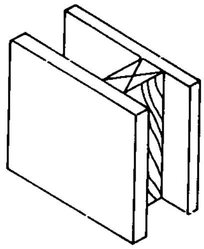
NOTE 4 The air space resistance value represents a compromise between actual summer and winter values. There is no mechanism in the current program for varying air space resistance as a function of temperature.

LIST OF WALLS

WALL-TYPE	Construction Type	Construction Weight	Number of Walls
WA00-0 to WA03-2	Wood Frame	Light Up to 20 lbs/ft^2	12
WB00-0 to WB00-2	Wood Frame with Brick Veneer	Medium 20 lbs/ft^2 to 60 lbs/ft^2	3
WC00-0 to WC01-2	Metal Frame	Light Up to 20 lbs/ft^2	6
WE00-0 to WE03-0	Curtain Walls	Light Up to 20 lbs/ft^2	5
WF00-0 to WF00-4	4 inch Brick	Medium 20 lbs/ft^2 to 60 lbs/ft^2	5
WF25-0 to WF27-2	8 inch Brick	Heavy 60 lbs/ft^2 and up	9
WF50-0 to WF55-2	8 inch Brick	Heavy 60 lbs/ft^2 and up	14
WF75-0 to WF76-2	12 inch Brick	Heavy 60 lbs/ft^2 and up	6
WG00-0 to WG03-1	12 inch Brick	Heavy 60 lbs/ft^2 and up	8
WH00-0 to WH02-1	4 inch LW Concrete Block	Medium 20 lbs/ft^2 to 60 lbs/ft^2	6
WH30-0 to WH31-1	4 inch MW Concrete Block	Medium 20 lbs/ft^2 to 60 lbs/ft^2	4
WH60-0 to WH62-1	4 inch HW Concrete Block	Medium 20 lbs/ft^2 to 60 lbs/ft^2	6
WJ00-0 to WJ09-2	4 inch LW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	32
WJ30-0 to WJ39-2	4 inch MW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	32
WJ60-0 to WJ69-2	4 inch HW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	32
WL00-0 to WL05-2	6 inch LW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	18
WL30-0 to WL35-2	6 inch MW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	18
WL60-0 to WL65-2	6 inch HW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	18

LIST OF WALLS

WALL-TYPE	Construction Type	Construction Weight	Number of Walls
WM00-0 to WM06-1	8 inch LW Concrete Block	Heavy 60 lbs/ft^2 and up	14
WM30-0 to WM36-1	8 inch MW Concrete Block	Heavy 60 lbs/ft^2 and up	13
WM60-0 to WM71-1	8 inch HW Concrete Block	Heavy 60 lbs/ft^2 and up	27
WN00-0 to WN06-2	8 inch LW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	26
WN30-0 to WN36-2	8 inch MW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	21
WN60-0 to WN66-2	8 inch HW Concrete Block with Brick Veneer	Heavy 60 lbs/ft^2 and up	21
WQ00-0 to WQ03-1	4 inch LW Concrete Precast	Medium 20 lbs/ft^2 to 60 lbs/ft^2	8
WQ30-0 to WQ32-2	4 inch MW Concrete Precast	Heavy 60 lbs/ft^2 and up	5
WQ60-0 to WQ65-2	4 inch HW Concrete Precast	Heavy 60 lbs/ft^2 and up	12
WR60-0 to WR61-2	6 inch HW Concrete Precast	Heavy 60 lbs/ft^2 and up	4
WT60-0 to WT66-1	8 inch HW Concrete Poured-in-place	Heavy 60 lbs/ft^2 and up	14
WT70-0 to WT70-2	8 inch HW Concrete Poured-in-place Brick Veneer	Heavy 60 lbs/ft^2 and up	3
WU60-0 to WU65-1	12 inch HW Concrete Poured-in-place	Heavy 60 lbs/ft^2 and up	11
WV00-0 to WV04-2	Clay Tile, One Cell	Medium 20 lbs/ft^2 to 60 lbs/ft^2	10
WV40-0 to WV45-1	Clay Tile, Two Cells	Heavy 60 lbs/ft^2 and up	13

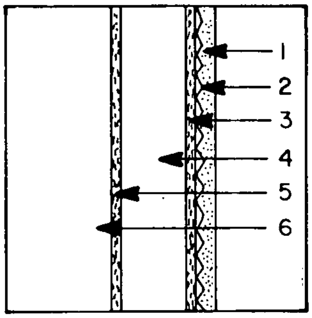


WALL

WOOD FRAME

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

WALL-TYPE WA00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	GP01	1/2" Gypsum Board	.45
4.	AL21	3-1/2" Air Space	.89
5.	GP02	5/8" Gypsum Board	.56
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.78

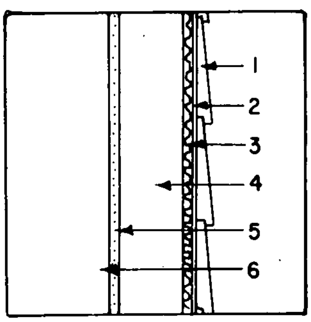
WALL-TYPE WA00-1 Like WA00-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

Total Resistance 10.31

WALL-TYPE WA00-2 Like WA00-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 13.73

WALL-TYPE WA01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	WS01	Wood Shingles	.87
2.	-	Building Paper	-
3.	PW03	1/2" Plywood Sheathing	.63
4.	AL21	3-1/2" Air Layer	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.52

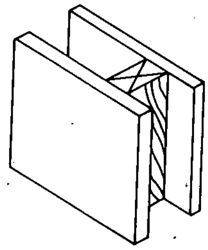
WALL-TYPE WA01-1 Like WA01-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

Total Resistance 11.05

WALL-TYPE WA01-2 Like WA01-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 14.47

See NOTES at the end of this SECTION

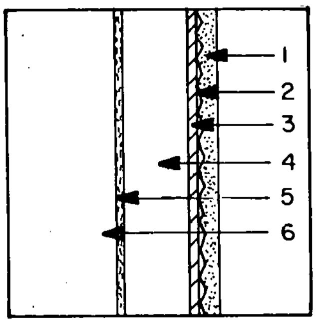


WALL

Wood Frame

Light Construction
Up to 20 lbs/ft^2

WALL-TYPE WA02-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Building Paper	-
3.	PW03	1/2" Plywood Sheathing	.63
4.	AL21	3-1/2" Air Space	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.85

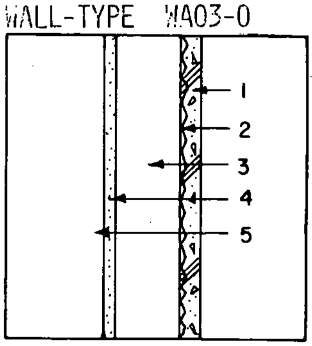
WALL-TYPE WA02-1 Like WA02-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

Total Resistance 10.38

WALL-TYPE WA02-2 Like WA02-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 13.80

WALL-TYPE WA03-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC01	1-1/4" Concrete (140 lb/ft^3) dried	.14
2.	-	Metal Lath	-
3.	AL21	3-1/2" Air Space	.89
4.	GP02	5/8" Gypsum Board	.56
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.27

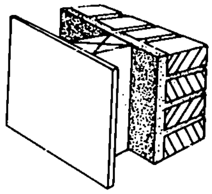
WALL-TYPE WA03-1 Like WA03-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

Total Resistance 9.80

WALL-TYPE WA03-2 Like WA03-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 13.22

See NOTES at the end of this SECTION

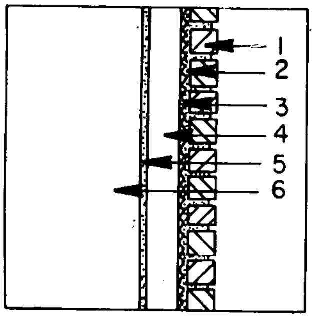


WALL

Wood Frame with Brick Veneer

Medium Construction
20 lbs/ft^2 to 60 lbs/ft^2

WALL-TYPE WB00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer (130 lb/ft^3)	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3 1/2" Air Layer	.89
5.	GP02	5/8" Gypsum Board	.56
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.66

WALL-TYPE WB00-1

Like WB00-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

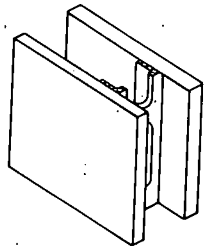
Total Resistance 10.29

WALL-TYPE WB00-2

Like WB00-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 13.61

See NOTES at the end of this SECTION

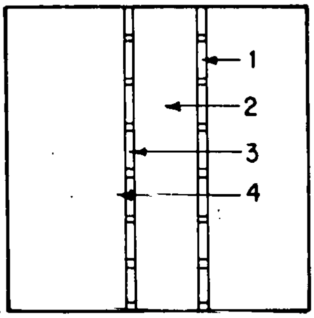


WALL

METAL FRAME

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

WALL-TYPE WC00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	-	Metal Sheathing/finish	-
2.	AL21	3-1/2" Air Layer	.89
3.	-	Metal Sheathing/finish	-
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	1.57

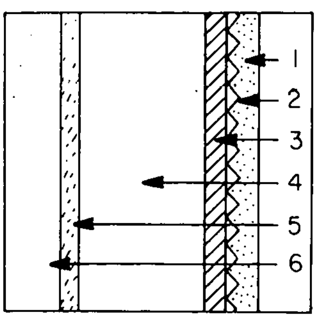
WALL-TYPE WC00-1 Like WC00-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

Total Resistance 9.10

WALL-TYPE WC00-2 Like WC00-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 12.52

WALL-TYPE WC01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Building Paper	-
3.	PW03	1/2" Plywood Sheathing	.63
4.	AL21	3-1/2" Air Layer	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.85

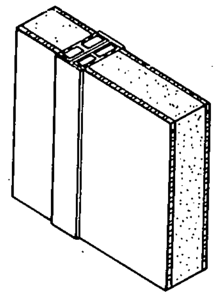
WALL-TYPE WC01-1 Like WC01-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is inserted into 3-1/2" air space. Note 1

Total Resistance 10.38

WALL-TYPE WC01-2 Like WC01-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is inserted into 3-1/2" air space

Total Resistance 13.80

See NOTES at the end of this SECTION

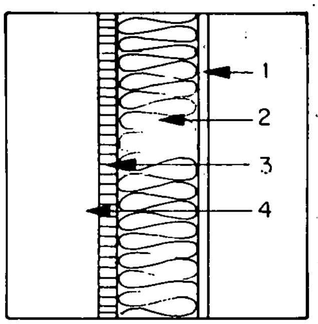


WALL

CURTAIN WALLS

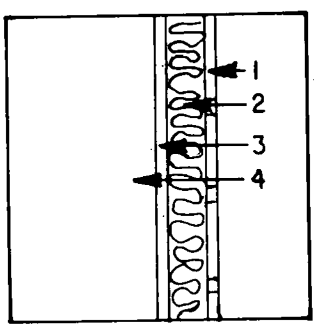
LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

WALL-TYPE WE00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	-	5mm (.005") Aluminum Foil Vaper Barrier	-
2.	IN22	1" Rigid Fiberglass	6.95
3.	GL01	1/4" Glass	.92
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	8.55

WALL-TYPE WE01-0

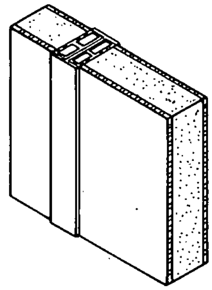


Layer No.	Code	List of Construction Layers	Resistance
1.	-	Steel	-
2.	IN21	7/8" Rigid Fiberglass	3.04
3.	GL01	1/4" Glass	.92
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.64

WALL-TYPE WE01-1

Like WE01-0; except 1/8" Asbestos-Cement Board (Layer No. AB01, R=0.03) is substituted for Steel

Total Resistance 4.67

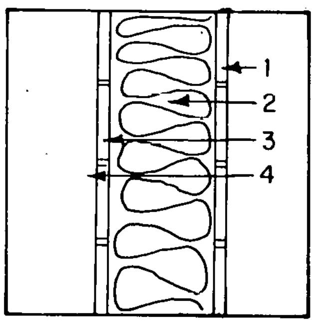


WALL

CURTAIN WALLS

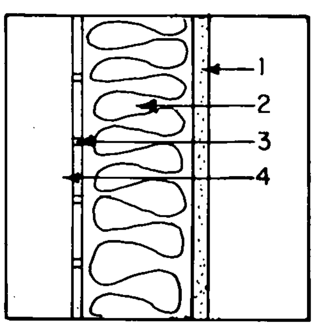
LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

WALL-TYPE WE02-0

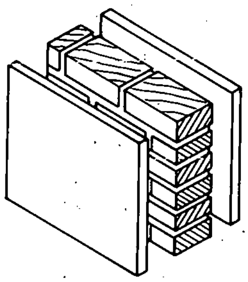


Layer No.	Code	List of Construction Layers	Resistance
1.	-	Metal Finish	-
2.	IN46	3" Polyurethane	18.80
3.	-	Metal Finish	-
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	19.48

WALL-TYPE WE03-0



Layer No.	Code	List of Construction Layers	Resistance
1.	GP01	1/2" Gypsum Board	.45
2.	IN47	4" Polyurethane Foam	25.00
3.	-	Metal Enclosure	-
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	26.13

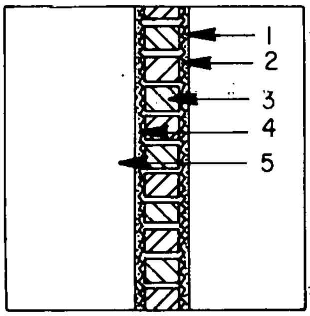


WALL

4 INCH BRICK

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WF00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	BK01	4" Common Brick	.80
4.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.15

WALL-TYPE WF00-1

Like WF00-0; except 2-3/4" Fiberglass Batt (Layer Code IN01; R=7.53) is added

Total Resistance 9.68

WALL-TYPE WF00-2

Like WF00-0; except 3-1/2" Fiberglass Batt (Layer Code IN02; R=11.84) is added

Total Resistance 13.99

WALL-TYPE WF00-3

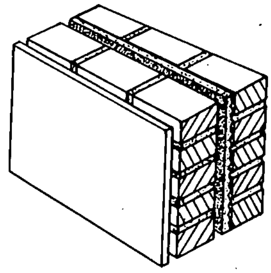
Like WF00-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is added

Total Resistance 8.41

WALL-TYPE WF00-4

Like WF00-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is added

Total Resistance 14.68

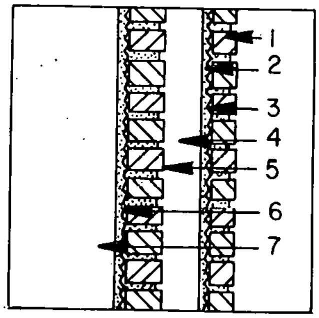


WALL

8 INCH BRICK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WF25-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	BK01	4" Brick, Common	.80
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.37

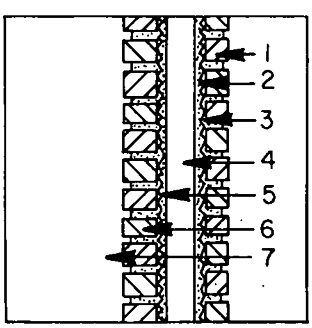
WALL-TYPE WF25-1 Like WF25-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.01

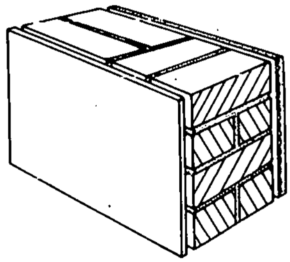
WALL-TYPE WF25-2 Like WF25-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.01

WALL-TYPE WF26-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CM01	1" Cement Mortar Grout with paperback metal lath	.20
6.	BK05	4" Brick Veneer	.44
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.74



WALL

8 INCH BRICK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

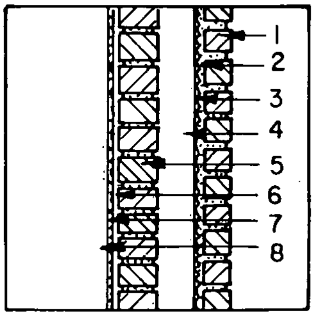
WALL-TYPE WF26-1 Like WF26-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 9.38

WALL-TYPE WF26-2 Like WF26-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 14.38

WALL-TYPE WF27-0



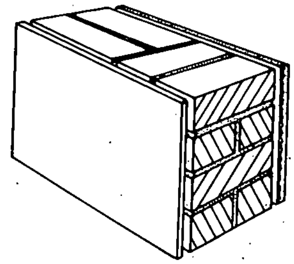
No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	BK01	4" Brick Common	.80
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.24

WALL-TYPE WF27-1 Like WF27-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.88

WALL-TYPE WF27-2 Like WF27-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.88

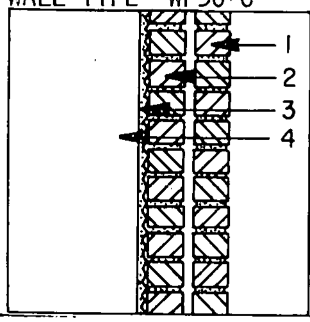


WALL

8 INCH BRICK

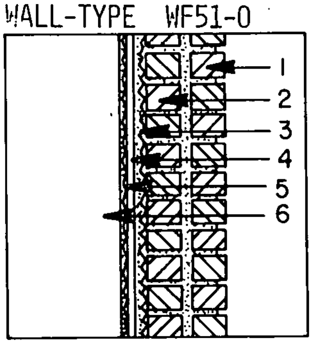
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WF50-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK05	4" Brick Veneer	.44
2.	BK01	4" Brick, Common	.80
3.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.39

WALL-TYPE WF51-0



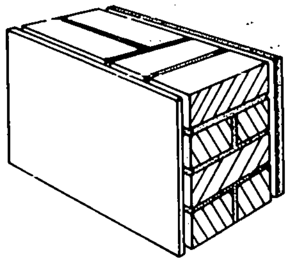
Layer No.	Code	List of Construction Layers	Resistance
1.	BK05	4" Brick Veneer	.44
2.	BK01	4" Brick, Common	.80
3.	CM01	1" Cement Mortar Grout	.20
4.	AL21	3/4" to 4" Air space	.89
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.48

WALL-TYPE WF51-1 Like WF51-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.12

WALL-TYPE WF51-2 Like WF51-o: except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.12



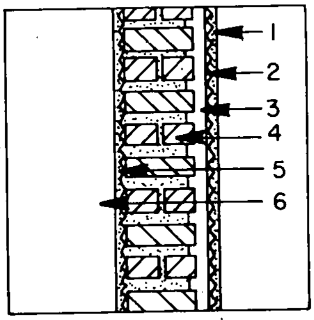
WALL

8 INCH BRICK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WF52-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	AL21	3/4" to 4" Air space	.89
4.	BK02	8" Brick, Common	1.60
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.84

WALL-TYPE WF52-1

Like WF52-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

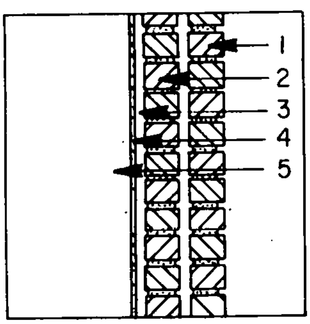
Total Resistance 10.48

WALL-TYPE WF52-2

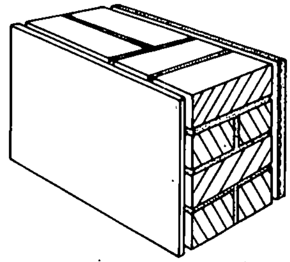
Like WF52-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.48

WALL-TYPE WF53-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK05	4" Brick Veneer	.44
2.	BK01	4" Brick, Common	.80
3.	AL21	7/8" Air space (Metal Furring space)	.89
4.	GP01	1/2" Gypsum Board	.45
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.26

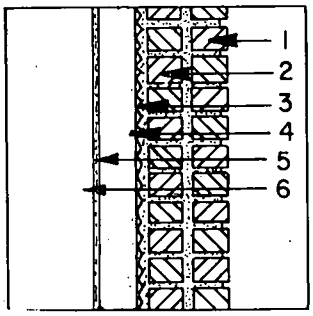


WALL

8 INCH BRICK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WF54-0



1.	BK05	4" Brick Veneer	.44
2.	BK01	4" Brick, Common	.80
3.	CM01	1" Cement Mortar Grout	.20
4.	AL21	3/4" to 4" Air Space	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.46

WALL-TYPE WF54-1

Like WF54-0;except 2-3/4" Fiberglass Batt (Layer Code INOL, R=7.53) is substituted for air space

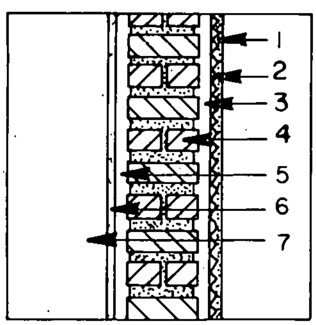
Total Resistance 10.10

WALL-TYPE WF54-2

Like WF54-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.10

WALL-TYPE WF55-0

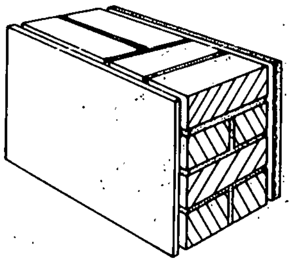


Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	AL21	3/4" to 4" Air Space	.89
4.	BK02	8" Brick, Common	1.60
5.	AL21	7/8" Air Layer (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.71

WALL-TYPE WF55-1

Like WF55-0;except 2-3/4"Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.35



WALL

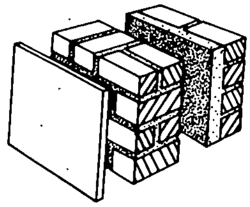
8 INCH BRICK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WF55-2 Like WF55-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance	16.35

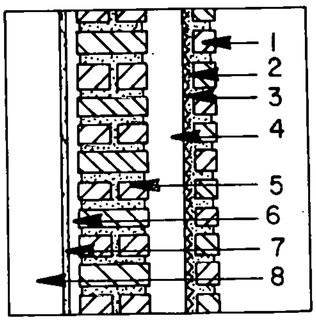


WALL

12 INCH BRICK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WF75-0



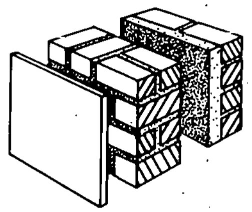
Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	BK02	8" Brick, Common	1.60
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.04

WALL-TYPE WF75-1 Like WF75-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

Total Resistance 11.68

WALL-TYPE WF75-2 Like WF75-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.68



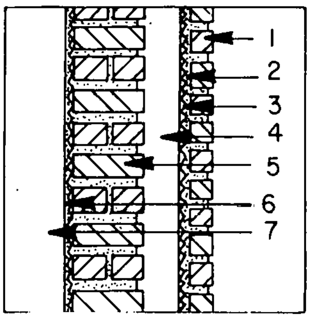
WALL

12 INCH BRICK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WF76-0



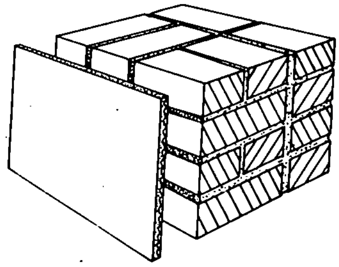
Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	BK02	8" Brick, Common	1.60
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.17

WALL-TYPE WF76-1 Like WF76-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.81

WALL-TYPE WF76-2 Like WF76-0: except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.81



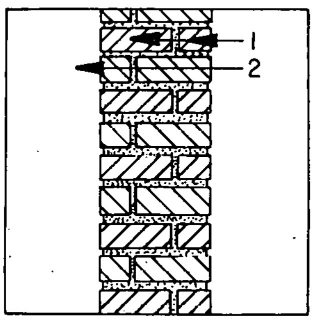
WALL

12 INCH BRICK

HEAVY CONSTRUCTION

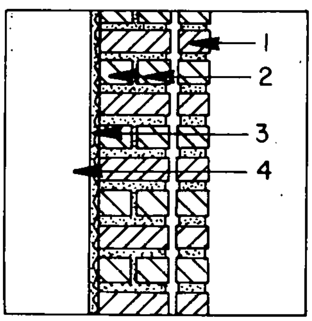
60 LBS/FT^2 AND UP

WALL-TYPE WG00-0



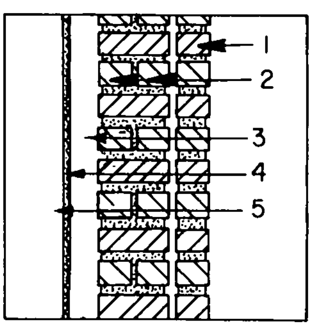
Layer No.	Code	List of Construction Layers	Resistance
1.	BK03	12" Brick, Common	2.40
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.08

WALL-TYPE WG01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK05	4" Brick Veneer	.44
2.	BK02	8" Brick, Common	1.60
3.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.19

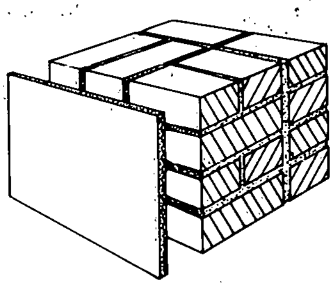
WALL-TYPE WG02-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK05	4" Brick Veneer	.44
2.	BK02	8" Brick Common	1.60
3.	AL21	3/4" to 4" Air Space	.89
4.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	1.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.08

WALL-TYPE WG02-1 Like WG02-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for 3-1/2" air space

Total Resistance 10.72

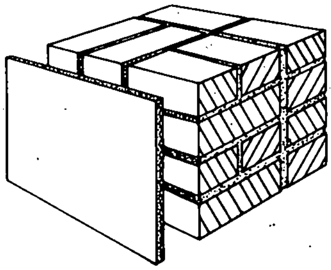


WALL

12 INCH BRICK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WG02-2	Like WG02-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is substituted for the air space	
	Total Resistance	9.45
WALL-TYPE WG02-3	Like WG02-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for the air space	
	Total Resistance	15.72

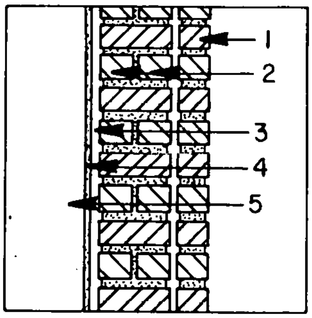


WALL

12 INCH BRICK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WG03-0

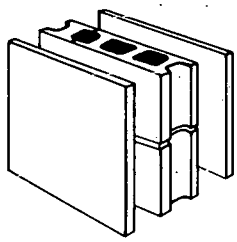


Layer No.	Code	List of Construction Layers	Resistance
1.	BK05	4" Brick Veneer	.44
2.	BK02	8" Brick Common	1.60
3.	AL21	7/8" Air Space (metal furring space)	.89
4.	GP01	1/2" Gypsum Board	.45
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.06

WALL-TYPE WG03-1

Like WG03-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for 7/8" air space

Total Resistance 10.70



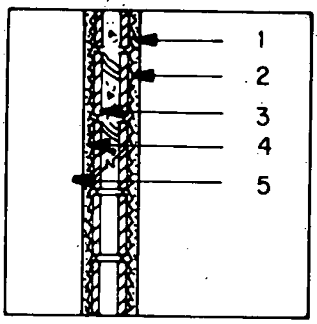
WALL

4 INCH LW CONCRETE BLOCK

MEDIUM CONSTRUCTION

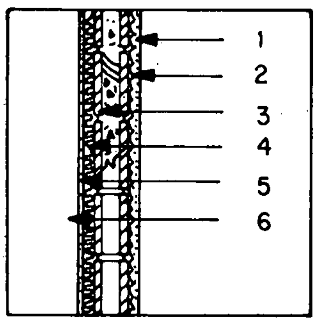
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WH00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB44	4" LW Concrete Block; Expanded Shale, Clay, Slate agg. Note 2.	1.19
4.	GP04	3/4" Gypsum Plaster, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.54

WALL-TYPE WH01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB44	4" LW Concrete Block; Expanded Shale, Clay, Slate agg. Note 2.	1.19
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP02	5/8" Gypsum Board	.56
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.10

WALL-TYPE WH01-1

Like WH01-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for the 1" Preformed Mineral Fiberboard

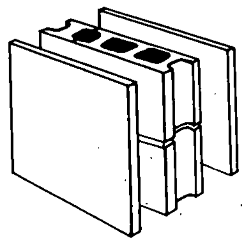
Total Resistance 9.58

WALL-TYPE WH01-2

Like WH01-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for the 1" Preformed Mineral Fiberboard

Total Resistance 13.05

See NOTES at the end of this SECTION



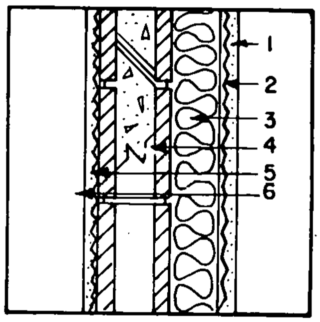
WALL

4 INCH LW CONCRETE BLOCK

MEDIUM CONSTRUCTION

20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WH02-0



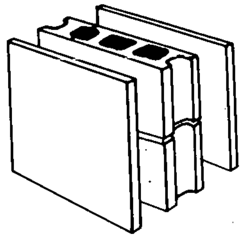
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Mineral Fiberboard	7.53
4.	CB44	4" LW Concrete Block; Expanded Shale, Clay, Slate agg. Note 2.	1.19
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.89

WALL-TYPE WH02-1

Like WH02-0; except 3-1/2" Mineral Fiberboard (Layer Code IN02, R=11.84) is substituted for the 2-3/4" Mineral Fiberboard.

Total Resistance	14.38

See NOTES at the end of this SECTION

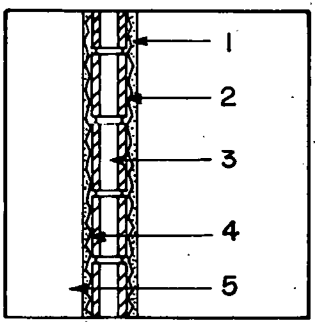


WALL

4 INCH MW CONCRETE BLOCK

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WH30-0



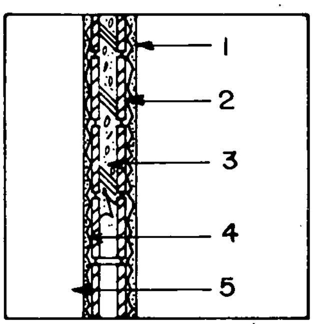
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB21	4" MW Concrete Block Cinder agg. Hollow Cores	1.11
4.	GP04	3/4" Gypsum Plaster on lath, light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.46

WALL-TYPE WH30-1

Like WH30-0; except 4 MW Concrete Block, Cinder agg. Perlite Filled Cores (Layer Code CB23, R=2.21) is substituted for the 4" MW Concrete Block with Hollow Cores.

Total Resistance 3.56

WALL-TYPE WH31-0



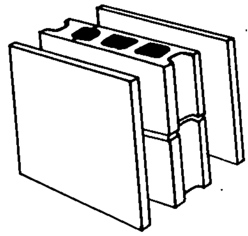
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB24	4" MW Concrete Block; Cinder agg. Note 2	1.01
4.	GP04	3/4" Gypsum Plaster, light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.36

WALL-TYPE WH31-1

Like WH31-0; except 4" MW concrete block with filled cores (Layer Code CB22, R=0.75) is substituted for 4" MW Concrete Block. Note 2

Total Resistance 2.10

See NOTES at the end of this SECTION



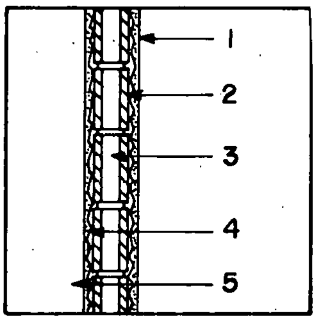
WALL

4 INCH HW CONCRETE BLOCK

MEDIUM CONSTRUCTION

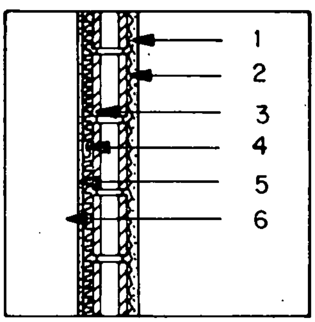
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WH60-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB01	4" HW Concrete Block, Sand and Gravel agg. Hollow Cores	.71
4.	GP04	3/4" Gypsum Plaster, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.06

WALL-TYPE WH61-0



1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB01	4" HW Concrete Block, Sand and Gravel agg. Hollow Cores	.71
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP02	5/8" Gypsum Board	.56
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.62

WALL-TYPE WH61-1

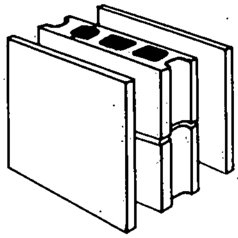
Like WH61-0; except 2" Preformed Mineral Fiberboard Layer Code IN23, R=6.95) is substituted for the 1" Preformed Mineral Fiberboard

Total Resistance 9.10

WALL-TYPE WH61-2

Like WH61-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for the 1" Preformed Mineral Fiberboard

Total Resistance 12.57

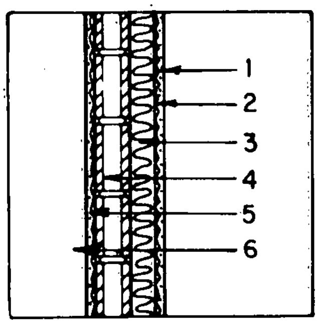


WALL

4 INCH HW CONCRETE BLOCK

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

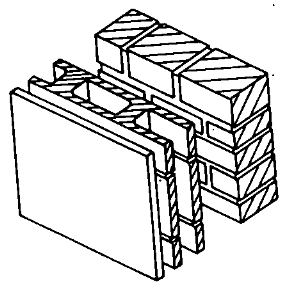
WALL-TYPE WH62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Mineral Fiberboard	7.53
4.	CB01	4" HW Concrete Block; Sand and Gravel agg. Hollow Cores	.71
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.59

WALL-TYPE WH62-1 Like WH62-0; except 3-1/2" Mineral Fiberboard (Layer Code IN02, R=11.84) is substituted for 2-3/4" Mineral Fiberboard

Total Resistance 13.90

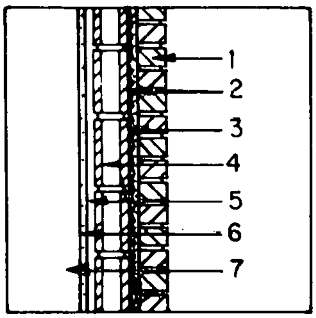


WALL

4 INCH LW CONCRETE BLOCK WITH BRICK VENEER

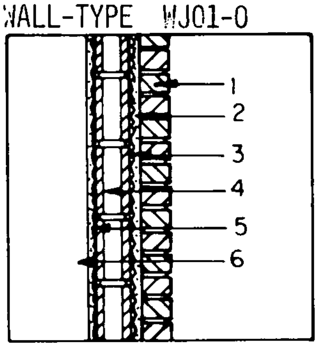
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ00-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB41	4" LW Concrete Block - expanded Shale, Clay, Slate agg.,Hollow cores	1.50
5.	AL21	7/8" Air Space Metal Furring Space	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.05

WALL-TYPE WJ01-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer (130 lb)	.33
2.	CM01	1" Cement Mortar Grouting	.20
3.	-	Paperback Metal Lath	-
4.	CB41	4" LW Concrete Block, Expanded Shale, Clay, Slate agg., Hollow Cores	1.50
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.18

WALL-TYPE WJ01-1

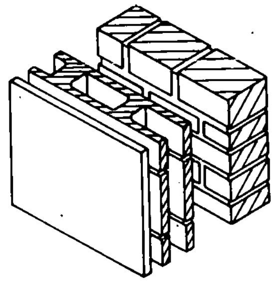
Like WJ01-0; except 1" Preformed Mineral Fiberboard (Layer Code IN22, R=3.47) is added

Total Resistance 6.65

WALL-TYPE WJ01-2

Like WJ01-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is added

Total Resistance 10.13



WALL

4 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

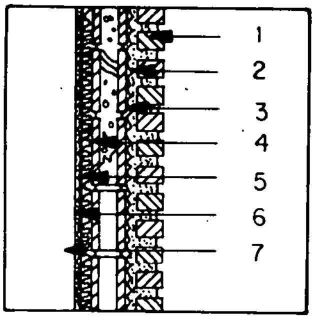
WALL-TYPE WJ01-3 Like WJ01-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is added

Total Resistance 9.44

WALL-TYPE WJ01-4 Like WJ01-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is added

Total Resistance 15.71

WALL-TYPE WJ02-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB44	4" LW Concrete Block Expanded Shal, Clay, Slate agg., Note 2	1.19
5.	IN22	1" Preformed Mineral Fiberboard	3.47
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.34

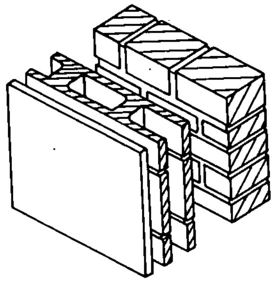
WALL-TYPE WJ02-1 Like WJ02-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.82

WALL-TYPE WJ02-2 Like WJ02-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.13

See NOTES at the end of this SECTION



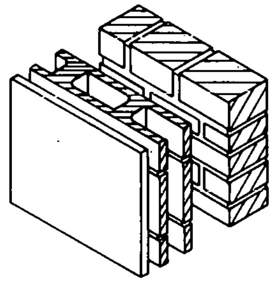
WALL

4 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ02-3   Like WJ02-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance   15.40

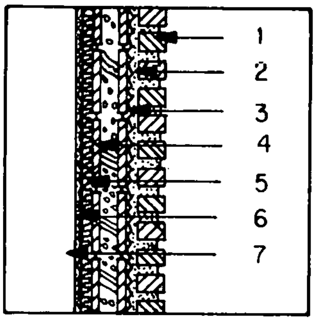


WALL

4 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ03-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB42	4" LW Concrete Block	
		Expanded Shale, Clay, Slate agg.,	
		Concrete Filled	.90
5.	IN21	1" Preformed Mineral Fiberboard	3.47
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.05

WALL-TYPE WJ03-1

Like WJ03-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.53

WALL-TYPE WJ03-2

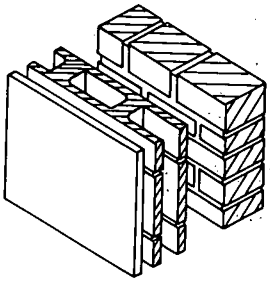
Like WJ03-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 8.84

WALL-TYPE WJ03-3

Like WJ03-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 15.11

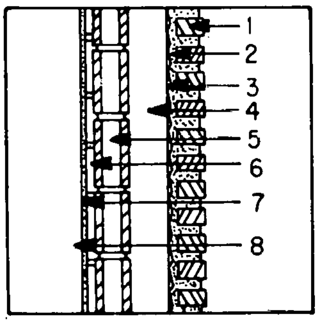


WALL

4 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJC4-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB41	4" LW Concrete Block Expanded Shale, Clay, Slate agg., Hollow Cores	1.50
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.94

WALL-TYPE WJ04-1

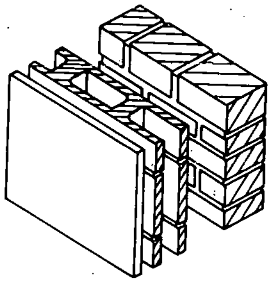
Like WJ04-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

Total Resistance 11.58

WALL-TYPE WJ04-2

Like WJ04-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R= 12.53) is substituted for air space

Total Resistance 16.58

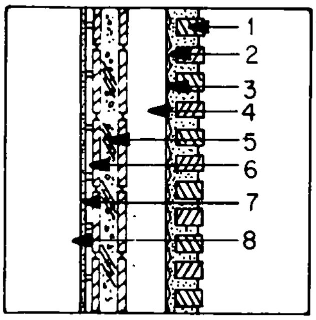


WALL

4 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ05-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB42	4" LW Concrete Block Expanded Shale, Clay, Slate Agg., Concrete filled.	.90
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.34

WALL-TYPE WJ05-1

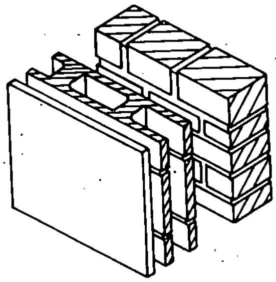
Like WJ05-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

Total Resistance 10.98

WALL-TYPE WJ05-2

Like WJ05-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.98

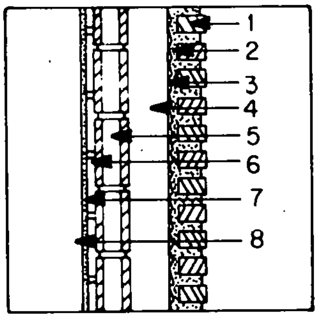


WALL

4 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ06-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB44	4" LW Concrete Block Expanded Shale, Clay, Slate agg. Note 2	1.19
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.63

WALL-TYPE WJ06-1

Like WJ06-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

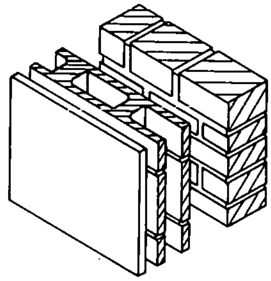
Total Resistance 11.27

WALL-TYPE WJ06-2

Like WJ06-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.27

See NOTES at the end of this SECTION

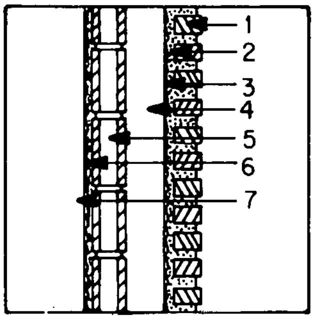


WALL

4 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ07-0



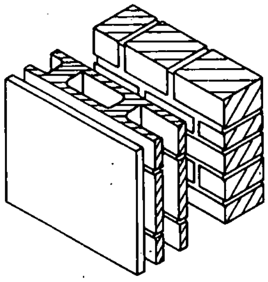
Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB41	4" LW Concrete Block Expanded Shale, Clay, Slate agg., Hollow Cores	1.50
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.07

WALL-TYPE WJ07-1 Like WJ07-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.71

WALL-TYPE WJ07-2 Like WJ07-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.71

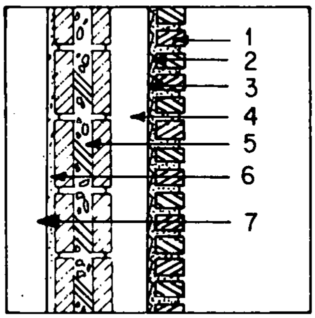


WALL

4 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ08-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3-1/2" Air Space (Cavity)	.89
5.	CB42	4" LW Concrete Block Expanded Shale, Clay, Slate agg., Concrete filled.	.90
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.47

WALL-TYPE WJ08-1

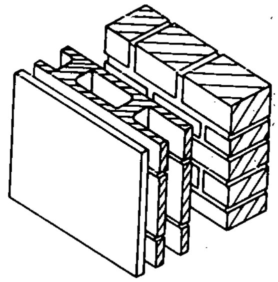
Like WJ08-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.11

WALL-TYPE WJ08-2

Like WJ08-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.11

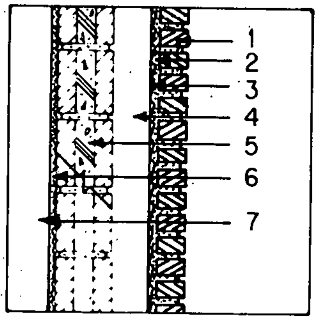


WALL

4 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ09-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB44	4" LW Concrete Block Expanded Shale, Clay, Slate agg. Note 2.	1.19
6.	GP04	3/4" Gypsum Plaster on Lath. Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.76

WALL-TYPE WJ09-1

Like WJ09-0; except 2-3/4" Fiberglass Batt (Layer Code INOL, R=7.53) is substituted for air space

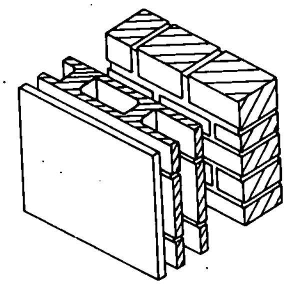
Total Resistance 10.40

WALL-TYPE WJ09-2

Like WJ09-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.40

See NOTES at the end of this SECTION



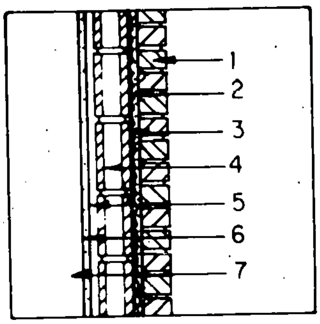
WALL

4 INCH MW CONCRETE BLOCK WITH BRICK VENEER

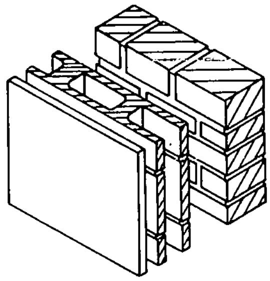
HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WJ30-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB21	4" MW Concrete Block Cinder agg., Hollow Core	1.11
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.66

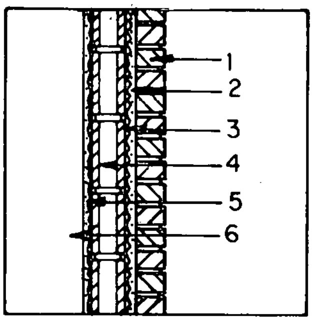


WALL

4 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ31-0



1.	BK04	3" Brick Veneer (130 lb)	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	CB21	4" MW Concrete Block; Cinder agg. Hollow Cores.	1.11
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.79

WALL-TYPE WJ31-1

Like WJ31-0; except 1" Preformed Mineral Fiberboard (Layer Code IN22, R=3.47) is added.

Total Resistance 6.26

WALL-TYPE WJ31-2

Like WJ31-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is added.

Total Resistance 9.74

WALL-TYPE WJ31-3

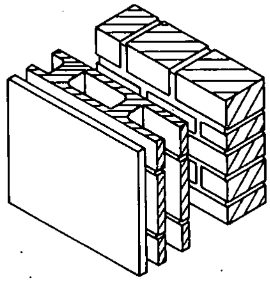
Like WJ31-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is added

Total Resistance 9.05

WALL-TYPE WJ31-4

Like WJ31-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is added

Total Resistance 15.32

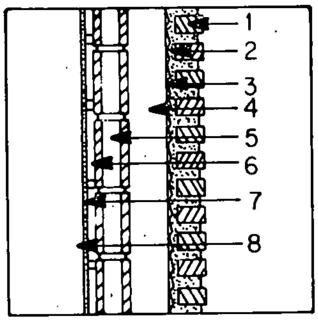


WALL

4 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ34-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB21	4" MW Concrete Block; Cinder agg., Hollow Cores	1.11
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.55

WALL-TYPE WJ34-1

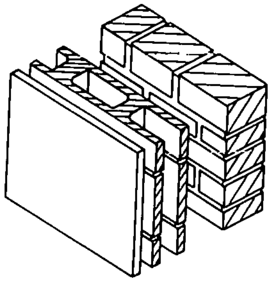
Like WJ34-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.19

WALL-TYPE WJ34-2

Like WJ34-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.19

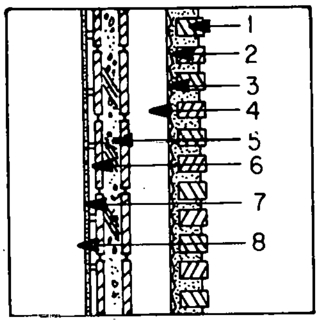


WALL

4 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ35-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB22	4" MW Concrete Block; Cinder agg., concrete filled.	.88
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.32

WALL-TYPE WJ35-1

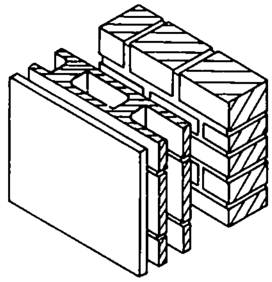
Like WJ35-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance	10.96

WALL-TYPE WJ35-2

Like WJ35-0; except 2" Expanded Polyurethane Board (Layer Code IN25, R=12.53) is substituted for air space

Total Resistance	15.96

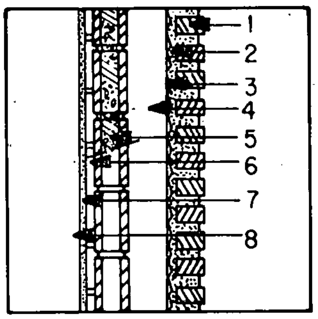


WALL

4 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ36-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB24	4" MW Concrete Block; Cinder agg. Note 2	1.01
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.45

WALL-TYPE WJ36-1

Like WJ36-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

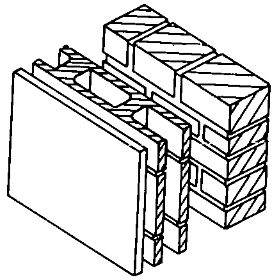
Total Resistance 11.09

WALL-TYPE WJ36-2

Like WJ36-0; except 2" Expanded Polyurethane Board (Layer Code IN25, R=12.53) is substituted for air space

Total Resistance 16.09

See NOTES at the end of this SECTION

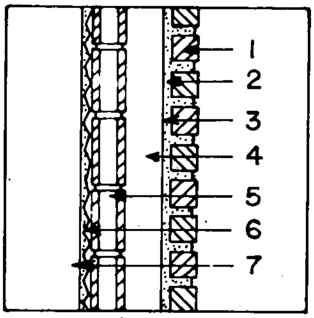


WALL

4 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ37-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB21	4" MW Concrete Block; Cinder agg., Hollow core.	1.11
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.68

WALL-TYPE WJ37-1

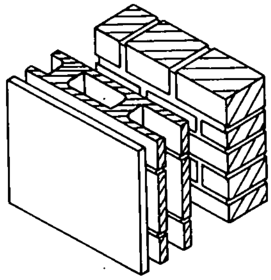
Like WJ37-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.32

WALL-TYPE WJ37-2

Like WJ37-0; except 2" Expanded Polyurethane Board (Layer Code IN25, R=12.53) is substituted for air space

Total Resistance 15.32

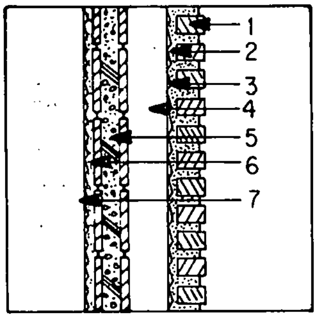


WALL

4 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ38-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB22	4" MW Concrete Block; Cinder agg., concrete filled	.88
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.45

WALL-TYPE WJ38-1

Like WJ38-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.09

WALL-TYPE WJ38-2

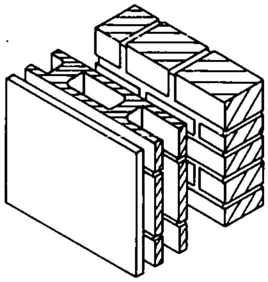
Like WJ38-0; except 2" Expanded Polyurethane Board (Layer Code IN25, R=12.53) is substituted for air space

Total Resistance 15.09

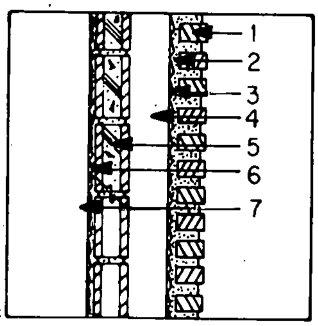
WALL

4 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP



WALL-TYPE WJ39-0



Layer No. Code		List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB24	4" MW Concrete Block; Cinder agg. Note 2	1.01
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.58

WALL-TYPE WJ39-1

Like WJ39-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

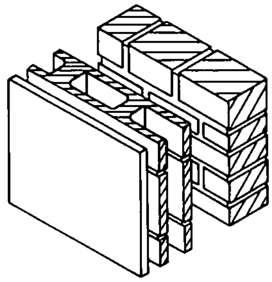
Total Resistance 10.22

WALL-TYPE WJ39-2

Like WJ39-0; except 2" Expanded Polyurethane Board (Layer Code IN25, R=12.53) is substituted for air space

Total Resistance 15.22

See NOTES at the end of this SECTION

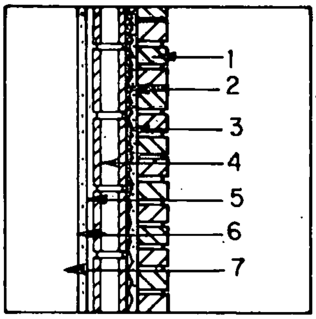


WALL

4 INCH HW CONCRETE BLOCK WITH BRICK VENEER

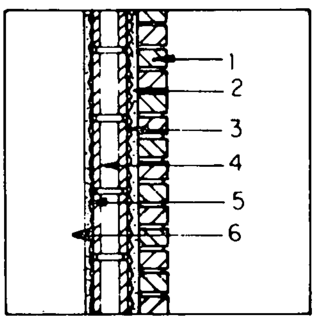
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ60-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB01	4" HW Concrete Block; Sand and Gravel agg., Hollow Cores	.71
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.26

WALL-TYPE WJ61-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer (130 lb)	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	CB01	4" HW Concrete Block; Sand and Gravel agg. Hollow Cores	.71
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.39

WALL-TYPE WJ61-1

Like WJ61-0; except 1" Preformed Mineral Fiberboard (Layer Code IN22, R=3.47) is added.

Total Resistance 5.86

WALL-TYPE WJ61-2

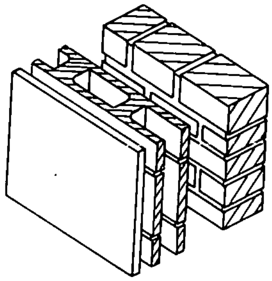
Like WJ61-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is added.

Total Resistance 9.34

WALL-TYPE WJ61-3

Like WJ61-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is added

Total Resistance 8.65



WALL

4 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

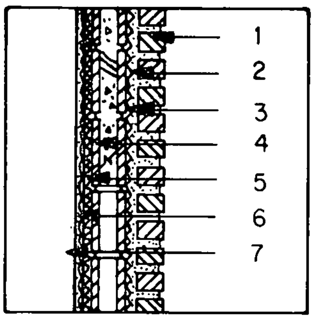
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ61-4

Like WJ61-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is added

Total Resistance	14.92

WALL-TYPE WJ62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB04	4" HW Concrete Block; Sand and Gravel agg. Note 2	.57
5.	IN22	1" Preformed Mineral Fiberboard	3.47
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.72

WALL-TYPE WJ62-1

Like WJ62-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance	9.20

WALL-TYPE WJ62-2

Like WJ62-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is substituted for 1" Preformed Mineral Fiberboard

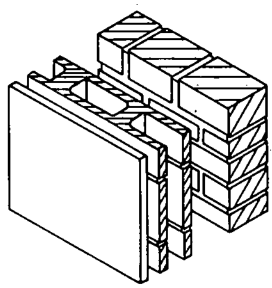
Total Resistance	8.51

WALL-TYPE WJ62-3

Like WJ62-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance	14.78

See NOTES at the end of this SECTION

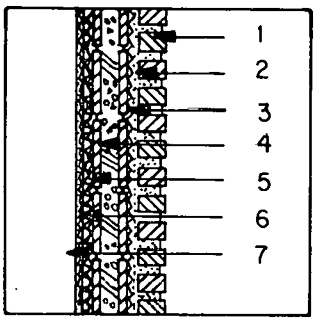


WALL

4 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ63-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB02	4" HW Concrete Block; Sand and Gravel agg., Concrete Filled	.44
5.	IN22	1" Preformed Mineral Fiberboard	3.47
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.59

WALL-TYPE WJ63-1

Like WJ63-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard.

Total Resistance 9.27

WALL-TYPE WJ63-2

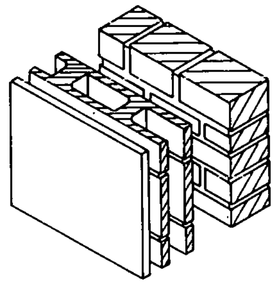
Like WJ63-0; except 1" Expanded Polyurethane Board (Layer Code IN43, R=6.26) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 8.35

WALL-TYPE WJ63-3

Like WJ63-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 14.65

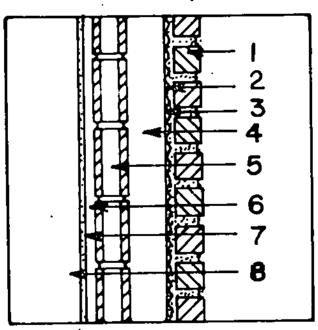


WALL

4 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ64-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB01	4" HW Concrete Block; Sand and Gravel agg., Hollow Cores	.71
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.15

WALL-TYPE WJ64-1

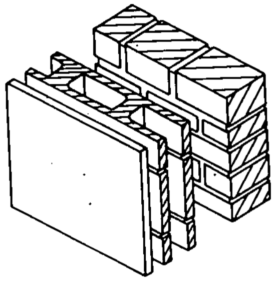
Like WJ64-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.79

WALL-TYPE WJ64-2

Like WJ64-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.79

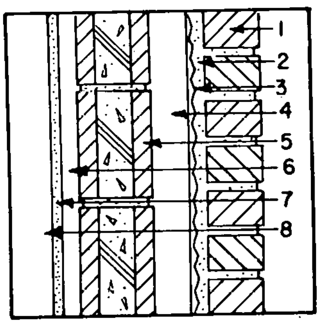


WALL

4 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ65-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Layer (cavity)	.89
5.	CB02	4" HW Concrete Block; Sand and Gravel agg., Concrete filled	.44
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.88

WALL-TYPE WJ65-1

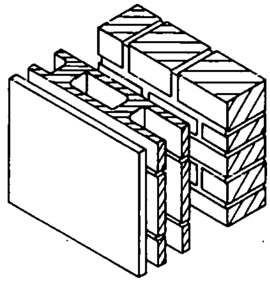
Like WJ65-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.52

WALL-TYPE WJ65-2

Like WJ65-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.52

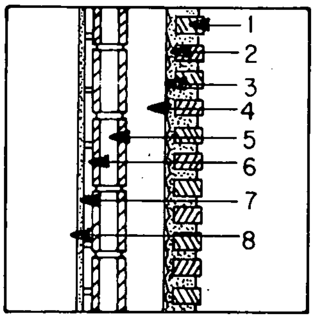


WALL

4 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ66-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB04	4" HW Concrete Block; Sand and Gravel agg. Note 2	.57
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.01

WALL-TYPE WJ66-1

Like WJ66-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

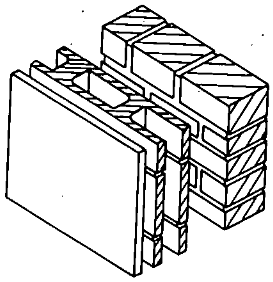
Total Resistance 10.65

WALL-TYPE WJ66-2

Like WJ66-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.65

See NOTES at the end of this SECTION

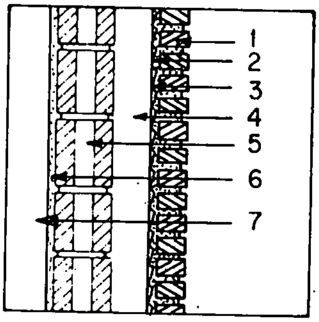


WALL

4 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ67-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB01	4" HW Concrete Block; Sand and Gravel agg., Hollow Core	.71
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.28

WALL-TYPE WJ67-1

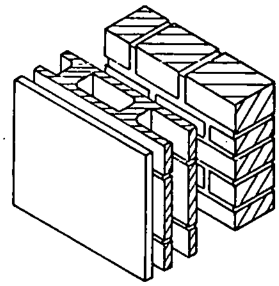
Like WJ67-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

Total Resistance 9.92

WALL-TYPE WJ67-2

Like WJ67-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 14.92

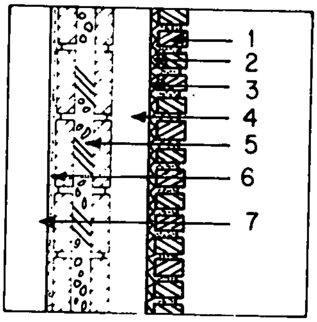


WALL

4 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ68-C



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB02	4" HW Concrete Block; Sand and Gravel agg., Concrete filled	.44
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.01

WALL-TYPE WJ68-1

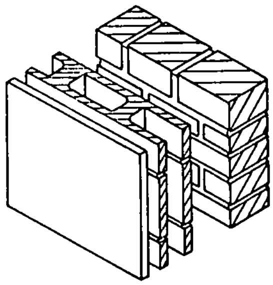
Like WJ68-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 9.65

WALL-TYPE WJ68-2

Like WJ68-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 14.65

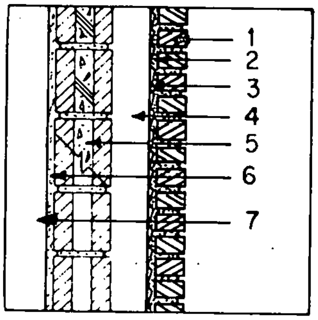


WALL

4 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WJ69-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB04	4" HW Concrete Block; Sand and Gravel agg. Note 2	.57
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.14

WALL-TYPE WJ69-1

Like WJ69-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

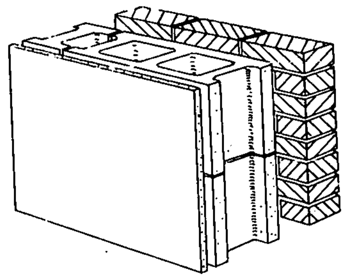
Total Resistance 9.78

WALL-TYPE WJ69-2

Like WJ69-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 14.78

See NOTES at the end of this SECTION



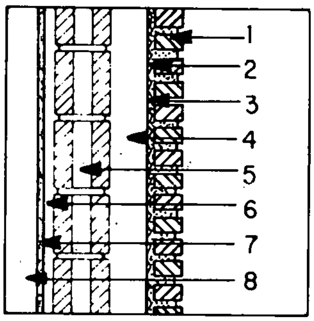
WALL

6 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION

$60\ LBS/FT^2$ AND UP

WALL-TYPE WL00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB46	6" LW Concrete Block Expanded Shale, Clay, Slate agg., Hollow Cores	1.80
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.24

WALL-TYPE WL00-1

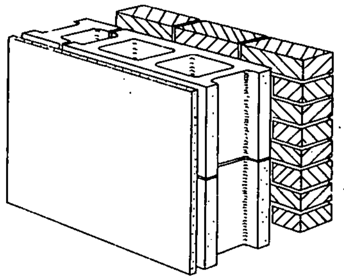
Like WL00-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.88

WALL-TYPE WL00-2

Like WL00-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.88

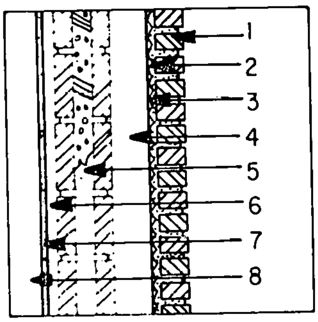


WALL

6 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Layer (Cavity)	.89
5.	CB49	6" LW Concrete Block Expanded Shale, Clay, Slate agg. Note 2	1.57
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.01

WALL-TYPE WL01-1

Like WL01-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

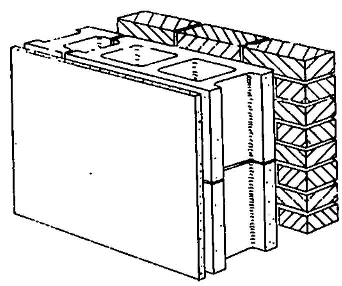
Total Resistance 11.65

WALL-TYPE WL01-2

Like WL01-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.65

See NOTES at the end of this SECTION

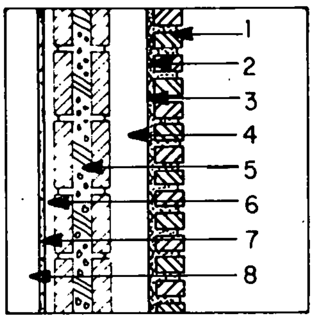


WALL

6 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL02-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB47	6" LW Concrete Block Expanded Shale, Clay, Slate agg.(2) Concrete Filled	1.31
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.75

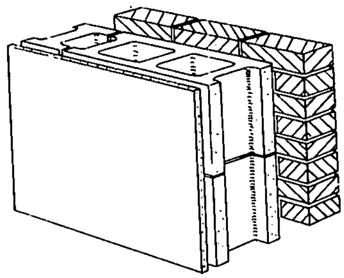
WALL-TYPE WL02-1 Like WL02-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.39

WALL-TYPE WL02-2 Like WL01-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.39

Numbers in parentheses refer to NOTES - see SECTION F

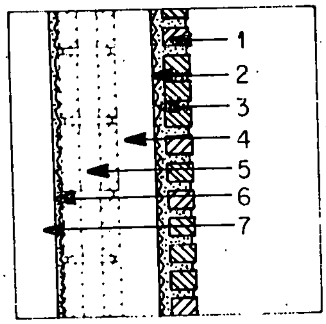


WALL

6 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL03-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB46	6" LW Concrete Block Expanded Shale, Clay, Slate agg., Hollow Cores	1.80
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.37

WALL-TYPE WL03-1

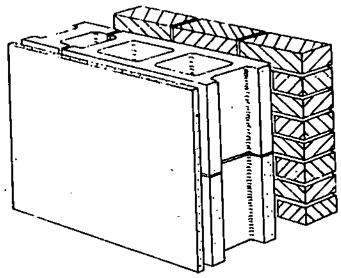
Like WL03-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.01

WALL-TYPE WL03-2

Like WL03-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.01

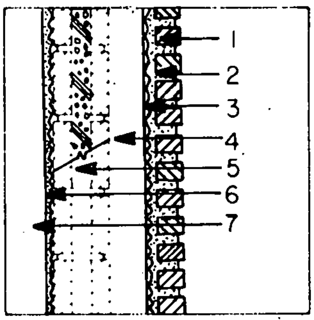


WALL

6 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL04-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB49	6" LW Concrete Block - expanded shale, clay, slate agg. Note 2	1.57
6.	GP04	3/4" Gypsum Plaster on Lath, light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.14

WALL-TYPE WL04-1

Like WL04-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

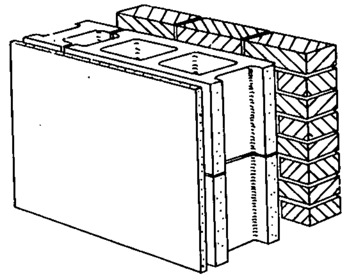
Total Resistance 10.78

WALL-TYPE WL04-2

Like WL04-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.78

See NOTES at the end of this SECTION

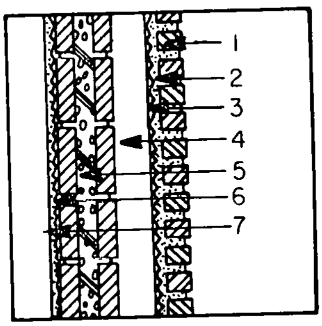


WALL

6 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL05-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB47	6" LW Concrete Block; Exapnded Shale, clay, slate agg. Concrete filled	1.31
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.88

WALL-TYPE WL05-1

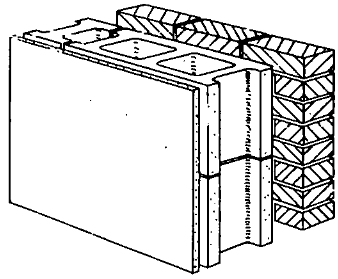
Like WL05-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.52

WALL-TYPE WL05-2

Like WL05-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.52

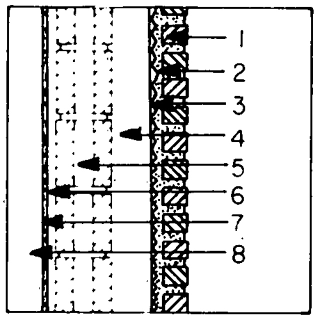


WALL

6 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL30-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB26	6" MW Concrete Block; Cinder agg., Hollow Cores	1.40
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.84

WALL-TYPE WL30-1

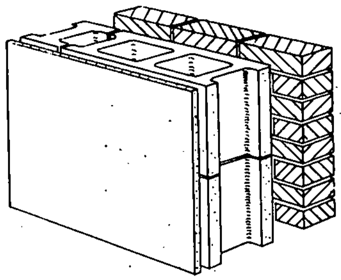
Like WL30-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.48

WALL-TYPE WL30-2

Like WL30-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.48

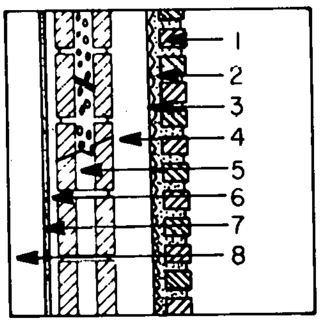


WALL

6 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL31-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB29	6" MW Concrete Block; Cinder agg. Note 2	1.36
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.80

WALL-TYPE WL31-1

Like WL31-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

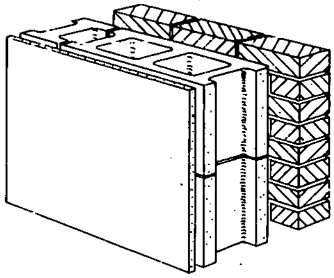
Total Resistance 11.44

WALL-TYPE WL31-2

Like WL31-0; except 2" Expanded Fiberglass Batt (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.44

See NOTES at the end of this SECTION

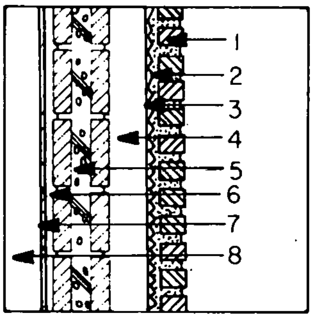


WALL

6 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL32-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB27	6" MW Concrete Block,Cinder agg.,Conc.filled	1.13
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.57

WALL-TYPE WL32-1

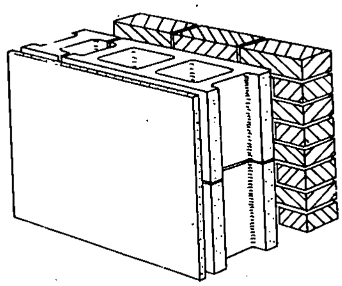
Like WL32-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.21

WALL-TYPE WL32-2

Like WL32-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.21

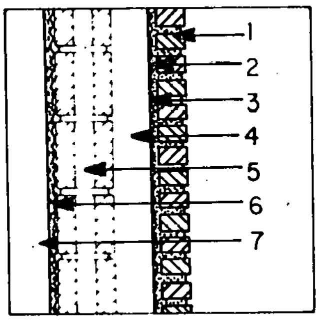


WALL

6 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL33-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB26	6" MW Concrete Block Cinder agg., Hollow Core	1.40
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.97

WALL-TYPE WL33-1

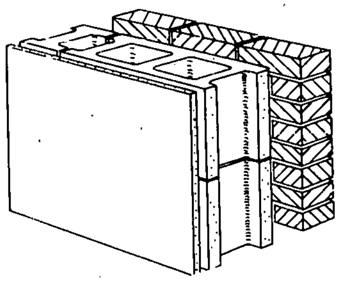
Like WL33-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.61

WALL-TYPE WL33-2

Like WL33-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.61

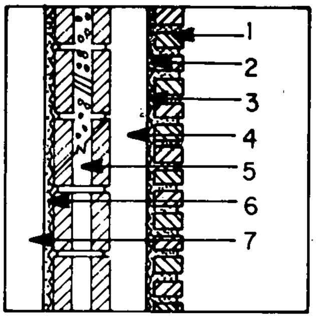


WALL

6 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL34-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB29	6" MW Concrete Block; Cinder agg. Note 2	1.36
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.93

WALL-TYPE WL34-1

Like WL34-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.57

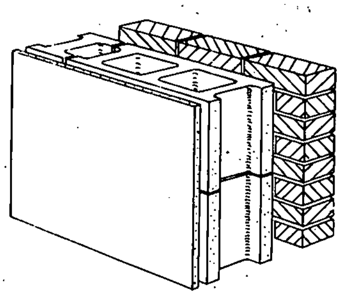
WALL-TYPE WL34-2

Like WL34-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.57

See

See NOTES at the end of this SECTION

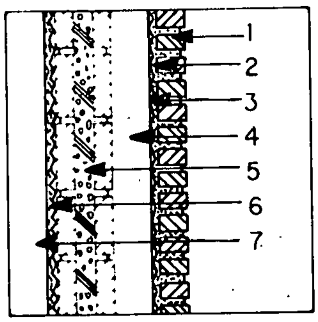


WALL

6 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL35-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB27	6" MW Concrete Block; Cinder agg., Concrete filled	1.13
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.70

WALL-TYPE WL35-1

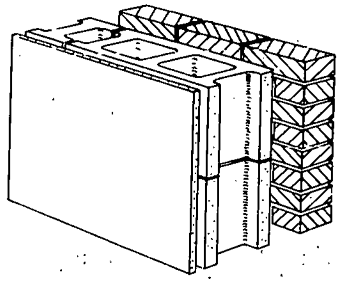
Like WL35-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.34

WALL-TYPE WL35-2

Like WL35-2; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.34

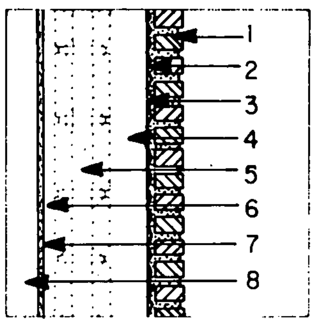


WALL

6 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL60-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air space (Cavity)	.89
5.	CB06	6" HW Concrete Block Sand and Gravel agg., Hollow Cores	.90
6.	AL21	7/8" Air space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.34

WALL-TYPE WL60-1

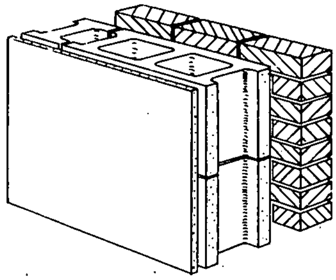
Like WL60-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.98

WALL-TYPE WL60-2

Like WL60-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.98

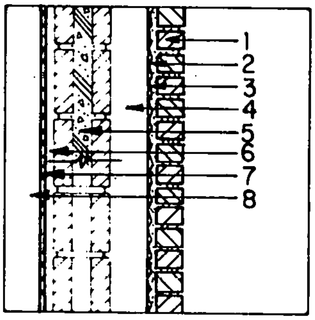


WALL

6 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL61-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB09	6" HW Concrete Block Sand and Gravel agg. Note 2	.82
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.26

WALL-TYPE WL61-1

Like WL61-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

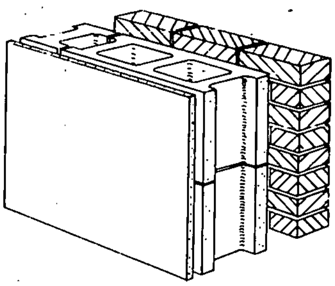
Total Resistance 10.90

WALL-TYPE WL61-2

Like WL61-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.90

See NOTES at the end of this SECTION

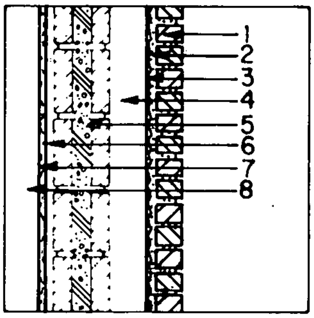


WALL

6 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB07	6" HW Concrete Block; Sand and Gravel agg. Concrete filled	.66
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.10

WALL-TYPE WL62-1

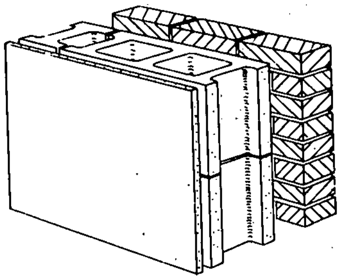
Like WL62-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.74

WALL-TYPE WL62-2

Like WL62-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.74

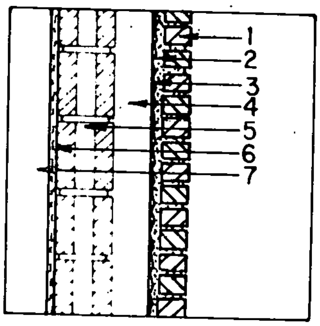


WALL

6 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL63-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB06	6" HW Concrete Block; Sand and Gravel agg., Hollow Cores	.90
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.47

WALL-TYPE WL63-1

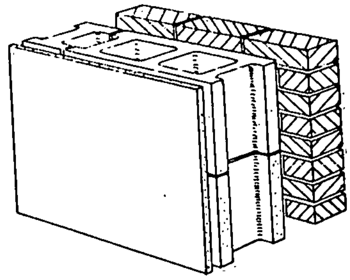
Like WL63-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.11

WALL-TYPE WL63-2

Like WL63-0: except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.11

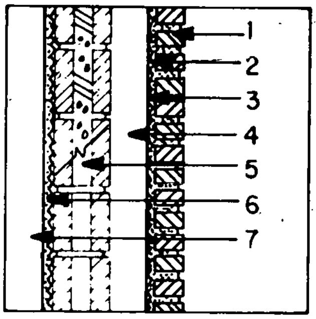


WALL

6 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL64-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB09	6" HW Concrete Block Sand and Gravel agg. Note 2	.82
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.39

WALL-TYPE WL64-1

Like WL64-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

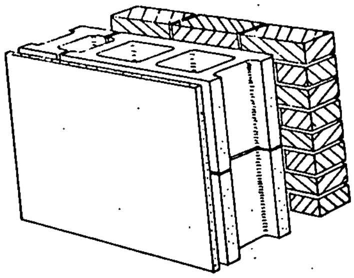
Total Resistance 10.03

WALL-TYPE WL64-2

Like WL64-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.03

See NOTES at the end of this SECTION

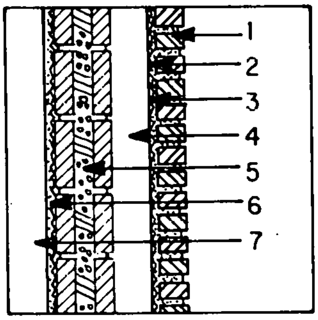


WALL

6 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WL65-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB07	6" HW Concrete Block Sand and Gravel agg., Conc. Filled	.66
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.23

WALL-TYPE WL65-1

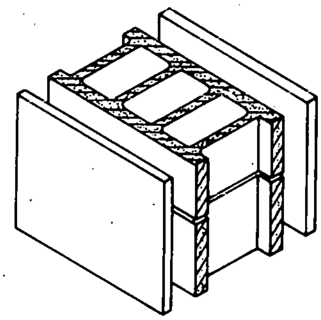
Like WL65-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 9.87

WALL-TYPE WL65-2

Like WL65-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 14.87



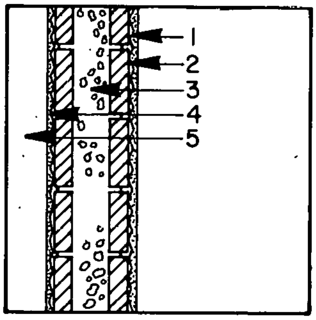
WALL

8 INCH LW CONCRETE BLOCK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WM00-0



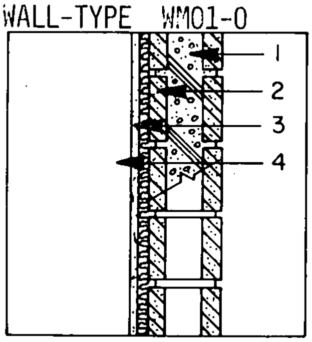
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB55	8" LW Concrete Block; Expanded Shale, Clay, Slate agg. Concrete and Perlite filled Note 3	3.18
4.	GP04	3/4" Gypsum Plaster, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.53

WALL-TYPE WM00-1

Like WM00-0; except 8" LW Concrete Block Note 2 (Layer Code CB54, R=1.73) is substituted for 8" LW Concrete Block with Concrete and Perlite Filled Cores Note 3

Total Resistance 3.08

WALL-TYPE WM01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CB54	8" LW Concrete Block; Expanded Shale, Clay, Slate agg. Note 2	1.73
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP02	5/8" Gypsum Board	.56
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.44

WALL-TYPE WM01-1

Like WM01-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

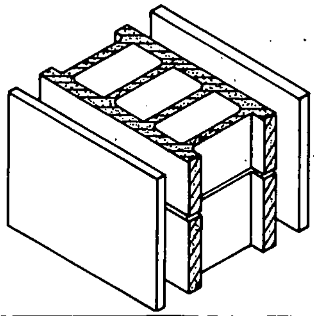
Total Resistance 9.92

WALL-TYPE WM01-2

Like WM01-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 13.39

See NOTES at the end of this SECTION

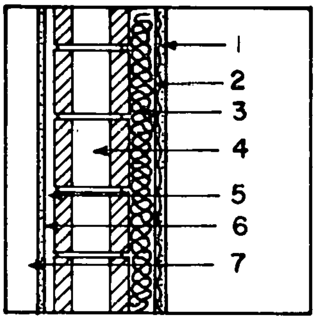


WALL

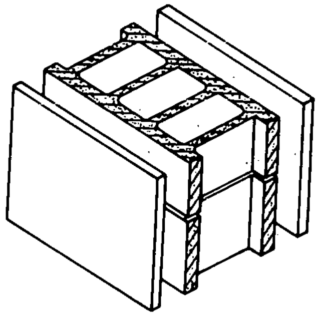
8 INCH LW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM102-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB51	8" LW Concrete Block; Expanded Shale, Clay, Slate agg., Hollow Cores	2.00
5.	AL21	7/8" Air Layer (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	11.75

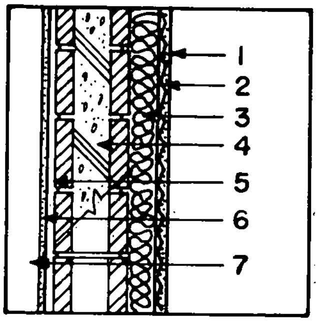


WALL

8 INCH LW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM03-0



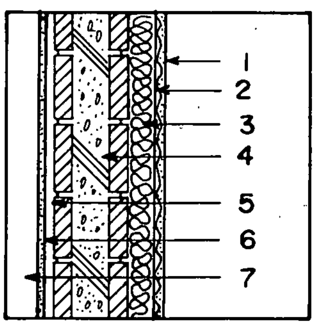
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB54	8" LW Concrete Block, Expanded Shale, Clay, Slate agg. Note 2	1.73
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	11.48

WALL-TYPE WM03-1

Like WM03-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt.

Total Resistance 15.79

WALL-TYPE WM04-0



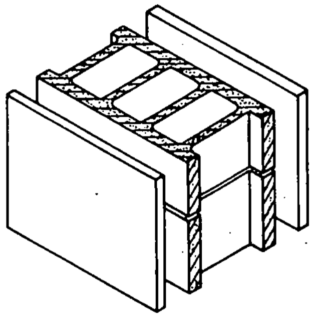
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB52	8" LW Concrete Block, Expanded Shale, Clay, Slate agg., Concrete filled	1.53
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	11.28

WALL-TYPE WM04-1

Like WM04-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 15.59

See NOTES at the end of this SECTION

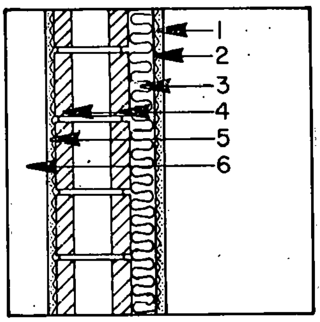


WALL

8 INCH LW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM05-0



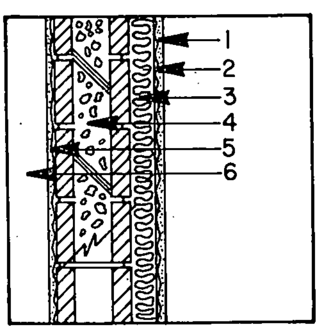
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Board	7.53
4.	CB51	8" LW Concrete Block; Expanded Shale, Clay, Slate agg., Hollow Cores	2.00
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.88

WALL-TYPE WM05-1

Like WM05-0; except 3-1/2" Fiberglass Board (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Board

Total Resistance 15.19

WALL-TYPE WM06-0



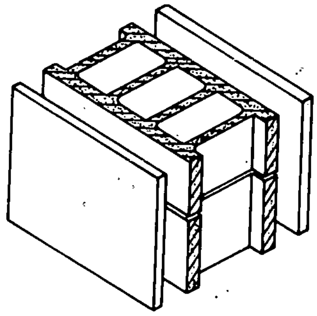
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB54	8" LW Concrete, Expanded Shale Clay, Slate agg. Note 2	1.73
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.61

WALL-TYPE WM06-1

Like WM06-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.92

See NOTES at the end of this SECTION

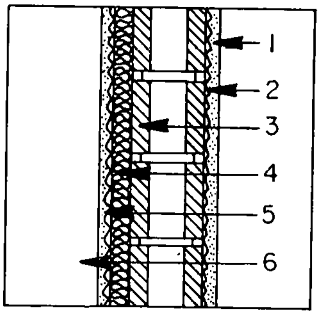


WALL

8 INCH MW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM30-0



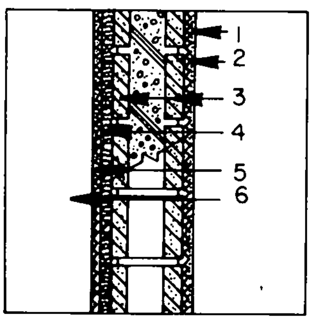
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB31	3" MW Concrete Block, Cinder agg., Hollow Cores	1.72
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.54

WALL-TYPE WM30-1

Like WM30-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 10.02

WALL-TYPE WM31-0



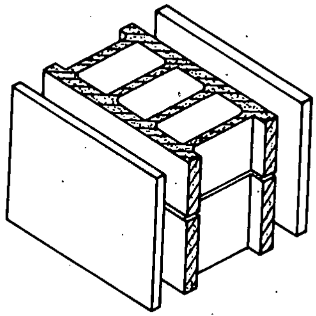
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB34	8" MW Concrete Block; Cinder agg. Note 2	1.53
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.35

WALL-TYPE WM31-1

Like WM31-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.83

See NOTES at the end of this SECTION



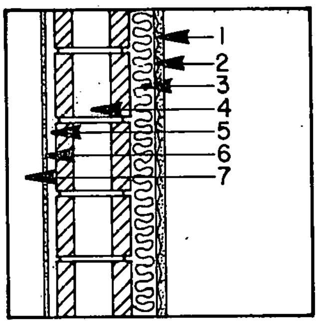
WALL

8 INCH MW CONCRETE BLOCK

HEAVY CONSTRUCTION

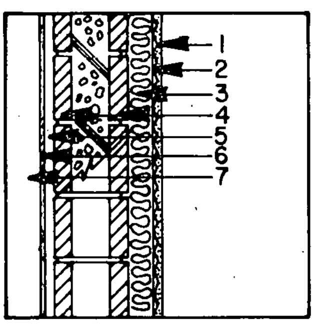
60 LBS/FT^2 AND UP

WALL-TYPE WM32-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB31	8" MW Concrete Block; Cinder agg. Hollow Cores	1.72
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	11.47

WALL-TYPE WM33-0



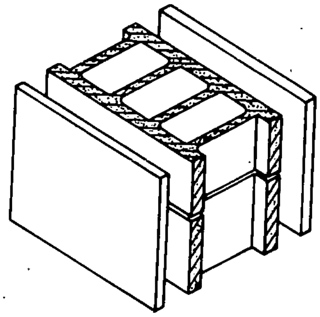
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB34	8" MW Concrete Block, Cinder agg. Note 2	1.53
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	11.28

WALL-TYPE WM33-1

Like WM33-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 15.59

See NOTES at the end of this SECTION

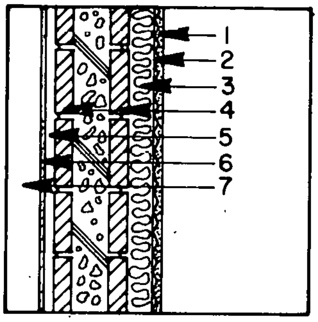


WALL

8 INCH MW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM34-0



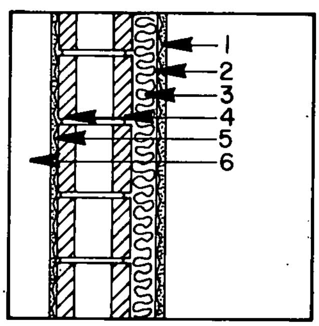
No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB32	8" MW Concrete Block, Cinder agg., Concrete filled	1.41
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	11.16

WALL-TYPE WM34-1

Like WM34-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 15.47

WALL-TYPE WM35-0

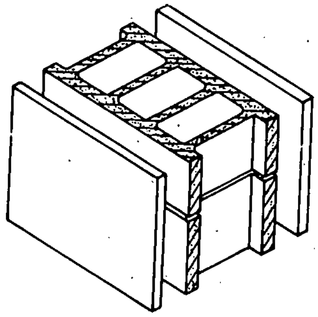


No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Board	7.53
4.	CB31	8" MW Concrete Block, Cinder agg., Hollow Cores	1.72
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.60

WALL-TYPE WM35-1

Like WM35-0; except 3-1/2" Fiberglass Board (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Board

Total Resistance 14.91



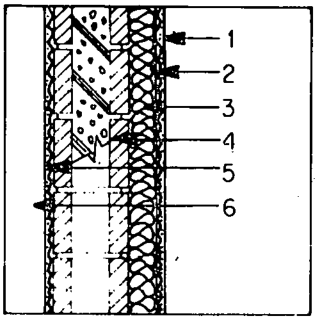
WALL

8 INCH MW CONCRETE BLOCK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WM36-0



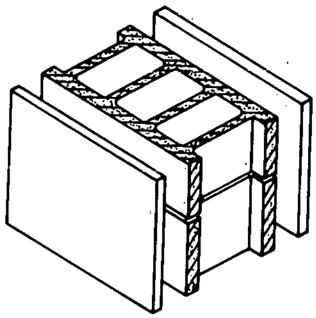
Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Board	7.53
4.	CB34	8" MW Concrete Block; Cinder agg. Note 2	1.53
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.41

WALL-TYPE WM36-1

Like WM36-0; except 3-1/2" Fiberglass Board (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Board

	Total Resistance	14.72

See NOTES at the end of this SECTION

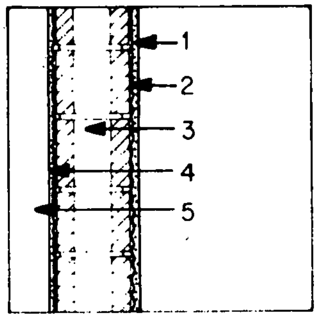


WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM60-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	"	Metal Lath	-
3.	CB11	8" HW Concrete Block, Sand and Gravel agg., Hollow Cores	1.11
4.	GP04	3/4" Gypsum Plaster, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.46

WALL-TYPE WM60-1

Like WM60-0; except 8" HW Concrete Block with Perlite Filled Cores (Layer Code CB13, R=2.93) is substituted for 8" HW Concrete Block with Hollow Cores

Total Resistance 4.28

WALL-TYPE WM60-2

Like WM60-0; except 8" HW Concrete Block Note 2 (Layer Code CB14, R=0.99) is substituted for 8" HW Concrete Block with Hollow Cores

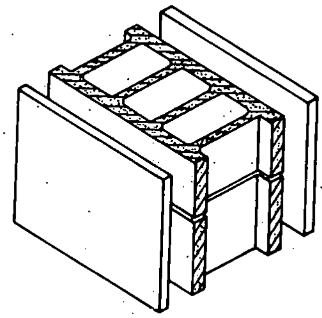
Total Resistance 2.34

WALL-TYPE WM60-3

Like WM60-0; except 8" HW Concrete Block with Concrete Filled Cores (Layer Code CB12, R=0.88) is substituted for 8" HW Concrete Block with Hollow Cores

Total Resistance 2.23

See NOTES at the end of this SECTION



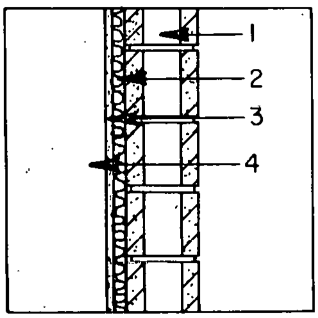
WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WM61-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	CB11	8" HW Concrete Block, Sand and Gravel agg., Hollow Core	1.11
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP02	5/8" Gypsum Board	.56
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.82

WALL-TYPE WM61-1

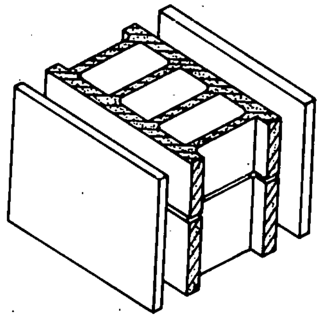
Like WM61-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.30

WALL-TYPE WM61-2

Like WM61-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 12.77

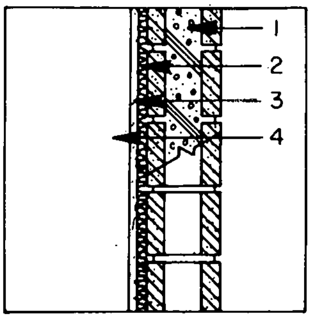


WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CB14	8" HW Concrete Block, Sand and Gravel agg. Note 2	.99
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP02	5/8" Gypsum Board	.56
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.70

WALL-TYPE WM62-1

Like WM62-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

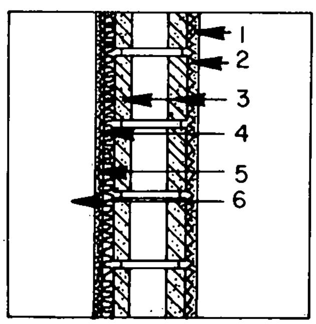
Total Resistance 9.18

WALL-TYPE WM62-2

Like WM62-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 12.65

WALL-TYPE WM63-0



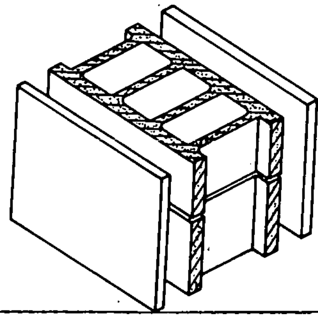
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB11	8" HW Concrete Block, Sand and Gravel agg. Hollow Cores	1.11
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.93

WALL-TYPE WM63-1

Like WM63-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.41

See NOTES at the end of this SECTION

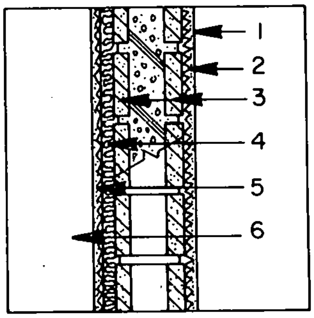


WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM64-0



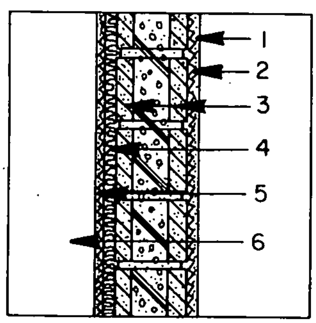
Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB14	8" HW Concrete Block, Sand and Gravel agg. Note 2	.99
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.81

WALL-TYPE WM64-1

Like WM64-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.29

WALL-TYPE WM65-0



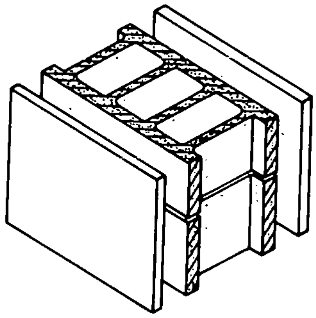
Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CB12	8" HW Concrete Block, Sand and Gravel agg. Concrete Filled	.88
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.70

WALL-TYPE WM65-1

Like WM65-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.18

See NOTES at the end of this SECTION

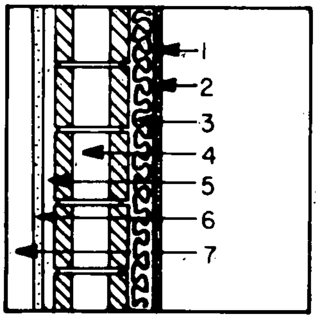


WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM66-0



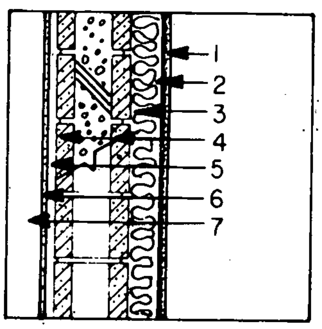
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB11	8" HW Concrete Block; Sand and Gravel agg. Hollow Cores	1.11
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.86

WALL-TYPE WM66-1

Like WM66-0; except 8" HW Concrete Block Note 3 (Layer Code CB14, R=0.99) is substituted for 8" HW Concrete Block with Hollow Cores

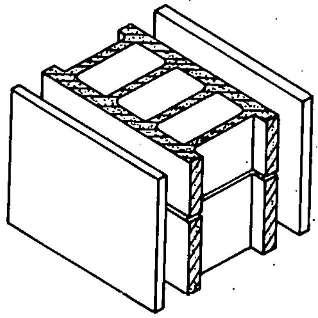
Total Resistance 10.74

WALL-TYPE WM67-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN02	3-1/2" Fiberglass Batt	11.84
4.	CB14	8" HW Concrete Block; Sand and Gravel agg. Note 2	.99
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	15.05

See NOTES at the end of this SECTION

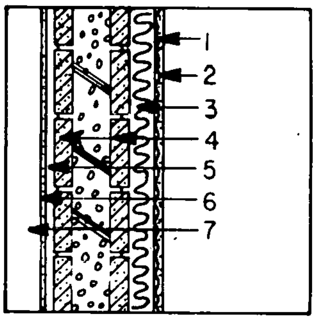


WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WM68-0



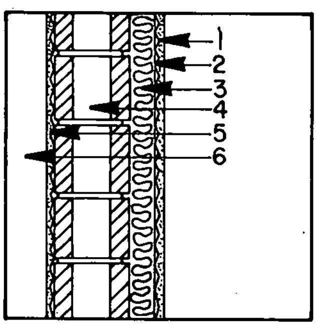
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB12	8" HW Concrete Block, Sand and Gravel agg., Concrete filled	.88
5.	AL21	7/8" Air Space (Metal Furring Space)	.89
6.	GP01	1/2" Gypsum Board.	.45
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.63

WALL-TYPE WM68-1

Like WM68-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.94

WALL-TYPE WM69-0

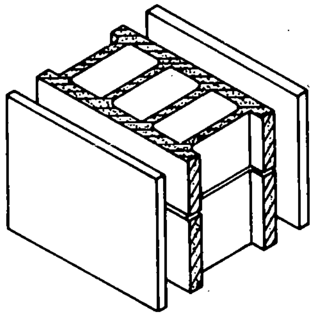


Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB11	8" Concrete Block, Sand and Gravel agg., Hollow Cores	1.11
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.99

WALL-TYPE WM69-1

Like WM69-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.30

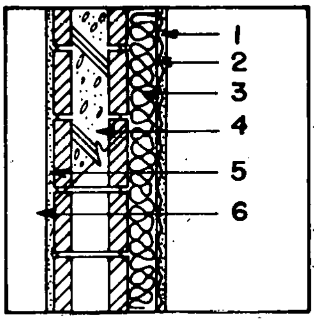


WALL

8 INCH HW CONCRETE BLOCK

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP.

WALL-TYPE WM70-0



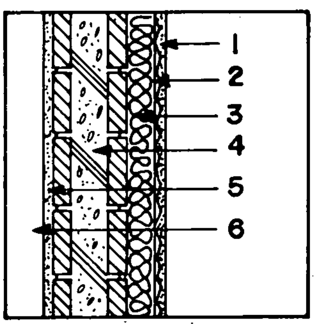
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB14	8" HW Concrete Block; Sand and Gravel agg. Note 2	.99
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.87

WALL-TYPE WM70-1

Like WM70-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.18

WALL-TYPE WM71-0



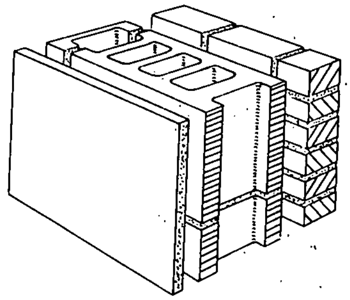
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CB12	8" HW Concrete Block; Sand and Gravel agg., Concrete filled	.88
5.	GP04	3/4" Gypsum Plaster, light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.76

WALL-TYPE WM71-1

Like WM71-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.07

See NOTES at the end of this SECTION

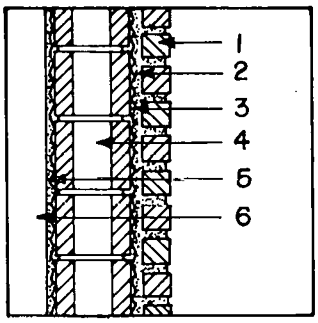


WALL

8 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB51	8" LW Concrete Block, Expanded Shale, Clay, Slate agg., Hollow Core.	2.00
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.68

WALL-TYPE WN00-1

Like WN00-0; except 8" LW Concrete Block Note 2 (Layer Code CB54, R=1.73) is substituted for 8" LW Concrete Block with Hollow Cores

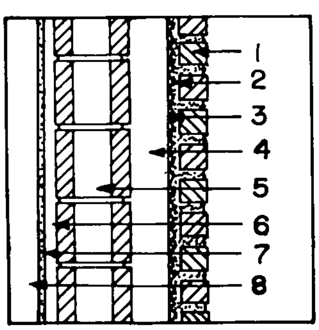
Total Resistance 3.41

WALL-TYPE WN00-2

Like WN00-0; except 8" LW Concrete Block with concrete filled cores (Layer Code CB52, R=1.53) is substituted for 8" LW Concrete Block with Hollow Cores

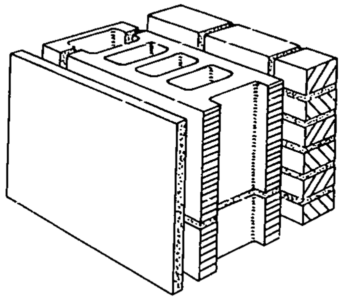
Total Resistance 3.21

WALL-TYPE WN01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB51	8" LW Concrete Block; Expanded Shale, Clay, Slate agg. Hollow Cores	2.00
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.44

See NOTES at the end of this SECTION



WALL

8 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN01-1

Like WN01-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

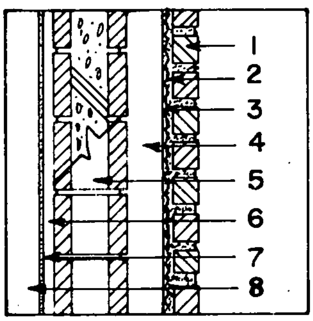
Total Resistance 12.08

WALL-TYPE WN01-2

Like WN01-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 17.08

WALL-TYPE WN02-0



No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB54	8" LW Concrete Block; Expanded Shale, Clay, Slate agg. Note 2	1.73
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.17

WALL-TYPE WN02-1

Like WN02-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

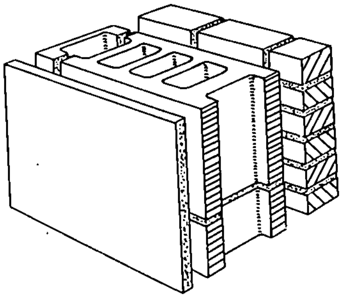
Total Resistance 11.81

WALL-TYPE WN02-2

Like WN02-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.81

See NOTES at the end of this SECTION

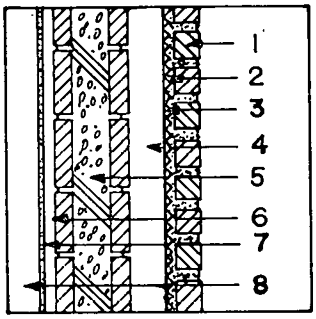


WALL

8 INCH LW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN03-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB52	8" LW Concrete Block; Expanded Shale, Clay, Slate agg., Concrete filled	1.53
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.97

WALL-TYPE WN03-1

Like WN03-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

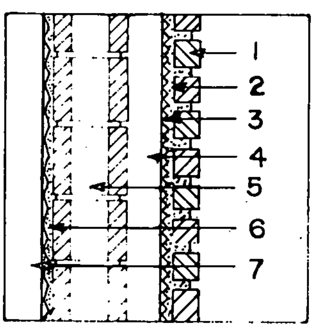
Total Resistance 11.61

WALL-TYPE WN03-2

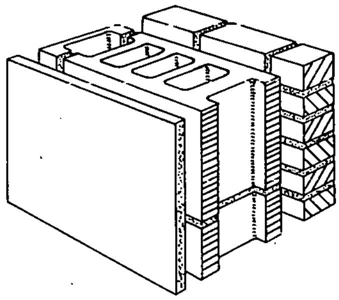
Like WN03-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.61

WALL-TYPE WN04-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB51	8" LW Concrete Block; Expanded Shale, Clay, Slate agg., Hollow Cores	2.00
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.57



WALL

8 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN04-1

Like WN04-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

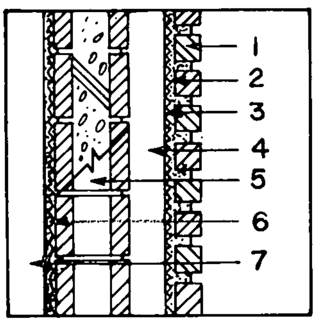
Total Resistance	11.21

WALL-TYPE WN04-2

Like WN04-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance	16.21

WALL-TYPE WN05-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB54	8" LW Concrete Block; Expanded Shale, Clay, Slate agg. Note 2	1.73
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.30

WALL-TYPE WN05-1

Like WN05-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

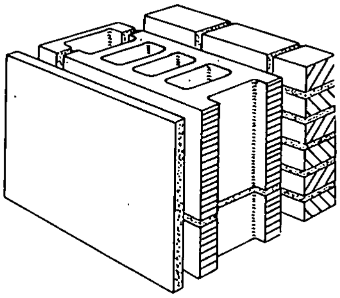
Total Resistance	10.94

WALL-TYPE WN05-2

Like WN05-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance	15.94

See NOTES at the end of this SECTION

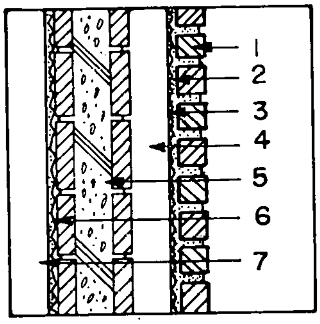


WALL

8 INCH LW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN06-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB52	8" LW Concrete Block; Expanded Shale, Clay, Slate agg. Concrete filled	1.53
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.10

WALL-TYPE WN06-1

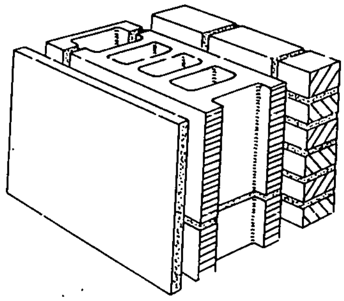
Like WN06-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.74

WALL-TYPE WN06-2

Like WN06-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 3.21

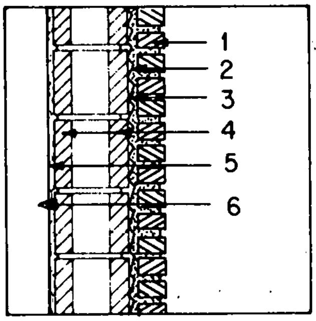


WALL

8 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN30-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB31	8" MW Concrete Block; Cinder agg., Hollow Core	1.72
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.40

WALL-TYPE WN30-1

Like WN30-0; except 8" MW Concrete Block Note 2 (Layer Code CB34, R=1.53) is substituted for 8" MW Concrete Block with Hollow Cores.

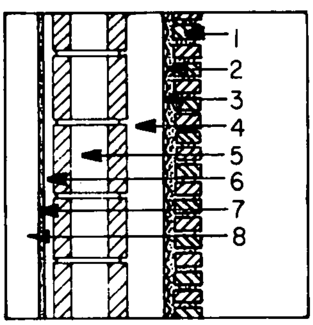
Total Resistance 3.21

WALL-TYPE WN30-2

Like WN30-0; except 8" MW Concrete Block with concrete filled cores (Layer Code CB32, R=1.14) is substituted for Concrete block with Hollow Cores

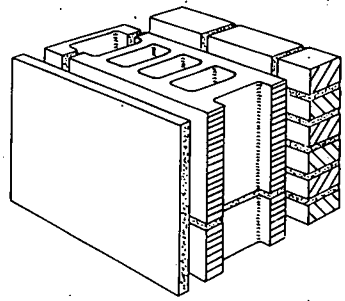
Total Resistance 3.09

WALL-TYPE WN31-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB31	8" MW Concrete block; cinder agg. Hollow Cores	1.72
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.16

See NOTES at the end of this SECTION



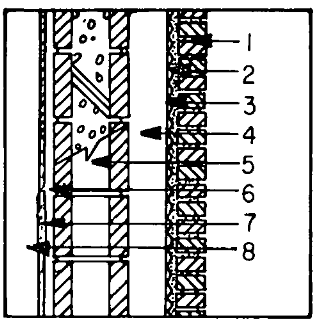
WALL

8 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

		Resistance
WALL-TYPE WN31-1	Like WN31-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space	
	Total Resistance	11.80
WALL-TYPE WN31-2	Like WN31-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space	
	Total Resistance	16.80

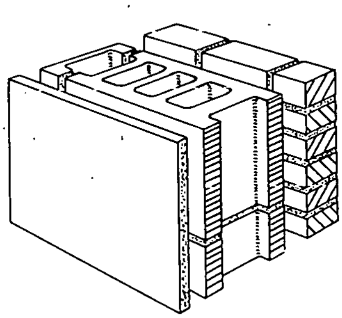
WALL-TYPE WN32-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB34	8" MW Concrete Block; Cinder agg. Note 2	1.53
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.97

WALL-TYPE WN32-1	Like WN32-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space	
	Total Resistance	11.61

See NOTES at the end of this SECTION



WALL

8 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

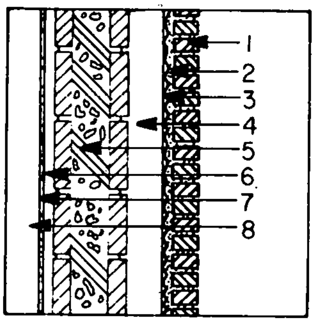
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN32-2

Like WN32-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.61

WALL-TYPE WN33-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CMC1	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB22	8" MW Concrete Block; Cinder agg. concrete filled.	1.41
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.85

WALL-TYPE WN33-1

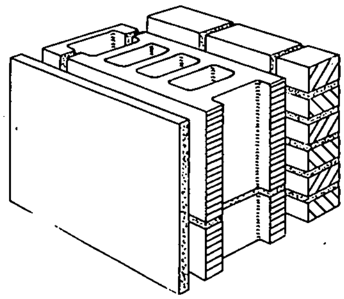
Like WN33-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.49

WALL-TYPE WN33-2

Like WN33-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.49

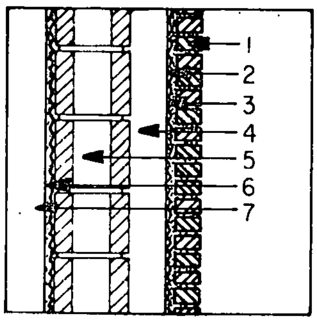


WALL

8 INCH MW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN34-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CMC1	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB31	8" MW Concrete Block; Cinder agg., Hollow Cores	1.72
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	ALC1	Inside Surface Air Film	.68
		Total Resistance	4.29

WALL-TYPE WN34-1

Like WN34-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

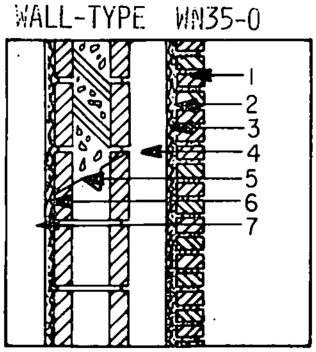
Total Resistance 10.93

WALL-TYPE WN34-2

Like WN34-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

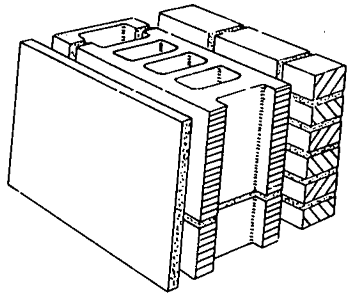
Total Resistance 15.93

WALL-TYPE WN35-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB34	8" MW Concrete Block; Cinder agg. Note 2	1.53
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.10

See NOTES at the end of this SECTION



WALL

8 INCH MW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN35-1

Like WN35-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

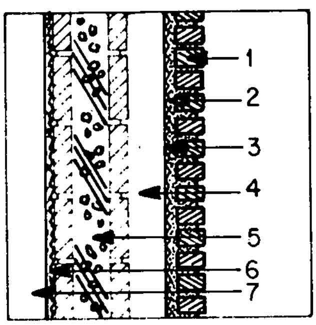
Total Resistance	10.74

WALL-TYPE WN35-2

Like WN35-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance	15.74

WALL-TYPE WN36-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (cavity)	.89
5.	CB32	8" MW Concrete Block; Cinder Agg., Concrete Filled.	1.41
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.98

WALL-TYPE WN36-1

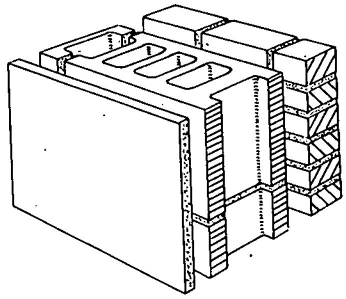
Like WN36-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance	10.62

WALL-TYPE WN36-2

Like WN36-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance	15.62

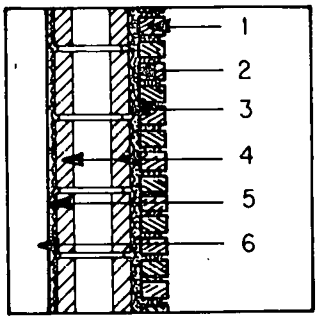


WALL

8 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
$60\ LBS/FT^2$ AND UP

WALL-TYPE WN60-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CB11	8" HW Concrete Block Sand and Gravel agg., Hollow Core	1.11
5.	GP04	3/4" Gypsum Plaster on Lath. Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.79

WALL-TYPE WN60-1

Like WN60-0; except 8" HW Concrete Block. Note 2 (Layer Code CB14, R=0.99) is substituted for 8" HW Concrete Block with Hollow Cores

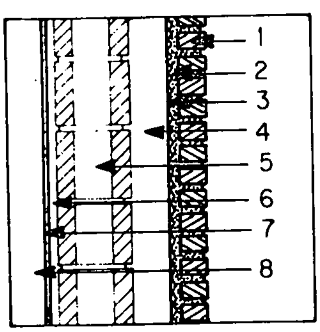
Total Resistance 2.67

WALL-TYPE WN60-2

Like WN60-0; except 8" HW Concrete Block with Concrete Filled Cores (Layer Code CB12, R=0.88) is substituted for 8" HW Concrete Block with Hollow Cores.

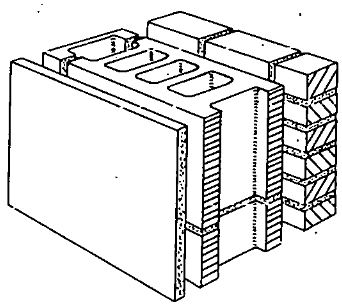
Total Resistance 2.56

WALL-TYPE WN61-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB11	8" HW Concrete Block Sand and Gravel agg., Hollow Cores	1.11
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Film	.68
		Total Resistance	4.55

See NOTES at the end of this SECTION



WALL

8 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

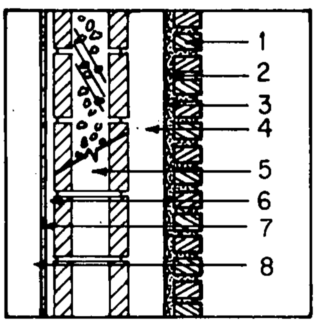
WALL-TYPE WN61-1 Like WN61-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.19

WALL-TYPE WN61-2 Like WN61-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.19

WALL-TYPE WN62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB14	8" HW Concrete Block Sand and Gravel agg. Note 2	.99
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.43

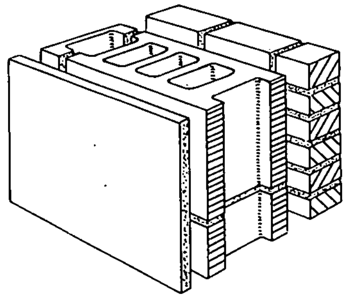
WALL-TYPE WN62-1 Like WN62-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 11.07

WALL-TYPE WN62-2 Like WN62-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 16.07

See NOTES at the end of this SECTION

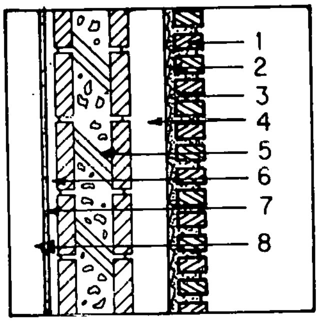


WALL

8 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN63-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" TO 4" Air Space (Cavity)	.89
5.	CB12	8" HW Concrete Block Sand and Gravel agg., Concrete Filled	.88
6.	AL21	7/8" Air Space (Metal Furring Space)	.89
7.	GP01	1/2" Gypsum Board	.45
8.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.32

WALL-TYPE WN63-1

Like WN63-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

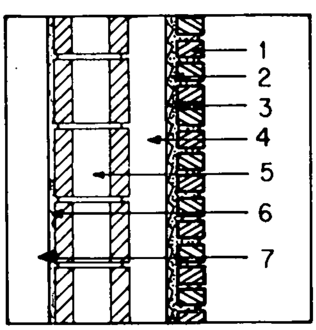
Total Resistance 10.96

WALL-TYPE WN63-2

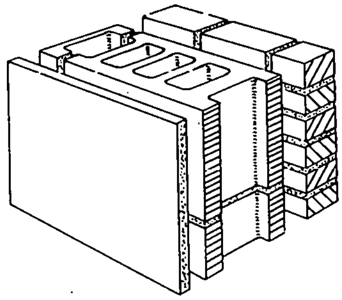
Like WN63-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.96

WALL-TYPE WN64-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB11	8" HW Concrete Block Sand and Gravel agg. Hollow Cores	1.11
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.68



WALL

8 INCH HW CONCRETE BLOCK
WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN64-1

Like WN64-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space.

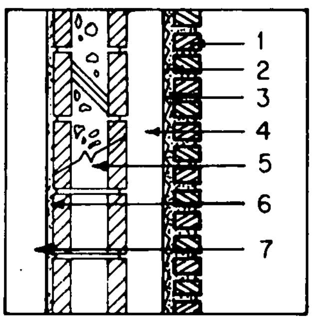
Total Resistance 10.32

WALL-TYPE WN64-2

Like WN64-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.32

WALL-TYPE WN65-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CB14	8" HW Concrete Block Sand and Gravel agg. Note 2	.99
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface AirFilm	.68
		Total Resistance	3.56

WALL-TYPE WN65-1

Like WN65-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

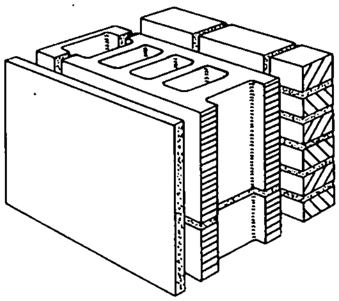
Total Resistance 10.20

WALL-TYPE WN65-2

Like WN65-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.20

See NOTES at the end of this SECTION

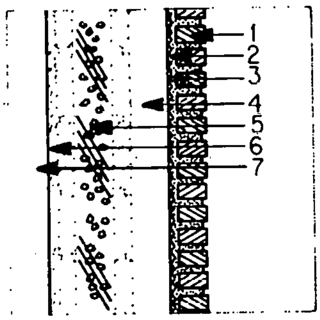


WALL

8 INCH HW CONCRETE BLOCK WITH BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WN66-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Layer (Cavity)	.89
5.	CB12	8" HW Concrete Block Sand and Gravel agg., Concrete Filled	.88
6.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.45

WALL-TYPE WN66-1

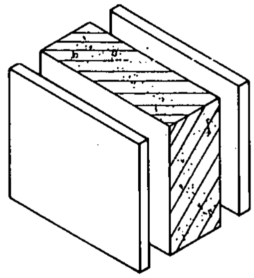
Like WN66-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.09

WALL-TYPE WN66-2

Like WN66-0; except 2" Expanded Polyurethane Board (Layer Code IN45, R=12.53) is substituted for air space

Total Resistance 15.09

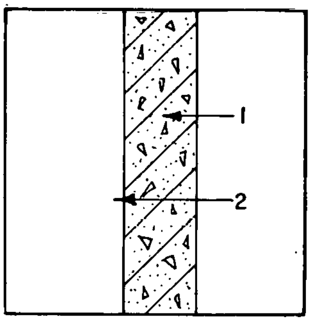


WALL

4 INCH LW CONCRETE PRECAST

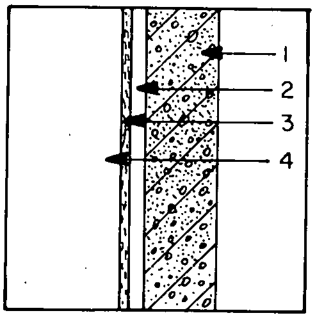
MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WQ00-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC34	4" Precast Concrete (30 lbs) Expanded Shale, Clay, Slate agg.	4.44
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.12

WALL-TYPE WQ01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC34	4" Precast Concrete (30lbs) light agg.	4.44
2.	AL21	7/8" Air Space (Metal Furring Space)	.89
3.	GPC1	1/2" Gypsum Board	.45
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.46

WALL-TYPE WQ01-1

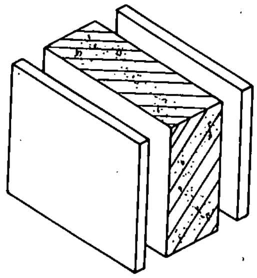
Like WQ01-0; except 1" Preformed Mineral Fiberboard (Layer Code IN22, R=3.47) is substituted for air space

Total Resistance 9.04

WALL-TYPE WQ01-2

Like WQ01-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for air space

Total Resistance 12.52

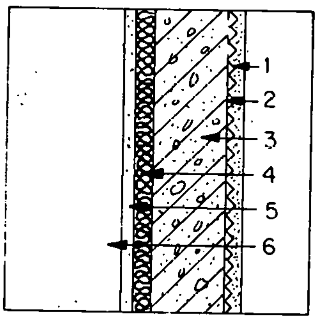


WALL

4 INCH LW CONCRETE PRECAST

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WQ02-0



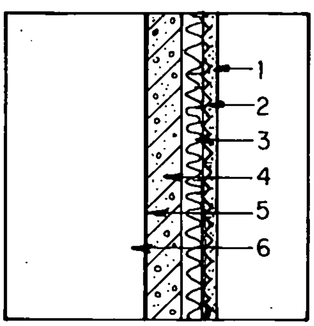
Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CC34	4" Precast Concrete (30 lbs.) Expanded Shale, Clay, Slate agg.	4.44
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.24

WALL-TYPE WQ02-1

Like WQ02-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 12.72

WALL-TYPE WQ03-0

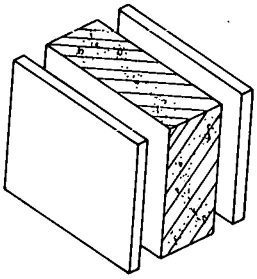


Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CC34	4" Precast Concrete (30 lbs) Expanded Shale, Clay, Slate agg.	4.44
5.	-	Painted Surface	-
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	12.85

WALL-TYPE WQ03-1

Like WQ03-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 17.16

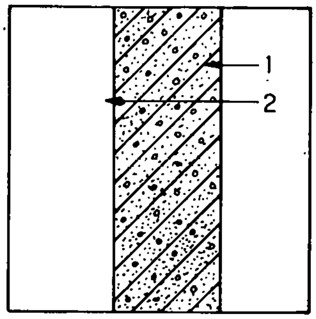


WALL

4 INCH MW CONCRETE PRECAST

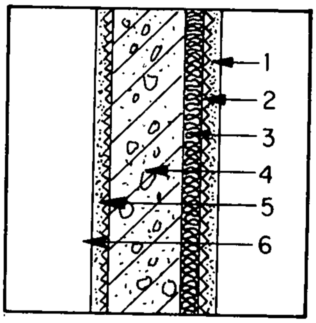
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WQ30-0

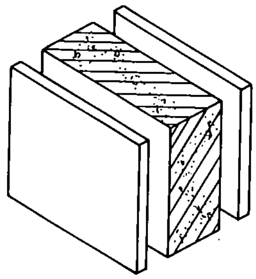


Layer No.	Code	List of Construction Layers	Resistance
1.	CC24	4" Precast Concrete (80 lbs) Cinder agg.	1.60
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.28

WALL-TYPE WQ31-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN22	1" Preformed Mineral Fiberboard	3.47
4.	CC24	4" Precast Concrete (80 lbs) Cinder agg.	1.60
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.42

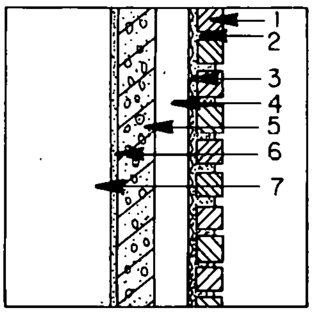


WALL

4 INCH MW CONCRETE
PRECAST

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WQ32-0



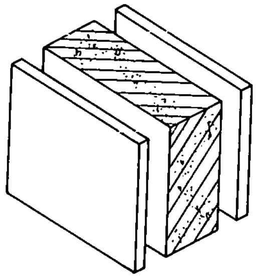
No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space	.89
5.	CC24	4" Precast Concrete (80 lbs) Cinder agg.	1.60
6.	GP04	3/4" Gypsum Plaster, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	4.17

WALL-TYPE WQ32-1 Like WQ32-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for air space

Total Resistance 10.81

WALL-TYPE WQ32-2 Like WQ32-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for air space

Total Resistance 15.12

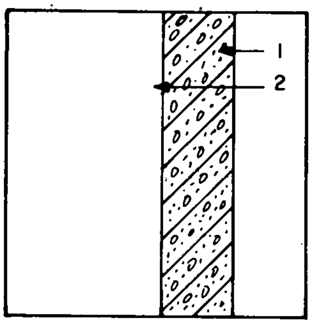


WALL

4 INCH HW CONCRETE
PRECAST

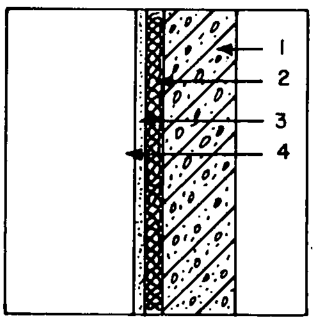
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WQ60-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC03	4" Precast Concrete (140 lbs) Sand and Gravel agg.	.44
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	1.12

WALL-TYPE WQ61-0

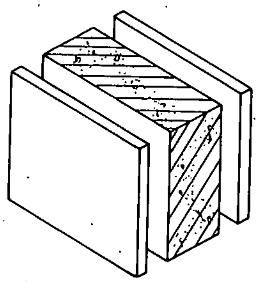


Layer No.	Code	List of Construction Layers	Resistance
1.	CC03	4" Precast Concrete (140 lbs) Sand and Gravel agg.	.44
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP01	1/2" Gypsum Board	.45
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.04

WALL-TYPE WQ61-1

Like WQ61-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 8.52

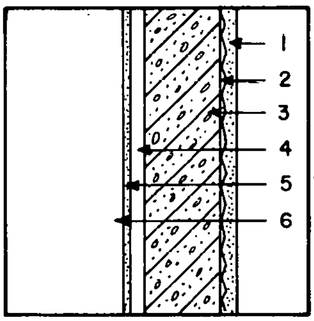


WALL

4 INCH HW CONCRETE PRECAST

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WQ62-0



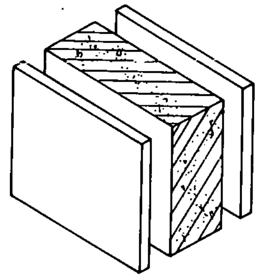
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CC03	4" Precast Concrete (140 lbs) Sand and Gravel agg., oven-dried	.44
4.	AL21	7/8" Air Space (Metal Furring Space)	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.66

WALL-TYPE WQ62-1 Like WQ62-0; except 1" Preformed Mineral Fiberboard (Layer Code IN22, R=3.47) is substituted for air space

Total Resistance 5.24

WALL-TYPE WQ62-2 Like WQ62-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for air space

Total Resistance 8.72



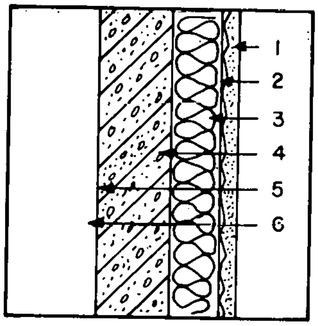
WALL

4 INCH HW CONCRETE PRECAST

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

WALL-TYPE WQ63-0



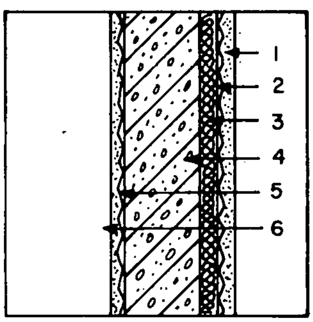
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CC03	4" Precast Concrete (140 lbs) Sand and Gravel agg.	.44
5.	-	Painted Surface	-
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	8.85

WALL-TYPE WQ63-1

Like WQ63-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

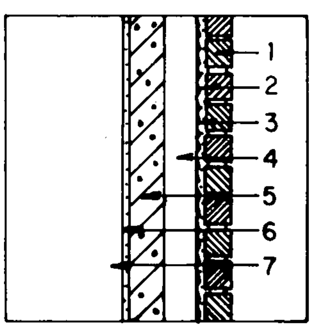
Total Resistance 13.16

WALL-TYPE WQ64-0

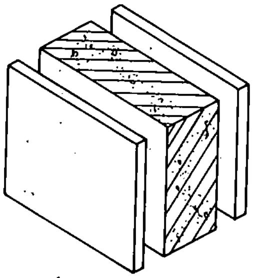


Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	IN22	1" Preformed Mineral Fiberboard	3.47
4.	CC03	4" Precast Concrete (140 lbs) Sand and Gravel agg.	.44
5.	GP04	3/4" Gypsum Plaster. Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.26

WALL-TYPE WQ65-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space	.89
5.	CC03	4" Precast Concrete (140 lbs) Sand and Gravel agg.	.44
6.	GP04	3/4" Gypsum Plaster. Light agg	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.01



WALL

4 INCH HW CONCRETE PRECAST

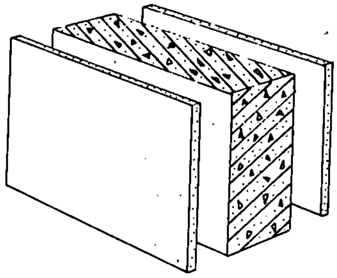
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WQ65-1 — Like WQ65-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for 3-1/2" Air Space

Total Resistance 9.65

WALL-TYPE WQ65-2 — Like WQ65-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 3-1/2" Air Space

Total Resistance 13.96

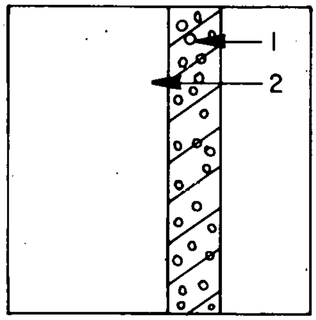


WALL

6 INCH HW CONCRETE PRECAST

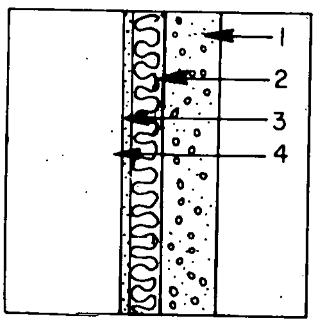
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WR60-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC04	6" Precast Concrete (140 lbs) Sand and Gravel agg.	.66
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	1.34

WALL-TYPE WR61-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC04	6" Precast Concrete (140 lbs) Sand and Gravel agg., oven-dried	.66
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP02	5/8" Gypsum Board	.56
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.37

WALL-TYPE WR61-1

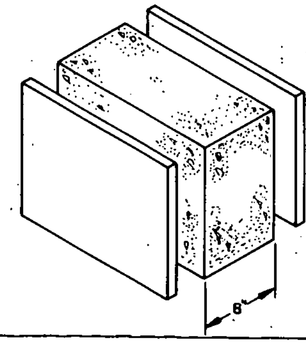
Like WR61-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 8.85

WALL-TYPE WR61-2

Like WR61-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=11.84) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 13.74

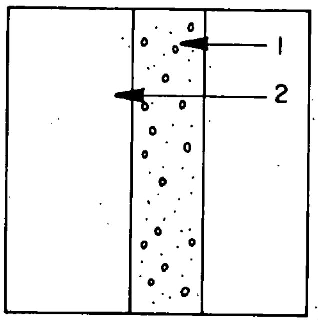


WALL

8 INCH HW CONCRETE POURED-IN-PLACE

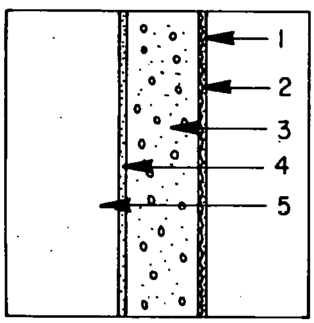
HEAVY CONSTRUCTION 60 LBS/FT^2 AND UP

WALL-TYPE WT60-0

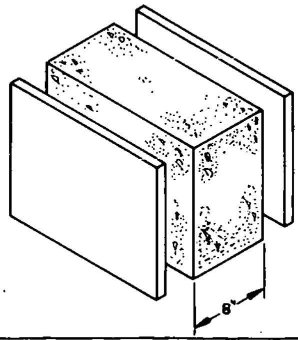


Layer No.	Code	List of Construction Layers	Resistance
1.	CC05	8" Concrete (140 lbs) Sand and Gravel agg., oven-dried	.88
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	1.56

WALL-TYPE WT61-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CC05	8" Concrete (140 lbs) Sand and Gravel agg., oven-dried	.88
4.	GP04	3/4" Gypsum Plaster, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.23

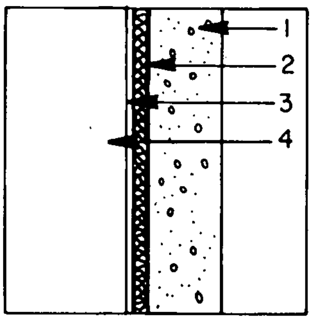


WALL

8 INCH HW CONCRETE
POURED-IN-PLACE

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WT62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC05	8" Concrete (140 lbs) Sand and Gravel agg., oven-dried	.88
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP02	5/8" Gypsum Board	.56
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.59

WALL-TYPE WT62-1

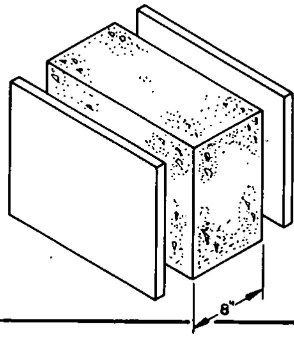
Like WT62-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.07

WALL-TYPE WT62-2

Like WT62-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

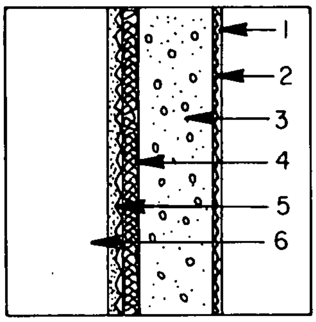
Total Resistance 12.54



WALL

8 INCH HW CONCRETE
POURED-IN-PLACE
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WT63-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CC05	8" Concrete (140 lbs) Sand and Gravel agg., oven-dried	.88
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	5.70

WALL-TYPE WT63-1

Like WT63-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

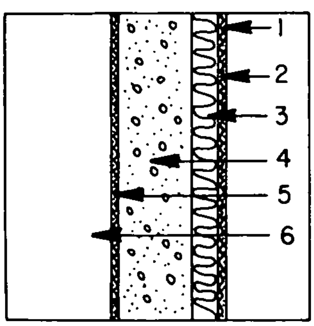
Total Resistance 9.18

WALL-TYPE WT63-2

Like WT63-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 12.65

WALL-TYPE WT64-0

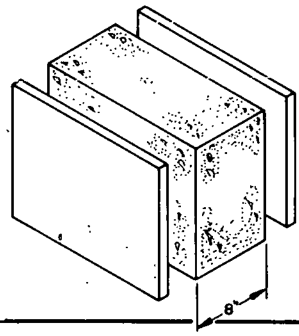


Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CC05	8" Concrete (140 lbs) Sand and Gravel agg. oven-dried	.88
5.	GP04	3/4" Gypsum Plaster on Lath. Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.76

WALL-TYPE WT64-1

Like WT64-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.07

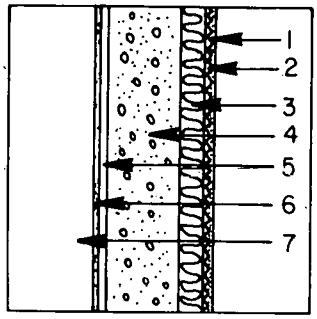


WALL

8 INCH HW CONCRETE POURED-IN-PLACE

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WT65-0



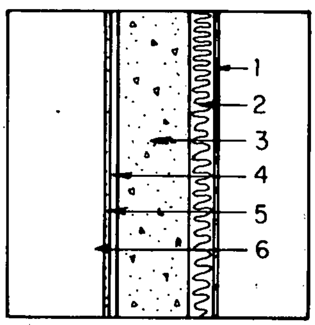
Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CC05	8" Concrete (140 lbs) Sand and Gravel agg., oven-dried	.88
5.	AL21	7/8" Air Space (Metal furring strip)	.89
6.	GP02	5/8" Gypsum Board	.56
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.74

WALL-TYPE WT65-1

Like WT65-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt.

Total Resistance 15.05

WALL-TYPE WT66-0

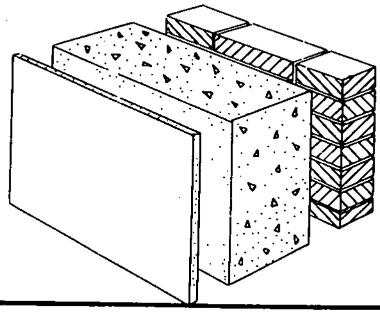


Layer No.	Code	List of Construction Layers	Resistance
1.	AS01	Steel Siding	-
2.	IN01	2-3/4" Fiberglass Batt	7.53
3.	CC05	8" Concrete (140 lbs) Sand and Gravel agg., oven-dried	.88
4.	AL21	7/8" Air Space (Metal furring strip)	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.43

WALL-TYPE WT66-1

Like WT66-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt.

Total Resistance 14.74

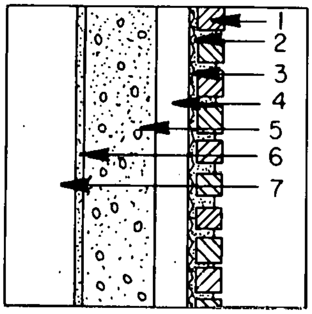


WALL

8 INCH HW CONCRETE
POURED-IN-PLACE
BRICK VENEER

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WT70-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	AL21	3/4" to 4" Air Space (Cavity)	.89
5.	CC05	8" Concrete (140 lbs)	.88
6.	GP04	3/4" Gypsum Plaster, Light agg.	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.45

WALL-TYPE WT70-1

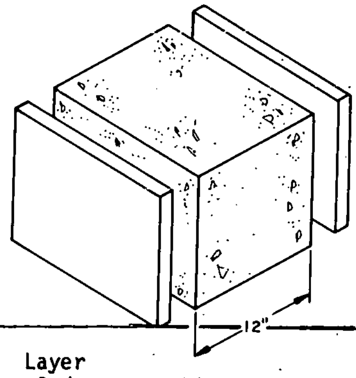
Like WT70-0; except 2-3/4" Fiberglass Batt (Layer Code IN01, R=7.53) is substituted for 3-1/2" Air Space

Total Resistance 11.07

WALL-TYPE WT70-2

Like WT70-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 3-1/2" Air Space

Total Resistance 15.38

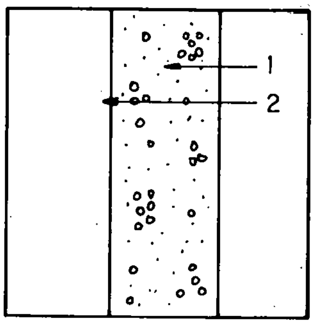


WALL

12 INCH HW CONCRETE POURED-IN-PLACE

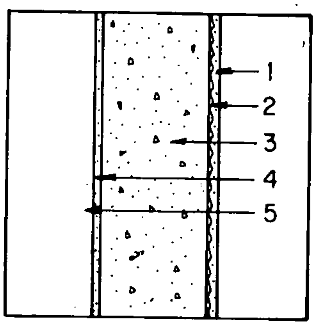
HEAVY CONSTRUCTION 60 LBS/FT^2 AND UP

WALL-TYPE WU60-0

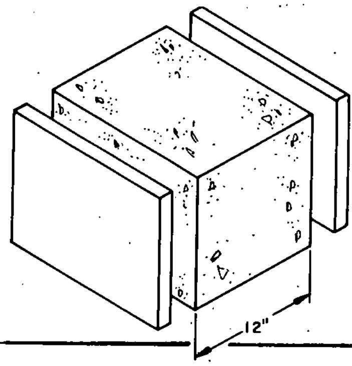


Layer No.	Code	List of Construction Layers	Resistance
1.	CC07	12" Concrete (140 lbs) Sand and Gravel agg.	1.32
2.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.00

WALL-TYPE WU61-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CC07	12" Concrete (140 lbs)	1.32
4.	GP04	3/4" Gypsum Plaster (Light agg.)	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.67

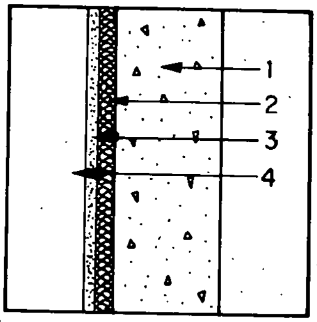


WALL

12 INCH HW CONCRETE
POURED-IN-PLACE

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WU62-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC07	12" Concrete (140 lbs) Sand and Gravel agg. over-dried	1.32
2.	IN22	1" Preformed Mineral Fiberboard	3.47
3.	GP02	5/8" Gypsum Board	.56
4.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.03

WALL-TYPE WU62-1

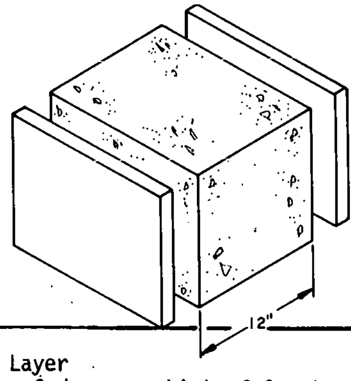
Like WU62-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 9.51

WALL-TYPE WU62-2

Like WU62-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 12.98

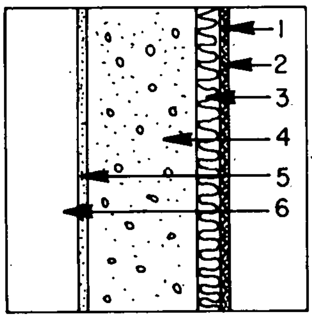


WALL

12 INCH HW CONCRETE
POURED-IN-PLACE

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WU63-0



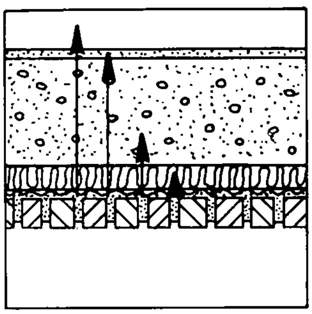
Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CC07	12" Concrete (140 lbs) Sand and Gravel agg., oven-dried	1.32
5.	GP04	3/4" Gypsum Plaster	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.20

WALL-TYPE WU63-1

Like WU63-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.51

WALL-TYPE WU64-0

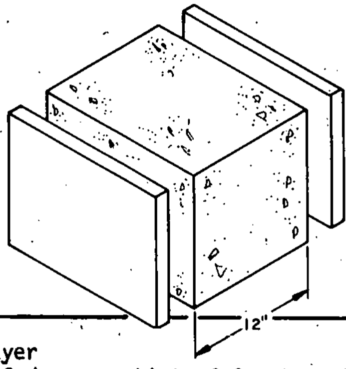


Layer No.	Layer Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Paperback Metal Lath	-
4.	IN01	2-3/4" Fiberglass Batt	7.53
5.	CC07	12" Concrete (140 lbs) Sand and Gravel agg., oven-dried	1.32
6.	GP04	3/4" Gypsum Plaster	.47
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.53

WALL-TYPE WU64-1

Like WU64-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.84

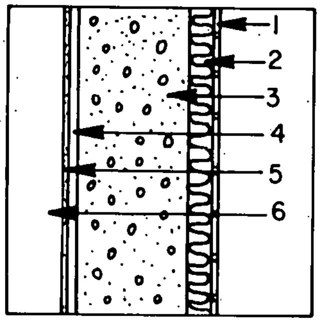


WALL

12 INCH HW CONCRETE
POURED-IN-PLACE

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

WALL-TYPE WU65-0

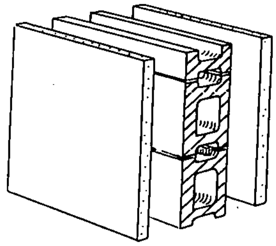


Layer No.	Code	List of Construction Layers	Resistance
1.	AS01	Steel Siding	-
2.	IN01	2-3/4" Fiberglass Batt	7.53
3.	CC07	12" Concrete (140 lbs) Sand and Gravel agg., oven-dried	1.32
4.	AL21	7/8" Air Space (Metal Furring space)	.89
5.	GP01	1/2" Gypsum Board	.45
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	10.87

WALL-TYPE WU65-1

Like WU65-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 15.18

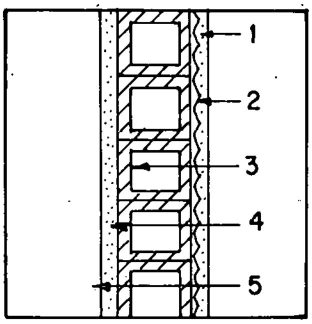


WALL

CLAY TILE, ONE CELL

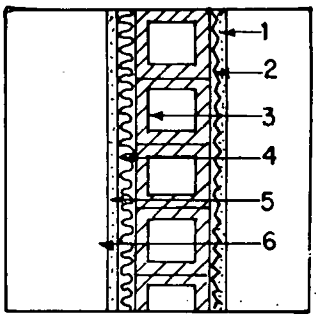
MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WV00-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CT02	4" Clay Tile	1.11
4.	GP04	Gypsum Plaster, Light agg.	.47
5.	AL01	Inside Surface Air Film	.68
		Total Resistance	3.46

WALL-TYPE WV01-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CT02	4" Clay Tile	1.11
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP02	5/8" Gypsum Board	.56
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.02

WALL-TYPE WV01-1

Like WV01-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

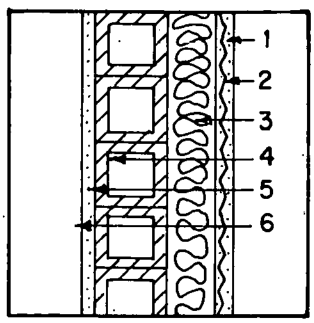
Total Resistance 9.50

WALL-TYPE WV01-2

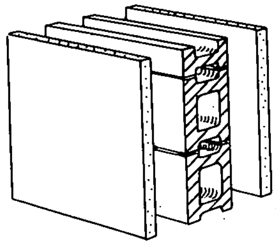
Like WV01-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 12.97

WALL-TYPE WV02-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	CT02	4" Clay Tile	1.11
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	9.99



WALL

CLAY TILE, ONE CELL

MEDIUM CONSTRUCTION

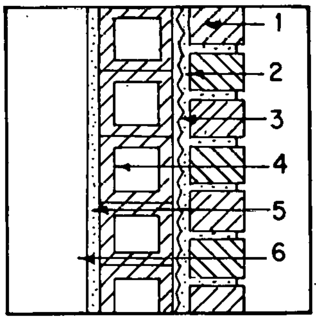
20 LBS/FT^2 TO 60 LBS/FT^2

WALL-TYPE WV02-1

Like WV02-0; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

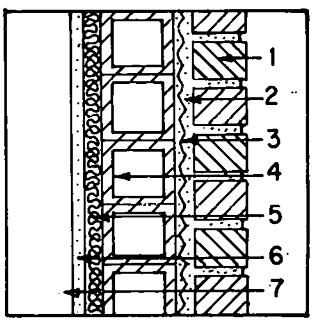
Total Resistance	14.30

WALL-TYPE WV03-0



Layer No.	Code	List of Construction Layers=	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CT02	4" Clay Tile	1.11
5.	GP04	3/4" Gypsum Plaster, Light agg.	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	2.79

WALL-TYPE WV04-0



Layer No.	Code	List of Construction Layers	Resistance
1.	BK04	3" Brick Veneer	.33
2.	CM01	1" Cement Mortar Grout	.20
3.	-	Metal Lath	-
4.	CT02	4" Clay Tile	1.11
5.	IN22	1" Preformed Mineral Fiberboard	3.47
6.	GP02	5/8" Gypsum Board	.56
7.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.35

WALL-TYPE WV04-1

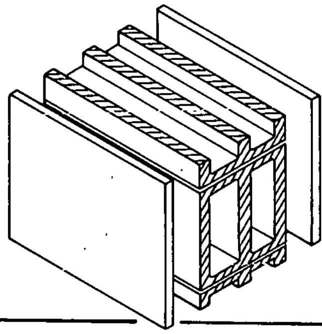
Like WV04-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance	9.83

WALL-TYPE WV04-2

Like WV04-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance	13.30

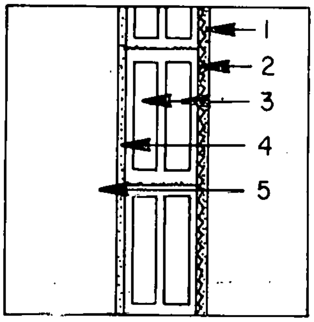


WALL

Clay Tile, Two Cells

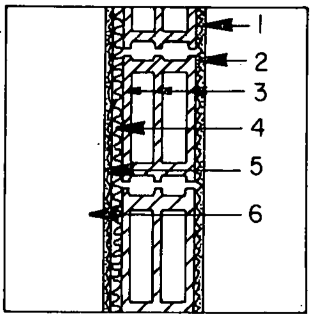
Heavy Construction 60 LBS/FT^2 AND UP

WALL-TYPE WV40-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CT04	8", Clay Tile 2 Cells	1.85
4.	GP04	3/4" Gypsum Plaster, on Lath	.47
5.	AL01	Inside Surface Film	.68
		Total Resistance	3.20

WALL-TYPE WV41-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	CT04	8" Clay Tile 2 Cell	1.85
4.	IN22	1" Preformed Mineral Fiberboard	3.47
5.	GP04	3/4" Gypsum Plaster	.47
6.	AL01	Inside Surface Air Film	.68
		Total Resistance	6.67

WALL-TYPE WV41-1

Like WV41-0; except 2" Preformed Mineral Fiberboard (Layer Code IN23, R=6.95) is substituted for 1" Preformed Mineral Fiberboard

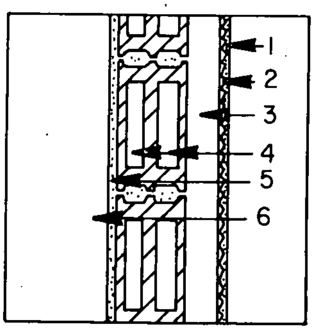
Total Resistance 10.15

WALL-TYPE WV41-2

Like WV41-0; except 3" Preformed Mineral Fiberboard (Layer Code IN24, R=10.42) is substituted for 1" Preformed Mineral Fiberboard

Total Resistance 13.62

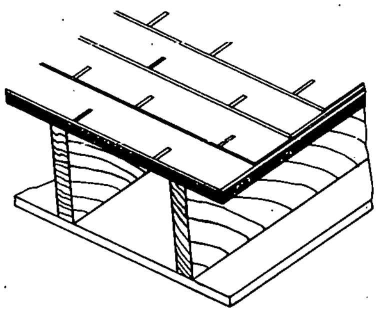
WALL-TYPE WV42-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Paperback Metal Lath	-
3.	AL21	3/4" to 4" Air Space (Cavity)	.89
4.	CT04	8", Clay Tile, 2 Cells	1.85
5.	GP04	3/4" Gypsum Plaster on Lath, Light agg.	.47
6.	AL01	Inside Surface Air FIlm	.68
		Total Resistance	4.09

LIST OF ROOFS

ROOF-TYPE	Construction Type	Construction Weight	Number of Roofs
RA51-0 to RA53-2	Wood Frame	Light Up to 20 lbs/ft^2	9
RB01-1 to RB02-4	Wood Frame	Light Up to 20 lbs/ft^2	8
RB03-1 to RB03-4	2 1/2 inch Wood Decking	Light Up to 20 lbs/ft^2	4
RB04-1 to RB04-4	3 1/2 inch Wood Decking	Light Up to 20 lbs/ft^2	4
RB51-1 to RB52-4	Wood Frame	Light Up to 20 lbs/ft^2	8
RB53-1 to RB53-4	2 1/2 inch Wood Decking	Light Up to 20 lbs/ft^2	4
RB54-1 to RB54-4	3 1/2" Wood Decking	Light Up to 20 lbs/ft^2	4
RC01-1 to RC01-4	Metal Decking	Light Up to 20 lbs/ft^2	4
RC51-1 to RC51-4	Metal Decking	Light Up to 20 lbs/ft^2	4
RD01-1 to RD03-4	Metal Decking	Medium 20 lbs/ft^2 to 60 lbs/ft^2	12
RD51-1 to RD53-4	Metal Decking	Medium 20 lbs/ft^2 to 60 lbs/ft^2	12
RE01-1 to RE02-4	4 inch Concrete Slab	Medium 20 lbs/ft^2 to 60 lbs/ft^2	8
RE51-1 to RE52-4	4 inch Concrete Slab	Medium 20 lbs/ft^2 to 60 lbs/ft^2	8
RF01-1 to RF02-4	6 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	8
RF51-1 to RF52-4	6 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	8
RG01-1 to RG02-4	8 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	8
RG51-1 to RG52-4	8 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	8
RH01-1 to RH01-4	10 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	4
RH51-1 to RH51-4	10 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	4

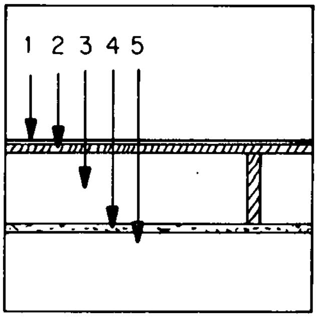


ROOF

WOOD FRAME

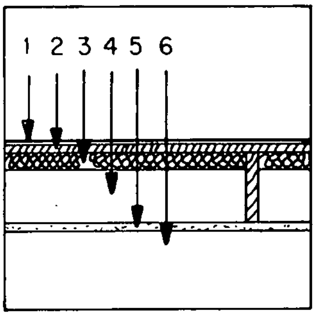
LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RA51-0



Layer No.	Code	List of Construction Layers	Resistance
1.	AR01	Asphalt Roll Roofing	.15
2.	PW04	5/8" Plywood Sheathing	.78
3.	AL33	Ceiling Air Space	.92
4.	GP01	1/2" Gypsum Board	.45
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	3.06

ROOF-TYPE RA51-1

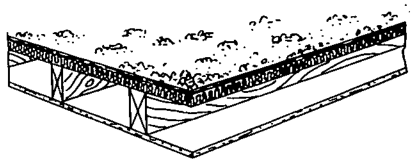


Layer No.	Code	List of Construction Layers	Resistance
1.	AR01	Asphalt Roll Roofing	.15
2.	PW04	5/8" Plywood Sheathing	.78
3.	IN01	2-3/4" Fiberglass Batt	7.53
4.	AL33	Ceiling Air Space	.92
5.	GP01	1/2" Gypsum Board	.45
6.	AL03	Inside Surface Air Film	.76
		Total Resistance	10.59

ROOF-TYPE RA51-2

Like RA51-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.90

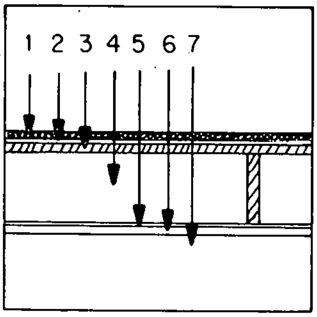


ROOF

WOOD FRAME

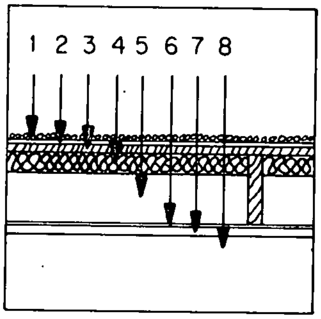
LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RA52-0



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	PW04	5/8" Plywood Sheathing	.78
4.	AL33	Ceiling Air Space	.92
5.	-	Metal Furring Strip	-
6.	GP01	1/2" Gypsum Board	.45
7.	AL03	Inside Surface Air Film	.76
		Total Resistance	3.29

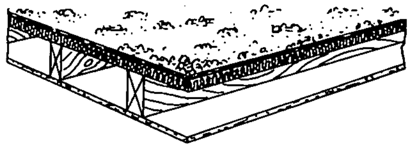
ROOF-TYPE RA52-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	PW04	5/8" Plywood Sheathing	.78
4.	IN01	2-3/4" Fiberglass Batt	7.53
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Strip	-
7.	GP01	1/2" Gypsum Board	.45
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	10.82

ROOF-TYPE RA52-2 Like RA52-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 15.12

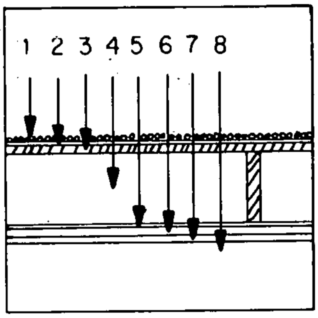


ROOF

WOOD FRAME

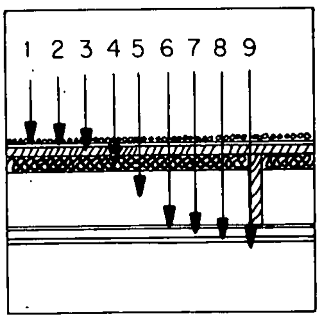
LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RA53-0



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	PW04	5/8" Plywood Sheathing	.78
4.	AL33	Ceiling Air Space	.92
5.	-	Metal Furring Strip	-
6.	GP01	1/2" Gypsum Board	.45
7.	AC01	3/8" Acoustic Tile	.95
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.24

ROOF-TYPE RA53-1

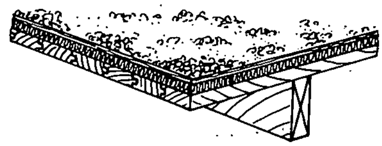


Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	PW04	5/8" Plywood Sheathing	.78
4.	IN01	2-3/4" Fiberglass Batt	7.53
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Strip	-
7.	GP01	1/2" Gypsum Board	.45
8.	AC01	3/8" Acoustic Tile	.95
9.	AL03	Inside Surface Air Film	.76
		Total Resistance	11.77

ROOF-TYPE RA53-2

Like RA53-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 16.08

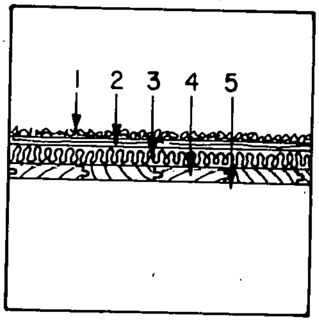


ROOF

WOOD FRAME

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD01	3/4" thick 1 x 4 Wood Sheathing	.94
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.86

ROOF-TYPE RB01-2

Like RB01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 6.25

ROOF-TYPE RB01-3

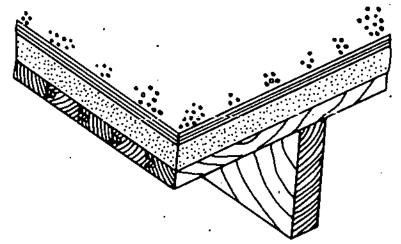
Like RB01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 7.74

ROOF-TYPE RB01-4

Like RB01-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 10.41

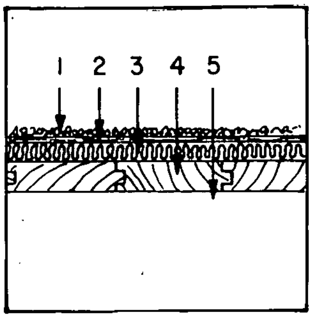


ROOF

Wood Frame

Light Construction
Up to 20 lbs/ft^2

ROOF-TYPE RB02-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD02	1-1/2" thick, 2 x 6 Wood Decking	1.87
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	5.79

ROOF-TYPE RB02-2 Like RB02-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

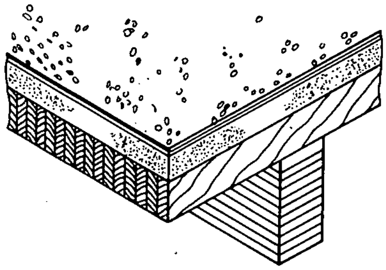
Total Resistance 7.18

ROOF-TYPE RB02-3 Like RB02-1, except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 8.67

ROOF-TYPE RB02-4 Like RB02-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 11.34

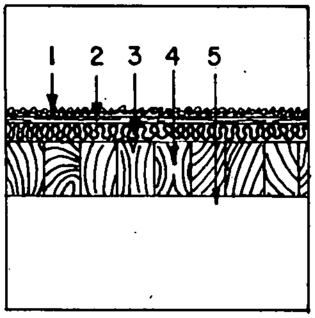


ROOF

2½ INCH WOOD DECKING

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB03-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD03	2 x 3 Wood Decking, on edge	3.12
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	7.04

ROOF-TYPE RB03-2 Like RB03-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

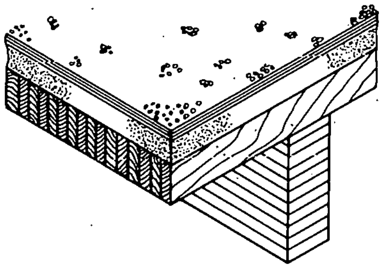
Total Resistance 8.40

ROOF-TYPE RB03-3 Like RB03-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.89

ROOF-TYPE RB03-4 Like RB03-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 12.59

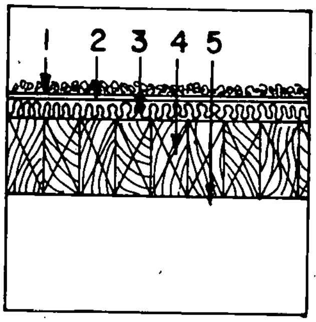


ROOF

3½ INCH WOOD DECKING

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB04-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD04	2 x 4 Wood Decking, on edge	4.37
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	8.29

ROOF-TYPE RB04-2 Like RB04-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

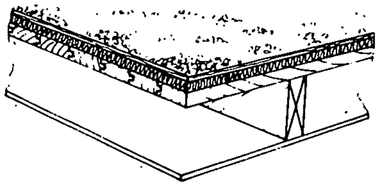
Total Resistance 9.68

ROOF-TYPE RB04-3 Like RB04-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 11.17

ROOF-TYPE RB04-4 Like RB04-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 13.84

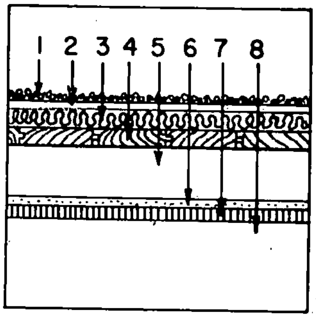


ROOF

WOOD FRAME

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB51-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD01	3/4" thick 1 x 4 Wood Sheathing	.94
5.	AL33	Ceiling Air Space	.92
6.	GP01	1/2" Gypsum Board	.45
7.	AC03	3/4" Acoustic Tile (glued)	1.89
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	8.12

ROOF-TYPE RB51-2

Like RB51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 9.51

ROOF-TYPE RB51-3

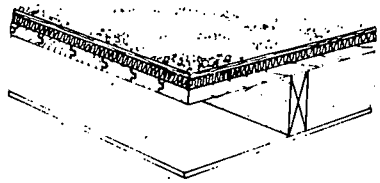
Like RB51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 11.00

ROOF-TYPE RB51-4

Like RB51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 13.67

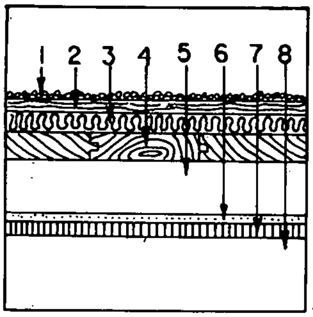


ROOF

WOOD FRAME

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB52-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD02	1-1/2" thick, 2 x 6 Wood Decking	1.87
5.	AL33	Ceiling Air Space	.92
6.	GP01	1/2" Gypsum Board	.45
7.	AC03	3/4" Acoustic Tile (glued)	1.89
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	9.05

ROOF-TYPE RB52-2 Like RB52-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

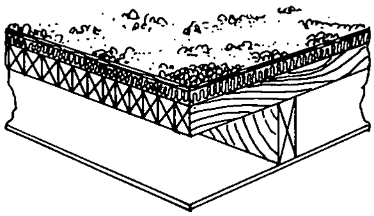
Total Resistance 10.44

ROOF-TYPE RB52-3 Like RB52-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 11.93

ROOF-TYPE RB52-4 Like RB52-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 14.60

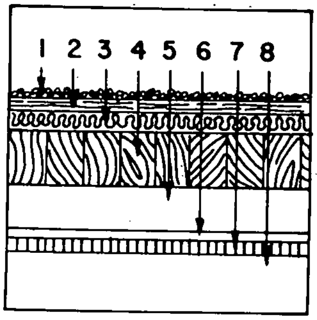


ROOF

2½ INCH WOOD DECKING

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB53-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD03	2 x 3 Wood Decking, on edge	3.12
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	—
7.	AC03	3/4" Acoustic Tile	1.89
8.	AL03	Inside Surface Film	.76
		Total Resistance	9.85

ROOF-TYPE RB53-2

Like RB53-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 11.24

ROOF-TYPE RB53-3

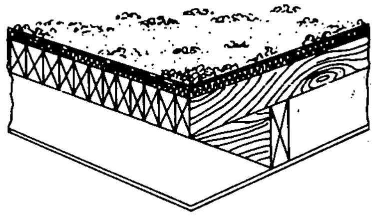
Like RB53-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 12.73

ROOF-TYPE RB53-4

Like RB53-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 15.40

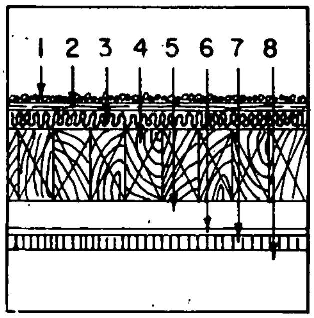


ROOF

3½ INCH WOOD DECKING

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RB54-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	WD04	2 x 4 Wood Decking, on edge	4.37
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC03	Acoustic Tile	1.89
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	11.10

ROOF-TYPE RB54-2

Like RB54-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 12.49

ROOF-TYPE RB54-3

Like RB54-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 13.98

ROOF-TYPE RB54-4

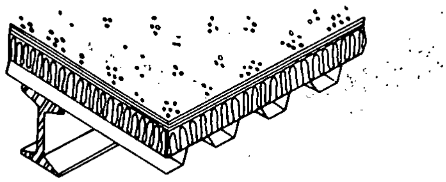
Like RB54-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 16.65

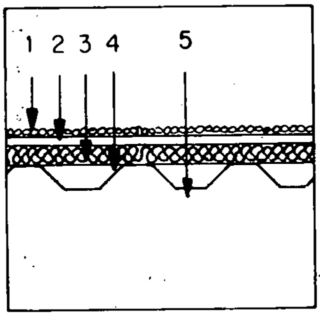
ROOF

METAL DECKING

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2



ROOF-TYPE RC01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	-	1-1/2" Metal Decking	-
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	3.89

ROOF-TYPE RC01-2

Like RC01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 5.31

ROOF-TYPE RC01-3

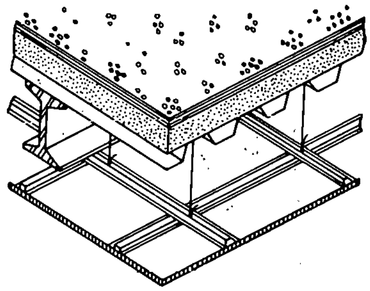
Like RC01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 6.80

ROOF-TYPE RC01-4

Like RC01-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 9.47

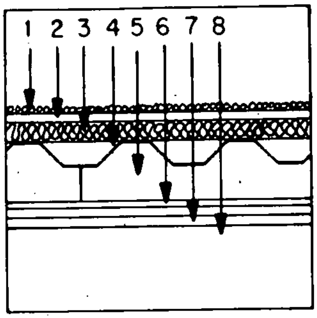


ROOF

METAL DECKING

LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

ROOF-TYPE RC51-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	-	1-1/2" Metal Decking	-
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC02	1/2" Acoustic Tile	1.26
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	6.10

ROOF-TYPE RC51-2

Like RC51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 7.49

ROOF-TYPE RC51-3

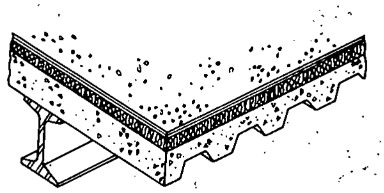
Like RC51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 8.98

ROOF-TYPE RC51-4

Like RC51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 11.65

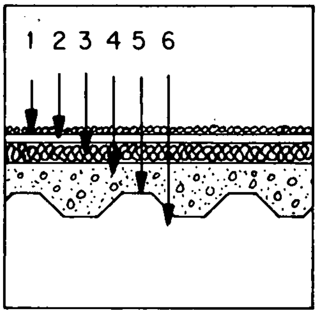


ROOF

METAL DECKING

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RD01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC02	Average 2" HW Concrete Fill, 140 lbs. Sand and Gravel agg., oven-dried	.22
5.	-	1-1/2" Metal Decking	-
6.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.14

ROOF-TYPE RD01-2 Like RD01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 5.53

ROOF-TYPE RD01-3 Like RD01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 7.02

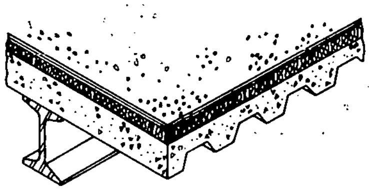
ROOF-TYPE RD01-4 Like RD01-1; except 3" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.69

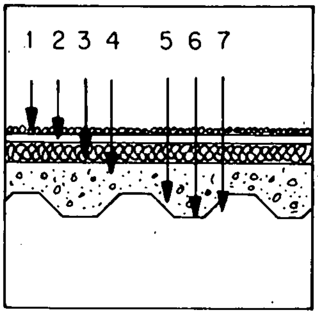
ROOF

METAL DECKING

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2



ROOF-TYPE RD02-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built=up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC23	2" LW Concrete, 80 lbs.	.80
5.	CC21	Average 3/4" LW Concrete Fill, 80 lbs. Cinder agg.	.30
6.	-	1-1/2" Metal Decking	-
7.	AL03	Inside Surface Air Film	.76
		Total Resistance	5.02

ROOF-TYPE RD02-2 Like RD02-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

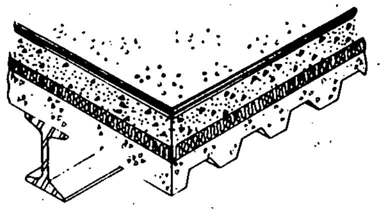
Total Resistance 6.41

ROOF-TYPE RD02-3 Like RD02-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 7.90

ROOF-TYPE RD02-4 Like RD02-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 10.57

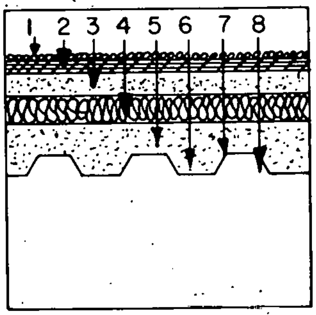


ROOF

METAL DECKING

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RD03-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	CC33	2" Insulating Concrete, 30 lbs.	2.22
4.	IN72	1" Roof Insulation	2.78
5.	CC23	2" LW Concrete, 80 lbs.	.80
6.	CC21	Average 3/4" LW Concrete Fill, 80 lbs.	.30
7.	-	1-1/2" Metal Decking	-
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	7.24

ROOF-TYPE RD03-2

Like RD03-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 8.63

ROOF-TYPE RD03-3

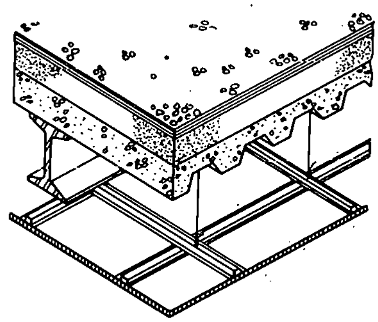
Like RD03-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 10.12

ROOF-TYPE RD03-4

Like RD03-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 12.79



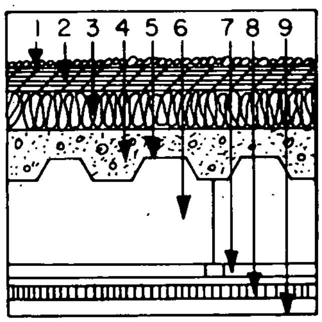
ROOF

METAL DECKING

MEDIUM CONSTRUCTION

20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RD51-1



Layer No.	Code	List of Construction	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC02	Average 2" HW Concrete, 140 lbs. Sand and Gravel agg., oven-dried	.22
5.	-	1-1/2" Metal Decking	-
6.	AL33	Ceiling Air Space	.92
7.	-	Metal Furring Channels	-
8.	AC03	3/4" Acoustic Tile	1.89
9.	AL03	Inside Surface Film	.76
		Total Resistance	6.95

ROOF-TYPE RD51-2

Like RD51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 8.34

ROOF-TYPE RD51-3

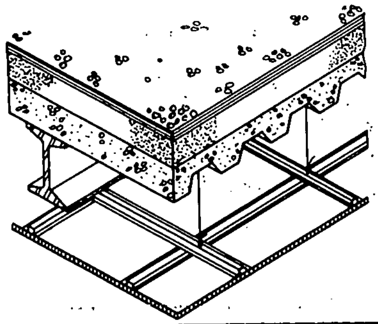
Like RD51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.83

ROOF-TYPE RD51-4

Like RD51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 12.50

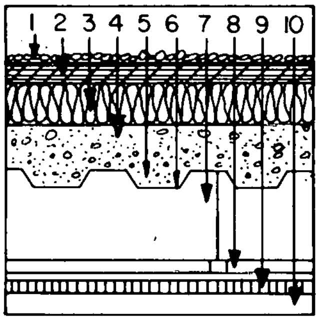


ROOF

Metal Decking

Medium Construction
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RD52-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC23	2" LW Concrete, 80 lbs.	.80
5.	CC21	Average 3/4" LW Concrete Fill, 80 lbs.	.30
6.	-	1-1/2" Metal Decking	-
7.	AL33	Ceiling Air Space	.92
8.	-	Metal Furring Channels	-
9.	AC03	3/4" Acoustic Tile	1.89
10.	AL03	Inside Surface Air Film	.76
		Total Resistance	7.83

ROOF-TYPE RD52-2 — Like RD52-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

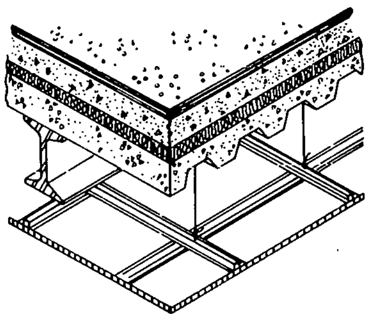
Total Resistance 9.22

ROOF-TYPE RD52-3 — Like RD52-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 10.71

ROOF-TYPE RD52-4 — Like RD52-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 13.38

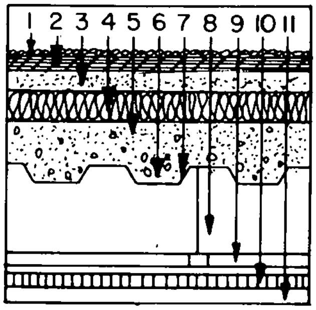


ROOF

METAL DECKING

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RD53-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	CC33	2" Insulating Concrete, 30 lbs.	2.22
4.	IN72	1" Roof Insulation	2.78
5.	CC23	2" LW Concrete, 80 lbs.	.80
6.	CC21	Average 3/4" LW Concrete Fill, 80 lbs.	.30
7.	-	1-1/2" Metal Decking	-
8.	AL33	Ceiling Air Space	.92
9.	-	Metal Furring Channels	-
10.	AC03	3/4" Acoustic Tile	1.89
11.	AL03	Inside Surface Air Film	.76
		Total Resistance	10.05

ROOF-TYPE RD53-2

Like RD53-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 11.44

ROOF-TYPE RD53-3

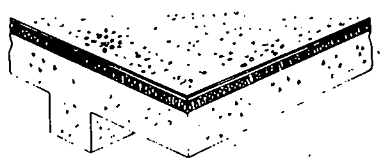
Like RD53-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 12.93

ROOF-TYPE RD53-4

Like RD53-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 15.60

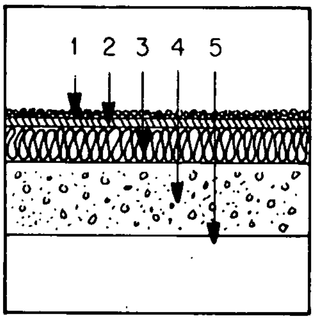


ROOF

4 INCH CONCRETE SLAB

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RE01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC24	4" LW Concrete, 80 lbs.	1.60
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	5.52

ROOF-TYPE RE01-2

Like RE01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 6.91

ROOF-TYPE RE01-3

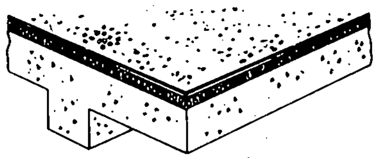
Like RE01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 8.40

ROOF-TYPE RE01-4

Like RE01-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 11.07

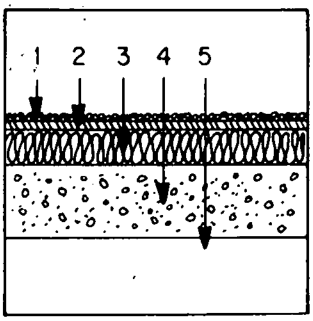


ROOF

4 INCH CONCRETE SLAB

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RE02-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC14	4" HW Concrete, 140 lbs., undried agg.	.32
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.24

ROOF-TYPE RE02-2

Like RE02-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 5.63

ROOF-TYPE RE02-3

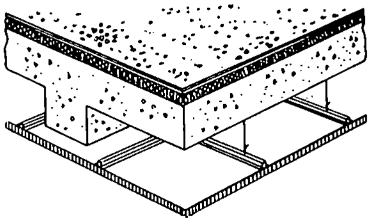
Like RE02-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 7.12

ROOF-TYPE RE02-4

Like RE02-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 9.79



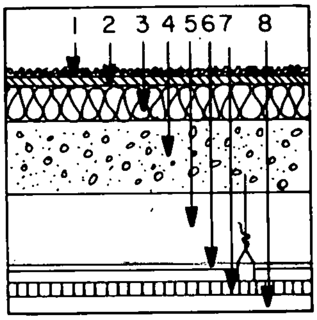
ROOF

4 INCH CONCRETE SLAB

MEDIUM CONSTRUCTION

20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RE51-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC24	4" LW Concrete, 80 lbs.	1.60
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC03	3/4" Acoustic Tile	1.89
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	8.33

ROOF-TYPE RE51-2 Like RE51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

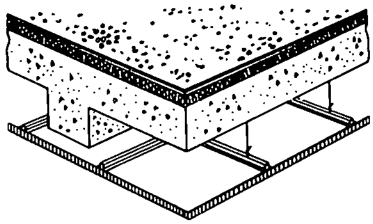
Total Resistance 9.72

ROOF-TYPE RE51-3 Like RE51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 11.21

ROOF-TYPE RE51-4 Like RE51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 13.88

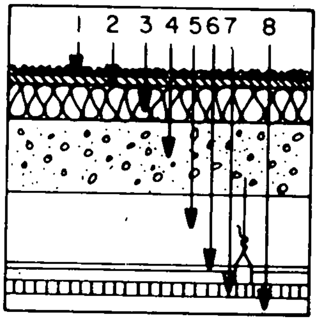


ROOF

4 INCH CONCRETE SLAB

MEDIUM CONSTRUCTION
20 LBS/FT^2 TO 60 LBS/FT^2

ROOF-TYPE RE52-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC14	4" HW Concrete, 140 lbs., undried agg.	.32
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC02	1/2" Acoustic Tile	1.26
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	6.42

ROOF-TYPE RE52-2

Like RE52-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 7.81

ROOF-TYPE RE52-3

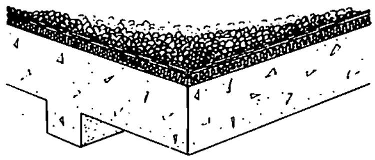
Like RE52-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.30

ROOF-TYPE RE52-4

Like RE52-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 11.97

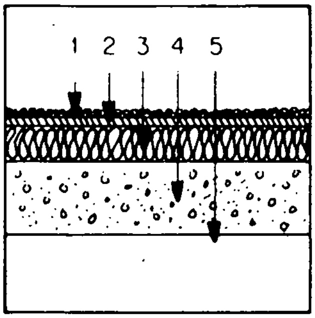


ROOF

6 INCH CONCRETE SLAB

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

ROOF-TYPE RF01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC25	6" LW Concrete, 80 lbs.	2.40
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	6.32

ROOF-TYPE RF01-2

Like RF01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 7.71

ROOF-TYPE RF01-3

Like RF01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.20

ROOF-TYPE RF01-4

Like RF01-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

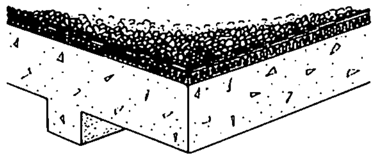
Total Resistance 11.87

ROOF

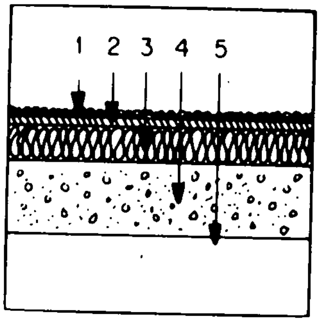
6 INCH CONCRETE SLAB

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP



ROOF-TYPE RF02-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC15	6" HW Concrete, 140 lbs., undried agg.	.48
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.40

ROOF-TYPE RF02-2

Like RF02-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 5.79

ROOF-TYPE RF02-3

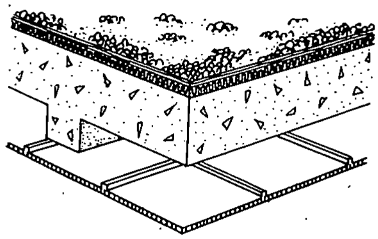
Like RF02-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 7.28

ROOF-TYPE RF02-4

Like RF02-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 9.95

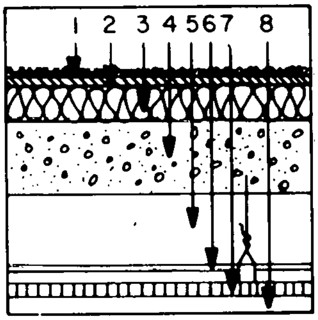


ROOF

6 INCH CONCRETE SLAB

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

ROOF-TYPE RF51-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC25	6" LW Concrete, 80 lbs	2.40
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC03	3/4" Acoustic Tile	1.89
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	9.13

ROOF-TYPE RF51-2

Like RF51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 10.52

ROOF-TYPE RF51-3

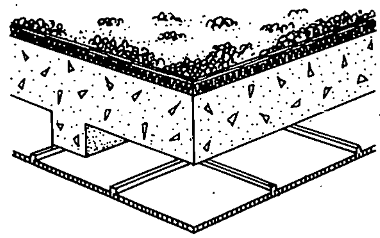
Like RF51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 12.01

ROOF-TYPE RF51-4

Like RF51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 14.68

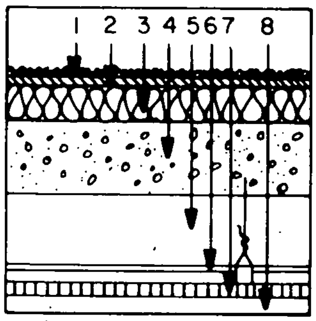


ROOF

6 INCH CONCRETE SLAB

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

ROOF-TYPE RF52-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC15	6" HW Concrete, 140 lbs., undried agg.	.48
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC02	1/2" Acoustic Tile	1.26
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	6.58

ROOF-TYPE RF52-2

Like RF52-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 7.97

ROOF-TYPE RF52-3

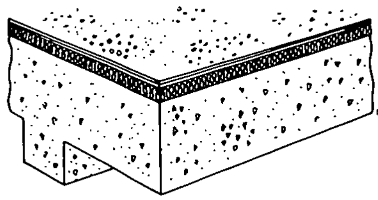
Like RF52-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.46

ROOF-TYPE RF52-4

Like RF52-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 12.13



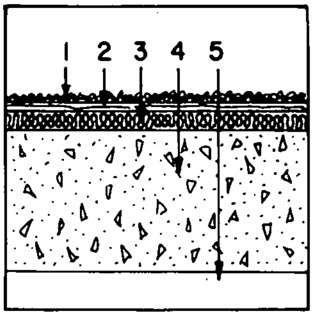
ROOF

8 INCH CONCRETE SLAB

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

ROOF-TYPE RG01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC26	8" LW Concrete, 80 lbs.	3.20
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	7.12

ROOF-TYPE RG01-2

Like RG01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 8.51

ROOF-TYPE RG01-3

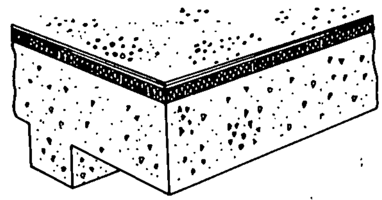
Like RG01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 10.00

ROOF-TYPE RG01-4

Like RG01-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 12.67

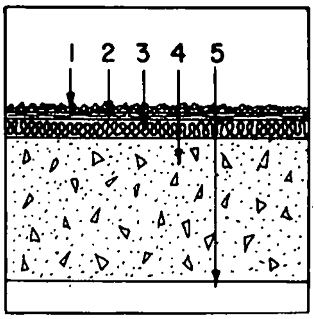


ROOF

8 INCH CONCRETE SLAB

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

ROOF-TYPE RG02-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC16	8" HW Concrete, 140 lbs., undried agg.	.64
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.56

ROOF-TYPE RG02-2

Like RG02-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 5.95

ROOF-TYPE RG02-3

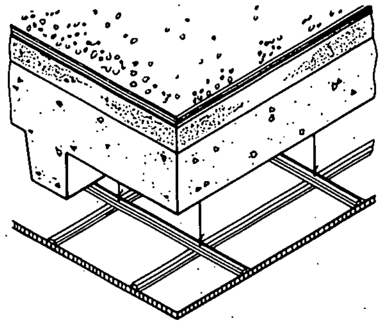
Like RG02-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 7.44

ROOF-TYPE RG02-4

Like RG02-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 10.11

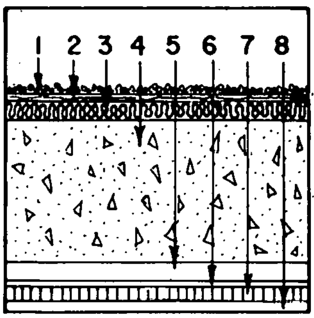


ROOF

8 INCH CONCRETE SLAB

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

ROOF-TYPE RG51-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC26	8" LW Concrete, 80 lbs.	3.20
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC03	3/4" Acoustic Tile	1.89
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	9.93

ROOF-TYPE RG51-2

Like RG51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 11.32

ROOF-TYPE RG51-3

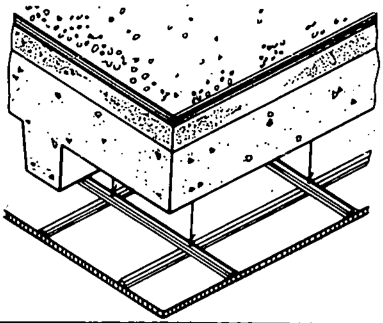
Like RG51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 12.81

ROOF-TYPE RG51-4

Like RG51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 15.48



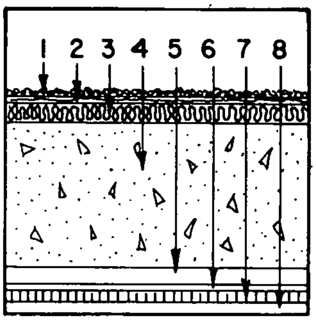
ROOF

8 INCH CONCRETE SLAB

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

ROOF-TYPE RG52-1



Layer No.	Code	List of Construction Layers	Resistance
1.	RG01	1/2" Roof Gravel or Slag	.05
2.	BR01	3/8" Built-up Roof	.33
3.	IN72	1" Roof Insulation	2.78
4.	CC16	8" HW Concrete, 140 lbs. undried agg.	.64
5.	AL33	Ceiling Air Space	.92
6.	-	Metal Furring Channels	-
7.	AC02	1/2" Acoustic Tile	1.26
8.	AC03	Inside Surface Air Film	.76
		Total Resistance	6.74

ROOF-TYPE RG52-2

Like RG52-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 8.13

ROOF-TYPE RG52-3

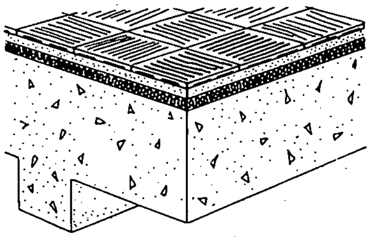
Like RG52-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 9.62

ROOF-TYPE RG52-4

Like RG52-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 12.29

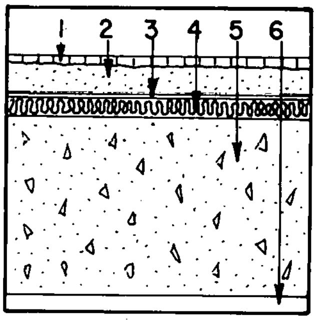


ROOF

10 INCH CONCRETE SLAB

HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

ROOF-TYPE RH01-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	CT11	3/8" Clay Tile Power	.03
2.	CM02	1-3/4" Cement Mortar, Setting Bed	.35
3.	BP02	Building Paper, Seal, Water Proofing	.12
4.	IN72	1" Roof Insulation	2.78
5.	CC06	10" HW Concrete, 140lbs. Sand and Gravel agg., oven-dried	1.10
6.	AL03	Inside Surface Air Film	.76
		Total Resistance	5.14

ROOF-TYPE RH01-2

Like RH01-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 6.53

ROOF-TYPE RH01-3

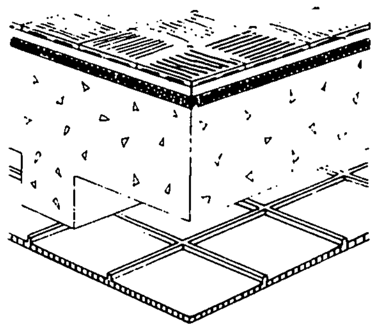
Like RH01-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 8.02

ROOF-TYPE RH01-4

Like RH01-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 10.69



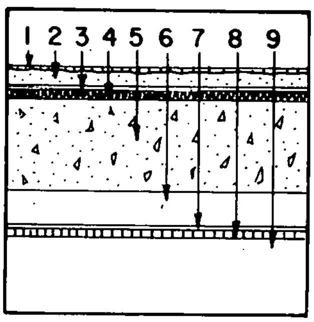
ROOF

10 INCH CONCRETE SLAB

HEAVY CONSTRUCTION

60 LBS/FT^2 AND UP

ROOF-TYPE RH51-1



No.	Layer Code	List of Construction Layers	Resistance
1.	CT11	3/8" Clay Tile Power	.03
2.	CM02	1-3/4" Cement Mortar, Setting Bed	.35
3.	BP02	Building Paper, seal, water proofing	.12
4.	IN72	1" Roof Insulation	2.78
5.	CC06	10" HW Concrete, 140 lbs. Sand and Gravel agg., ovendried	1.10
6.	AL33	Ceiling Air Space	.92
7.	-	Metal Furring Channels	-
8.	AC03	3/4" Acoustic Tile	1.89
9.	AL03	Inside Surface Air Film	.76
		Total Resistance	7.95

ROOF-TYPE RH51-2

Like RH51-1; except 1-1/2" Roof Insulation (Layer Code IN73, R=4.17) is substituted for 1" Roof Insulation

Total Resistance 9.34

ROOF-TYPE RH51-3

Like RH51-1; except 2" Roof Insulation (Layer Code IN74, R=5.66) is substituted for 1" Roof Insulation

Total Resistance 10.83

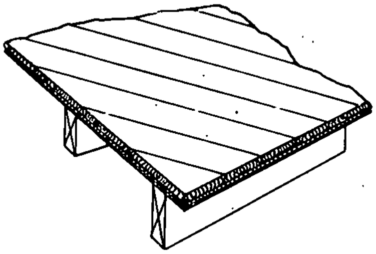
ROOF_TYPE RH51-4

Like RH51-1; except 3" Roof Insulation (Layer Code IN76, R=8.33) is substituted for 1" Roof Insulation

Total Resistance 13.50

LIST OF FLOORS

FLOOR-TYPE	CONSTRUCTION TYPE	CONSTRUCTION WEIGHT	NUMBER OF FLOORS
FA01-0 to FA03-2	Wood Frame	Light Up to 20 lbs/ft^2	11
FB01-0 to FB02-2	Metal Decking	Heavy 60 lbs/ft^2 and up	6
FC01-0 to FC01-2	6 inch Concrete Slab	Heavy 60 lbs/ft^2 and up	3

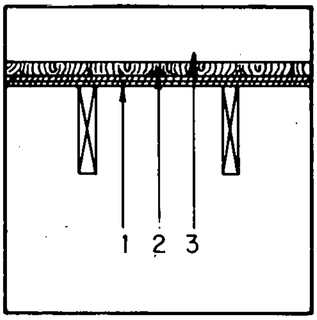


FLOOR

WOOD FRAME

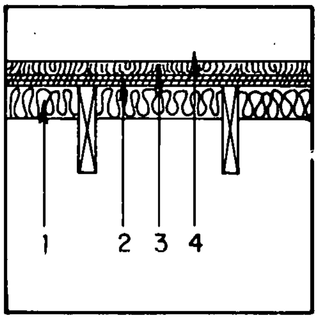
LIGHT CONSTRUCTION
UP TO 20 LBS/FT^2

FLOOR-TYPE FA01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	PWO	5/8" Plywood Subfloor	.78
2.	WD11	3/4" Hard Wood Flooring	.68
3.	AL03	Inside Surface Air Film	.76
		Total Resistance	2.22

FLOOR-TYPE FA01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	IN02	3-1/2" Mineral Wool, Batt	11.84
2.	PW04	5/8" Plywood Subfloor	.78
3.	WD11	3/4" Hard Wood Flooring	.68
4.	AL03	Inside Surface Air Film	.76
		Total Resistance	14.06

FLOOR-TYPE FA01-2

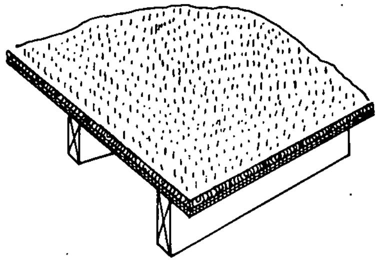
Like FA01-1; except 6" Mineral Wool Batt (Layer Code IN03, R=20.43) is substituted for 3-1/2" Mineral Wool Batt

Total Resistance 22.65

FLOOR-TYPE FA01-3

Like FA01-1; except 9-1/2" Mineral Wool Batt (Layer Code IN05, R=32.26) is substituted for 3-1/2" Mineral Wool Batt

Total Resistance 34.48

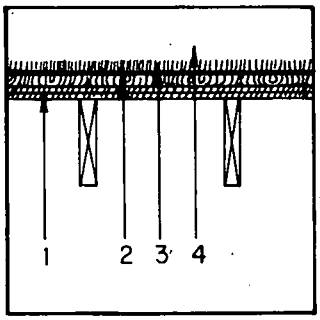


FLOOR

Wood Frame

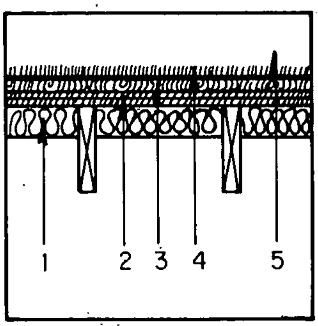
Light Construction
Up to 20 lbs/ft^2

FLOOR-TYPE FA02-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	PW04	5/8" Plywood Subfloor	.78
2.	WD11	3/4" Hard Wood Flooring	.68
3.	CP02	Carpet w/ Rubber Pad	1.23
4.	AL03	Inside Surface Air Film	.76
		Total Resistance	3.45

FLOOR-TYPE FA02-1



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	IN02	3-1/2" Mineral Wool, Batt	11.84
2.	POW4	5/8" Plywood Subfloor	.78
3.	WD11	3/4" Hard Wood Flooring	.68
4.	CP02	Carpet w/ Rubber Pad	1.23
5.	AL03	Inside Surface Air Film	.76
		Total Resistance	15.29

FLOOR-TYPE FA02-2

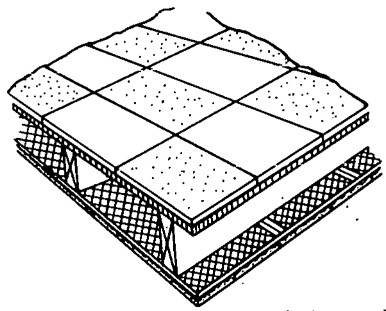
Like FA02-1; except 6" Mineral Wool Batt (Layer Code IN03, R=20. 43) is substituted for 3-1/2" Mineral Wool Batt

Total Resistance 23.88

FLOOR-TYPE FA02-3

Like FA02-1; except 9-1/2" Mineral Wool Batt (Layer Code IN05, R=32.26) is substituted for 3-1/2" Mineral Wool Batt

Total Resistance 35.71

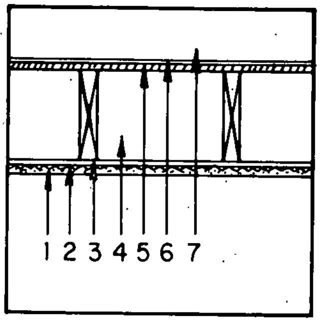


FLOOR

Wood Frame

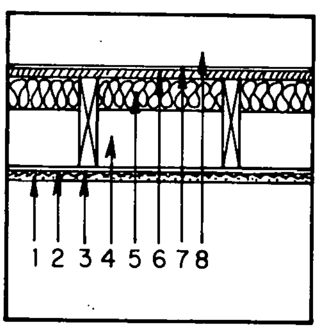
Light Construction
Up to 20 lbs/ft^2

FLOOR-TYPE FA03-0



Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	-	Metal Furring Channels	-
4.	AL33	Air Space	.92
5.	PW05	3/4" Plywood Subfloor	.94
6.	AV01	Asbestos Vinyl Tile	.05
7.	AL03	Inside Surface Air Film	.76
		Total Resistance	2.87

FLOOR-TYPE FA03-1

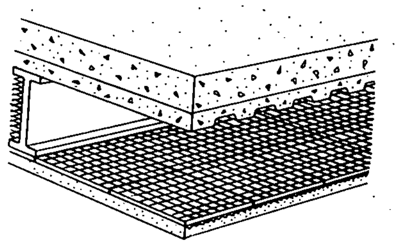


Layer No.	Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	-	Metal Furring Channels	-
4.	AL33	Air Space	.92
5.	IN01	2-3/4" Fiberglass Batt	7.53
6.	PW05	3/4" Plywood Subfloor	.94
7.	AV01	Asbestos Vinyl Tile	.05
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	10.40

FLOOR-TYPE FA03-2

Like FA03-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.71

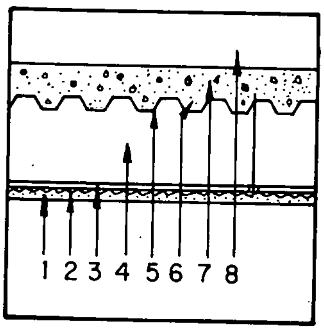


FLOOR

METAL DECKING

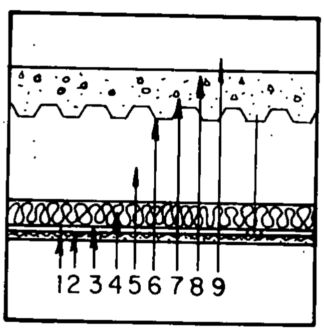
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

FLOOR-TYPE FB01-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	-	Metal Furring Channels	-
4.	AL33	Air Space	.92
5.	-	1-1/2" Metal Decking	-
6.	CC11	Average 3/4" HW Concrete Fill, 140 lbs undried agg.	.06
7.	CC13	3-1/4" HW Concrete, 140 lbs., undried agg.	.26
8.	AL03	Inside Surface Air Film	.76
		Total Resistance	2.20

FLOOR-TYPE FB01-1

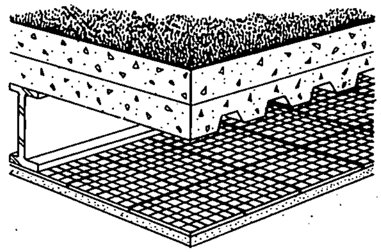


Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	-	Metal Furring Channels	-
4.	IN01	2-3/4" Fiberglass Batt	7.53
5.	AL33	Air Space	.92
6.	-	1-1/2" Metal Decking	-
7.	CC11	Average 3/4" HW Concrete Fill, 140 lbs undried agg.	.06
8.	CC13	3-1/4" HW Concrete, 140 lbs., undried agg.	.26
9.	AL03	Inside Surface Air Film	.76
		Total Resistance	9.73

FLOOR-TYPE FB01-2

Like FB01-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 14.04

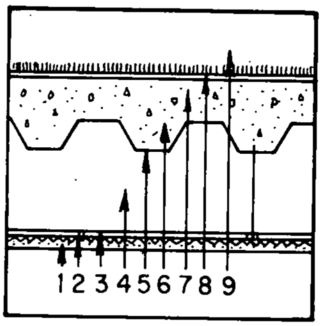


FLOOR

METAL DECKING

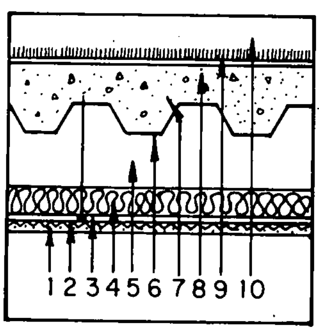
HEAVY CONSTRUCTION
60 LBS/FT^2 AND UP

FLOOR-TYPE FB02-0



Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	-	Metal Furring Channels	-
4.	AL33	Air Space	.92
5.	-	3-1/4" Metal Decking	-
6.	CC12	Average 1-3/8" HW Concrete Fill, 140 lbs undried agg.	.11
7.	CC13	3-1/4" HW Concrete, 140 lbs., undried agg.	.26
8.	CP01	Carpet w/ Fiberous Pad	2.08
9.	AL03	Inside Surface Air Film	.76
		Total Resistance	4.33

FLOOR-TYPE FB02-1

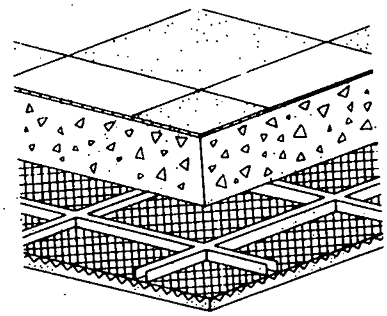


Layer No.	Layer Code	List of Construction Layers	Resistance
1.	SC01	1" Stucco	.20
2.	-	Metal Lath	-
3.	-	Metal Furring Channels	-
4.	IN01	2-3/4" Fiberglass Batt	7.53
5.	AL33	Air Space	.92
6.	-	3-1/4" Metal Decking	-
7.	CC12	Average 1-3/8" HW Concrete Fill, 140 lbs undried agg.	.11
8.	CC13	3-1/4" HW Concrete, 140 lbs., undried agg.	.26
9.	CP01	Carpet w/ Fiberous pad	2.08
10.	AL03	Inside Surface Air Film	.76
		Total Resistance	11.86

FLOOR-TYPE FB02-2

Like FB02-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt.

Total Resistance 16.17



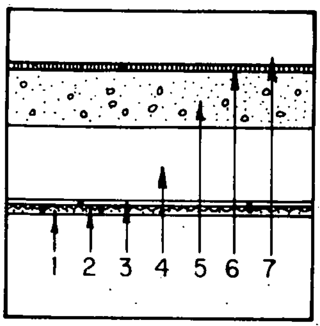
FLOOR

6 INCH CONCRETE SLAB

HEAVY CONSTRUCTION

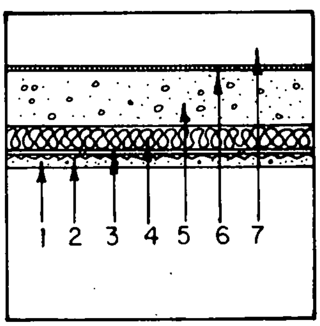
60 LBS/FT^2 AND UP

FLOOR-TYPE FC01-0



Layer No.	Code	List of Construction Layers	Resistance
1.	CC22	1-1/4" LW Concrete, 80 lbs Cinder agg.	.50
2.	-	Metal Lath	-
3.	-	Metal Furring Strip	-
4.	AL23	Air space	.87
5.	CC15	6" HW Concrete, 140 lbs	.48
6.	AV01	Asbestos Vinyl Tile	.05
7.	AL03	Inside Surface Air Film	.76
		Total Resistance	2.66

FLOOR-TYPE FC01-1



Layer No.	Code	List of Construction Layers	Resistance
1.	CC22	1-1/4" LW Concrete, 80 lbs. Cinder agg.	.50
2.	-	Metal Lath	-
3.	-	Metal Furring Strip	-
4.	IN01	2-3/4" Fiberglass Batt	7.53
5.	CC15	6" HW Concrete, 140 lbs undried agg.	.48
6.	AV01	Asbestos Vinyl Tile	.05
7.	AL03	Inside Surface Air Film	.76
		Total Resistance	9.32

FLOOR-TYPE FC01-2 Like FC01-1; except 3-1/2" Fiberglass Batt (Layer Code IN02, R=11.84) is substituted for 2-3/4" Fiberglass Batt

Total Resistance 13.63

NOTES

TO

Library of Walls, Floors and Roofs

GENERAL NOTES

(Applicable to all walls, roofs and floors)

NOTE A Resistance of the outside air film is not included in the total resistance shown. The program recalculates this value, which depends on wall roughness and prevailing wind conditions, every hour, and adds it to the values shown on the table to get actual "total resistance" for that hour. For manual calculations, add an average value of outside air film resistance.

NOTE B The effect of framing or structural members on total resistance is not considered.

NOTE C The air space resistance values used in the various walls, roofs and floors represent 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.

NOTE D Units of resistance used in this Library are $\frac{Hr \cdot {}^{o}F \cdot Ft^2}{Btu}$

SPECIFIC NOTES

(Applicable only where noted by number in parenthesis)

NOTE (1) Resistance (0.89) of the 3/4 inch air space remaining after insertion of insulation is included in the total.

NOTE (2) One filled and reinforced concrete core every 24 inches of wall length.

NOTE (3) One filled and reinforced concrete core every 24 inches of wall length with the remaining cores filled with perlite insulation