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DOE-1 USERS GUIDE

DOE-1 Group

Energy and Environment Division
Lawrence Berkeley Laboratory
Berkeley, California

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Supported by United States Department of Energy
Office of Assistant Secretary for Conservation and Solar Applications
Division of Buildings and Community Systems

Lawrence Berkeley Laboratory

Argonne National Laboratory

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INTRODUCTION

A What is DOE-1?

DOE-1 is a public domain computer program which allows users to explore the energy behavior of proposed and existing buildings and their associated heating, ventilation and air conditioning (HVAC) systems. Incorporating mathematical models (called algorithms) and utilizing hourly weather data, DOE-1 calculates the hour by hour performance and response of a building whose description has been provided by the user. In addition, DOE-1 can produce an economic analysis of the energy use and the costs and benefits of making alterations in design.

DOE-1 is the first in a proposed sequence of programs (as its name suggests — DOE-2 is not far behind). Each of the algorithms of DOE-1 is being tested, and as improvements are discovered, they will be incorporated into future versions. In addition, simplifying input and output procedures are being developed to enhance the use of the program by a wider and wider group of people.

B For whom is DOE-1?

DOE-1 is intended to be used by architects, engineers, and others who are concerned with the energy analysis of buildings and with the consequent economic implications. Although energy analysis was initially the concern of the mechanical engineer alone, it is now recognized that the architect also has tremendous influence on the energy usage of buildings. Before the rise of modern HVAC equipment, the architect was the primary determiner of the energy consumption of a building and architectural building design included consideration of how the occupants were to be sheltered and kept comfortable. Use of passive solar heating and ventilating was a primary concern. With the rise of cheap and apparently abundant energy and with the development of technologically clever delivery systems, it became less incumbent on the architect to be as energy conscious when designing a building. The secondary HVAC systems could be relied upon to make up for the lack of natural heating and ventilating and to provide a comfortable interior climate. The realization that energy is no longer plentiful and inexpensive has re-awakened the architect to the need to consider the energy analysis of his/her building design.

The same need has arisen for the mechanical engineer. Since the aim is no longer simply to provide a system which will meet the heating and cooling loads of the building, but also to do that efficiently so that the loads are met with the least expenditure of energy, the mechanical engineer can no longer deliberately oversize the equipment to ensure

meeting the loads. Oversizing often means the equipment operates most of the time in its least efficient mode and avoiding this energy loss requires knowing what in fact is required.

This manual reflects the broad interests and backgrounds of its intended readers with the result that some sections will seem trivial to some while being difficult for others. It is recommended that the reader skim those portions on the first reading that seem obscure and return to them later.

C Why computer analysis?

Master carpenters are fond of impressing their young apprentices by measuring a desired length of lumber by running their thumbs along the board and making a thumbnail impression at the point where they intend to saw. When the apprentice measures the mark with a rule, it is inevitably accurate. Although an architect or an engineer applies more sophisticated techniques in his/her design, there is even in these professions an appreciation — indeed, a certain amount of reverence — for the ability to sift through the complex considerations that go into the design of a building or a HVAC system and to specify the dimensions and the components without recourse to detailed computations. At most the calculations should be limited to ``the back of an envelope.'' To require more is often perceived as a detriment to good design and the sign of a failure to be well trained. After all, the person is a designer and not a computator!

The energy and economic considerations mentioned above, however, have made many old ``rules of thumb'' out of date. To design energy (and money) conserving buildings and systems depends upon paying attention to the subtle interactions of a large number of design features. When one is operating not in the safe zone of over-sizing, but close to the edge of comfort, the energy consumption becomes increasingly sensitive to the many variables which describe the design. To keep track of this large number of variables, a computer becomes essential.

Even if a hand calculation were possible, to consider a number of alternatives would require a number of hand-done analyses. The tedium of such a task is what a computer is designed for and what a computer allows. The outgrowth of making parametric runs, as the recalculation of many alternatives is called, is the development of a more informed ``rule of thumb,'' and this is also a contribution that the computer can make.

D What are the costs and benefits of DOE-1?

As one knows from the First Law of Thermodynamics, one cannot get something for nothing. Here, too, there is ``no free lunch.'' The first cost of using the DOE-1 program — or indeed any computerized program — is that one must learn how to communicate with the computer. What need to be communicated to DOE-1, however, is not how to do the calculation — the how is contained in the DOE-1 source program — but what is to be

calculated. What DOE-1 needs to do its job is a description of the building, its schedules of operation, a description of the HVAC system and its schedules, a description of the plant, and a specification of the initial component costs and utility rates. A special language called BDL —for Building Design Language — has been developed to enable the user to describe what DOE-1 is to work with.

A second cost of DOE-1 is its flexibility. This is, of course, also potentially its great benefit, but initially it may appear as a cost. The flexibility requires that the user specify what he/she wants in great detail. There are few ``packages'' in which a whole set of predefined variables are set; rather the user must design his/her own package. There are, however, built into DOE-1, ``default'' values for a large number of variables, i.e., the program will assign values to variables if the user fails to do so. The user, however, must take responsibility for seeing that the default values are appropriate for his/her building. Other variables require user input and this means that the user must know or at least choose values for such variables.

On the other hand, the flexibility of DOE-1 allows the user to decide how precisely to model a specific building. It is possible to provide a minimal amount of building and systems description and to obtain a rough estimate of the energy usage and system response for the building. How much detail is required depends upon how detailed and how accurate the user wants the results to be.

E What printed aids exist for the user?

In this Guide there is a description and an application of the DOE-1 program. Included here are a number of hints and cautions for setting up an input deck as well as an explanation of the various output reports. Among the appendices is a BDL SUMMARY which contains tables of the various commands and keywords of BDL along with default values and allowed ranges of the variables. In addition, there is a removable example problem which can be used and followed along with the text.

In addition to the Users Guide, there are five other books and manuals. The Sample Run Book includes a large number of sample buildings and their DOE-1 input and output which the beginning user can study to see how to use DOE-1 to model a building. The Reference Manual is a detailed description of the BDL commands, keywords, and code-words and the rules for writing an input deck. The Program Manual is a description of the algorithms and subroutines used in DOE-1 for those who want to know in detail what goes on inside the black box. A report entitled Remote Operation of DOE-1 on the Lawrence Berkeley Laboratory CDC 7600, 6600 and 6400 Computers , describes the methodology for running the DOE-1 program at Lawrence Berkeley Laboratory, either at Berkeley or from remote sites through teletype or batch processing.

These manuals may be obtained from

Document Control Center
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439
Att: P. R. Hirsch, Bldg. 24
Tel: (312) 972-5268 or FTS 972-5268

In addition to the manuals a DOE-1 source code appropriate for the CDC computer is available from the National Energy Software Center(NESC) at Argonne:

National Energy Software Center
Argonne National Laboratory
9700 South Cass Avenue
Argonne, Illinois 60439
Tel: (312) 972-7250 or FTS 972-7250

An IBM version is being prepared and will be available in the Spring of 1979.

F How to use the DOE-1 program

The new user of DOE-1 is advised as a first step to read this Guide to obtain an overview of the program, to learn its special language (BDL), to go through the input and output of an example building, and to pick up some general tips on building energy analysis. With this background the new user would be served by attending a workshop where experts on the program can answer specific questions. The next step would be to write the input for a building and to run it through DOE-1. For this purpose the user might take a building from the Sample Run Book and compare results. The fourth step is to attack the problem the user wanted to solve in the first place. Here the Reference Manual will be essential, since the building chosen or the degree of detail desired might differ widely from that chosen as an example in this Guide. The fifth thing the user will need is assistance when problems arise that elude resolution.

How easy it is to have access to the necessary resources depends at present upon the user's relationship to the Department of Energy (DOE). For DOE contractors the Lawrence Berkeley Laboratory (LBL) is currently equipped to provide workshops, entry to the LBL computer and ongoing assistance. For others, the time-sharing networks, such as CYBERNET and Boeing Computer Services, can and do provide the same services. DOE is planning to extend the workshops to those not related to DOE in the next year. As mentioned above, the source program is available from NESC and DOE-1 can be run in this manner on any CDC 7600 computer. By the Spring of 1979 an IBM version will also be available. Finally, a growing number of private firms with energy analysis capability and familiarity with DOE-1 exist around the country and can give assistance to the user.

G How valid is DOE-1?

The reliability of DOE-1 as a simulator of the energy use in buildings is currently being verified by contractors working with the Los Alamos Scientific Laboratory.[1] A comprehensive test manual is being prepared by those contractors, which will describe the results of comparing 60 algorithms in DOE-1 with hand calculations. The test manual will include the DOE-1 input assumptions which were used to make the comparisons and a description of the algorithms. This test manual will therefore be useful to users in building their confidence in the ability of DOE-1 and will hopefully illustrate the importance of correct assumptions in the use of DOE-1.

DOE-1 is a tool for use by mechanical engineers and others responsible for the energy design of buildings. As with any tool which is continually used, the user's skill will improve with increased familiarity. Like other tools, if it is misused, it will not give reliable results. Assumptions made about buildings and their systems and particularly errors in input will drastically affect output. Users are cautioned to think through their assumptions and to prepare their input with care.

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1 DOE-1 Verification Program Plan, (Report #LA-7552-MS) S.C.Diamond, B.D.Hunn, T.E.McDonald, Los Alamos Scientific Laboratory.

Section 1 - Energy Analysis of Buildings

A General Outline

Energy use analysis of buildings involves four principle steps. First is the calculation of heat loss and gain to the building spaces and the heating and cooling loads imposed upon the building HVAC systems. This calculation is carried out for a space temperature fixed in time and is commonly called the Loads calculation. It answers the question: how much heat addition or extraction is required to maintain the space at a constant temperature as the outside weather conditions and internal activity vary in time. Second is the calculation of the energy addition and extraction actually supplied by the HVAC system in order to meet the possibly varying temperature set-points and humidity criteria subject to the schedules of fans, boilers and chillers, and to outside air requirements. This calculation results in the demand for energy that is made on the primary energy sources of the building. This step, called the Systems calculation, answers the question: How are the accumulative heat extraction and addition rates modified, when the characteristics of the HVAC system, the time-varying temperature set-points, and the heating, cooling and fan schedules are taken into account? Third is the determination of the fuel requirements of primary equipment such as boilers and chillers, and of the energy production of solar collectors, etc., in the attempt to supply the energy demand of the HVAC systems. This Plant calculation answers the question: how much fuel and electrical input is required to feed the secondary HVAC system given the efficiency and operating characteristics of the plant equipment and components. The fourth step evaluates the costs of equipment, fuel, electricity, labor and retrofit components against the alternative of investing the money in other ways. It answers the question: Is the expenditure of funds for energy conserving materials and systems cost effective, when compared with alternative systems and investment possibilities?

The first three steps are illustrated in Figure 1, showing the flow of energy. The different methods of performing these steps differ essentially in the degree to which the mathematical models chosen to simulate these steps match the actual world. The continually varying outside weather conditions, the movement of people, and lighting and equipment schedules inside the buildings lead to a cooling and/or heating requirement that is always changing — not only in total amount — but in its distribution in the building. Even if there were valid mathematical models for all of the simultaneous processes, an exact calculation of the dynamic response of the structure would not be possible. Every energy analysis program must then make approximations and assumptions. In particular the continuous time dependence of phenomena is approximated by making the calculation in small discrete time intervals.

DIAGRAM OF ENERGY FLOWS IN A BUILDING

Definition of terms

QC – Total space cooling load

QH – Total space heating load

Q'C – System cooling load or plant cooling output

Q'H – System heating load or plant heating output

EL – Electrical energy required by light and space equipment (typewriters, etc.)

ES – Electrical input to run systems (fans, pumps, etc.)

EP – Miscellaneous plant electrical demand (pumps, boiler, fans, etc.)

EC – Electrical input for cooling

ET – Total plant electrical demand = EL + ES + EC + EP

FH – Fuel input for heating

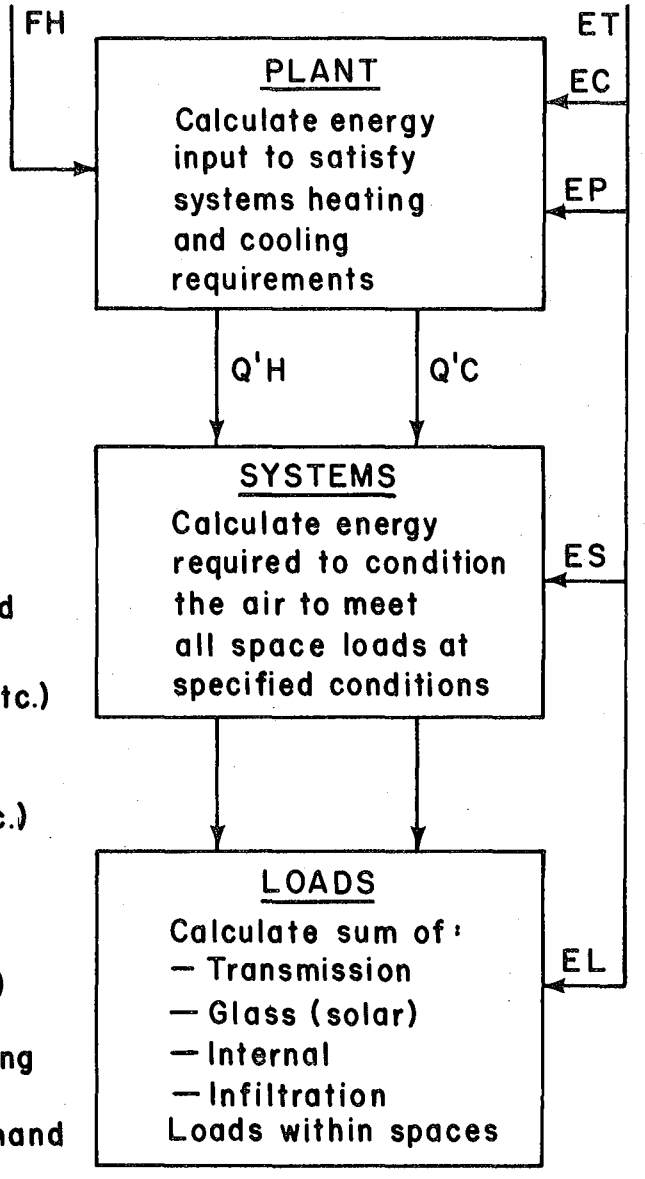

Figure 1

XBL 791-128

The objective of more refined calculational procedures is to simulate the heating and cooling loads and system responses by making the time interval as small as is practicable. DOE-1 is programmed to compute the building behavior in hourly intervals which permits a more realistic approximation than energy analysis programs which use an average day per month.

Such a small interval — implying 8760 steps in a calendar year — would be impossible without the use of advanced computer methods, especially when it is realized that careful design will require the calculation to be made several times to test alternatives. The long history of development of such calculational procedures has been justified on the basis that more accurate calculations will give improved analysis of life cycle costs of buildings, more precise sizing of equipment and more carefully controlled operation of the primary and secondary HVAC systems.

B Uses for the Program

Because of the flexibility of its input, the DOE-1 program can be of assistance in many applications, especially the consideration of energy conserving alternatives and in building and systems design:

1. Energy Conservation Studies

   a) Effect of the thickness, type and relative position of exterior walls and roofs;

   b) Effect of thermal storage;

   c) Effect of occupant, lighting and equipment schedules;

   d) Evaluation of intentionally undersized primary HVAC systems (plant) by calculating room temperature and humidity deviations from a design set point;

   e) Evaluation of the thermal environment of various zones during spring and autumn, when the heating or cooling requirements are small, yet system energy consumptions do not reflect these lessened demands;

   f) Effect of intermittent operation, such as the shutdown of HVAC systems during the night and/or on weekends and holidays;

   g) Effect of reduction in outside air requirements; use of outside air for cooling;

   h) Effective use of internal and external shading;

   i) Off-peak heating or cooling of buildings to reduce peak heating or cooling electric demand;

j) Use of solar energy for heating and cooling;

k) Comparison of loads and equipment selections using design day features versus those that result from weather tapes.

2. Building design studies

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

b) Evaluation, during the design stage, of specific design concepts and modifications;

c) Evaluation, during construction, of contractor proposals for deviations from the construction plans and specifications;

d) Monitoring the operation and maintenance of the finished building to provide the greatest return on energy investment;

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

f) Analysis of electric load management schemes as applied to single buildings or multi-building complexes.

Section 2 - DOE-1 Structure

DOE-1 comprises one translation and four simulation sub-programs,[1] the latter corresponding to the four steps of the energy analysis program briefly described in Section 1. These four sub-programs are executed in sequence, with the output of one becoming the input to the next. Each of these four sub-programs also produces printed reports of the results of its calculations. The function of each sub-program is summarized below:

1) BDL - The Building Design Language translator.

   This subprogram reads the flexibly formatted data supplied by the user and translates that data into computer recognizable forms. It also calculates response factors for the time-dependent heat flow in thick walls for later subprograms to use. The basic syntax and vocabulary of BDL is described in Section 3 of this manual.

2) LOADS - the loads simulation sub-programs.

   This sub-program calculates the sensible and latent components of the hourly heating or cooling load for each user-designated space in the building under the following conditions. It is assumed that each space is kept at a constant temperature selected by the user and the sub-program does not take into account the outside air deliberately brought into the building for ventilation purposes. LOADS is responsive to weather and solar conditions, to schedules of people, lighting and equipment, to infiltration, to the time delay of heat transfer resulting from massive walls and roofs and to the effect of building shade on solar radiation. A variety of reports are available to the user including peak space and building loads by source and hourly data for a wide variety of variables. The user input to the LOADS sub-program is illustrated in Section 5.B.

3) SYSTEMS - the secondary HVAC simulation sub-program.

---

[1] In addition there are two utility programs: the Weather Processor and PONSFAC. The Weather Processor allows the user to transform various standard weather tapes to the DOE-1 format, to edit the tapes and to list them. PONSFAC allows the user to create his/her own library of response factors for composite walls. See the Reference Manual for details of these utility programs.

LOADS produces what may best be described as a first approximation of the energy demands of a building. The function of SYSTEMS is to correct this approximation by taking into account the outside air requirements, the building's, i.e., the plant's, operating schedules, the HVAC Equipment control schedules and the transient response of the building when neither heating nor cooling is required to maintain the temperature and humidity set points. The output of SYSTEMS is a list of peak loads and heat extraction (and addition) rates actually required from the secondary HVAC systems (the portion of the HVAC system that actually delivers conditioned air to the building spaces), if they are to satisfy the user specified comfort range within the user specified limits of their capacities. It is these hourly rates that are passed on to the primary HVAC systems (that portion of the HVAC system that converts fuel to heat energy). The user input to the SYSTEMS sub-program is discussed in Section 6.D.

4) PLANT - the primary HVAC simulation subroutine

The PLANT subprogram simulates the behavior of boilers, turbines, chillers, cooling towers, solar collectors, etc., in delivering to the secondary systems the heat extraction and addition required. Taking into account the part-load characteristics of the primary equipment and the user-specified priorities for distribution of the tasks among the several components, PLANT calculates the fuel and electrical demands of the building as well as the costs of these energy sources. The user input to the PLANT sub-program is described and illustrated in Section 7.C.

5) ECONOMICS - the economic analysis subprogram

This subprogram makes a life cycle cost analysis of different LOADS, SYSTEMS, and PLANT alternatives of interest to the user. It can be used to compare the costs of different building designs or to calculate savings to investment statistics for retrofits to an existing building. The details of the user input to the ECONOMICS subprogram are given in Section 8.B.

Section 3 - The Building Design Language (BDL)

A Input Data

A source code is a set of instructions to a computer to perform a sequence of calculations and file manipulations written in a quasi-English, quasi-mathematical form. An object code is the translation of the source code into machine language and depends upon the idiosyncratic internal logic of the computer. The average DOE-1 user does not need to be concerned about these codes.

What is important is the nature of the data upon which the object code operates. Providing that data in a form that the object code can recognize is the task of the user.

Many programs require the data to be punched onto data cards according to a strict and rigid format such as ``the night-time temperature set point must be in columns 59-60 of the 15th card.'' Such requirements are not only stringent, allowing little or no flexibility to the user, but also result in a deck of cards that is almost unintelligible to the user unless the exact locations are memorized for each datum.

The Building Design Language (BDL) has been developed to allow the designer to translate design concepts into a form the computer can recognize and to allow the designer to see easily what has been done. With very few exceptions the designer does not need to be concerned with what column of the card[1] is being used and in every case the input data are labelled with recognizable words for easy identification.

The reader may find it useful at this point to xerox the BDL input for the example building from Appendix 4 and to have it handy for scanning in association with the following text.

---

[1] In this Guide the input will be described as being punched onto 80 column data cards. A line of BDL input corresponds to a single card. Users who use teletype machines for writing their input are restricted to placing their input in the first 80 columns of the teletype. Such a line of teletype input corresponds to a single data card.

B Elements of BDL

Every language has a syntax and a vocabulary. The syntax is a set of rules which regulate the positions of the words or symbols of the vocabulary and the punctuation. BDL is no different in this respect, except that it is simpler than most. In this Section the emphasis will be primarily on the syntax of BDL, i.e., the structure of the language. The reader may want to re-read this Section after he/she has more acquaintance with the meanings of the special words introduced to illustrate the grammar. The vocabulary will be described in later sections and in the Reference Manual.

BDL[2] is composed of four input programs: the Loads Design Language (LDL), the Systems Design Language (SDL), the Plant Design Language (PDL), and the Economics Design Language (EDL). The purpose of each of these is to translate the input data into a form usable by the Loads, Systems, Plant and Economics simulations, respectively. The syntax for each of these is the same.

B.1 BDL Instructions

The basic structure of BDL is the instruction. An instruction corresponds roughly to an English sentence and always includes a command and a terminator . Each instruction is assumed by BDL to be in effect until, by scanning from left to right sequentially through the cards, BDL sees a terminator. At that point it assumes a new instruction and seeks out the controlling command word of that instruction. This process continues until BDL discovers the command STOP. It recognizes STOP to mean that there are no more instructions for it to translate. Note that no reference is made here to coming to the end of a card. An instruction may stretch over many cards without the user needing to indicate that the second and following cards are continuations of the first. BDL assumes that they are continuations as long as it has not discovered a terminator. This permissiveness of BDL allows the user to arrange the input in any fashion that is appealing and informative.

B.2 Terminator

The symbol for the terminator is .. (two periods with no space between them and with a blank space between the terminator and anything else (including the end of the card)).

---

[2] In this Guide the acronym BDL will be used both as the name of the language and as the name of the DOE-1 subprogram which translates the language into machine readable form.

B.3 Reserved Words

Each separate command is identified by being one of a reserved set of words. ``Reserved'' means that the word must not be used in any other context. For example, the first command to be entered when writing an input deck is

```
INPUT LOADS                                    ..
```

B.4 Code-words

The word **LOADS** following the command **INPUT** belongs to another set of words or symbols called code-words. Each code-word has a pre-defined meaning to BDL. The code-word value is given meaning by the command that it follows. In this case it tells BDL that the input data that follow are for the LOADS subprogram.

B.5 INPUT Command

Before inputting data for any particular sub-program, the user must — through use of the **INPUT** command — tell BDL which program data are being presented next. The input data for the LOADS sub-program will be discussed in detail in Section 5.

Following the LOADS input data are the following commands:

```
END                                            ..
COMPUTE LOADS                                  ..
INPUT SYSTEMS                                  ..
```

B.6 END Command

The first command in the sequence, **END**, forms a pair with the **INPUT** command. It tells BDL that the data for the program indicated by the preceding **INPUT** command is now complete. Thus the cards between an **INPUT** and **END** command pair must contain all data needed to perform the simulation for the program indicated.

B.7 COMPUTE Command

The next line introduces the **COMPUTE** command. This command requests that a simulation be performed for a program using the previous set of input data for that program. In this case a LOADS simulation is requested and the LOADS data ENDed by the previous line will be used. The sequence then continues by informing BDL to prepare to accept SYSTEMS data input.

B.8 Keywords

Other BDL commands require or can accept many additional pieces of information that serve to describe the content of the command. The identification of the specific content is through another set of reserved words, called keywords.

Keywords always appear in the form: keyword = value, where ``value'' is specified by the user. As an example, consider the command **BUILDING-LOCATION**. This command informs BDL that the data that follow are going to specify where the building is, how the building is oriented, and what calendar and time-conditions exist at that location:

```
BUILDING-LOCATION          LATITUDE=42 LONGITUDE=88
                           ALTITUDE=610 TIME-ZONE=6
                           BUILDING-AZIMUTH=0                    ..
```

In this example there are five keyword=value pairs. Note that the spacing between lines, commands, keywords, etc., is arbitrary except that a blank indicates the end of a keyword=value pair. For this reason there may not be an imbedded blank space within a single word. The keyword **TIME-ZONE** is one word, whereas omitting the dash, viz. **TIME ZONE**, produces two words and is not a keyword. Since, with one exception to be described later, commas, spaces and equal signs may be used interchangeably as separators, BDL will interpret the two words **TIME ZONE** as **TIME** = **ZONE** and will abort with an error message. Equal signs are not required between a keyword and its value. A blank space between them will be interpreted as an equal sign.

B.9 DEFINE Command

In the above example the keywords belonging to the command **BUILDING-LOCATION** were given numerical values. BDL expects these specific keywords to have numerical values or to be equated to user-created words which have previously been given numerical values in a **DEFINE** command. The **DEFINE** command is an optional command which is very useful when several runs are anticipated with a different value for a given keyword in each run. An example of the **DEFINE** command is

```
                    DEFINE          LATX=42 LONX=88 TZON=6          ..
```

Here three user-created words have been introduced: **LATX**, **LONX** and **TZON** and have been given values 42, 88 and 6, respectively. If subsequently in the command **BUILDING-LOCATION**, the keyword=value pairs **LATITUDE** = **LATX**, **LONGITUDE** = **LONX** and **TIME-ZONE** = **TZON** appear, BDL will insert the values indicated in the **DEFINE** command. Different runs for different locations of the building (parametric runs) will require changing only the **DEFINE** instruction.

```
DEFINE                    LATX=42 LONX=88 TZON=6                  ..
BUILDING-LOCATION         LATITUDE=LATX LONGITUDE=LONX
                          ALTITUDE=610 TIME-ZONE=TZON
                          BUILDING-AZIMUTH=0                      ..
```

Other keywords have code-words as values. For example, the keyword **THERMOSTAT-TYPE** which occurs in SDL has the following allowed values: **PROPORTIONAL** and **TWO-POSITION**. The meanings of these code-words are given in the Reference Manual under the **ZONE-CONTROL** command.

B.10 Referenced Commands and U-names

Finally there are keywords that are really referenced-commands and whose values are user-created names, which will be referred to as u-names. A referenced-command is a command in one instruction and a keyword in a subsequent instruction. The use of referenced-commands allows the user to collect data in one instruction and to use the same data in several later instructions. A u-name is any alpha-numeric string of 16 or fewer symbols which have no imbedded spaces and that are different from all commands, keywords and code-words or their corresponding abbreviations.

To illustrate the use of referenced-command keywords and u-names, the procedure for specifying the construction of a wall will now be described. The first step is to indicate the various layers of the wall starting from the outside surface. This is given by an instruction whose command is the referenced-command **LAYERS**, which must be given a u-name. The u-name chosen in the Example Building for the Users Guide is **WLLAY-1**. This symbol string reminds the user that he/she is naming the layers of a wall and, by using a numerical suffix, permits the possibility of describing other wall layers with u-names **WLLAY-2**, **WLLAY-3**, etc. The full instruction is

```
WLLAY-1          =LAYERS          MATERIAL-1=BK05 M2=IN33
                                  M3=CB46 M4=AL11 M5=GP01
                                  INSIDE-FILM-RES=.68                ..
```

When giving a u-name to a command, a referenced-command or a subcommand (to be defined below), the equal sign is mandatory. This is the exception mentioned earlier. Spaces or commas will give an error message and BDL will abort. The general rule is that a command must be the first word in a sentence unless it is preceded by a u-name with an intervening equal sign.[3] There are two other points to note in the above example. The first is that the keywords **MATERIAL-1**, **MATERIAL-2**, etc., have acceptable abbreviations M1, M2, etc. Most commands and keywords as well as some code-words have specified abbreviations. The second is

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

that the values of these keywords are code-words. These particular code-words are taken from the list of materials described in the Materials section of the Reference Manual.

The reason that the **LAYERS** command requires a u-name is that in a subsequent instruction describing the construction of a particular kind of wall, **LAYERS** appears as a keyword. Its value is the u-name the user has given to the particular ordered set of materials above. Thus

```
EXTW-1        =CONSTRUCTION        LAYERS=WLLAY-1 ABSORPTANCE=.88
                                   ROUGHNESS=2                    ..
```

Again, **CONSTRUCTION** is a referenced-command and has been given the u-name **EXTW-1** to remind the user that it describes the construction type of the first kind of exterior wall.

To complete the chain of referenced-commands, somewhere in the building there is a specific exterior wall whose construction type is **EXTW-1**. For example,

```
WALL-1          =EW          HEIGHT=9 WIDTH=15 AZIMUTH=180
                             CONS=EXTW-1 MULTIPLIER=5          ..
```

The command **EXTERIOR-WALL** (abbreviated here as **EW**) has also been given a u-name: **WALL-1**. This is optional and is not required. There are two reasons for u-naming specific walls, windows and the like. The first is that several of the optional reports in the LOADS sub-program are verifications of input organized in an informative manner. Unless the various components are u-named, it is difficult to tell which wall, for example, is being described. The second reason is to make use of the labor-saving keyword **LIKE**.

B.11 LIKE Keyword

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

```
WALL-2          =EW          LIKE WALL-1 WIDTH=25 X=45 M=1        ..
```

In this example, the **LIKE** keyword instructs BDL to assign to the exterior wall, u-named **WALL-2**, the same values to the keywords **HEIGHT**, **WIDTH**, **AZIMUTH**, **CONS** (an abbreviation for **CONSTRUCTION**) and **MULTIPLIER**[4]

---

[4] The keyword **MULTIPLIER** allows the user to specify one of a number of identical spaces, walls, windows and the like once and to instruct BDL to multiply the heat extraction or transmission by the value of **MULTIPLIER**.

as were assigned to **WALL-1**. The explicit use of the keywords **WIDTH**, **X**, and M (an abbreviation for **MULTIPLIER**) modifies the effect of the **LIKE** keyword in these explicit cases, i.e., BDL is being instructed to make **WALL-2** the same as **WALL-1** except for the keyword values that follow.

B.12 Default values

This example demonstrates another property of BDL. Note that **WALL-2** sets a value for the keyword **X**, while **WALL-1** made no explicit mention of that keyword. **X** is the keyword that specifies the x-coordinate relative to the space coodinate system of the lower left hand corner of the wall as observed from the outside. The default value for this keyword is 0. Many (but not all) keywords have been given default values which will automatically be assigned by BDL to that keyword, if a given command expects that keyword, but does not find it explicitly. Thus in **WALL-1** the keyword **X** was set equal to 0 by BDL. Since X = 45 in **WALL-2** and not X = 0, it is necessary to override the **LIKE** keyword in this instance. The default values for all keywords are given in the BDL SUMMARY as well as in the Reference Manual.

B.13 SET\-DEFAULT Command

It is apparent from this example that the use of default values when writing the BDL input can be another labor-saving device when the default values are appropriate. It would be convenient if the user had some control over the default values, and LDL gives the user this power.[5] The command **SET-DEFAULT** performs this function:

```
SET-DEFAULT          FLOOR-WEIGHT=70 GLASS-HEIGHT=4
                     GLASS-WIDTH=6 GLASS-TYPE=WINGLS-1
                     SETBACK=0.5 TEMPERATURE=73                    ..
```

Note in this example that the keywords **GLASS-WIDTH**, **GLASS-HEIGHT**, **GLASS-TYPE** and **SETBACK** have all been assigned default values (**GLASS-TYPE**, being a referenced-command as well as a keyword, is identified with a previously defined u-name). It turns out that these four keywords are adequate to define a window, if we are indifferent to the position of the window on the wall.[6] Thus the subsequent instruction

```
                                WINDOW                             ..
```

is sufficient to describe a window, since BDL will assign to that window either the default values listed in the **SET-DEFAULT** command or its own

---

[5] In DOE-1 only LDL will allow the user to set the default values. In later versions this command will be available in SDL, PDL and EDL as well.

[6] If a window is on the South wall, say, and is unshaded by other surfaces, its location on the wall is immaterial for the purpose of energy analysis by DOE-1.

built-in default values for the keywords not mentioned, e.g., the position of the window is in the lower left corner of the wall.

B.14 Subcommands

Similar to the referenced-command is the subcommand. A subcommand, like the referenced-command, is a command that is refered to by a subsequent command through the use of a u-name. Unlike a referenced-command, however, the keywords of a subcommand can be included within the subsequent command. This will be illustrated in Section 5.B in the discussion of schedules and of the **SPACE-CONDITIONS** subcommand. It need be stressed here that **LAYERS** is not a subcommand. Its keywords may not be listed under the **CONSTRUCTION** command. They may only appear under the **LAYERS** command.

The purpose up until now has been merely to introduce BDL and its language structure and possibilities and not to define and describe the various commands, keywords and code-words. These definitions and descriptions will be covered later in this manual and are summarized in the Reference Manual.

Section 4 - Planning for an Energy Analysis

There are so many variables that contribute to the thermodynamic behavior of a building that anyone contemplating an energy use analysis needs to do preliminary planning before actually preparing input to the DOE-1 program. In Appendix 1 there is a check list of the items that must be decided upon in each phase of the input. The purpose of this section is to elaborate on some of the more important considerations and to suggest some strategic methodology.

A Building Geometry

One of the first steps in energy analysis is to have or to make architectural and mechanical drawings for the building to be simulated. The next step is to remember that one's goal is to create a model of the building for the purpose of analyzing thermal energy flow and not for the purpose of describing what the building looks like to a person in or out of the building. This means that the user can save much time and computer costs by adequately describing the building geometry from an energy perspective rather than from an architectural perspective.

To understand this more fully, it is necessary to know how DOE-1 treats the boundaries of spaces. DOE-1 does not attempt to reconstruct the space from the user's description of the bounding surfaces. DOE-1 calculates the flow of energy only through the surfaces that the user describes and assumes that the net energy (per hour) so computed is the total external energy gain (per hour) for that space. It does not test whether walls meet or even whether the surfaces describe an enclosed three dimensional space. It is possible, for example, to define a space with a floor area and a volume and then to describe only one exterior wall facing South. DOE-1 accepts the user's word that all that is wanted is to examine the energy flow in the space through that one surface. It is not even necessary that the wall specified be actually continguous to the space. All that is necessary is that the user assign the wall to the space.

Now why is DOE-1 so blasé about what to the eye would be an absurdity? The reason is that, with two exceptions, it is adequate to know only the orientation of a wall or roof or window to the sun.[1] Where these components are is immaterial from an energy perspective. The result for the user of this property of DOE-1 is the possibility for a substantial reduction of input to adequately describe a building.

---

[1] It is important, however, that the area of a window — or of all the windows on a given wall — be less than the area of the wall! DOE-1 will abort if this condition is not satisfied.

As an example, consider the input for the Example Building:

```
PLENU-1      =SPACE      FLOOR-AREA=4500 SPACE-HEIGHT=3
                         VOLUME=13500 FLOOR-WEIGHT=5
                         ZONE-TYPE=UNCONDITIONED                    ..
PLWL-1         =EW       HEIGHT=3 WIDTH=100 AZIMUTH=180
                         CONS=EXTW-1                                ..
                 EW      LIKE PLWL-1 WIDTH=45 AZIMUTH=90            ..
                 EW      LIKE PLWL-1 A=0                            ..
                 EW      LIKE PLWL-1 W=45 A=270                     ..
ROOF-1         =ROOF     HEIGHT=45 WIDTH=100 AZIMUTH=180
                         TILT=0 CONS=ROF-1 GND-REFLECTANCE=0        ..
```

The plenum space of the building is being described. Note that the exterior wall u-named **PLWL-1** has been given a width and height, from which the surface area can be calculated; an orientation, which in this case is to the south; and a construction type. On the other hand there is no specification of where the wall is located. For this purpose it would be necessary to give the x,y, and z coordinates of the lower left hand corner of the wall. Not mentioning these keywords allows them to default to zero. Since the next three walls are defined to be **LIKE PLWL-1**, they too, are located at the origin! Taken literally, the walls as defined form a cross at the building origin. Since, by immediately following the **SPACE** command, they are assigned to **PLENU-1**, DOE-1 will correctly calculate the flow of heat through and solar radiation on each of the walls. Similarly the roof, u-named **ROOF-1** is literally located on the ground! Again, it makes no difference to DOE-1.

The reason DOE-1 is indifferent is that no two surfaces can shade one another unless the user makes use of the **BUILDING-SHADE** command and specifies where the shading surface is located relative to the surface being shaded. This is the first of the two exceptions mentioned above. When a building surface is capable of being shaded from the sun either by a remote object such as another building, a tree, or a hill, or by itself —as in L or U-shaped buildings — it is necessary for the exact position of the shaded wall to be specified. Not only the position of the wall must be specified in this case, but the position of any windows that can be shaded on that wall must also be located geometrically within their wall surfaces. The method of describing shading surfaces will be described in Section 5.

The other situation that requires more precise geometric modelling occurs when the user chooses to simulate infilration by using the ``crack method.'' This method requires that actual window sizes be specified for each window section through which infiltration may be expected to occur and that the infilration flow coefficient per linear foot of each crack also be given. The user must also specify the building's ``neutral zone height'' — that height where the ``stack effect'' causes infiltration to switch over to exfiltration. In order that this height be meaningful the z-coordinate of all windows must be provided. The stack effect is important only in high rise buildings; for low rise buildings, it is more desirable to calculate the infiltration by the ``air-change'' method. This latter method relieves the user of having to input the building geometrically in order to account for

infiltration in a satisfactory manner. Again, the details for inputting infilration will be described in Section 5.B.2.d.

B Internal Zoning

Related to the building geometry and almost the first decision the user must make is how to divide the inside of the building into discrete spaces or zones. For the purpose of DOE-1 a space and a zone are synonymous and yet, paradoxically are not interchangeable! In LOADS these regions are referred to as ``spaces'' and in SYSTEMS these identical regions are called ``zones.'' The reason for this potential source of confusion is historical and not logical. When thinking about the structure and use of the building the word ``space'' seems appropriate. When designing an HVAC system, on the other hand, the central concern relates to that set of regions which are under the same thermostatic control, whose loads profile are closely correlated and which can be lumped together as a single load on the HVAC system. This latter set of regions, called zones, is <u>not necessarily related to the placement of internal partitions and walls</u>. If the user intends to run a SYSTEMS simulation on a building, it is important that the selection of internal regions for the LOADS calculations be made with the SYSTEMS calculation in mind.

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

It is not even necessary to have zones separated by real partitions or interior walls. A building might, for example, have one floor which has no internal walls. Nevertheless it is common in building energy analysis to create one internal zone and four external zones (one for each exposure as in Figure 2). The internal ``walls'' can be simulated

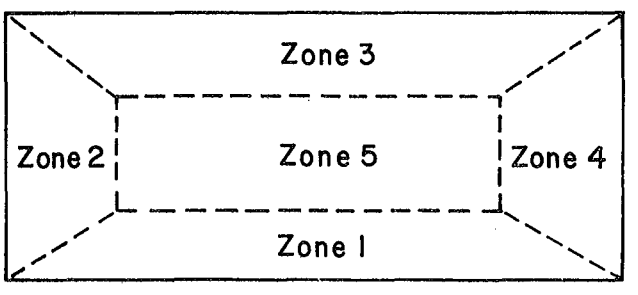

Figure 2

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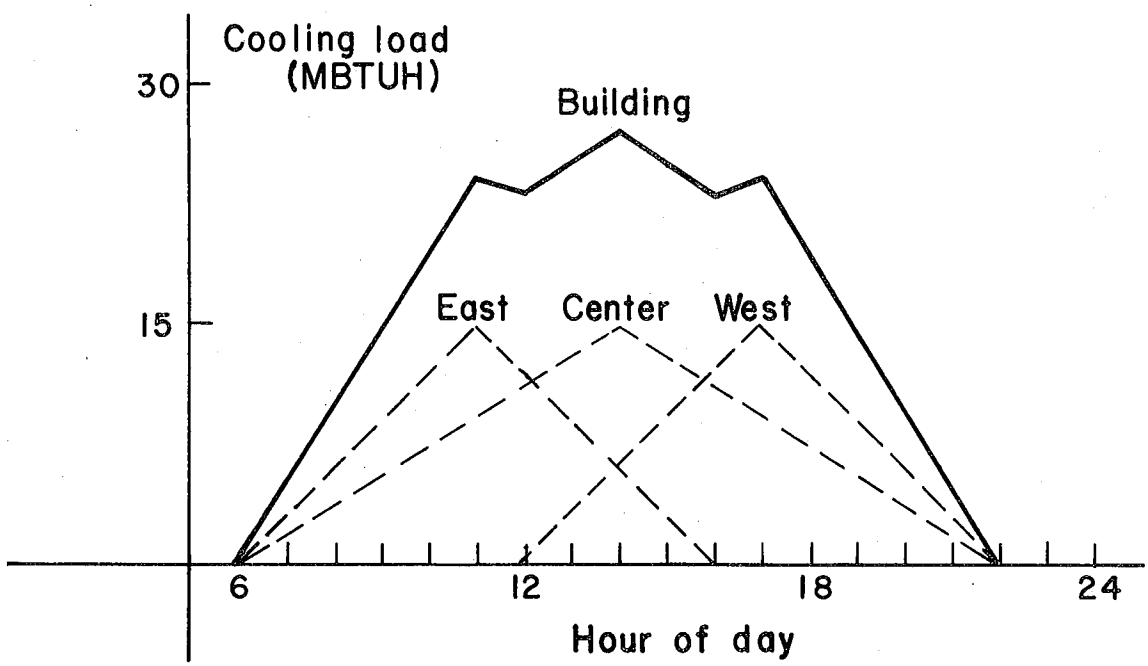
in DOE-1 by attributing a large U-value to account for convection between the zones.[2]

The failure to define more than one zone — which is tempting in the name of simplicity — results in what is called a building ``block'' load — the net load on the buiding as a whole. Since HVAC systems are sized on the basis of the loads, when only the ``block'' load is known, portions of the building may be too warm while other portions may have inadequate heat. Some energy programs can analyze only the block load of the building. DOE-1, on the other hand, differentiates between the coincident building peak load (or ``block'' load) and the sum of the non-coincident peak zone loads that result from the movement of the sun from east to west.

To understand this distinction suppose that there are three zones: east, center and west. Suppose further that due to the movement of the sun, the east zone reaches its peak cooling load at 11:00 A.M., the center zone at 2:00 P.M. and the west zone at 5:00 P.M.; and for simplicity the peak load in each zone is 15 MBTUH. The sum of the non-coincident peak zone loads is 45 MBTUH, whereas the peak block load is



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[2] Large means that U ~ 0.01578 Volume/(Area x τ) where Volume is the mean volume of the two zones between which the heat is transferred, Area is the area of the ``wall'' between the zones, and τ is the mean time in which the transfer takes place. Any larger U-value will violate the second law of thermodynamics — taking more heat energy from the air in the zone than is available. For τ ~ 1 minute and for usual geometries, U ~ 13.5. This is a maximum U-value for non-existent partitions or for open doors.

27 MBTUH.

The importance of these considerations may be seen in the possible desire to compare for a given building the performance of a constant volume air system with a variable volume air system. Constant volume air supply rates are based on non-coincident zone peak loads, whereas variable air volume systems reflect the sum of coincident peak loads, since these systems can actually shunt air from east to south to west zones. To study the difference between these two systems, the user must plan ahead and zone the building accordingly at the time the spaces are defined in the LOADS program.

Another case in point is the possibility that the user may want to study the application of a double bundle heat recovery chiller plant. If external zone air systems have not been separated from internal zone air systems — so that the heat exchange can be calculated — the study will not be valid.

One might think that since the LOADS calculation is made at constant temperature, the internal partition between the zones could be ignored. This would work for LOADS, but would not be appropriate for SYSTEMS where the dispersion of internal heat when the fans are off will not be computed appropriately unless the transfer surfaces are defined.

C Plenums

Much of the discussion relevant to partitions can also be applied to plenums. Given a shopping center, one story in height, with the ceiling space acting as a return plenum, it is likely that the plenum and the space below will be functioning at different temperatures, and a heat transfer may occur downward in summer and upward in winter. Such a situation clearly calls for defining a plenum space. On the other hand, in a high-rise building, return plenums may only run a few degrees above space temperatures. The user may be tempted to model the plenum on each floor; however, such attention to detail may only prove costly in computer time without seriously affecting the energy analysis. Often only the plenum on the top floor need be modeled. The contribution of the heat from lighting to return air can be modeled simply by assigning the code-word **DUCT** to the keyword **RETURN-AIR-PATH** in the **SYSTEM** command and no mention of a plenum zone need be made.

D Retrofit vs. New Building Design

The approach to making an energy analysis can be very different depending on whether one is designing a new building or attempting to model an existing building. In the latter case one is likely to be interested in discovering energy conserving retrofits, but the first task is to create a model of the building as it now exists. The constraints in such a case are more severe than when designing a new building in that monthly energy usage is known through fuel and electric billings. It is not enough merely to look at the original architectural and mechanical drawings, but rather it is necessary through field

measurements to discover what was actually implemented and how the building is actually operated. Among the field observations to be made are:

1. How tight are the windows? Are they left open at times? For what reasons, e.g., overheating or poor ventilation? What is the schedule of door openings? Are building seams sound?

2. How are window shades scheduled? What has been constructed or planted nearby that might cause building shade?

3. What are local weather conditions like? How different from the local airport or weather station? How must weather tapes be modified?

4. When are people in each zone during the day throughout the year? How are lights scheduled? What is the type and kilowattage of the light? Similarly for equipment? What is the latent and sensible component of the heat addition due to equipment?

5. How are exhaust fans scheduled? If different from HVAC fans, it may be necessary to simulate the effect by using infiltration schedules in LOADS rather than describing the exhaust in SYSTEMS.

6. How are walls and roofs actually constructed? Has insulation been added since the initial construction?

7. What are the thermostat setpoints? How are they scheduled? Which zones are master zones and which are the slaves? Do actual zone temperatures match the thermostatic set-points?

8. Are outside air dampers operable? Are they responsive to the design specifications, i.e., not stuck open or closed? How much outside air is being drawn into the building?

9. How are the fans scheduled? What are the fan characteristics? What is the supply cfm? How much air is delivered to each zone? Similarly for return fans.

10. What is the temperature of the supply air? What is actual heating capacity of the baseboards?

11. What are the schedules for boilers and chillers, i.e., when is heating and cooling available? Are all pumps and other plant equipment operable? What is efficiency of plant components and their operating characteristics?

Experience has shown that each of the items mentioned above often deviates from the original plans and the failure to take the changes into account may make it impossible to match actual fuel and electricity use by the building. In any case, it may be unreasonable to expect to match actual consumption to within 10 percent or better. People behavior often overrides theoretical expectations of building performance. Lights are not turned off on schedule, windows are inadvertantly left

open and building engineers often respond to complaints of over- or under-heating by manually adjusting the design schedules and set-points.[3] Such behavior is seldom logged and provided in official schedules for the use of energy analysts.

After one has the facts, there is yet another difference between the analysis of existing buildings and that of a planned building. With all the flexibility of the DOE-1 SYSTEMS simulation it is possible to discover existing HVAC systems which cannot be modelled accurately by DOE-1.

An example occurs in many older schools equipped with classroom unit ventilators. Those ventilators often are turned on during the occupied hours and put on automatic during nights and weekends — supplying heat only when the night setback demands it. The dampers are closed at night so that there is no outside air being introduced to the classroom. Unfortunately in DOE-1 the user cannot schedule outside air nor assign the zone to a unit ventilator system during the day and to a unit heater system during the night. A solution is the following:

1. Schedule the fans to be off at night.

2. Introduce baseboards into the zone with a **BASEBOARD-RATIO** = 0.5 and set **BASEBOARD-CONTROL** = **THERMOSTATIC**.

3. Set **HEATING-SCHEDULE** on all night.

4. Set the **HEAT-TEMP-SCHED** to reflect the daytime and nighttime temperature set-points.

Although this solution neglects the electrical consumption of the fans at night, it does model the heat addition actually supplied by the unit ventilator, including the heating of the outside air during the day. The major problem with this solution is that it overestimates the heat addition rate during the day. Since the SYSTEMS simulation adds heat only in the amount necessary to meet the current hour heating load, this problem is not significant, if the unit ventilator is adequately sized to meet those loads by itself. Future modifications of DOE-1 will permit the scheduling of outside air.

The user may have to be similarly ingenious to resolve other deficiencies in the DOE-1 program. By informing the User's Office[4] at Lawrence Berkeley Laboratory of such difficulties, the users can

---

[3] In a recent test of DOE-1 the field observers were told that the janitor manually turned off the HVAC fans each afternoon when he left work. One evening he waved good-by to the observers and flipped the fan switch. Later one of the observers heard the drone of the fans and discovered that what the janitor for years had thought was the fan switch was in fact not wired to the fans!

[4] DOE-1 User's Office, Room 3076, Building 90, Lawrence Berkeley Laboratory, Berkeley, CA 94720. Telephone (415) 486-5711 or FTS 451-5711.

influence the future development of DOE-1.

E Use of Comments

One of the important practices of computer programming is that of providing documentation of what has been done. The same applies to preparing input to DOE-1. In spite of the possibility of using recognizable u-names to label commands it is difficult to remember all the reasons one has for assigning values to the various keywords or for organizing the data in the way one has. Coming back to one's input after a month, one may have difficulty reconstructing what one had in mind. The problem is compounded if someone else will have access to the input and will be expected to use and to modify it. BDL allows the user to introduce comments into the body of the input without affecting the translation of the data into machine language.

The symbol pair which BDL recognizes as the beginning and end of a comment is /* */. Any string of characters punched between these symbols is ignored by BDL in translation and is echoed back in the output. The only restriction on the use of the comment symbol pair is that the comment may be no longer than five lines long. Longer comments require multiple use of the comment symbol pair.

To illustrate, examine the sample input. At the top of the form is a long comment listing the specifications of the sample building. After every fifth line the comment is closed with the symbol */ and the next line starts with the symbol /*, indicating the beginning of a new comment as far as BDL is concerned.

Another example is demonstrated by the titles before each section of the input. Finally consider the abstract from the sample input reproduced below:

```
CEIL-1      =CONS        U=.8     /* CONSTRUCTION OF CEILING */   ..
PART-1      =CONS        U=10     /* FALSE PARTITIONS */          ..
FLOR-1      =CONS        U=.05    /* SLAB ON GROUND */            ..
DOR-1       =CONS        U=1.0 ROUGHNESS=6  /* BACK DOOR */       ..
WINGLS-1    =GLASS-TYPE  PANES=2 GLASS-SHADING=.86                ..
DORGLS-1    =GT          GTC=3     /* FRONT DOOR */               ..
```

Here the various construction commands are clarified to the user by use of comments imbedded within the command/instruction. The only caution in this use of the comment is that the symbol pairs must not include within them any commands, keywords, values or terminators that the user wants BDL to interpret. BDL does not read the comments! It ignores them, stores them, and prints them in the echo of the user's input deck.

F Parametric Runs

When each energy analysis costs from $300 to $500, a user is not likely to want to explore what the effect on energy consumption is when a single design variable is changed through a series of values. Such an exploration becomes not only feasible, but desirable, as a design tool when the cost is reduced by a factor of five. DOE-1 simulations have costs in the range of $60 to $100, depending upon the number of zones and the complexity of the building and even these costs can be reduced as described below.

Making multiple runs on the same building while varying only a single design parameter is known as a parametric study. By restricting the change from run to run to be a single parameter, the designer discovers the impact of that design feature alone on the energy consumption of the building. When several different design features are changed, the designer is left not knowing which of the features was responsible for the change in the output.

To make effective use of the possibility of making parametric studies in DOE-1, the user must plan ahead and make use of the **DEFINE** command. Suppose, for example, in the sample building, the user wanted to test the effect of changing the size of the overhang over the front door. Without using the **DEFINE** command it would be necessary to repunch the line reading:

```
BUILDING-SHADE    HEIGHT=5 WIDTH=10 TRANSMITTANCE=0
```

using, say 2, 5, 8, and 10 for the value of the keyword **HEIGHT**. The other alternative is to punch the line initially as:

```
BUIDING-SHADE    HEIGHT=HITE WIDTH=10 TRANSMITTANCE=0
```

and to create a new set of cards to be placed one at a time toward the beginning of the deck reading:

```
DEFINE        HITE=2        ..
DEFINE        HITE=5        ..
DEFINE        HITE=8        ..
DEFINE        HITE=10       ..
```

By changing this card in each run, BDL will interpret the u-name **HITE** as 2, 5, 8, 10 respectively in the **BUILDING-SHADE** instruction.

This example is not so impressive, since in either alternative only one card needed to be changed. The situation is much different when the keyword to be changed is repeated many times. For example, suppose the designer wanted to explore different night set-back temperatures. In the SYSTEMS input is the **WEEK-SCHEDULE** command that assigns the thermostatic set-point for each hour of the day:

```
HEATWK-1      =WEEK-SCHEDULE      (WD)      (1,7) 50 (8,18) 70
                                            (19,24) 50
                                  (WEH)     (1,24) 50                ..
```

Here three cards would have to be changed, if in place of 50 the user wanted to try the sequence 40, 45, 50, 55, 60, 65, 70. By using the DEFINE command and changing the initial instruction as follows, only one card need be changed from run to run:

```
HEATWK-1      =WEEK-SCHEDULE      (WD)      (1,7) NITEMP (8,18) 70
                                            (19,24) NITEMP
                                  (WEH)     (1,24) NITEMP            ..
```

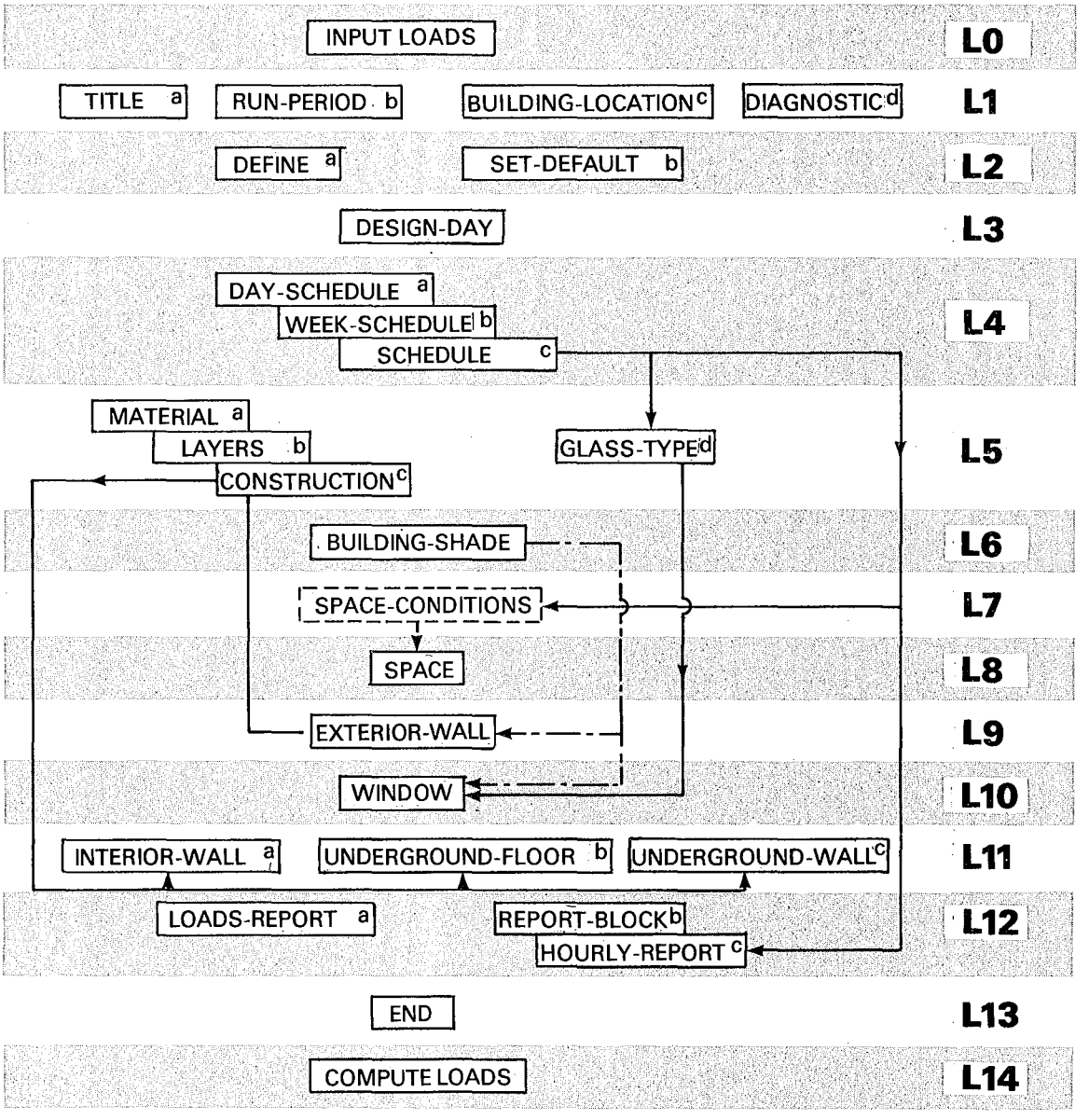
where the user wants one of the following for each run:

```
                    DEFINE                NITEMP=40                ..
                    DEFINE                NITEMP=45                ..
                    etc.
```

This last example — where the parameter to be changed is in SYSTEMS — allows further reduction in the costs of making the parametric runs. Since the LOADS simulation will be the same for each of the runs and is the most expensive of the simulations, the possibility of doing it only once and saving the output to be used in a sequence of SYSTEMS runs is clearly a money saver. The user may discover how to do this by reading the manual, Remote Operation of DOE-1 on the Lawrence Berkeley Laboratory CDC 7600, 6600 and 6400 Computers.[5]

[5] In DOE-2 the procedure for doing parametric runs with this saving of the output file will be much simplified.

LOADS COMMAND CHART



——— Referenced command routing

------ Subcommand routing

—·—·— Implied command routing

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Section 5 - LOADS

A Introduction

The LOADS section of DOE-1 calculates the heating and cooling loads of a building, assuming a fixed indoor air temperature. The calculational program itself is not particularly innovative. It has evolved from previous programs and is based on standard ASHRAE algorithms and techniques. The input processor LDL, on the other hand, has many new and innovative features. Proper understanding and use of LDL will give the user more concise, readable, and error-free input decks than was possible with previous energy analysis programs.

Before using LOADS, the user should have some understanding of the calculational procedures employed in the program. The load is divided into components, which are calculated hourly. The components can be divided into two classes, external and internal. The external components are the loads due to heat conduction through walls, heat conduction through windows, infiltration through windows and walls, and solar gain through windows. The internal components are the loads due to people, lights, and equipment inside the building. The program performs its calculations in a hierarchical fashion. The hierarchy is:

1. Building
2. Space
3. Wall
4. Window

The program calculates the external load components for all the windows on a wall, then for all the walls in a space. At the space level, it combines the wall loads, yielding the external load for the space. Next, it calculates the internal load components for the space and combines them, giving the internal load for the space. Finally the external and internal loads are combined to give the total load for the space. At the building level, the space loads are summed, giving the total heating or cooling load for the hour. We will see this hierarchical structure reflected in the LDL input deck

It is the user's responsibility to provide the program with sufficient information to calculate each of the load components. To calculate the external load components, the program needs the material properties of the walls and windows, the outside environmental conditions, the orientation and location of the building, the orientation of the walls and windows, the combined floor-weight of the walls, floor and furnishings of each space, and the internal temperature for each space. The outside environment is usually specified by selecting a DOE-1 weather file. A complete list of the required weather parameters may be

found in the description of the DESIGN-DAY command.[1] The actual location of walls and windows needs to be specified only if they will be shaded by an external shading device. To calculate the internal load components, the program needs to be given the maximum energy input to each space from people, lights, and equipment. The user should also normally provide a schedule for each of the internal components.

As was discussed in Section 4, the user must make a decision about the level of detail he/she wishes to use in modeling the building. The simplest possible level is to describe the building as one space (i.e., one thermal zone). For most purposes, this is too crude. The next level might be one interior zone and four exterior zones. This level of detail can be very useful and will be used in our Example Building. The most detailed description, in which the user inputs each wall, window, and room in the building, is probably just as useless as the one zone model. It is costly, time consuming and confusing. The user loses any intuitive feel he/she might have for what is going on in the building. Finally, it should be emphasized once again that the user must model the building in LOADS in such a way that it will be compatible with the SYSTEMS input.

B Example Building

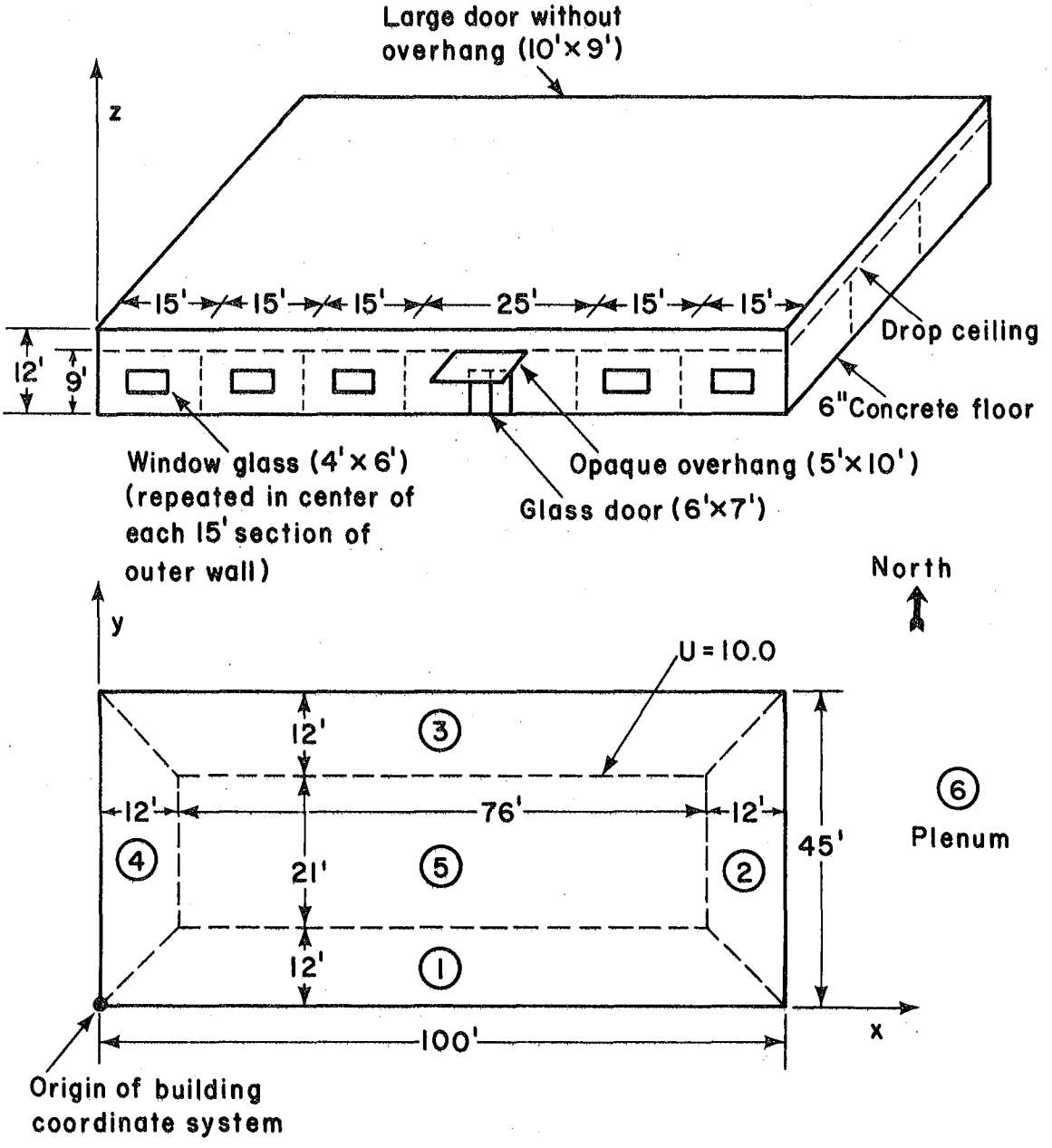
To illustrate the use of DOE-1, an example building has been chosen. In each of the next four Sections of this Manual, including this Section, a step by step description of the input in LOADS, SYSTEMS, PLANT and ECONOMICS will be given. The input described and printed in its entirety in Appendix 4 is only one way among many of describing the building using BDL. Once the user becomes familiar with the input language, he/she may be able to produce a more concise and readable input. The process begins with LDL.

B.1 Example Building Specifications

The Sample Building is a single story office building located in Chicago. Figure 3 is an isometric sketch and plan view of the building with all necessary dimensions. The building is well insulated; its walls are of face brick and concrete block construction; its roof is a built-up roof. The windows contain double pane glass with ASHRAE shading coefficient of 0.86; the glass is mounted six inches inside the exterior wall surface. The front door is 1/4" thick plate glass; the back door is one inch thick wood. The floor is six inch thick concrete in contact with the soil. A drop ceiling serves as a plenum. The lighting fixtures have fluorescent bulbs; the return air passes through the fixture. The maximum energy used for lighting is 3 watts/sq. ft.; the maximum energy for equipment is 1 watt/sq. ft. The number of people per space is at most 45. The infiltration when the building is unoccupied is 0.5 air changes per hour.

---

[1] See the Reference Manual.



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Isometric and Plan View of the Example Building

Figure 3

To show the exposure effect, the building is divided into one interior and four exterior spaces. The plenum is considered to be an unconditioned sixth space. The depth of the exterior spaces is assumed to be 12 feet. The convective and conductive energy exchange between interior and exterior spaces is calculated by assuming fictitious interior walls with U-value of 10.

B.2 Example Building Input

With the specifications as given above the LDL input for the Example Building can now be given.

B.2.a Heading

After the mandatory first line

```
INPUT LOADS                                                    ..
```

is what might be called the Heading section. It consists of the following commands: **TITLE**, **DIAGNOSTIC**, **RUN-PERIOD**, **LOADS-REPORT**, and **BUILDING-LOCATION**. The **TITLE** command may be used to identify the building and any other information the user wants to include about the building, the date, his/her organization, etc. The first 40 characters of each line following the **TITLE** commands are reproduced on each output sheet. The **DIAGNOSTIC** command will be discussed in Section 9.C.

The **RUN-PERIOD** command establishes the duration and year of the simulation. BDL knows when the legal holidays and weekends occur in the year given, so it is important in later schedules to use the appropriate calendar. In the Example Building the **RUN-PERIOD** is for the entire year. It could have been for as short as one day, e.g.

```
RUN-PERIOD          APR 15 1974 THRU APR 15 1974                ..
```

DOE-1 automatically precedes the production run with four days of building operation by using the first day's weather over and over to bring the building up to an operating condition. This is a long enough period to allow all transients to disappear and the results for the one day run illustrated above should accurately represent the building energy behavior on that date. In any case the inclusive dates must fall within a calendar year. For example the instruction

```
RUN-PERIOD          SEP 4 1974 THRU JUN 13 1975                 ..
```

is illegal and will produce an **ERROR** message.

There are many different reports available to the user from the LOADS simulation and these are defined in the Reference Manual. A few examples are described in Appendix 2. To obtain information on the peak heating and cooling loads in each space and for the building as a whole the code-word is L02 and thus:

```
LOADS-REPORT                    L02                    ..
```

Since the building is in Chicago, the data for the **BUILDING-LOCATION** command must reflect the geographical data for that location. In the BDL SUMMARY is a table of geographical data for the fifty largest cities in the United States. Furthermore, we are given in the specifications that the building faces South.[2] Looking at the building plans in Figure 4, one can see that the building coordinate system has been set up so that the y-axis points to the North. Since the **BUILDING-AZIMUTH** is defined as the angle measured in a counter-clockwise direction between the building y-axis and North, in this case the value is 0:

```
BUILDING-LOCATION          LATITUDE=42 LONGITUDE=88
                           ALTITUDE=610 TIME-ZONE=6
                           BUILDING-AZIMUTH=0                ..
```

Note that since the default value for **BUILDING-AZIMUTH** is 0, this keyword could have been omitted. Since standard holidays are presumed to be in effect and daylight savings is observed, it is sufficient to allow the keywords **HOLIDAY-CODE** and **DAYLIGHT-SAVINGS** to default to 0. The default values and allowable ranges form all keywords are listed in the BDL SUMMARY.

B.2.b Building Construction

The next portion of the input for the Example Building treats the way in which the various components of the building are constructed. For outer surfaces such as walls and roofs it will be desirable to describe their construction in such a way as to permit a time delay in the transmission of heat. To do this it is necessary to describe the properties of the materials used, the way the materials are arranged in layers to make up the wall or roof and finally the properties of the finish of the outer surface. This is handled by a sequence of three referenced commands, generally, i.e., **MATERIAL** , **LAYERS** and **CONSTRUCTION** In the case of the Example Building it was decided to use the materials described in the Reference Manual and stored in the materials library of DOE-1 according to code-words. The use of these code-words, when appropriate, allows the user to avoid using a series of **MATERIAL** commands and to start with the **LAYERS** command.

```
WLLAY-1        =LAYERS        MATERIAL-1=BK05 M2=IN33
                              M3=CB46 M4=AL11 M5=GP01
                              INSIDE-FILM-RES=.68            ..
RFLAY-1        =LAYERS        M1=RG01 M2=BR01 M3=IN76
                              IFR=.76                        ..
```

[2] Which face of the building is the front is, of course, arbitrary; however, once the user has chosen a coordinate system for the building, it is necessary that he/she be consistent thereafter.

The layers are listed from the outside in and in the case of the layers of the roof, u-named **RFLAY-1**, the outmost layer is 1/2 inch of roof gravel (RG01). Beneath that is 3/8 inch of built-up roofing (BR01) over three inches of preformed roof insulation (IN76). In addition the resistance of the inside air film is given as .76 hr-ft^2-^{o}F/Btu. BDL will perform a response factor calculation and, by using the **COMMENT** keyword in the **DIAGNOSTIC** command, the user may look at and evaluate the response factors and effective U-value of the **LAYER** defined (see Figure 9, page 9-5).

The construction of the walls and roof of the Example Building is completed with the following instructions:

```
EXTW-1      =CONSTRUCTION     LAYERS=WLLAY-1 ABSORPTANCE=.88
                              ROUGHNESS=2                          ..
ROF-1       =CONS             WALL-TYPE=RFLAY-1 ABS=.5 RO=1        ..
```

The keyword **WALL-TYPE** is equivalent to **LAYERS**. The **ABSORPTANCE** is the fraction of normally incident radiation which is absorbed, while **ROUGHNESS** uses code-numbers to specify the quality of the outer surface which is important in determining the nature of the outside air film. Note that in the definition of **LAYERS** only the inside air film is specifically indicated and should be so specified by using the **INSIDE-FILM-RES** keyword and <u>not</u> a **MATERIAL** keyword.

The remaining partitions, ceilings and floors are on the inside of the building and their construction is adequately described as quick walls with a U-value.

```
CEIL-1      =CONS       U=.8  /*CONSTRUCTION OF CEILING*/        ..
PART-1      =CONS       U=10  /*FALSE PARTITIONS*/                ..
FLOR-1      =CONS       U=.05 /*SLAB ON GROUND*/                 ..
DOR-1       =CONS       U=1.0 ROUGHNESS=6  /*BACK DOOR*/         ..
```

Note that the back door, **DOR-1**, uses the keyword **ROUGHNESS** and a U-value. **ROUGHNESS** and **ABSORPTANCE** may only be used on exterior walls, although the U-value style of **CONSTRUCTION** may be used on either interior or exterior walls. The U-values for inner walls should include a contribution from the air film on <u>both</u> sides of the wall.

The building construction information is completed by specifying the glazing via the **GLASS-TYPE** command:

```
WINGLS-1    =GLASS-TYPE       PANES=2 GLASS-SHADING=.86          ..
DORGLS-1    =GT               GTC=3  /*FRONT DOOR*/               ..
```

DOE-1 allows two alternative methods for defining window glass. For **WINGLS-1** the number of panes is given as 2 and the ASHRAE shading coefficient[3] is given as .86. This completely defines the transmission,

---

[3] See the Reference Manual and the <u>1977 ASHRAE Handbook of Fundamentals</u> for the shading coefficients of a wide variety of windows.

reflection and absorption properties of the window. For **DORGLS-1** the second method or **GLASS-TYPE-CODE** (**GTC**) was used. The program allows eight different values (1 to 8) for **GLASS-TYPE-CODE**. Each value corresponds to a different set of transmission, absorptance and reflection properties.[4] The user may use either the **GLASS-SHADING** or the **GLASS-TYPE-CODE** keywords, but never both. Note that for **DORGLS-1** the number of panes has been allowed to default to one.

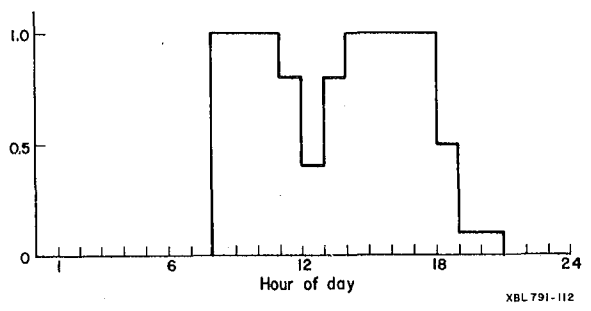
B.2.c Schedules

The interior loads of a building depend upon the movement of people, the intensity of the lighting, the operation of equipment and the amount of infiltration. To account for these loads on an hourly basis DOE-1 divides the task into two parts: a schedule profile which indicates the relative intensity of each of these components for each hour of the year and maximum load for each component which is modulated (multiplied) by the appropriate schedule profile. In this sub-section the input of schedule profiles is discussed.

The fundamental idea to be kept in mind when establishing a schedule is that every hour of the year must be accounted for, even if the run period is less than a year. In DOE-1 this is facilitated through three commands. The first, **DAY-SCHEDULE**, calls for the assignment of a relative intensity for each of the 24 hours of a day. The period from midnight to 1:00 A.M. is called hour 1; from 1:00 A.M. to 2:00 A.M. is hour 2 and so on up to the period from 11:00 P.M. to midnight, which is hour 24. Thus the first command in the Schedule sub-section is:

```
DAYSC-1     =DAY-SCHEDULE     (1,8) 0 (9,11) 1 (12,14) .8,.4,.8
                              (15,18) 1 (19,21) .5,.1,.1 (22,24) 0    ..
```

The sequence (1,8) 0 assigns the value 0 to the period from midnight to 8:00 A.M. and similarly (9,11) 1 assigns the value 1 from 8:00 A.M. to 11:00 A.M. The next sequence (12,14) .8,.4,.8 assigns the value .8 to the 12th hour from 11:00 A.M. to 12 noon, .4 to the 13th hour from noon to 1:00 P.M., and .8 again to the 14th hour from 1:00 P.M. to 2:00 P.M. When using this option for specifying the value for each hour, the number of values must equal the number of hours indicated in parentheses immediately before the list of values. The net effect of this command is to produce a 24 hour profile that looks like this:



[4] See the Reference Manual.

The next instruction

```
DAYSC-2          =DS          (1,24) 0          ..
```

uses the abbreviation **DS** for the command **DAY-SCHEDULE** and sets the value equal to zero for the entire 24 hour period.

With these day schedules defined it is now possible to define what happens during a normal work week:

```
WKPEOP-1    =WEEK-SCHEDULE    (MON,FRI) DAYSC-1 (WEH) DAYSC-2    ..
```

This instruction says that the hourly profile will be that described by **DAYSC-1** for weekdays and by **DAYSC-2** for weekends and holidays. As might be guessed from the u-name **WKPEOP-1**, what is being expressed is the fraction of the maximum number of people present in the building at any time during the week.

What has been described in these instructions is the following: No one is in the building from 9:00 P.M. in the evening until 8:00 A.M. in the morning during the week and the building is entirely unoccupied on weekends and holidays. During a work day the entire work-force is there from 8:00 A.M. to 11:00 A.M. In the next hour 20 percent of the people leave for lunch. During the noon hour only 40 percent of the staff are present and that rises to 80 percent from 1:00 P.M. to 2:00 P.M. The entire work-force is present from 2:00 P.M. until 6:00 P.M. and during the next hour half the people leave. From 7:00 P.M. until 9:00 P.M. the hard working executives and janitorial staff who constitute 10 percent of the work-force, remain in the building and leave at the end of that time.

To complete the description of the people density for the whole year, it is now necessary to use the **SCHEDULE** command:

```
PEOPSC-1          =SCHEDULE          THRU DEC 31 WKPEOP-1          ..
```

This is the simplest form of a **SCHEDULE** instruction in the sense that every week of the year is identical. Later in Section 6 more complex yearly schedules will be illustrated.

Since **DAY-SCHEDULE** is a subcommand of **WEEK-SCHEDULE**, all of the data can be written directly under a **WEEK-SCHEDULE** command. Thus to describe the weekly lighting schedule, one could input:

```
WKLITE-1    =WS    (MON,FRI)    (1,8) .05 (9,14) .9,.95,1,.95,.8,.9
                                (15,18) 1 (19,21) .6,.2,.2
                                (22,24) .05
                   (WEH)        (1,24) .05                          ..
```

where **WS** is the abbreviation for **WEEK-SCHEDULE**. The equipment schedule is defined in a parallel manner.

Finally, the **WEEK-SCHEDULE** command is a subcommand of the **SCHEDULE** command and all of the data can be written once in the latter command. In the Example Building this is illustrated in the infiltration schedule:

```
INFLSC-1    =SCH    THRU DEC 31    (MON,FRI)    (1,7) 1 (8,18) 0
                                                (19,24) 1
                                   (WEH)        (1,24) 1                ..
```

Here the infiltration is being set equal to zero during the day when the fans are on, suggesting that the resulting pressurization of the building inhibits infiltration.

B.2.d Building Shade

The reason for specifying the latitude, longitude, altitude, timezone, building azimuth and daylight savings status in the **BUILDING-LOCATION** command is that DOE-1 requires that information to compute the daily motion of the sun relative to the building in order to determine the direction of the solar radiation with respect to the walls, roofs and windows of the building. Where the radiation is prevented from striking the building with full intensity because of an obstruction, DOE-1 must be informed of that fact. It does this through the **BUILDING-SHADE** command.

In the Example Building the only such shading surface is the overhang over the front door. From an energy perspective it is a relatively small surface and will make little difference in its net effect. It has been included here to illustrate the **BUILDING-SHADE** command.

```
BUILDING-SHADE    HEIGHT=5 WIDTH=10 TRANSMITTANCE=0
                  X-BUILDING=52.5 Y-BUILDING=0 Z-BUILDING=9
                  SURFACE-AXIMUTH=180 TILT=180                          ..
```

To understand the input the following procedure is recommended. It can be generalized to any other shading surface. Mentally rotate the surface upwards from its actual position until it lies in a vertical plane and define the normal (perpendicular) to the surface as that direction which points away from the building. In this orientation the horizontal breadth of the surface is the **WIDTH** and the vertical extension is the **HEIGHT**. The **SURFACE-AZIMUTH** is the angle between the building y-axis and the normal, measured in a clockwise direction. If one examines the surface by looking back along the normal, the values for **X-BUILDING**, **Y-BUILDING**, and **Z-BUILDING** are the coordinates of the lower left hand corner of the surface in the building coordinate system. Finally **TILT** is defined as the angle between the z-axis and the normal. Obviously in the vertical orientation to which it has been moved **TILT** = 90 which is its default value. Now let the surface rotate back to its actual position and measure the angle between the z-axis and the normal. This is the value to be entered for **TILT**.

In the case of the Example Building the overhang can be rotated upward until it lies in the surface of the wall above the door. The outwardly drawn normal now points to the South, which is 180 degrees from the y-axis, which has been chosen to point North. Thus **SURFACE-AZIMUTH** = 180. The horizontal dimension in this orientation is 10 feet and the vertical dimension is 5 feet. The position of the lower left corner of the surface has coordinates x = 52.5, y = 0 and z = 9. Now, let the surface rotate back to its actual position; one sees that the normal now points down toward the ground. This is 180 degrees from the direction of the z-axis.

The **TRANSMITTANCE** is the fraction of the direct incident radiation which passes through the shading surface. **TRANSMITTANCE** = 0 implies that the surface is opaque.

It must be emphasized that DOE-1 has no self-shading feature. Shading can only be accomplished by defining a shading surface using the **BUILDING-SHADE** command or by using the **SETBACK** keyword in the **WINDOW** command. The latter will be discussed later in this subsection.

When a building can shade itself, it is necessary to input a fictitious building shade which can accomplish the same thing. The usual practice is to put the shading surface just inside the building wall which is responsible for shading the rest of the building. Such a placement prevents the fictitious surface from shading the wall it is representing, since DOE-1 is smart enough to know that shading can only take place when the shading surface is between the sun and the surface being shaded. For a building with a concave exterior shell several such fictitious shading surfaces might be required. On the other hand the building shade subroutine is time consuming and the user is advised to introduce only those building shades which are energy significant.

In Section 3 the **SET-DEFAULT** command was described. In the Example Building input this command was used as follows:

```
SET-DEFAULT    FLOOR-WEIGHT=70 GLASS-HEIGHT=4
               GLASS-WIDTH=6 GLASS-TYPE=WINGLS-1
               SETBACK=0.5 TEMPERATURE=73          ..
```

The default value for **SETBACK** has been set to 6 inches. Consequently it will not be necessary to specify this keyword in subsequent **WINDOW** commands. All windows will be set back 6 inches from the outer wall surface and the shading subroutine will compute the effect of the resulting shading of the incident solar radiation.

B.2.e Space Conditions

The next section of input illustrates the use of a sub-command. The **SPACE-CONDITIONS** command is used, like the **LIKE** keyword, to reduce the amount of repetitive input. All the keywords attached to the **SPACE-CONDITIONS** command can be inserted in the **SPACE** command. By using the convenience of the **SPACE-CONDITIONS** command, the data may be entered once and later associated with all applicable spaces.

```
COND-1      =SPACE-CONDITIONS      NUMBER-OF-PEOPLE=45
                                   PEOPLE-ACTIVITY=400
                                   PEOPLE-SCHEDULE=PEOPSC-1
                                   LIGHTING-TYPE=2
                                   LIGHT-TO-SPACE=80
                                   LIGHTING-W/SQFT=3
                                   LIGHTING-SCHEDULE=LITESC-1
                                   EQUIPMENT-W/SQFT=1
                                   EQUIPMENT-SCHEDULE=EQUIPSC-1
                                   AIR-CHANGES/HR=.5
                                   INF-METHOD=1
                                   INF-SCHEDULE=INFLSC-1          ..
```

Since most spaces will have an occupancy of 45 people using the same schedule; the same lighting type, wattage per square foot and schedule; and the same density of equipment, it makes sense to place those data in the **SPACE-CONDITIONS** command. Since the number of people is only 5 in **SPACE-2** and **SPACE-4**, the keyword=value pair **NUMBER-OF-PEOPLE** = 5 can be placed explicitly in those **SPACE** commands, overriding the value from **SPACE-CONDITIONS**. **LIGHTING-TYPE** is defined in the Reference Manual and the code-value, 2, signifies fluorescent lamps, vented to the return air as given in the building specifications. **LIGHT-TO-SPACE** = 80 means that 80% of the heat from the lights goes to the space, while 20% goes to the plenum. Not shown here is the **TEMPERATURE** keyword that sets the constant indoor air temperature for the LOADS simulation. It has been allowed to take on the default value of 73 which was established in the **SET-DEFAULT** command. The value was chosen to be between the heating and cooling setpoints as given in the specifications.[5]

B.2.f Infiltration

The remaining keywords in **SPACE-CONDITIONS** refer to infiltration. The user has an option of two different infiltration algorithms (air-change or crack) by setting the keyword **INF-METHOD** equal to 1 or 2 respectively. The default, **INF-METHOD** = 0, means that no infiltration occurs.

If the air-change method is chosen, the user should assign a value either to **AIR-CHANGES/HR** or to **INF-CFM/SQFT** to specify the magnitude of the infiltration. The **AIR-CHANGES/HR** keyword tells the program to compute the infiltration as a linear function of wind speed from 0 infiltration at zero wind speed through the specified value of **AIR-CHANGES/HR** at 10 knots, independent of the direction of the wind. If **INF-CFM/SQFT** is used, no correction is made for wind speed, i.e., the value specified

---

[5] Although DOE-1 allows the user to set different values of the **TEMPERATURE** keyword in different spaces, the user is warned not to make the **TEMPERATURE** different for two spaces separated by an **INTERIOR-WALL**. The reason is that this passes to SYSTEMS a false load which cannot be corrected by the ASHRAE algorithm used by SYSTEMS in its floating temperature routine.

is the amount of infiltration, modified only by the infiltration schedule. For both of these keywords the diurnal variation of the infiltration can be modified by specifying the **INF-SCHEDULE**.

If the crack method is chosen, ordinarily an infiltration schedule should not be used. The user should select infiltration flow coefficients for the windows and walls and specify the values for the keyword **WALL-INFILTRATION** (**WIF**) in the **CONSTRUCTION** command and the keyword **GLASS-INFILTRATION** (**GI**) in the **GLASS-TYPE** command. A value should also be given for the keyword **NEUTRAL-ZONE-HT** in each **SPACE**. This value specifies the signed distance from the midpoint of the space to the point on the building where the inside-outside pressure difference due to the stack effect vanishes.

These fairly complex rules are summarized in the BDL SUMMARY and typical values for WIF and GI are found in the Reference Manual and in the 1977 ASHRAE Handbook of Fundamentals.

B.2.g Space Descriptions

What remains is the description of each of the spaces in the building. The user is reminded here of the hierarchy mentioned in Section 5.A. LDL is informed of the assignment of external and internal walls to a space and of the assignment of windows to a wall by the order of input. The rules for these assignments are as follows:

1) All **EXTERIOR-WALL**, **INTERIOR-WALL**, **UNDERGROUND-FLOOR** and **UNDERGROUND-WALL** commands are assigned to the previous **SPACE**.

2) All **WINDOW** commands are assigned to the previous **EXTERIOR-WALL**.

The Example input obeys these rules by using the following format:

```
SPACE
  EXTERIOR-WALL (if any)
    WINDOW's (if any)
      .
      .
      .
  EXTERIOR-WALL
    WINDOWS (if any)
  UNDERGROUND-FLOOR (if any)
  INTERIOR-WALL's (if any)
  UNDERGROUND-WALL (if any)
```

The first space defined is the plenum space:

```
PLENU-1     =SPACE            FLOOR=AREA=4500 SPACE-HEIGHT=3
                              VOLUME=13500 FLOOR-WEIGHT=5
                              ZONE-TYPE=UNCONDITIONED                  ..
PLWL-1        =EXTERIOR-WALL  HEIGHT=3 WIDTH=100 AZIMUTH=180
                              CONS=EXTW-1                              ..
               EW             LIKE PLWL-1 WIDTH=45 AZIMUTH=90          ..
               EW             LIKE PLWL-1 A=0                          ..
               EW             LIKE PLWL-1 W=45 A=270                   ..
ROOF-1        =ROOF           HEIGHT=45 WIDTH=100 AZIMUTH=180 TILT=0
                              CONS=ROF-1 GND-REFLECTANCE=0             ..
CEILING-1     =INTERIOR-WALL  AREA=1056 NEXT-TO SPACE-1 CONS=CEIL-1    ..
CEILING-2     =IW             AREA=396 NEXT-TO SPACE-2 CONS=CEIL-1     ..
               IW             LIKE CEILING-1 NEXT-TO SPACE-3           ..
               IW             LIKE CEILING-2 NEXT-TO SPACE-4           ..
               IW             AREA=1396 NEXT-TO SPACE-5 CONS=CEIL-1    ..
```

Since the keyword **SPACE-CONDITIONS** is not used, none of the data from the **SPACE-CONDITIONS** subcommand are passed to this space and consequently many defaults of keywords become operational. The dimensions of the space are given and a very light floor weight is specified, indicating that there is little thermal mass in this region.[6] The keyword=value pair **ZONE-TYPE = UNCONDITIONED** simply tells the program that this space is neither heated nor cooled.

The four surrounding exterior walls are defined next. Since each is 3 feet high and made of the same construction, the **LIKE** keyword is used to repeat the data given in **PLWL-1** with the exceptions given immediately afterwards. **PLWL-1** is the South wall of the plenum space. The next three are oriented East, North and West respectively. Note that no x, y and z coordinates are specified for the walls. Since nothing can shade these walls, it is not necessary to locate them geometrically in the building coordinate system. Since the **GND-REFLECTANCE** keyword is not specified, it will default to 0.2.

The **ROOF** command is a synonym for the **EXTERIOR-WALL** command. The synonym is chosen as a mnemonic to remind the user that a roof is being described. As with the **BUILDING-SHADE** instruction the **HEIGHT, WIDTH, AZIMUTH** and **TILT** are defined by rotating the roof until it is vertical and following the procedures described earlier, when discussing the **BUILDING-SHADE** command. The choice here was to rotate the roof about its Southern-most edge until it is in a vertical plane. The outwardly drawn normal points South. Thus **AZIMUTH** =180 and, when the roof is restored to its actual position the normal points straight up in the dirction of the z-axis. Therefore **TILT** =0. Also, since the ground is invisible to the roof, there is no solar radiation reflected from the ground onto the roof and thus **GND-REFLECTANCE** =0.

---

[6] In DOE-1 the floor weight actually used is 30 lb/ft^2 for any value less than 50 lb/ft^2.

The inner walls in the case of the plenum space, **PLENU-1**, are the portions of the ceiling that separate PLENU-1 from the other spaces. Note that this is the last time these walls are mentioned. It is important not to mention the partition between two spaces more than once. Having dealt with the ceiling in **PLENU-1**, it is not necessary to deal with the ceiling when describing, say, **SPACE-1**.

```
SPACE-1  =SPACE                 SPACE-CONDITIONS=COND-1 FA=1056 SH=9
                                V=9504                                  ..
WALL-1     =EW                  HEIGHT=9 WIDTH=15 AZIMUTH=180
                                CONS=EXTW-1 MULTIPLIER=5                ..
WIND-1       =WINDOW                                                    ..
WALL-2     =EW                  LIKE WALL-1 WIDTH=25 X=45 M=1           ..
DOOR-1       =WI                GLASS-HEIGHT=7 GLASS-WIDTH=6 SETBACK=0
                                GLASS-TYPE=DORGLS-1 J=9.5               ..
FLOOR-1    =UNDERGROUND-FLOOR   AREA=1056 CONS=FLOR-1                   ..
```

In **SPACE-1** all the data from **COND-1** is applicable and is incorporated by using the keyword **SPACE-CONDITIONS**. In fact it is superfluous to specify both the **SPACE-HEIGHT** and **VOLUME**, since DOE-1 is concerned only with the **VOLUME**.[7]

The next entry in **SPACE-1** is **WALL-1**, which is actually one of the 5 identical panels along the South face of the building. The keyword **MULTIPLIER** tells DOE-1 that this wall is repeated for a total of 5 times. This allows the user to specify only one window, **WIND-1**, since each panel contains a single window. As mentioned in Section 3, all the values of the necessary keywords for the **WINDOW** command have been specified in the **SET-DEFAULT** command. Consequently their omission in **WIND-1** results in the default values being used.

The South wall is completed by describing the sixth panel which contains the front door. **WALL-2** is the same as **WALL-1** except that it is 25 feet wide and there is only one panel. The keyword X has been specified since there is a shade over the door and the physical location of the wall relative to the shade now becomes important.

The door itself, being glass, is described as a window. It is necessary to specify the required keywords, since none of the default values established in the **SET-DEFAULT** command apply. The keyword J is the x-coordinate in the plane of the wall of the lower left hand corner of the window relative to the lower left hand corner of the wall-section previously defined. The keyword K which is the corresponding y-coordinate has been allowed to take on its default value 0 since the door is flush with the bottom of the wall.

---

[7] When the user uses **SPACE-HEIGHT** and omits **VOLUME**, the program computes the **VOLUME** by multiplying the **SPACE-HEIGHT** by the **FLOOR-AREA**. If the user specifies both **SPACE-HEIGHT** and **VOLUME**, DOE-1 uses the input **VOLUME** and ignores the potential discrepancy with **SPACE-HEIGHT** x **FLOOR-AREA**, due perhaps to a typographical error.

Finally the concrete-on-ground floor is described in **FLOOR-1**. The inner ``walls'' separating **SPACE-1** from **SPACE-2**, **SPACE-4**, and **SPACE-5** are listed under thoses spaces and thus should not be repeated here.

SPACE-2 should provide no difficulty to the new user. It has only three panels on its external wall as indicated by the M = 3 keyword=value pair. The fictitious walls between **SPACE-2** and **SPACE-1** and **SPACE-3** are described with **CONSTRUCTION** given by a large U-value.

The next interesting input occurs in **SPACE-3** where a trick is utilized to simulate the back door. The pertinent instructions are:

```
EW      LIKE WALL-2 A=0                          ..
  WI    LIKE DOOR-1 GLASS-WIDTH=10
        GLASS-HEIGHT=9 M=0                       ..
  EW    WIDTH=10 HEIGHT=9 A=0 CONS=DOR-1         ..
```

The first instruction establishes a wall 25 feet by 9 feet and oriented toward the North. The second instruction is the tricky one. At first glance it looks as though a window is being placed in the wall, except that the dimensions of the window are the same as those of the back door. At the end of the instruction the keyword **MULTIPLIER**, abbreviated here as **M**, is given the value 0. This tells LDL that a section is being taken out of the original wall of the correct dimensions, but it is not to be treated as a window. LDL will arrange things so that the heat transmission through the window is multiplied by the **MULTIPLIER**, i.e., by zero. Therefore, there will be no contribution to the loads from this window. The last instruction describes a wall with **CONSTRUCTION** = DOR-1 of just the right dimensions to fit into the hole made by the previous **WINDOW** command.

In DOE-1 this is the only way to describe a door which is not made of glass. The user must be very careful, when using this trick, to describe the door after all the windows on a wall have previously been described. the reason for this is that LDL takes the space for a subsequent **WINDOW** command out of the immediately previous **EXTERIOR-WALL**. If the user should inadvertantly describe the door first and then describe windows, LDL will try to put the windows on the door. When all the area of a wall has been used up with windows, LDL prints an **ERROR** message saying that the allowable area has been exceeded.

For similar reasons it is not possible to describe two doors on the same wall. If the user is faced with such a situation, there are two possible solutions: 1) combine the doors into one door of twice the area, or 2) break the wall into two sections, describe each separately and attach a door to each section.

Finally, it will be noted that the pseudo-window and door have not been located in space along the wall. Since the sun strikes the North wall only in the early morning and late afternoon during the Summer and in any case there is no shading on that surface, such positioning is not necessary.

B.2.h Hourly Reports

The final input to LOADS is a series of instructions which generate hourly reports for certain quantities of interest. The first instruction

```
REPTSCHD-1        =SCHEDULE        THRU JUL 15 (ALL) (1,24) 0
                                   THRU JUL 16 (ALL) (1,24) 1
                                   THRU DEC 31 (ALL) (1,24) 0        ..
```

tells LDL that the report wanted is for each of the 24 hours of the 16th of July. Generally one may indicate any hours one wants out of the entire year by labelling those hours with the code-number 1 and all other hours with the code-number 0. Remember that all hours of the year must be accounted for, one way or the other.

The next three instructions

```
REPTBLK-1         =REPORT-BLOCK    VARIABLE-TYPE=BUILDING
                                   VARIABLE-LIST=6,23                ..
REPTBLK-2         =REPORT-BLOCK    VARIABLE-TYPE=GLOBAL
                                   VARIABLE-LIST=6,20,21,22          ..
REPTBLK-3         =R-B             V-TYPE=DOOR-1 V-L=13,15           ..
```

describe the data on which reports are desired. In Chapter II of the Reference Manual is a list of available variables on which hourly reports can be made. These variables are divided into groups designated by the keyword **VARIABLE-TYPE**. They are then identified within each of these groups by code-numbers. The variables chosen for the Example Building are those which provide some information on the effect of the overhang over the front door:

BUILDING
- 6- Building load due to solar radiation through window (Net building heating load)
- 23- Building load due to solar radiation through window (Net building cooling load)

GLOBAL
- 6- Cloud amount (0.0 to 10.00)
- 20- Cloud cover multiplier (0 to 1)
- 21- Direct normal solar times Cloud cover multiplier
- 22- Diffuse solar on horizontal surface times Cloud cover multiplier

DOOR-1
- 13- Solar energy transmitted through glass
- 15- Heat through window by radiation

The last group, labeled with the u-name **DOOR-1**, takes its variables from the window **VARIABLE-TYPE**.

The last instruction in this subsection collects the report blocks into an hourly report.

```
SOLAR      =HOURLY-REPORT      REPORT-SCHEDULE=REPTSCHD-1
                               R-B=REPTBLK-1,REPTBLK-2,REPTBLK-3      ..
```

There is room on the computer print-out for 9 variables to be reported on a single page. If the total number of variables listed exceeds 9, the report will require two or more pages for a single hour's report.

The user is encouraged to make frequent use of the hourly reports both in LOADS and SYSTEMS. Often one can get a much better feeling for how well one has modelled the building or the system by observing the hourly data than from the monthly total alone.

B.3 Summary of LOADS input

Having been through a detailed description of the input for the LOADS simulation, the reader can now appreciate the logic of the overall input deck structure. Obviously a certain structure is imposed upon the user by the space-wall-window hierarchy. Another element of structure is brought in by the fact that generally speaking a command can be referenced by another command (i.e., subcommands or referenced commands mentioned by a keyword in another command) only if it has been previously defined. For example, the **SPACE-CONDITIONS** command must be given before the **SPACE** command that refers to it. The exceptions to this rule are:

(a) A **SPACE** referred to by a **NEXT-TO** keyword in the **INTERIOR-WALL** command. The **SPACE** command may precede <u>or</u> follow the IW command.

(b) The **LAYERS** command need not precede the **CONSTRUCTION** command that refers to it.

(c) The **REPORT-SCHEDULE** and **REPORT-BLOCK** commands need not precede **HOURLY-REPORT**

Finally **BUILDING-SHADE** commands must precede all **SPACE** commands and <u>ipso facto</u> all **EXTERIOR-WALL** and **WINDOW** commands. There will be no problems if the user places the commands in subsections as illustrated in the Example Building with one exception. If the **SHADING-SCHEDULE** keyword in the **GLASS-TYPE** command is used, the corresponding schedule must precede it. This is illustrated in Section 8.B.2.

C LOADS Output

Governed by the **LOADS-REPORT** code-words, listed by the user, a number of reports are generated by DOE-1. These are described in Appendix 2. In addition, the following information is passed from LOADS to SYSTEMS for each of the 8760 hours of the year for each space:

1) Space sensible loads - separate values for each component (i.e., walls, glass, infiltration, etc.)

2) Space latent loads

3) Electric loads due to lights and equipment

4) Space CFM due to infiltration

5) Plenum sensible loads, including the heat due to lighting which is passed to the return air stream.

The full hourly weather tape is also reread as SYSTEM performs its simulation. In addition certain design information is also provided from LOADS to SYSTEMS:

1) Building peak coincident sensible and latent loads

2) Space floor areas, volumes, and construction types

3) Space peak loads

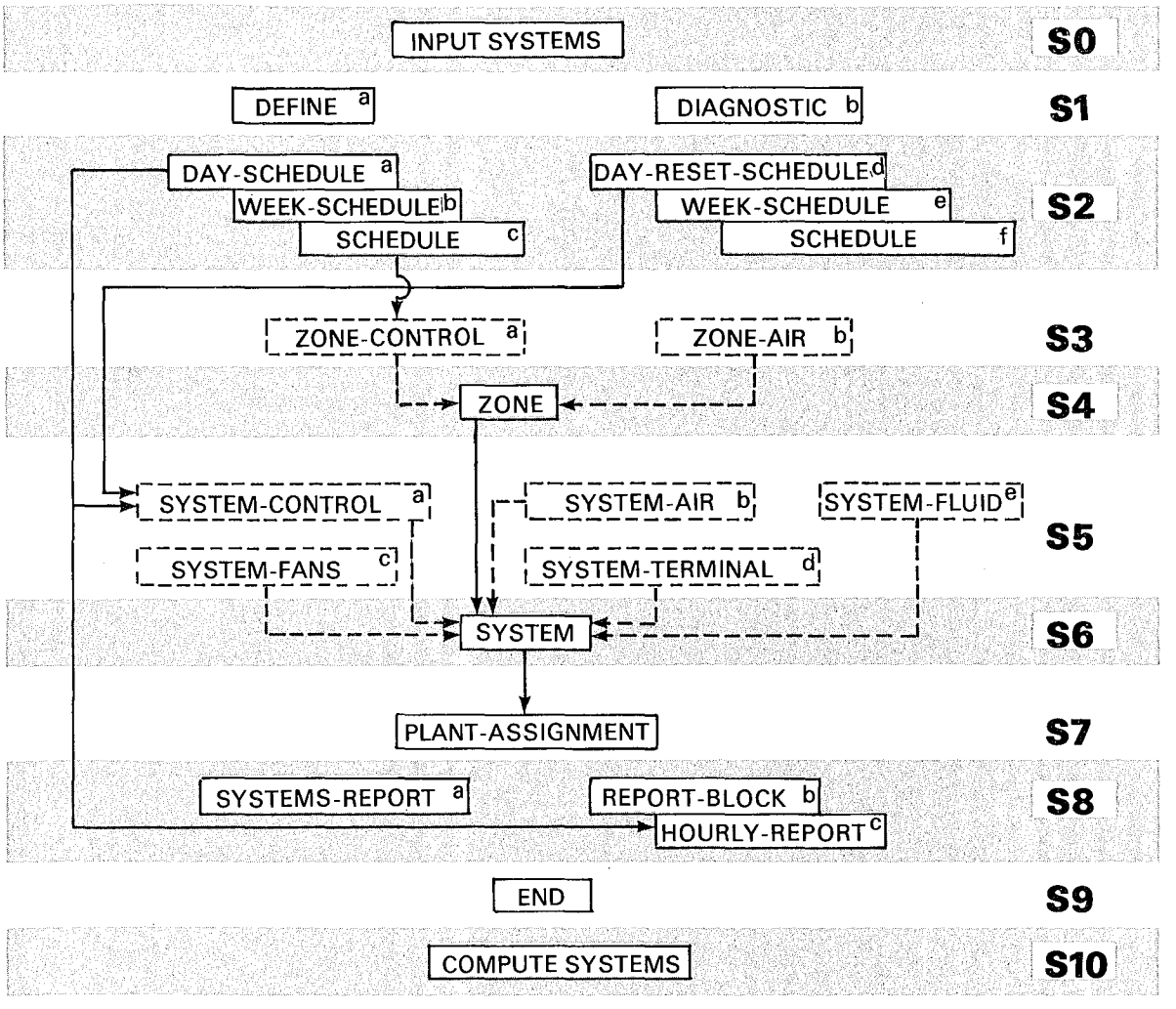
4) Surface conductances of each space

5) Location and heat transfer coefficients of internal partitions.

If the user specifies **DESIGN-DAY** data, all of the above information is passed to SYSTEMS, but only for the days specified.

The next step is to understand how to prepare input for the SYSTEMS simulation.

SYSTEMS COMMAND CHART



——— Referenced command routing

– – – – – Subcommand routing

XBL 7811-12785

Section 6 - SYSTEMS

A Introduction

Fifteen years ago when building energy analysis programs were first introduced, the SYSTEMS section was the least complicated section of the entire program. The loads calculated in the LOADS section were passed to SYSTEMS and two corrections were made. Heat gains and losses due to the provision of the minimum outside air required for ventilation were calculated as well as the effect of an economizer damper to simulate how cooling loads were reduced when outside air temperatures were below 60 to 65°F. Beyond these two calculations no process in the HVAC system was recognized as very significant. These inadequately estimated coil loads were passed directly to primary equipment simulations that determined the part-load efficiency of operation of boilers, chillers, pumps, cooling towers, etc.

Only recently has the HVAC industry begun to recognize the importance of the energy distribution systems in the building's energy use. DOE-1 reflects this new awareness and its SYSTEMS simulation gives primary importance to the individual operating characteristics of the numerous air and water distribution systems. The net result is a tremendous improvement in accuracy, but at a cost to the casual user. DOE-1 requires a much more detailed understanding by the user of how systems operate than did earlier energy analysis programs. A general description of types of systems is given in subsection 6.B of this manual and the options presently available in DOE-1 are listed in subsection 6.C. More detailed descriptions of the DOE-1 systems types can be found in the Reference Manual.

Another innovation of DOE-1 is the treatment of floating temperatures. In LOADS the space temperatures are assumed to be constant, and the thermal loads are calculated at a single set-point. In SYSTEMS the set-point temperatures may be reset for day-night and summer-winter conditions. The floating temperature routine[1] calculates the thermal response of the building when no mechanical heating or cooling is

---

[1] The floating temperature routine is based on the ASHRAE algorithm developed by G.P.Metalis and D.G.Stephenson (See 1977 ASHRAE Handbook of Fundamentals, Chapter 25). This algorithm treats the perturbation of a non-linear system in the neighborhood of a known nominal solution, the LOADS calculation. It uses the mathematical technique of ``transform functions'' and the zone temperatures are computed using the ``Z'' transform function equation. This equation is solved simultaneously with another that describes the thermostat with the coil maximum and minimum heat extraction/addition rates as boundaries. Under conditions where space heating or cooling loads are not met, the temperatures are allowed to float. Users may, using **HOURLY-REPORTS**, display this information for both temperature and humidity levels.

ocurring. It simulates the decay in space temperatures when the systems are turned off and the lag in recovery of space temperatures when the systems are turned back on. Finally this routine takes into account the throttling range of the thermostat and the limitation of equipment heating and cooling capacities. All of these interactions are significant to the energy transferred on coil surfaces and this is the energy that is relevant to the primary energy sources, the concern of the PLANT simulation. It should be stressed that designers who want to investigate the actual energy demands on the building plant must run the SYSTEMS simulation.

B General Discussion of Systems

Once the new user has understood the structure used for the LOADS input, there should be little difficulty in preparing the SYSTEMS input from a structural standpoint. The major problem most users have is that DOE-1 offers a high degree of flexibility for SYSTEMS input. To use this flexibility wisely requires a concommitantly higher level of knowledge of HVAC systems of the user than was required by previous energy analysis programs. In these earlier programs the user could simply assign the name of the desired system and the program would pull from its file all of the necessary features. To a degree this can be done with DOE-1 by relying on default values and prestored control methods. This is not the recommended procedure, however, and is an option to be used only until the user feels comfortable with specifying the many commands and keywords explicitly.

It is the purpose of this subsection to describe the properties of HVAC systems for users whose knowledge in this area is limited. It is important to know what various systems do and not know them only by what they are called . This discussion will stress the common features and heritage of various systems rather than concentrating on their differences. In each case the DOE-1 code-word for the **SYSTEM-TYPE** keyword is linked to the discussion in the title.

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

1. Variable Air Temperature Systems (Constant Volume)

2. Reheat Systems (Constant Volume)

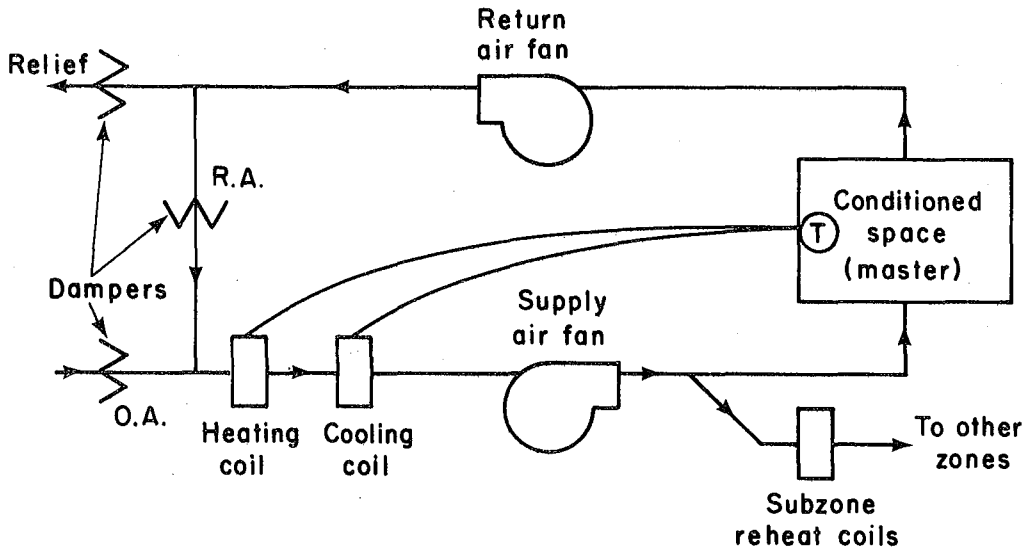
3. Air Mixing Systems (Constant Volume)

4. Variable Air Volume Systems (Constant Temperature)

5. Hybrid Systems - A mixture of Systems 1 through 4

B.1 Variable Air Temperature Systems (Constant Volume)(SZRH)

The beginning of air conditioning industry really started with variable air temperature single zone systems. Remember the theaters back in the 1930s and 1940s with the big advertisements — ``COOL INSIDE.'' True, it was cool, but the humidity soon began to make the patron very



Variable Air Temperature System

Figure 4

XBL 791-123

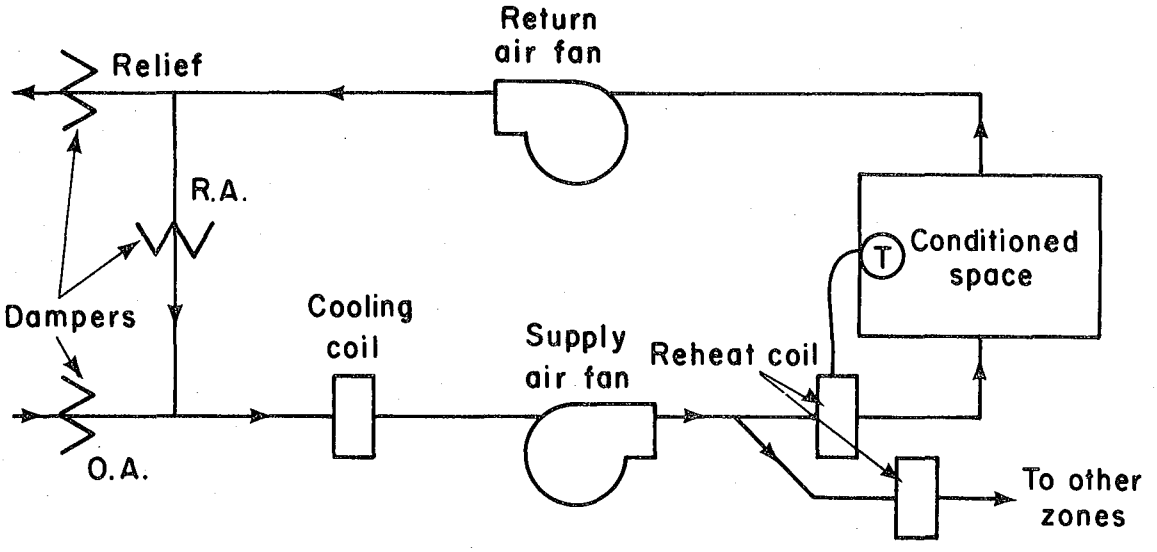
uncomfortable as these systems paid no attention to dehumidification.

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

B.2 Reheat Systems (Constant Volume) (RHFS)

Reheat Systems were a natural outgrowth of the single zone variable air temperature system. As can be seen from Figure 5, the location of the reheating coil is downstream of the cooling coil so that all supply air is cooled as well as dehumidified (the supply air is maintained at a constant temperature).

This makes the cooling extraction rate unresponsive to space loads, whereas the reheat is responsive to space loads, but inversely so. For example, when space heat gains are at their maximum, reheating is not



Reheat System

Figure 5

XBL 791-124

required to hold space temperatures. However, as space heat gains decrease, reheating must increase to compensate for the disappearing space heat gains. Under all conditions the cooling coil cools the air to a constant temperature fixed for the maximum anticipated loading. This is, therefore, an energy intensive system. In humid climates, the reheat system is the system that is used most often to insure that space relative humidities are maintained at their design set points.

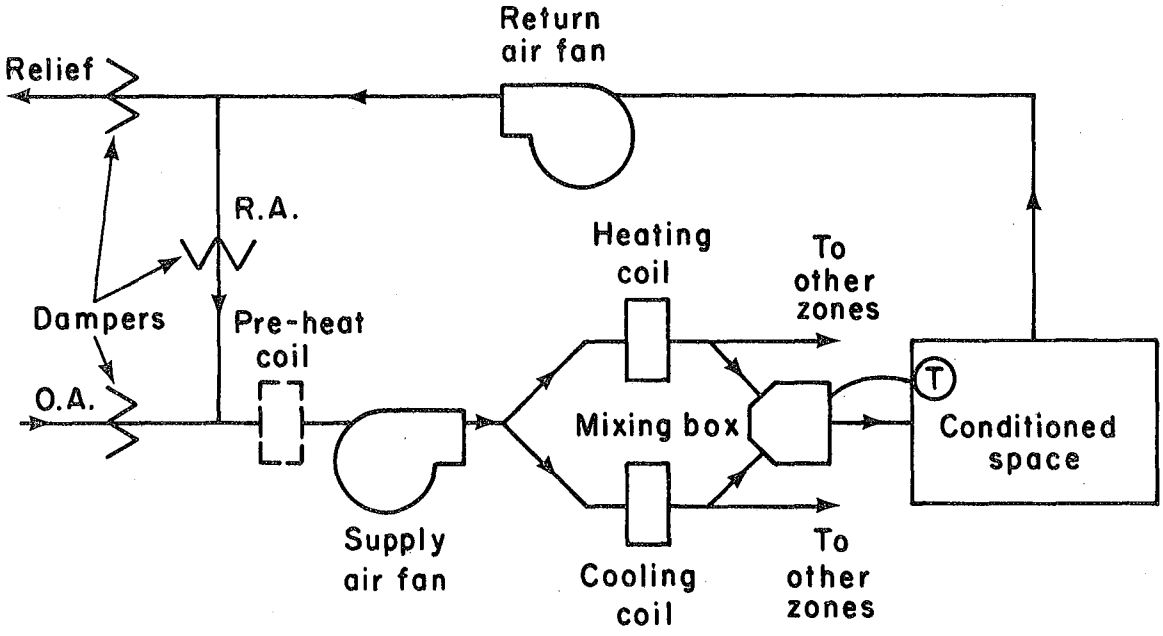
B.3 Air Mixing Systems (Constant Volume) (DDS and MZS)

These systems are commonly referred to as Dual Duct and Multi-Zone Systems. They control space temperatures by the mixing of two air streams, one of which is above the space temperature and the other below the space temperature. These systems were much in vogue in the 1960s but they were recognized to be almost as energy consuming as reheat systems. Refer to Figure 6 for a schematic of a Dual Duct System.

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

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

If, on the other hand, the hot deck is 155°F and all other criteria remain unchanged, then the cold deck will pass 4 parts, and the hot deck 1 part, to cancel each other. The cooling and heating energy expended on the excess air for these two hypothetical cases is 1.6 times as much for the second case as for the first.[2] The situation can be even worse as a result of over-designing since the net effect of providing twice the air flow rate to this space over that necessary to satisfy its peak heat gains (at the 155°F hot and 55°F cold deck temperatures) results in



Dual Duct System

Figure 6

XBL 791-121

3 to 4 times as much energy being expended.

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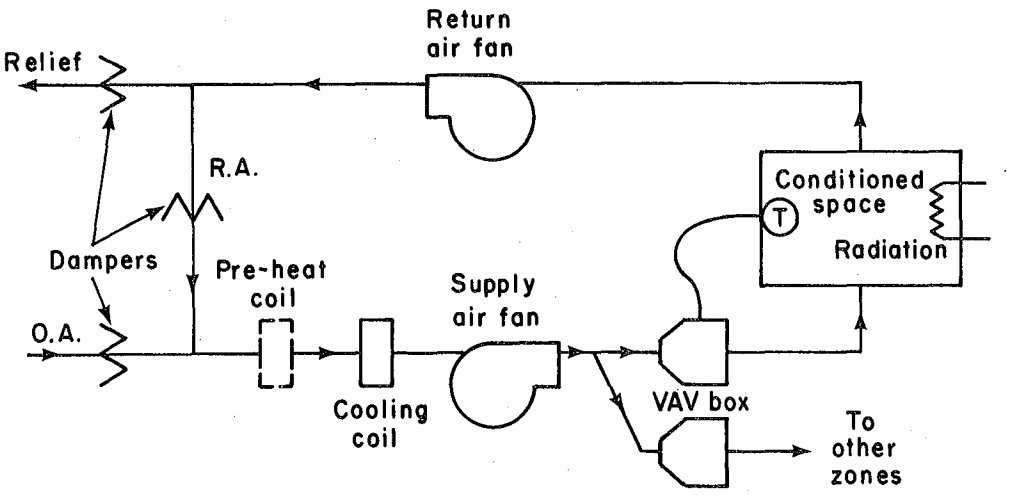
[2] The ratio of the heating plus cooling energy required to condition the excess air in case 2 relative to case 1 is given by

$$\frac{T_{H_2} - T_S}{T_{H_1} - T_S} \cdot \frac{T_{H_1} - T_C}{T_{H_2} - T_C}$$

where T_{H_1} and T_{H_2} are the hot deck temperatures in the respective cases, T_C is the cold deck temperature and T_S is the zone set temperature.

B.4 Variable Air Volume (Constant Temperature) (VAV)

Variable Air Volume systems (Figure 7) are the least difficult of systems to understand. With a decreasing heat gain in the space, the system responds directly with a corresponding decrease in (cold) air supply to the space. Most systems have a minimum beyond which the air supply is no longer decreased. The ratio of this minimum air-flow-rate to the design air-flow-rate is referred to as **MIN-CFM-RATIO** in this program. Since building codes often dictate the minimum allowable outside air change rate for the recirculated air supply to an occupied space, the **MIN-CFM-RATIO** keyword may be used to ensure meeting this requirement. Normally, if a space is occupied, the heat gain from lights and people will require a minimum air supply, however, in perimeter spaces with large glass areas the heat losses of the glass may offset the heat gains from lights and people. It is then necessary to set the minimum cfm ratio to provide sufficient ventilation air; and either reheat or baseboard radiation is used to offset the cooling effect of the minimum allowable air supply. DOE-1 allows one to simulate the baseboard under



VAV System

Figure 7

XBL 791-122

the control of the space thermostat or as reset by outside temperature.

B.5 Hybrid Systems

a. Hybrid Systems are defined as a combination of any of the first four systems described. For example, we have VAV-Reheat Systems with a 0.50 **MIN-CFM-RATIO**. Typically, this system acts as a VAV system if the total air supply is above the **MIN-CFM-RATIO** setting. Whenever the system supply air needed is equal or less than that allowed by the **MIN-CFM-RATIO**, the system conforms to a standard reheat system.

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

c. Ceiling Induction (SZCI) systems are truly variable volume systems which have a 50% minimum supply air set point. The unique feature of these supply air terminals is that as the cooling load and thus the supply volume decreases, a damper opens to allow the induction of ceiling plenum air into the supply air stream. Since the ceiling return plenum has picked up light heat, introducing this higher temperature air into the supply stream results in the control of space temperature. Thus the space sees an almost constant volume of recirculated air whereas the main fan system sees a reduction of air, as space loads decrease. The user should set **MAX-HUMIDITY** = .009 or less to insure moisture removal and should also be careful that the first zone assigned requires the most cooling.[3]

d. Ceiling Bypass Systems (CBVAV). These systems are another type of system where the supply air device reduces the volume of supply into the space in response to space loads. But, in doing so, the air box relieves the excess air back into the ceiling plenum. Therefore, the main supply fan <u>sees</u> a constant volume system with colder air returning to the air handling unit in response to a reduction in space heat gains. This system has gained favor in small commercial buildings both as a new system and as a retrofit to terminal reheat low pressure duct systems.

e. Variable-Air-Temperature/Constant-Volume-Reheat/Air-Mixing-Systems. When we add a discriminator control to reset the supply air temperature to satisfy the warmest or coldest zone, we have combined two of these three system types. Limits can be placed on how high the cold air temperature is reset by the value given to **MAX-HUMIDITY**.

B.6 Other System Types

a. Fan Coil (TPFC and FPFC). Fan Coil Units are either 4-pipe units (i.e., a heating coil plus a cooling coil) or 2-pipe where a single coil in each zone serves to cool in the summer and to heat in the winter. Depending on the type of control, the unit conforms to either variable air volume or variable temperature systems. If the fan speed is modulated or the fan is cycled, the system conforms to a VAV system since pulsing the flow of air is no different from modulating the flow of air. The net result is the same. On the other hand, a unit which modulates the flow of water to the coil(s) conforms to a variable air temperature system. Outside air for fan coil systems is normally assigned to the interior zone air systems

---

[3] Otherwise, subsequent zones would be deprived of the coolest air, since the supply air temperature is controlled by the requirements of the first zone named in this system type.

(when available), although in mild climates and for small commercial and residential units, fan coil units are often supplied with fixed minimum outside air intakes.

b. Induction Systems (TPIU and FPIU). Induction units are very similar to fan coil units in concept, and can be either two pipe or four pipe units. The difference lies in the motivating force for circulating air through the coil(s) which in induction units is effected by a high velocity jet of air leaving the nozzles to induce secondary air flow through the coil. The power to induce air is derived from the primary air fan system, whereas individual fan motors provide the motivating force in fan coil units.

One of the most significant aspects of induction units is that the primary air supplied to the space normally has a humidity ratio low enough to completely absorb the space moisture gains. This allows the cooling coils of induction units to operate dry, and only to do sensible cooling.

c. California Heat Pump (HP). The California Heat Pump, which is also referred to as the Reverse Cycle System, can be simulated by this program. These systems are composed of small self-contained cooling/heat-pump units connected to a common water circuit. Units on cooling reject heat to the circuit, and those units on heating utilize this low temperature heat source and pump it up to a higher level. A hot water generator is a supplemental heat source when the majority of units are heating. An evaporative cooler is used to reject heat to the atmosphere when the majority of units are cooling.

d. Heating Only Systems. DOE-1 has the capability to simulate a number of heating-only systems which the user may specify. They are as follows:

i. Unit Heaters (UHT)

ii. Unit Ventilators with fixed outside air (UVT)

iii. Radiant Floor Panels (FPH)

iv. Baseboard Radiation

The first three types of heating-only units are described in the Reference Manual in detail. They are especially useful for buildings which were built before air conditioning became so popular and are now the subject of retrofit studies.

Baseboard radiation can be simulated with all systems except Floor Radiation Panels (FPH). The user must specify a value for the keyword **BASEBOARD-RATIO** (the ratio of the heating capacity of the baseboards to the total heating capacity of the zone). In addition, the user must specify the kind of **BASEBOARD-CONTROL**, either **OUTSIDE-RESET** (the default) or **THERMOSTATIC**. The former requires a **BASEBOARD-SCHEDULE**, while the latter uses the **HEAT-TEMP-SCHED**.

These keywords will be described later.

Heating and Ventilating Units with outside air cooling can be simulated using the Single Zone Reheat System (SZRH) with the **COOLING-SCHEDULE** set to zero at all times. In this case the keyword **OUTSIDE-CONTROL** should be given the value **TEMP** and the keyword **ECONO-LIMIT-TEMP** set equal to 95 to prevent the outside air dampers from returning to their minimum open position.

e. Recovery Systems. The DOE-1 program allows the user to simulate a coil-run-around heat recovery cycle. The input is very easy; all that is needed is to specify under the **SYSTEM** command the keyword **RECOVERY-EFFECT**. A 60% efficient sensible heat recovery would be input as **RECOVERY-EFFECT** = 0.6. Heat recovery is especially applicable to air systems that require a large percentage of outside air in relation to supply air. A note of caution to the user: The program can simulate the exhaust air coil positioned only in the relief (or exhaust) air duct. Exhaust air assigned to any zone(s) through the **EXHAUST-CFM** keyword will not be included in the recovery effect. To simulate heat recovery from exhaust air the user must employ the keyword **RETURN-CFM** instead of **EXHAUST-CFM**. Suppose, for example, the user wants to simulate a system with 100% outside air being supplied to laboratory hoods, which in turn are venting exhaust air to a heat recovery system. Rather than specifying the exhaust air using the keyword **EXHAUST-CFM** in the **ZONE-AIR** command, the user must use the **RETURN-CFM** keyword in the **SYSTEM-AIR** command. In other words the exhaust system must be treated as though it was in fact a relief air system.

f. Sum. The user may assign the code-word **SUM** to **SYSTEM-TYPE**. **SUM** is primarily used for diagnostics; it is not a real system. If the keyword=value pair **VARIABLE-TEMP** = **OFF** is used, the program will sum all of the space loads passed to SYSTEMS ignoring schedules and ventilation air. If **VARIABLE-TEMP** = **ON** is used, the program will sum all of the space loads as adjusted by the floating temperature subroutine with scheduled heating and cooling but will ignore outside ventilation requirements. The SUM system can be informative for residential buildings where one wants to know the actual loads under a floating temperature situation with night set-backs and set-ups.

C The DOE-1 System Types

There are presently 16 different system types in DOE-1 with separate code-words assigned to them. If the reader will refer to this Book or to the Sample Run Book, he/she will find inputs representative of the following systems.

0) SUM - No example presently available.

1) SZRH - Single Zone-Sub Zone Reheat. See Sample Run Book - Medical Building : Atrium - Page 373.

2) MZS - Multizone System. See alternative sample run in this manual - Appendix 3.

3) DDS - Dual Duct Fan System. See Sample Run Book - Office Building :
   Run #1 - DDS - CV - Page 130
   Run #2 - DDS - VV - Page 364
   Run #8 - DDS - CV w/Discriminator Controls - Page 251.

4) SZCI - Single Zone-Ceiling Induction. See Sample Run Book - Office Building : Run #7 - Page 234.

5) UHT - Unit Heater. No example presently available.

6) UVT - Unit Ventilator. See Sample Run Book - Office Building : Run #10 - Basement Storage - Page 300.

7) FPH - Floor Panel Heating System. No example presently available.

8) TPFC - Two Pipe Fan Coil. See Sample Run Book - Office Building : Run #8 - Page 251.

9) FPFC - Four Pipe Fan Coil. See Sample Run Book - Medical Building : Office Area - Page 373.

10) TPIU - Two Pipe Induction Unit System. See Sample Run Book - Office Building : Run #9 - Page 275.

11) FPIU Four Pipe Induction Unit System. See Sample Run Book - Office Building : Run #10 - Page 300.

12) VAVS - Variable Volume Fan System. See Sample Run Book - Office Building :
   Run #5 - VAV w/Baseboard Thermostatically Controlled - Page 206
   Run #6 - VAV w/Baseboard Reset by O.A. - Page 220
   Run #10 - VAV for Interior Area - Page 300.

13) RHFS - Reheat Fan System. See Sample Run Book - Office Building :
   Run #3 - RHFS-Constant Volume - Page 178
   Run #4 - RHFS-Variable Volume - Page 192.

14) HP - Unitary Heat Pump System. No example presently available.

15) CBVAV - Ceiling Bypass System. See baseline sample run in this manual - Appendix 3.

The user will also find a list of applicable keywords for each SYSTEM-TYPE in the BDL Summary.

With this introduction to types of systems available on DOE-1, the next step is to describe the input for the Example Building.

D Example Building Input

D.1 Systems Specifications

To describe the SYSTEMS input it may be helpful to describe the mental processes that the engineering designer goes through to design a system for a new building. Bracketed figures that appear in this discussion correspond to specific program input in Section 6.D.6, so that the user may correlate the systems specifications with the appropriate commands and keywords.

When the architect first shows the engineer the basic drawings for the building certain criteria for the building are established and a number of questions for the engineer must be answered: How is the building to be used? Will there be room for an air distribution system in the ceiling? Will humidity control be required for winter? For summer? The small size of the building will dictate the type of refrigeration equipment, but the choice must still be made on the method of heating. Will there be fin radiation under the windows, or will all the heating be done with heating coils in the air distribution system?

The architect will also establish the hours of occupancy and the lighting levels and operating hours during the week and on weekends. These data have already been incorporated into the LOADS input as well as the engineer's decision on how to divide the building into thermal zones.

Assume from the answers to the above questions that the engineer selects a Ceiling Bypass Variable Volume System [15] with heating coils at each terminal box [13]. He chooses a supply air temperature of 55°F [7] which is also to be reset to satisfy the warmest zone [9]. The maximum temperature of the reheat coils is designed to be 105°F [8] or, during start-up, to be 50°F above the supply air temperature, whichever is smaller [13]. He/she then decides to use an enthalpy controlled economizer [11] set to return to minimum outside air at 72°F [16]. The control system is a proportional type thermostat set at 70°F in winter and 75°F in summer with a throttling range of 2°F (±1°F) [5]. The ceiling plenum will be used for return air [6] and [17]. To meet the building code a ventilation of 7 cfm per person is chosen [4], and a minimum recirculation rate of 30% of the design supply volume is established [14]. He/she wants a humidity override control to keep the humidity ratio below .01 lb water/lb air and to humidify in the winter to insure that the minimum humidity is above 40% RH at 70°F space temperature [10].

About the only items left undecided are the periods the equipment is to be operated. The architect has said the building will be occupied from 8:00 A.M. to 5:00 P.M. for five days a week with occasional use evenings and on Saturdays. The engineer wants to program the equipment to reflect this usage; therefore, he/she will specify that the air handling units shall operate from 7:00 A.M. to 6:00 P.M. weekdays, but will be turned off on weekends during the cooling season. From January through March and from November through December the air handling units

shall operate continuously [1]. The heating equipment will be available the whole year when the fans are on with a night and weekend setback to 50°F [2], while the cooling system will be turned on from April 1 through October 31 with a night and weekend setup to 99°F [3]. In this way all equipment will be conditioning one hour prior to occupancy to pick up the load in the morning and stay on one hour after normal working hours to simulate occasional use on weekends and evenings. From experience the engineer knows that the supply fan static pressure will be about 3.5 inches TSP (total static pressure), the return fan static pressure 1.0 inches TSP and the fan efficiency approximately 66 percent [12]. Her/his fan selection will be a packaged air handler.

The engineer would also like to compare the Ceiling-Bypass system with a five zone Multi-Zone system that would be less expensive to install [18]. He/she would want to control the hot deck to satisfy the coldest zone [18] and the cold deck to satisfy the warmest zone.

D.2 Example Building Input

In the previous subsection describing the engineers thought processes in designing the system for the Example Building, the discussion was intentionally not ordered to match the SYSTEMS input. Every engineer has an idiosyncratic way of thinking about a system and its application to a particular building. The input for DOE-1, however, does have certain rules which must be followed as described in Section 3 on the Building Design Language. The Example Building input described here should be viewed as a structural guide to be followed; the user will learn in time what liberties exist and what deviations may be made from the guide format. Again the reader is advised to take the Example Building input from Appendix 4 and to have it available as the line-by-line input is described below.

The first two lines of the SYSTEMS input are

```
INPUT SYSTEMS                                                    ..
SYSTEMS-REPORT    VERIFICATION=SV-A SUMMARY=SS-A                 ..
```

The first line has already been discussed and must initiate the SYSTEMS input. Because of a peculiarity in the echo routine of BDL, it will appear in print-outs as the last line in the LOADS section. The user, however, should view it as the first line of the SYSTEMS input.

The second line specifies the reports desired from the SYSTEMS simulation. The **SUMMARY** report is always provided, whereas the **VERIFICATION** report is optional and must be specified, if desired. The decription of the **SUMMARY** report and its format is given in Appendix 2.

The next section of input treats the scheduling of equipment and control systems. The bracketed numbers refer to the engineer's description provided above.

[1]

```
FAN-1     =SCHEDULE     THRU MAR 31     (ALL)     (1,24) 1
                        THRU OCT 31     (WD)      (1,7) 0 (8,18) 1
                                                  (19,24) 0
                                        (WEH)     (1,24) 0
                        THRU DEC 31     (ALL)     (1,24) 1                ..
```

The air-handling schedule is being described here. The non-zero entry (in this case 1) for the periods January through March and November through December tell SDL that the fans are operating continuously all day and every day. For the period from April through October the fans are on only from 7:00 A.M. to 6:00 P.M. during the work days and are off (code-number 0) otherwise. The u-name **FAN-1** was chosen to remind the user that a fan schedule is being defined. This schedule has not been designed to conserve energy, but to illustrate a more complex schedule than was provided in Section 5.

The heating schedule is the same as the fan schedule (see **HEATING-SCHEDULE** below); however, it is necessary to schedule the night and weekend temperature setback (see **HEAT-TEMP-SCHED** below).

[2]

```
HEATWK-1    =WEEK-SCHEDULE    (WD)            (1,7) 50 (8,18) 70
                                              (19,24) 50
                              (WEH)           (1,24) 50                 ..
HTEMP-1     =SCH              THRU DEC 31     HEATWK-1                  ..
```

The schedule has been u-named **HTEMP-1** and will be referenced later in the input when it becomes necessary to define the temperature set-points in the various zones. The assumption is that the thermostat is either changed daily by the plant engineer or that it is equipped with an automatic timer.

The scheduling of cooling is a little more complicated and in fact two schedules must be defined to describe the periods of cooling:

[3]

```
COOL-1      =SCH      THRU MAR 31 (ALL) (1,24) 0
                      THRU OCT 31 (ALL) (1,24) 1
                      THRU DEC 31 (ALL) (1,24) 0                        ..
COOLWK-1    =WS       (MON,FRI) (1,7) 99 (8,18) 75 (19,24) 99
                      (WEH)     (1,24) 99                               ..
CTEMP-1     =SCH      THRU MAR 31 (ALL) (1,24) 99
                      THRU OCT 31 COOLWK-1
                      THRU DEC 31 (ALL) (1,24) 99                       ..
```

The first schedule, u-named **COOL-1**, simply states that cooling is available only from April 1 through October 31. The second, **CTEMP-1**, specifies the temperature set-points during the cooling season as being those described in **COOLWK-1**. The system will maintain the temperature at 75°F from 7:00 A.M. to 6:00 P.M. during the week and allow it to drift to

99°F at nights and on weekends.

The next section of DOE-1 input treats the descriptions of the zones. The first command is **ZONE-AIR**, which is a subcommand of **ZONE**. It is under this subcommand that the quantity of air being supplied and exhausted from a zone can be placed. In view of the engineer's specifications it is desirable to use the keyword **OUTSIDE-CFM/PER** (CFM of outside air per person) as in the following instruction:

[4]

ZNAIR-1	=ZONE-AIR	OUTSIDE-CFM/PER=7	..

The u-name **ZNAIR-1** will allow this datum to be supplied to each appropriate zone.[4]

The next subcommand in the SYSTEMS input is **ZONE-CONTROL**. It is here that the user specifies the design temperatures[5] for the zones. The design temperatures should not only be equal to the corresponding temperatures in **HTEMP-1** and **CTEMP-1** during the periods when people are present, but they should bracket the temperature used in LOADS in the

---

[4] The **ZONE-AIR** subcommand contains three different sets of keywords: those treating the supply air to a zone; those treating the outside or ventilation air to the zone; and those treating the exhausted or vent air from the zone. The last set concerns that part of the air which is <u>not</u> returned to the system for recycling.

The supply air can alternatively be specified through the **SUPPLY-CFM** keyword in the **SYSTEM-AIR** subcommand. When this alternative is chosen, the supply air to a zone is made adequate to meet the peak cooling and heating loads of the zone or to supply the maximum heat extraction/addition rates indicated by the keywords **COOL-MAX** and **HEAT-MAX** in the **ZONE** command, if these keywords are used. The choices of which alternatives to use depends upon the type of system and the constraints the user wishes to impose upon the system.

Similarly the specification of the quantity of outside air for a given zone can be made through one of the set of keywords in the **ZONE-AIR** subcommand or through the **MIN-OUTSIDE-AIR** keyword in the **SYSTEM-AIR** subcommand. If both of these are specified, DOE-1 will choose the one that corresponds to the maximum amount of outside air.

See Chapter VD1 of the Reference Manual for a more detailed discussion.

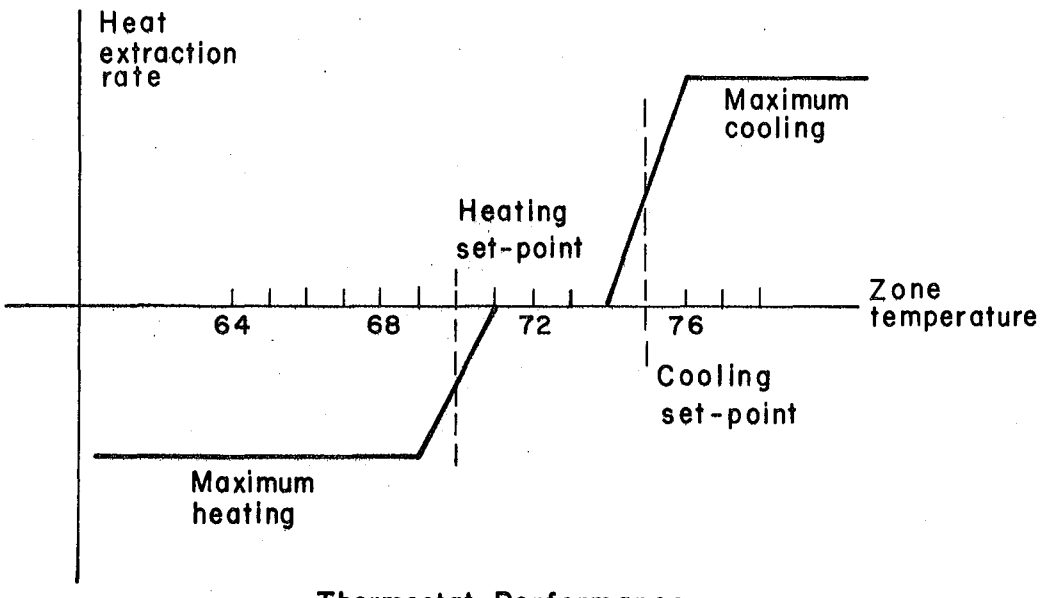
[5] Both **DESIGN-HEAT-TEMP** and **DESIGN-COOL-TEMP** are required keywords in SYSTEMS and must be specified for all conditioned zones, <u>even if the system lacks the capacity for heating or for cooling</u>. Thus a unit heater which has no cooling capability can be modeled in DOE-1 only if **DESIGN-COOL-TEMP** is specified. This is a programming peculiarity of DOE-1 and simply means that an artificial value must be supplied for this keyword.

SPACE-CONDITIONS subcommand (**TEMPERATURE** = 73). Since the LOADS input precedes the SYSTEMS input, this implies once again that the LOADS input must be done with SYSTEMS in mind.
[5]

```
ZNCON-1        =ZONE-CONTROL        DESIGN-HEAT-TEMP=70
                                    DESIGN-COOL-TEMP=75
                                    HEAT-TEMP-SCHED=HTEMP-1
                                    COOL-TEMP-SCHED=CTEMP-1
                                    THERMOSTAT-TYPE=PROPORTIONAL        ..
```

The identification of **HTEMP-1** and **CTEMP-1** with the temperature set-point schedule is made in the third and fourth lines.

The thermostat type chosen by the engineer was proportional and that is indicated in the last keyword=value pair. Since the default value for **THERMOSTAT-TYPE** is **PROPORTIONAL**, this keyword could have been omitted. The throttling range has not been specified since its default is $2^{o}F$ or $\pm 1^{o}F$ from the setpoint, which is what the engineer wanted. This produces a dependence of the extraction rate on temperature as shown in



Thermostat Performance
Figure 8

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Figure 8. There is a dead-band between 71 and $74^{o}F$ in which the temperature will float.

The next series of commands complete the description of the zones:

[6]

```
PLENU-1      =ZONE      ZONE-TYPE=PLENUM                          ..
SPACE-1      =ZONE      ZONE-AIR=ZNAIR ZONE-CONTROL=ZNCON-1       ..
SPACE-2      =ZONE      LIKE SPACE-1                              ..
SPACE-3      =ZONE      LIKE SPACE-1                              ..
SPACE-4      =ZONE      LIKE SPACE-1                              ..
SPACE-5      =ZONE      LIKE SPACE-1                              ..
```

The plenum zone above the ceiling, **PLENU-1**, is specified as a **PLENUM** by using that code word for the keyword **ZONE-TYPE**. Being unconditioned, no other information need be supplied for **PLENU-1**. Since the default for **ZONE-TYPE** is **CONDITIONED**, it is not necessary to specify it in the other zones. Note that exactly the same u-names are used for **ZONE** as were used for **SPACE** in LOADS. SYSTEMS will abort if this is not the case. The use of the subcommands **ZONE-AIR** and **ZONE-CONTROL** as keywords in the **ZONE** command allows the data introduced in those subcommands to apply to the zone **SPACE-1**. Since **SPACE-2,...,** SPACE-5 are made **LIKE SPACE-1**, the same data apply to them as well. Thus each of these zones has 7 cfm per person of outside air supplied, is scheduled to receive heating and cooling as described above and is thermostatically controlled with a proportional type of thermostat.

The next series of commands is concerned with the system as a whole. There are five subcommands to the command **SYSTEM**. Not all of them are applicable to each system. To determine which is applicable the user is directed to the Reference Manual and to the Applicability Tables of the BDL SUMMARY.

The first subcommand is **SYSTEM-CONTROL**:

```
SCON-1       =SYSTEM-CONTROL      COOLING-SCHEDULE=COOL-1
                                  HEATING-SCHEDULE=FAN-1
                                  MIN-SUPPLY-TEMP=55
                                  MAX-SUPPLY-TEMP=105
                                  COOL-CONTROL=WARMEST
                                  MIN-HUMIDITY=.006
                                  MAX-HUMIDITY=.01              ..
```

The first two keywords simply express when the system will be available to provide conditioning: [1] and [3].

[7] **MIN-SUPPLY-TEMP** specifies the minimum supply air temperature for cooling which the engineer chose to be 55°F.

[8] **MAX-SUPPLY-TEMP** sets the maximum supply temperature. These last two temperatures are used along with **DESIGN-COOL-TEMP** and **DESIGN-HEAT-TEMP** to calculate the air flow rates required to meet the cooling and heating loads. The program calculates these two

rates and uses the maximum as the design air-flow-rate.[6]

[9] The engineer wanted the system controlled for cooling so that the warmest zone determines the supply air temperatures. This is accomplished with the **COOL-CONTROL** keyword set equal to **WARMEST**.

[10] Finally the keywords **MAX-HUMIDITY** and **MIN-HUMIDITY** are used to limit the humidity ratio of the system return air. If **MAX-HUMIDITY** = .01 is exceeded, the **COOL-CONTROL** = **WARMEST** is overriden on all but multi-zone and dual duct systems and the supply air temperature is reset as required, but not lower than **MIN-SUPPLY-TEMP**. If the return air humidity is less than **MIN-HUMIDITY** = .006, the program simulates humidification to hold the relative humidity to 40% at 70°F.[7]

The subcommand **SYSTEM-AIR** accomplishes for the command **SYSTEM** what **ZONE-AIR** did for **ZONE**.

[11]

```
SAIR-1        =SYSTEM-AIR        OUTSIDE-CONTROL=ENTHALPY        ..
```

The economizer control is specified by this keyword. Associated with this type of damper control, is another keyword **ECONO-LIMIT-TEMP** which is listed under the **SYSTEM** command. It will be described later.

The nature and characteristics of the fans are described next:

[12]

```
SFAN-1      =SYSTEM-FANS      SUPPLY-STATIC=3.5 SUPPLY-EFF=.66
                              RETURN-STATIC=1.0 RETURN-EFF=.66
                              FAN-SCHEDULE=FAN-1                ..
```

The last subcommand that is applicable to the systems chosen by the engineer is **SYSTEM-TERMINAL**.

```
STERM-1        =SYSTEM-TERMINAL        REHEAT-DELTA-T=50
                                       MIN-CFM-RATIO=.3        ..
```

---

[6] The formula is

$$CFM = \frac{Load}{1.08 \times \Delta T},$$

where ΔT = DESIGN-COOL-TEMP - MIN-SUPPLY-TEMP for cooling and ΔT = DESIGN-HEAT-TEMP - MAX-SUPPLY-TEMP for heating. The actual CFM chosen is then multiplied by a factor to account for the change of air density with altitude and rounded up to the next factor of ten.

[7] From the psychometric chart the humidity ratio of lb H_2O/lb Air is .0062 at 40% relative humidity at 70°F.

[13]The first keyword specifies the maximum temperature difference between the cold supply air and the reheated air.

[14]The keyword **MIN-CFM-RATIO** sets the minimum allowable reduction of air through the terminal box as a ratio of the design air-flow-rate.

Each of these subcommands has been u-named for later reference. The user is reminded that all of the keywords in these commands could have been inserted dirctly into the **SYSTEM** command, which will be covered next. Since only one system is operating at any one time in the Example Building, there was really no point in using the subcommands. No savings in input has been accomplished. They were used here for illustrative purposes. Their major utility occurs when several different systems are operating simultaneously and the same data would apply to all or to some of them.

The culminating command is the **SYSTEM** command:

```
CEILBYPS-1      =SYSTEM      SYSTEM-TYPE=CBVAV
                             SYSTEM-CONTROL=SCON-1
                             SYSTEM-AIR=SAIR-1
                             SYSTEM-FANS=SFAN-1
                             SYSTEM-TERMINAL=STERM-1
                             ECONO-LIMIT-TEMP=72
                             RETURN-AIR-PATH=PLENUM-ZONES
                             PLENUM-NAMES=PLENU-1
                             ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
                                        SPACE-4,SPACE-5,PLENU-1      ..
```

[15]The most important keyword is **SYSTEM-TYPE** whose value must be one of 16 code-words listed in Section 6.C and described in detail in the Reference Manual. The applicable keywords for each **SYSTEM-TYPE** are given in the BDL SUMMARY. In this case the engineer wanted to use a Ceiling Bypass Variable Volume System whose code-word is **CBVAV**.

The next four keywords make reference to the subcommands defined earlier and serve to incorporate the data listed there.

[16]Earlier in **SYSTEM-AIR** the system was set up to bring in outside air to provide cooling when the outside air temperature was cooler than the set-temperature for cooling, subject only to enthalpic considerations. The keyword **ECONO-LIMIT-TEMP** sets the upper limit on the temperature of the outside air to be used in this economizing control system.

[17]The engineer wants the ceiling plenum area to be used as the **RETURN-AIR-PATH** and indicates this by using the code-word **PLENUM-ZONES**. The next keyword **PLENUM-NAMES** goes on to define which of the **ZONES** is a plenum. The effect of these keyword=value pairs is that DOE-1 will calculate the flow of heat between the plenum and the other spaces, incorporate the heat due to the lighting which was provided in LOADS through the **LIGHT-TO-SPACE** keyword in the **SPACE-CONDITIONS** command, and wall and roof loads. All of these

will affect the temperature of the return air and the amount of further heating or cooling that will be necessary to convert the return air into new supply air.

Finally the zones that will be assigned to the system must be specified. In the case of the Example Building, where there is only one system, all the zones including the plenum must be given.

[18]As mentioned in Section 6.D, the engineer wanted to compare the less expensive Multi-Zone System with the Ceiling Bypass System.

```
MULTIZON-1      =SYSTEM     LIKE CEILBYPS-1 SYSTEM-TYPE=MZS
                            HEAT-CONTROL=COLDEST MIN-CFM-RATIO=1
                            PLENUM-NAMES=PLENU-1
                            ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3
                                       SPACE-4,SPACE-5,PLENU-1        ..
```

Here MULTIZON-1 has been defined to be **LIKE CEILBYPS-1** and then given a **SYSTEM-TYPE** of **MZS**. As will be pointed out in Section 9.C, this creates a **WARNING** message since the two systems have different **SYSTEM-TYPE**'s even though they are made **LIKE** to one another. The engineer knows this and can ignore the **WARNING** message. The keyword **HEAT-CONTROL** is set equal to **COLDEST** so that the system will provide a hot deck air flow adequate to meet the heating load of the coldest zone. Note that the keyword **HEAT-CONTROL** belongs to the subcommand **SYSTEM-CONTROL** and yet it is placed here under the command **SYSTEM**. This illustrates the property of a subcommand mentioned earlier. Any of its keywords can be placed in the command to which it is a subcommand.

Setting **MIN-CFM-RATIO** = 1, is equivalent to establishing **MULTIZON-1** as a constant volume system. Ordinarily this keyword could have been omitted since 1 is its default value. In this case, however, it was set equal to .3 under **CEILBYPS-1** and **MULTIZON-1** was made **LIKE CEILBYPS-1**. The consequence of the **LIKE** keyword is to pull all of the values of keywords into the new command. To restore the appropriate value of **MIN-CFM-RATIO** it was necessary to overwrite the **LIKE** keyword by explicitly setting the new value. The plenum and zone assignments are required keywords and must be explicitly mentioned.

The next set of commands tells DOE-1 what systems, among those mentioned, are connected to the plant and are to be considered as contributing to the load seen by the building plant:

```
PLANT-1         =PLANT-ASSIGNMENT       SYSTEM-NAMES=CEILBYPS-1        ..
PLANT-2         =PLANT-ASSIGNMENT       SYSTEM-NAMES=MULTIZON-1        ..
```

Since the two systems being defined are to be considered as alternatives, each must be treated as belonging to a separate plant. The user is warned that, when two **PLANT-ASSIGNMENT**s are made, only the first will be recognized by the subsequent PLANT program.

Finally the commands END and **COMPUTE SYSTEMS** complete the SYSTEM input for the Example Building. The output of the SYSTEMS simulation is described in Appendix 2.

Before proceding to the PLANT input, it may be useful to explore some of the options in the SYSTEMS input.

E Program Options

E.1 Introduction

Throughout the Reference Manual, the user will find several input options for various keywords. The intent of these options may be obvious to the experienced designer; however, others may require further explanation of the options and some examples of how to apply them.

E.2 System-Control Options

E.2.a Heat Extraction Rate

The fundamental equation of the SYSTEMS simulation is

$$\text{Heat Extraction Rate} = 1.08 \times \text{CFM} \times \Delta T$$

where ΔT is either **DESIGN-HEAT-TEMP - MAX-SUPPLY-TEMP** or **DESIGN-COOL-TEMP - MIN-SUPPLY-TEMP**. Obviously if SYSTEMS is to calculate one of these variables, the others must be supplied either by the user or by LOADS. As mentioned in discussing the SYSTEMS input, both **DESIGN-HEAT-TEMP** and **DESIGN-COOL-TEMP** are required input. The same is true of **MIN-SUPPLY-TEMP** for all systems which provide cooling. If **MAX-SUPPLY-TEMP** is not required by a system and is not provided by the user, SYSTEMS will calculate it as **MIN-SUPPLY-TEMP + REHEAT-DELTA-T**, when the latter is provided.

The Heat Extraction Rate is either the peak heating or cooling load from LOADS or **HEAT-MAX** or **COOL-MAX** as provided by the user. When the equation is being used to compute the design air-flow-rate, SYSTEMS calculates all of these possibilities and takes the largest as the design air-flow-rate.

E.2.b Control of Heating and Cooling Coils

An important option is in regard to how the heating and cooling coils are controlled. If the temperature of the cooling air is to be held at a 55°F set point, the user must specify **COOL-CONTROL = CONSTANT** and also declare the temperature by setting the keyword **COOL-SET-TEMP** = 55. Normally the heating temperature of the coils is controlled by the zone thermostats; however, on Multi-Zone and Dual Duct systems, the hot

deck temperature is controlled at the HVAC unit. The user, therefore, must specify tthe method of control. **HEAT-CONTROL = CONSTANT** and **HEAT-SET-TEMP** = 105 is one option, and yet is totally unresponsive to the environment. Another alternative is to reset the hot deck temperatures, depending on the outside air temperature. This option requires a different set of keyword-value pairs, **HEAT-CONTROL = RESET** and **HEAT-RESET-SCHED** = a u-named reset schedule. This sort of schedule is not hourly, but rather is a table of T_{DECK} vs. $T_{OUTSIDE}$. The description of this type of schedule is given in Section 6.E.3.

A final alternative is to use a discriminator control of either the hot deck or the cold deck temperatures, or both. In this case the user sets **HEAT-CONTROL** equal to **COLDEST** to set the hot deck temperature to satisfy the zone requiring the most heating and **COOL-CONTROL = WARMEST** to set the cold deck temperature to satisfy the zone requiring the most cooling.

E.2.c Control of Outside Air Dampers

The control of outside air dampers has three options. **OUTSIDE-CONTROL = FIXED** sets the damper to satisfy a minimum outside ventilation rate. **OUTSIDE-CONTROL = TEMP** allows the dampers to open to provide a cooling effect whenever the outside temperature is below the set-point of the **ECONO-LIMIT-TEMP**. **OUTSIDE-CONTROL = ENTHALPY** allows the dampers to open to provide cooling whenever the total heat content (enthalpy) of the outside air is less than the total heat content of the return air. The **ECONO-LIMIT-TEMP** set-point overrides the enthalpy controller to return the dampers to a minimum when the outside temperature is too high.

E.2.d Fan Control

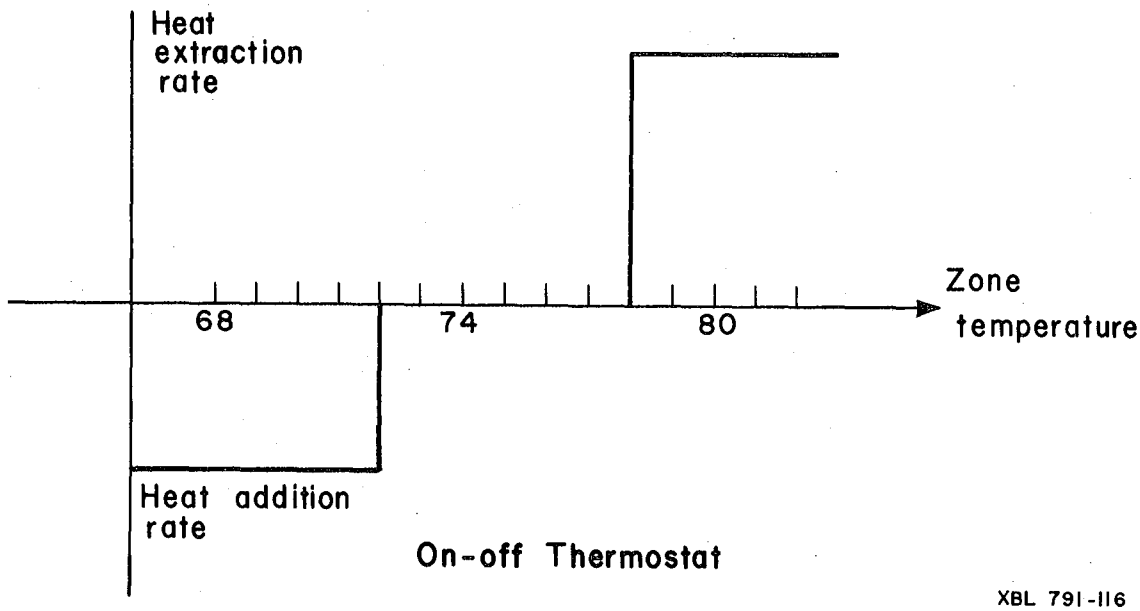
There are three fan control options which allow the user to specify the type of fan control desired to simulate the various Variable Volume Systems. **FAN-CONTROL = SPEED** applies to variable speed motors or fluid drives. It is also the default for constant volume systems since the speed can be held constant. **FAN-CONTROL = INLET** is for fan inlet vane damper control. **FAN-CONTROL = DISCHARGE** is for discharge dampers located at the fan or when the volume controls in terminal VAV boxes are expected to control the system air volume. The effect of these options is to change the electrical load of the fans depending upon how the fans are controlled and their power is altered.

E.2.e Thermostat Types

There are two thermostat types that may be specified by the user: **THERMOSTAT-TYPE = PROPORTIONAL** or **TWO-POSITION**. It is important that this terminology not be confused with that of the manufacturers. The user can model almost every thermostatic control scheme on DOE-1 and yet care should be taken that the scheme described is indeed physically possible with the HVAC system being used. The program does no such check.

There are three general cases to be considered.

Case 1: On-Off Thermostats with Narrow Deadband

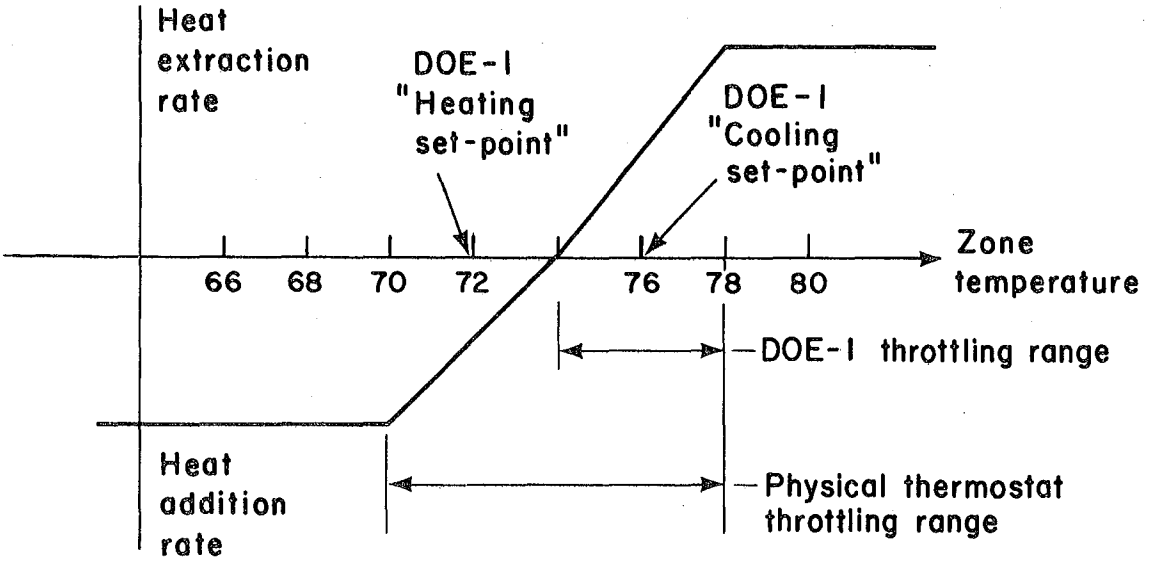


In this example there is heating below 72°F and cooling above 78°F. The input to simulate this consists of the following keywords (in their appropriate commands) and scheduling instructions.

```
                                DESIGN-HEAT-TEMP=72
                                DESIGN-COOL-TEMP=78
                                THERMOSTAT-TYPE=TWO-POSITION
                                THROTTLING-RANGE=*unused*
                                HEAT-TEMP-SCHED=H-SCH1
                                COOL-TEMP-SCHED=C-SCH1
where
H-SCH1        =SCHEDULE         THRU DEC 31 (ALL) (1,24) 72        ..
and
C-SCH1        =SCHEDULE         THRU DEC 31 (ALL) (1,24) 78        ..
```

The schedule could be more complex with night setbacks or setups and the heating or cooling schedules can be omitted if either of these capacities is missing.

Case 2: Single Thermostat with Proportional Range Around a Set-Point that Throttles from Full Heating to Full Cooling.



Proportional Thermostat-Single Set-Point

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Here there is an 8° throttling range around a set-point of 74° with cooling above and heating below. This is simulated on DOE-1 as two setpoints: one for heating and one for cooling with an equal throttling range around each. The input to model this is:

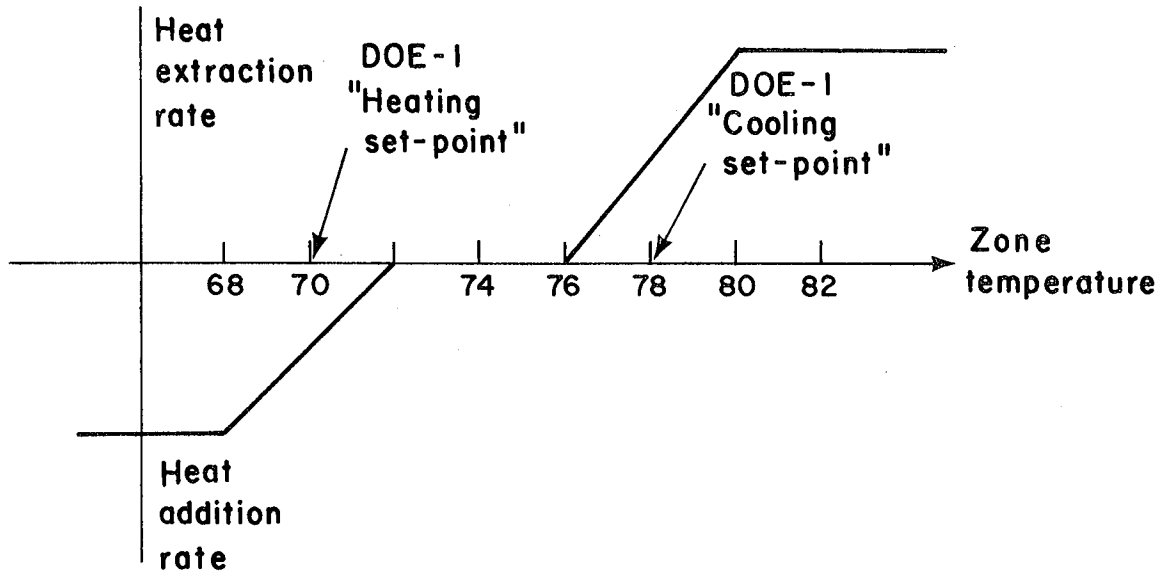
```
                                DESIGN-HEAT-TEMP=72
                                DESIGN-COOL-TEMP=76
                                THERMOSTAT-TYPE=PROPORTIONAL
                                THROTTLING-RANGE=3.99[8]
                                HEAT-TEMP-SCHED=H-SCH2
                                COOL-TEMP-SCHED=C-SCH2
where
H-SCH2        =SCHEDULE         THRU DEC 31 (ALL) (1,24) 72        ..
and
C-SCH2        =SCHEDULE         THRU DEC 31 (ALL) (1,24) 76        ..
```

In this case, if a setback or setup is desired, both schedules must be changed to reflect the movement upwards or downwards of the entire 8° range. If either the heating or the cooling capacity is not present in the system being used, the appropriate schedule is omitted, the remaining schedule set-point and design temperature are set equal to 74 and the throttling range is set equal to 8.

---

[8] Due to an idiosyncracy of DOE-1, the heating and cooling throttling ranges must not overlap, even at a point. Using 3.99 in place of 4.0 for the throttling range avoids this difficulty.

Case 3: Single or Multiple Thermostats with Proportional Range Around Heating and Cooling Set-Points Separated by a Deadband



Proportional Thermostat-Two Set-Points

XBL 791-126

In this example there is a deadband between 72° and 76°. Below 72° there is a throttling range to full heating at 68°. Above 76° there is proportional throttling to full cooling at 80°. To simulate this the input is as follows:

```
                                DESIGN-HEAT-TEMP=70
                                DESIGN-COOL-TEMP=78
                                THERMOSTAT-TYPE=PROPORTIONAL
                                THROTTLING-RANGE=4
                                HEAT-TEMP-SCHED=H-SCH3
                                COOL-TEMP-SCHED=C-SCH3
where
H-SCH3        =SCHEDULE         THRU DEC 31 (ALL) (1,24) 70        ..
and
C-SCH3        =SCHEDULE         THRU DEC 31 (ALL) (1,24) 78        ..
```

Note that all schedules may change hourly and seasonally, allowing day-night and summer-winter and even finer adjustments of set-points. Care must be taken, however, that, where a heating schedule is changed, the cooling schedule may have to be changed correspondingly to preserve the condition of the thermostat being modelled.

E.2.f Return Air Path Options

The return air path for a given air system may be described by three separate code-words. **RETURN-AIR-PATH = PLENUM-ZONE** should be used only if plenum spaces have been described in LOADS with **ZONE-TYPE = UNCONDITIONED** and in SYSTEMS with **ZONE-TYPE = PLENUM**. In addition, the keyword **PLENUM-NAMES** must be set equal to a list of the u-names of the plenum spaces.

RETURN-AIR-PATH = DUCT describes a ducted return air path with a return fan, but the program will also add the heat due to electric lights, if the **LIGHT-TO-SPACE** keyword has been set to less than 100 in LOADS, even though plenums have not been defined.

RETURN-AIR-PATH = DIRECT (the default) is used for Fan Coil units, Unit Ventilators and Heaters, and Single Zone Air conditioning units with no return fan, or generally when no heat from the lights is added to the return air, even if the system has a return fan.

E.3 Schedules

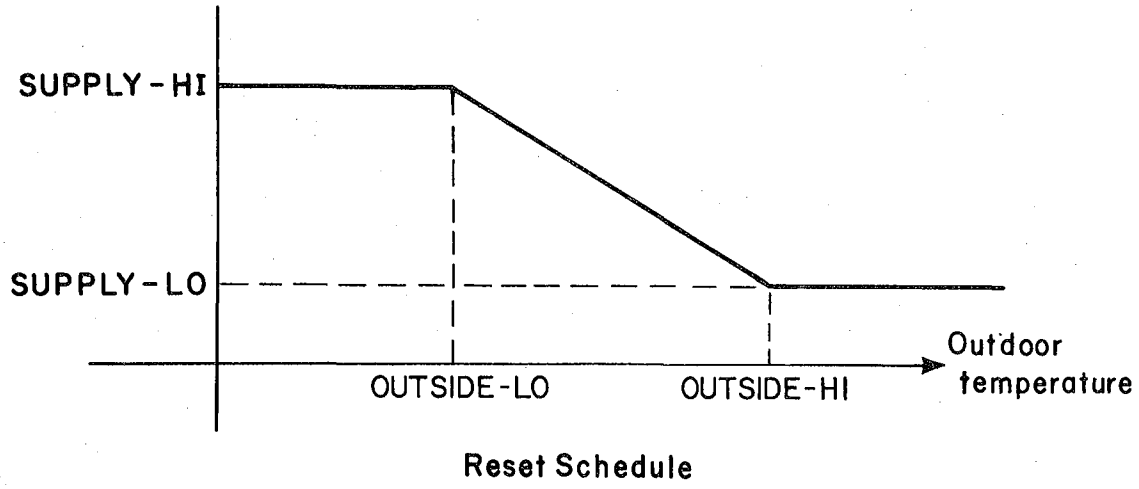
There are three different types of schedules in SYSTEMS: ON-OFF schedules, temperature set-point schedules and reset-schedules.

a) ON-OFF schedules, such as **FAN-SCHEDULE**, **HEATING-SCHEDULE**, and **COOLING-SCHEDULE**, are designed simply to inform the program when equipment is available. The code-number in the **DAY-SCHEDULE** portion of the schedule is 0 for OFF and 1 (or any non-zero number) for ON. The default for not giving an ON-OFF schedule is always ON.

b) Set-point schedules are **HEAT-TEMP-SCHED** and **COOL-TEMP-SCHED**; and the code-number in the **DAY-SCHEDULE** portion of the schedule is the set-point temperature for the hours given. The default, if a set-point schedule is not provided, is the absence of that type of conditioning, regardless of the presence of a **HEATING-SCHEDULE** or a **COOLING-SCHEDULE**.

c) Reset schedules have not been illustrated in the Users Guide to this point. The purpose of a reset schedule is to regulate some control or heating system based upon the outside temperature. The keywords calling for a reset schedule are **BASEBOARD-SCHED**, **HEAT-RESET-SCHED** and **COOL-RESET-SCHED**.

   The reset schedule is the same as a normal schedule except in the **DAY-SCHEDULE** subcommand, for which the DOE-1 equivalent **DAY-RESET-SCHEDULE** is sometimes used. Rather than specifying the hours of the day, the input for **DAY-RESET-SCHEDULE** is through four keywords which serve to specify the coordinates of a straight line:



The important thing to remember is that **SUPPLY-HI** goes with **OUTSIDE-LO** and vice versa.

For the **HEAT-RESET-SCHED** and **COOL-RESET-SCHED** the value of **SUPPLY-HI** is the deck temperature when the outside temperature is less than or equal the value of **OUTSIDE-LO**; and the value of **SUPPLY-LO** is the deck temperature when the outside temperature is **OUTSIDE-HI** or above.

For the **BASEBOARD-SCHEDULE** the value of **SUPPLY-HI** is the fraction of the baseboard heating capacity that is available when the outside temperature is less than or equal to the value of **OUTSIDE-LO**. The value of **SUPPLY-LO** is the fraction of the baseboard heating capacity when the outside temperature is greater than or equal to the value of **OUTSIDE-HI**.

i) Hot Deck Reset Schedule

```
RS1       =DAY-RESET-SCHEDULE     OUTSIDE-HI=90 OUTSIDE-LO=40
                                  SUPPLY-LO=70 SUPPLY-HI=105      ..
HDRS1     =SCHEDULE               THRU DEC 31 (ALL) RS1           ..
```

The purpose of this schedule is to reset a Dual Duct or Multizone System hot deck. It calls for a hot deck of 105°F at 40°F and below outside; of 70°F at 90°F and above outside; and a linear reset for outdoor temperatures between 40°F and 90°F.

ii) Baseboard Reset Schedule

```
BBRS1    =SCH    THRU APR 30 (ALL)    OUTSIDE-HI=70 OUTSIDE-LO=20
                                      SUPPLY-LO=0 SUPPLY-HI=1.0
                 THRU OCT 31 (ALL)    OUTSIDE-HI=70 OUTSIDE-LO=20
                                      SUPPLY-LO=0 SUPPLY-HI=0
                 THRU DEC 31 (ALL)    OUTSIDE-HI=70 OUTSIDE-LO=20
                                      SUPPLY-LO=0 SUPPLY-HI=1.0      ..
```

This schedule provides a linear reset of the baseboard from 100% of capacity at 20°F outside air to 0% capacity at 70°F outside air. It also deactivates the baseboard heating from May 1st through October 31st.

iii) Primary Air Reset for 2 Pipe Induction System

```
PARS1    =SCH    THRU APR 30 (ALL)    OUTSIDE-HI=90 OUTSIDE-LO=40
                                      SUPPLY-LO=50 SUPPLY-HI=50
                 THRU OCT 31 (ALL)    OUTSIDE-HI=90 OUTSIDE-LO=40
                                      SUPPLY-LO=50 SUPPLY-HI=105
                 THRU DEC 31 (ALL)    OUTSIDE-HI=90 OUTSIDE-LO=40
                                      SUPPLY-LO=50 SUPPLY-HI=50      ..
```

Here the primary air is held at a constant temperature during the heating season at 50°F, allowing the heating to be provided by the zone coils. During the cooling season the primary air temperature is reset from 50°F supply air at 90°F outside air to 105°F supply air at 40°F outside air.

E.4 Sizing Systems by Assignment of Zone Air Quantities or Zone Heat Extraction/Addition Rates.

There are two situations where the capability of the user to assign zone cfm quantities or alternatively zone heat extraction/addition rates allow the study of system performance. The first occurs when the user desires deliberately to under-size the system and the other when the user is making retrofit comparisons for existing buildings.

a) There are many proponents of intentionally undersizing systems and plants, as a means of reducing energy use. The main focus of attention has been on the undersizing of refrigeration equipment; however, the user must realize that the DOE-1 SYSTEMS simulation does not know when refrigeration capacities are ``not met.'' This evaluation is made in the PLANT simulation. Rather the user must deliberately undersize the system and then observe the effect on the refrigeration plant loading in the PLANT report to analyze the problem correctly.

The problem is to know how to undersize the system. The solution is to run the SYSTEMS simulation without specifying air-flow quantities. SYSTEMS will provide in its reports the design air-flow-rate for each zone which is adequate to meet the peak load. Undersizing is accomplished either by specifying in the **ZONE-AIR**

command the keyword **ASSIGNED-CFM** with a value less than that sized by SYSTEMS to meet the peak cooling load or by specifying the value of **COOL-MAX** in the **ZONE** command to be less than the peak loads. Running SYSTEMS again using either of these alternatives will result in decreasing the refrigeration load and therefore the equipment size.

By generating hourly reports, the user can then assess the degradation of the space environment and determine whether the savings that result from operating a smaller refrigeration unit is an acceptable alternative.

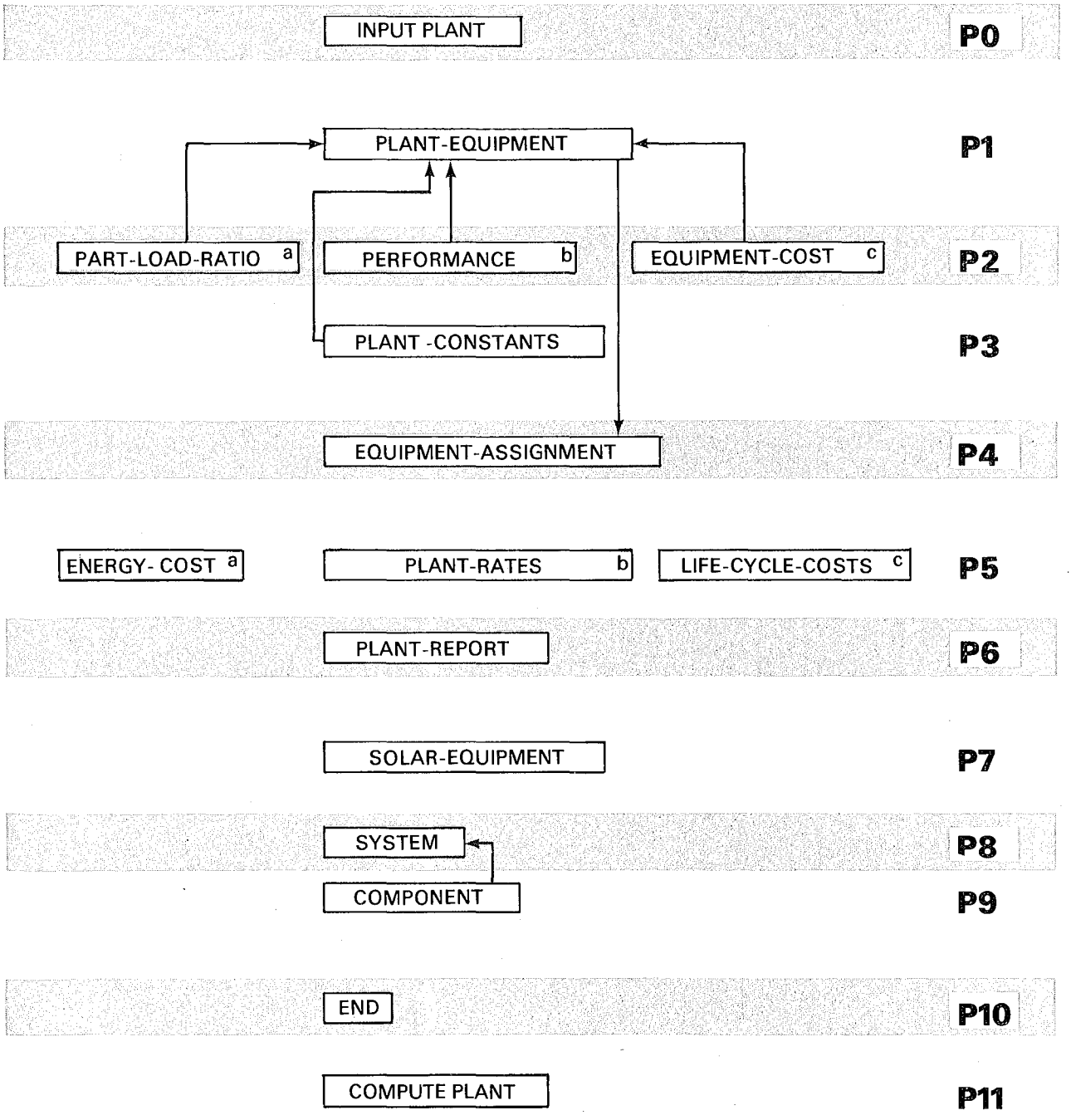
b) When in existing buildings the zone air-flow rates have been measured accurately and are used as input to SYSTEMS, again using the **ASSIGNED-CFM** keyword, there is good assurance that reasonable comparisons between baseline consumption and retrofit measures will occur. Alternatively if maximum heating or cooling capacities are measured, the user may specify **HEAT-MAX** or **COOL-MAX** to accomplish the same thing.

When addressing the retrofit of a constant volume system to that of a variable air volume system, the user should <u>also</u> input under **SYSTEM-AIR** the keyword **SUPPLY-CFM**, especially if the capacity of the fans is to be reduced.

Building retrofits do not always result in the degradation of space environment, but since they often do, DOE-1 is a powerful tool to investigate those negative aspects by using the hourly report capability.

A good analogy to the retrofits of building systems is the replacement of a 330 cubic inch displacement V-8 engine with a 180 c.u.i.d. 6 cylinder engine in a car. The reason this retrofit is widely accepted is that it saves fuel; but the driver of the car must now anticipate the performance required to pass another car or to climb a hill. When systems and equipment capacities are reduced in buildings, anticipation of system start-up loads becomes necessary. Reducing lighting levels or load shedding of electric motors to reduce peak electrical demands also results in the need to anticipate equipment loading.

PLANT COMMAND CHART



XBL7811-12788

Section 7 - PLANT

A Introduction

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

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

For Boilers, Chiller, Electric Utility or Total Energy Plant

Heating Load in MBtu/hr
Cooling Load in MBtu/hr
Electric Load in kW

} As modified by SYSTEMS

For Cooling Tower Simulation

Ambient air temperature in ^{o}F
Humidity ratio in lb water/lb dry air

For Solar Collector Simulation

Weighted average mixed air temperature in ^{o}F
Hourly heating coil energy in Btu/hr
Hourly supply air flow rate in CFM

Electric utility usage is based on a conversion factor called TOTUEF, currently equivalent to 10,239 Btu/kWH, to reflect the energy consumed at the source to create the electricity.[1] All energy conversions are based on actual curve fits of representative equipment. Users should examine the default parameters to be sure that they represent the equipment to be simulated.

---

[1] The keyword TOTUEF in the PLANT-CONSTANTS command has the default of 0.333 and is the fraction of the source fuel energy which is converted to useable electric energy. That efficiency divided into the conversion factor for Btu/kWH (3413) gives the conversion factor above. Since this factor may vary from utility to utility the user is cautioned not to accept the default without investigating the local utility efficiency. Department of Energy reports must be based on 11,600 Btu/kWH or TOTUEF = .294.

B The Engineers Plant Description

The best approach to describe PLANT input is to describe first the mental processes that the engineering designer goes through to arrive at a design for a buiding, using the same building for which LOADS and SYSTEMS input have already been described. Since the building is small there is little question that the engineer will choose reciprocating type refrigeration equipment. The present program limits him/her to one choice and that is a reciprocating chiller connected to a cooling tower. In the future the PLANT program will be expanded to include air-cooled equipment. The engineer is also limited by the program for such a small building to two types of heating: a steam boiler, using either natural gas or fuel oil, or solar heating. Again, the program will be expanded in the near future to include hot water generators and electric resistance heating. For the purposes of the Example Building, there has been no attempt to locate the equipment physically, since this information is not pertinent to energy usage.

To illustrate the PLANT program's ability to accept equipment presized by the engineer (an alternative is to let the program size the equipment) the engineer will presize the boiler and assign costs to it, and let the program size the chiller and cooling tower. The costs for the chiller and cooling tower will be automatically scaled by the program from default values stored in the program library. The engineer has presized the boiler at 0.15 million Btu/hr, assigned a cost of $2000.00 and an installation cost multiplier of 1.4[2], and a maintenance cost of $350/year. The engineer also knows the present electric rate cost is 4.5 cents/kWH and natural gas is 22 cents/therm.

All users should review the default values found for **PLANT-COMPONENTS** in the Table V5 in Chapter V of the Reference Manual, since these values may not be in agreement with those of his/her locale or experience. The user may override the default values by explicitly providing the cost data.

C Example Building Input

The PLANT input described in this subsection must be viewed as the input for a very simple plant. The next subsection will describe some program options. Again the reader is urged to follow the text in the Example Building input in Appendix 4.

The **INPUT PLANT** instruction instructs the computer to recognize the data that follows as PLANT input.

---

[2] Installation cost multiplier equals the cost of equipment plus the cost of installation divided by the cost of equipment, in this case: ($2000 + $800)/$2000 equals 1.4.

The next set of instructions describes the plant equipment:

```
SBOIL-1        =EQUIPMENT        TYPE=STMB NUMBER=1
                                 AVAILABLE=1 SIZE=.15          ..
CHILL-1        =EQUIPMENT        TYPE=COMPR NUMBER=1
                                 AVAILABLE=1 SIZE=-999.        ..
CTOW-1         =EQUIPMENT        TYPE=CTOWR NUMBER=1
                                 AVAILABLE=1 SIZE=-999.        ..
```

The first instruction describes a steam boiler (**TYPE = STMB**) by using the code-word **STMB**. There is one unit and that one is available to be drawn upon. It has been pre-sized at 0.15 million Btu/hr (or 150,000 Btu/hr rated output). For later reference it has been u-named **SBOIL-1**.

The next instruction defines a single reciprocating chiller (code-word **COMPR**). There is one installed and available at all times. The use of **SIZE** = -999. indicates that the user desires DOE-1 to size the equipment automatically, based upon the peak system demand. It is important to include all the equipment to be used, even if the sizing is not specified. DOE-1 will put a cooling tower into the program, if the user does not; however, it will not include the appropriate energy use of the cooling tower.

The engineer specified the cost of the boiler and the data regarding this expenditure is included in the next command.

```
                COST-OF-EQUIPMENT    FOR SBOIL-1
                                     COST=2 INSTALLATION=1.4
                                     MAINTENANCE=350 LIFE=200000
                                     MINOR-OVHL-COST=200
                                     MINOR-OVHL-INVL=4000
                                     MAJOR-OVHL-COST=700
                                     MAJOR-OVHL-INVL=20000        ..
```

The costs for the boiler **SBOIL-1** are specified to be the following: The purchase price (**COST**) is 2 ($2000). The initial cost including installation is 1.4 x 2 or $2800. 350 hours of maintenance per year are required. The useful **LIFE** of the boiler is 200,000 hours, and the program will compute the cost of replacing it as often as necessary during the project life. The boiler will be overhauled every 4000 hours at a cost of $200 each time in current dollars. Major overhauls occur every 20,000 operating hours and cost $700 each time.

The next concern is the cost of energy:

```
                ENERGY-COST      RESOURCE=BOILER UNIT=100000
                                 COST=.22 ESCALATION=10        ..
                ENERGY-COST      RESOURCE=ELECT UNIT=3413
                                 COST=.045 ESCALATION=6        ..
```

For the boiler fuel the unit is 100000 Btu or 1 therm and the cost per unit, i.e., per therm, is $0.22 for the natural gas. The engineer has guessed that this cost will escalate by 10% per year <u>over the general inflation</u>. For the electrical energy the unit is 3413 Btu or 1 kWH.

The cost per kWH is $0.045. Escalation is estimated to be 6% per year over the general inflation for the electrical cost.

The last substantive input treats other economic considerations:

```
LIFE-CYCLE-RATES   DISCOUNT-RATE=10 LABOR-INFLTN=0   ..
LIFE-CYCLE-COSTS   LABOR=25 PROJECT-LIFE=25          ..
```

The discount rate used by the program in calculating life-cycle equipment and energy costs is 10%. What this means is that the money spent on equipment and energy could have been invested and have earned 10% interest. The choice to forego this investment and to spend the money on the environment of the building means forfeiting the earnings. This is a realistic cost that must be included. At the same time the engineer is assuming that labor costs will not rise above nor fall below the general inflation rate. In current dollars the cost of labor which is involved in maintenance is $25/hour. The project life is given as 25 years and is the period over which the life-cycle cost calculation is made. DOE-1 assumes that the weather tape chosen is for a typical year and uses the output of SYSTEMS as the average annual energy usage for the entire project life. The input is completed with the commands **END** and **COMPUTE PLANT** as in the previous sections.

The PLANT output is described in Appendix 2.

D User Options for Plant Configurations

D.1 Introduction

Automatic sizing ought not be used on complicated plant configurations (e.g.,those involving peak shaving or heat recovery, or those supporting complex systems), and the user should enter his/her own cost figures (when known) for equipment rather than allowing default values to be used in the calculation. The user must also realize that since SYSTEMS calculates start-up loads (which can be much greater than operating peak loads) he/she should inspect carefully all equipment sizes from the automatic sizing routines to insure that they are not oversized. Normally, chiller plants should be sized to handle operating peak loads and not start-up loads. To display the space temperatures during the time periods prior to the point that set point temperatures are satisfied, the user must rerun SYSTEMS with the systems deliberately undersized to reflect the capacity of the chillers. The user should remember also that at the point of start up, the humidity ratio inside the building is assumed equal to the outside ambient. This can result in a very high dehumidification load.

The following discussion will serve two purposes — the first to describe various plant configurations and the second to give examples of how and where to use the optional commands itemized below:

PART-LOAD-RATIO
PERFORMANCE
EQUIPMENT-ASSIGNMENT
PLANT-CONSTANTS
SOLAR-EQUIPMENT

D.2 Conventional Plants composed of Two Boilers, Two Centrifugal Chillers and Two Cooling Towers.

The input for this plant would be very much like that in the Example Building described in 7.C, except that two units of each equipment type are desired. However, the cooling tower must be considered as one unit with two cells.

Suppose that the user wants to stage the chillers automatically. It will be necessary to size them in ascending order rather than make them of equal size. The PLANT input would look as follows:

```
            INPUT PLANT                                          ..
SBOIL-2     =EQUIPMENT     TYPE=STMB NUMBER=2
                           AVAILABLE=2 SIZE=10.0                 ..
CHILL-21    =EQUIPMENT     TYPE=COMPC NUMBER=1
                           AVAILABLE=1 SIZE=16.0                 ..
CHILL-22    =EQUIPMENT     TYPE=COMPC NUMBER=1
                           AVAILABLE=1 SIZE=17.0                 ..
CTOW-2      =EQUIPMENT     TYPE=CTOWER NUMBER=2 /*CELLS*/
                           AVAILABLE=2 SIZE=33.0                 ..
            ENERGY-COST    RESOURCE=BOILER UNIT=100000 COST=.22  ..
            ENERGY-COST    RESOURCE=ELECT UNIT=3413 COST=.045    ..
            END                                                  ..
```

D.3 Absorption Chiller Plant with District Steam

Since the loading of a single building does not have a significant impact on a total district steam service, it is adequate to assume that the efficiency of production of steam is a constant over the whole range of building loads. This can be simulated in DOE-1 by supplying a value for the keyword **CONSTANT** in the **PERFORMANCE** command and very small values (e.g., .00001) for the keywords **LINAR-TERM** and **QUADRATIC-TERM** for a steam boiler (indicated by setting the keyword **COEFFICIENT** equal to the code-word **RFUELB**). The peak efficiency that is stored as a default value for a steam boiler at 100% load is approximately 87%. The value set for **CONSTANT** can be made less than unity to account for transmission losses. In this way the input will reflect the source energy used to satisfy the building's needs.

Since the default values stored under the **PLANT-CONSTANTS** command are appropriate for a centrifugal but not an absorption chiller, it will be necessary to change some of these default values. The entering tower water temperature will be changed from the default of 60°F to 85°F and

the capacity of the tower will be increased from 3.0 gpm/ton of absorption chiller capacity to 4.0 gpm/ton. It will be assumed that there is one boiler, one chiller,and one tower, except that the one ceramic cooling tower will have two cells.

```
         INPUT PLANT                                                  ..
SBOIL-3  =EQUIPMENT       TYPE=STMB NUMBER=1
                          AVAILABLE=1 SIZE=10.0                        ..
         PERFORMANCE      COEFFICIENT=RFUELB
                          CONSTANT-TERM=0.9 /*FOR TRANSMISSION LOSS*/
                          LINEAR-TERM=.00001 QUADRATIC-TERM=.00001     ..
ABSORP-3 =EQUIPMENT       TYPE=ABS2 /*TWO STAGE ABSORPTION*/
                          NUMBER=1 AVAILABLE=1
                          SIZE=15.0                                    ..
CTOW-3   =EQUIPMENT       TYPE=CTOWC NUMBER=2 /*CELLS*/
                          AVAILABLE=2 SIZE=12.0                        ..
         PLANT-CONSTANTS  TTOWR=85 RWCA=4.0                            ..
         ENERGY-COST      RESOURCE=BOILER /*DISTRICT STEAM PLANT*/
                          UNIT=100000 COST=0.51                        ..
         ENERGY-COST      RESOURCE=ELECT
                          UNIT=3413 COST=0.045                         ..
         END                                                           ..
```

The user should also enter a cost for the steam line connection to the District Steam Service and <u>not</u> let the program use the default values, which are based on furnishing a boiler plus installation and yearly maintenance. This is accomplished by using the command **EQUIPMENT-COST** and the keywords **FOR** and **COST**. The **INSTALLATION** keyword should be allowed to default to 1 and all other keywords in this command should be set equal to very small non-zero numbers, e.g., to .00001.

D.4 Double Bundle Heat Recovery Chiller Plant with Supplementary Electric Boiler

At present the program is not written to accept an electric boiler; however, a 100% efficient unit throughout its operating range can be simulated. To achieve this set the performance coefficients of a steam boiler as follows

COEFFICIENT = **RFUELB**
CONSTANT = 1.149
LINEAR-TERM = .000001
QUADRATIC-TERM = .000001

In this way the default value for the efficiency of a steam boiler at full load of 87% is cancelled out. Assigning an electric cost rate to **RESOURCE** = **BOILER**, allows the program to calculate the operating cost correctly. Since a steam boiler is being used as the plant equipment, the energy consumed will show up in the PLANT output as heat energy and not electic energy. To compute the actual Electric Source Energy, the user must divide the heat energy by **TOTUEF** (whose default is .333) and add the result to the Electric Source Energy shown in the PLANT output. This will be explained in more detail in the description of the Central

Plant Energy Utilization Summary Report (See Appendix 2).

There are also plant constants and performance coefficients that need to be changed to reflect the double bundle chiller. By changing the **ELECTIC-INPUT-RATIO** value to .25, the electric input is raised for all load ranges due to the double bundle chiller's high lift impeller. This is about 10% higher than the default value of .2275 for the **ELECTRIC-INPUT-RATIO**. A conventional chiller will unload to 10% of its capacity (which is represented in DOE-1 by the default value of .1 for **MIN-RATIO**). To prevent surging as the evaporator load decreases, the user should set **MIN-RATIO** = .3 or higher, which will simulate a false loading of the compressor.

Again it is assumed there is one boiler, one centrifugal chiller, one double bundle chiller, and one tower with two cells.

```
          INPUT PLANT                                                  ..
EBOIL-4   =EQUIPMENT        TYPE=STMB NUMBER=1
                            AVAILABLE=1 SIZE=10.0                      ..
          PERFORMANCE       COEFFICIENT=RFUELB
                            CONSTANT-TERM=1.149 LINEAR-TERM=.000001
                            QUADRATIC-TERM=.000001                     ..
HTREC-4   =EQUIPMENT        TYPE=DBUN NUMBER=1
                            AVAILABLE=1 SIZE=12.00                     ..
          PART-LOAD-RATIO   TYPE=DBUN MIN-RATIO=0.3
                            ELECTRIC-INPUT-RATIO=0.25                  ..
CNTRF-4   =EQUIPMENT        TYPE=COMPH NUMBER=1
                            AVAILABLE=1 SIZE=12.2                      ..
CTOW-4    =EQUIPMENT        TYPE=CTOWR NUMBER=2 /*CELLS*/
                            AVAILABLE=2 SIZE=14.4                      ..
          PLANT-CONSTANTS   TTOWR=85                                   ..
          ENERGY-COST       RESOURCE=BOILER
                            UNIT=3413 COST=0.045                       ..
          ENERGY-COST       RESOURCE=ELECT
                            UNIT=3413 COST=0.045                       ..
          END                                                          ..
```

D.5 Base Loaded Centrifugal Chiller with Absorption Chiller for Peak Shaving of Electric Demand

This system will have two steam boilers, one hermetic centrifugal chiller and one absorption chiller with equipment staged in order of ascending size, i.e., the absorption chiller will come on only if the cooling demand exceeds the capacity of the centrifugal chiller. There will be one tower assigned but with four cells, each of 11.6 MBTU/HR capacity. The program will accept only <u>one</u> tower assignment for any one plant, and the user must divide the total heat rejection by the number of cells available. This treatment may be in conflict with the actual installation for, as in this case, the engineer would in all probability design for two towers of two cells each.

```
            INPUT PLANT                                                 ..
SBOIL-5     =EQUIPMENT          TYPE=STMB NUMBER=2
                                AVAILABLE=2 SIZE=10.0                   ..
CNTRF-5     =EQUIPMENT          TYPE=COMPH NUMBER=1
                                AVAILABLE=1 SIZE=12.0                   ..
ABSRP-5     =EQUIPMENT          TYPE=ABS1 NUMBER=1
                                AVAILABLE=1 SIZE=12.5                   ..
CTOW-5      =EQUIPMENT          TYPE=CTOWR NUMBER=4 /*CELLS*/
                                AVAILABLE=4 SIZE=11.6                   ..
            PLANT-CONSTANTS     RWCA=4.0 TTOWR=85                       ..
            ENERGY-COST         RESOURCE=BOILER
                                UNIT=100000 COST=0.22                   ..
            ENERGY-COST         RESOURCE=ELECT
                                UNIT=3413 COST=0.045                    ..
            END                                                         ..
```

D.6 Total Energy Plant

The design concept of a total energy (TE) plant simulated in the DOE-1 program is conventional. The electric load is met by the diesel generator or gas turbines. Their waste heat dirctly serves the heating requirements and indirectly the cooling requirements through absorption chillers. The steam boiler is only used to supplement the heating and cooling requirements when electrical generation alone does not result in sufficient waste heat.

The user may also specify a steam turbine but it should be understood that the simulation is for a waste steam turbine using a single stage condensing turbine which in turn uses approximately 68,000 Btu/hr per kW (5% efficiency) whereas a modern power plant normally operates above 30% efficiency

The input below is for the system described above without the steam turbine but with one diesel and two gas turbines. The part load efficiency of gas turbines is very poor; therefore, it would be desirable to do whatever load trimming is possible with the diesel generator and to provide equipment assignments to the gas turbines to load them as heavily as possible. When both diesel and gas turbines are operating, the load is split between them in the DOE-1 simulation when in actuality an operator would force load the gas turbine and use the diesel to trim the remaining load. Therefore, one could expect better overall performance from a real system than the results of the DOE-1 simulation will show.

```
         INPUT-PLANT                                                  ..
SBOIL-6  =EQUIPMENT            TYPE=STMB NUMBER=2
                               AVAILABLE=2 SIZE=15.0                  ..
ABSRP-6  =EQUIPMENT            TYPE=ABS1 NUMBER=2
                               AVAILABLE=2 SIZE=10.0                  ..
DGEN-6   =EQUIPMENT            TYPE=DIESL NUMBER=1
                               AVAILABLE=1 SIZE=3.4 /*MBTU/HR*/       ..
         PLANT-CONSTANTS       CTYPE=2                                ..
GTGEN-6  =EQUIPMENT            TYPE=GTURB NUMBER=2
                               AVAILABLE=2 SIZE=6.8                   ..
         EQUIPMENT-ASSIGNMENT  TYPE=GTURB MAX-LOAD=6.8
                               SIZE1=GTGEN-6 ASSIGN1=1                ..
         EQUIPMENT-ASSIGNMENT  TYPE=GTURB MAX-LOAD=13.6
                               SIZE1=GTGEN-6 ASSIGN1=2                ..
CTOW-6   =EQUIPMENT            TYPE=CTOWC  /*SIZED FROM HEAT*/
                               SIZE=28.0   /*REJECTION FROM CHILLER*/
                               AVAILABLE=2 /*AND GENERATORS*/
                               NUMBER=2 /*CELLS*/                     ..
         PLANT-CONSTANTS       RWCA=4.0 TTOWR=85                      ..
         ENERGY-COST           RESOURCE=BOILER
                               UNIT=140000 COST=0.39 /*OIL*/          ..
         ENERGY-COST           RESOURCE=ELECT
                               UNIT=3413 COST=0.09                    ..
         ENERGY-COST           RESOURCE=DIESEL
                               UNIT=140000 COST=0.39                  ..
         ENERGY-COST           RESOURCE=GASTUR
                               UNIT=140000 COST=0.39                  ..
         END                                                          ..
```

D.7 Dummy Plant for HP System

The Reverse Cycle (California) Heat Pump System requires that the user specify a dummy chiller to pass the heat rejected by all of the individual HP units to an evaporative cooler. A cooling tower will be used to simulate the evaporative cooler assuming that the condenser pump energy is approximately equal to that of the recirculating pump on the evaporative cooler, plus the added horsepower needed to overcome the additional static pressure on the air side. The following plant will fit the Medical Building in the Sample Run Book.

```
            INPUT PLANT                                                 ..
SBOIL-7     =EQUIPMENT          TYPE=STMB NUMBER=1
                                AVAILABLE=1 SIZE=0.7                    ..
DUMCH-7     =EQUIPMENT          TYPE=COMPH NUMBER=1
                                AVAILABLE=1 SIZE=0.6                    ..
            PART-LOAD-RATIO     TYPE=COMPH
                                ELECTRIC-INPUT-RATIO=0.001              ..
                                /*CAUTION — DO NOT SET EIR=0.0*/
EVAPCL-7    =EQUIPMENT          TYPE=CTOWR NUMBER=1
                                /*EQUIVALENCED TO EVAP COOLER*/
                                AVAILABLE=1 SIZE=0.9                    ..
            ENERGY-COST         RESOURCE=BOILER
                                UNIT=100000 COST=0.22                   ..
            ENERGY-COST         RESOURCE=ELECT
                                UNIT=3413 COST=0.045                    ..
            END                                                         ..
```

D.8 Plant Utilizing Storage

The present storage routines need to be enhanced before they can be used effectively. In the near future, there will be a means provided to determine when the stored heating or cooling is to be used based on a scheduled time of day or targeted demand peak.

D.9 Solar Heating Plants

The solar design package of DOE-1 is capable of supplying heat to satisfy space heating and 1-stage absorption chiller needs. The solar package is also able to interface with the California heat pump system.

The Reference Manual is quite explicit in its explanation of how to input a SOLAR PLANT.

It should be noted that the PLANT report, CENTRAL PLANT ENERGY UTILIZATION SUMMARY, may give confusing information, when using the solar package. See the report description in the Reference Manual for more details.

ECONOMICS COMMAND CHART

INPUT ECONOMICS	E0
COMPONENT-COST	E1
BASELINE	E2
COMPONENT-RATES	E3
END	E4
COMPUTE ECONOMICS	E5
STOP	E6

XBL 7811-12787

Section 8 — ECONOMICS

A Introduction

The ECONOMICS program has two principle applications:

(1) The determination of the life-cycle cost of a building, including capital, operation, and energy costs. The program can be run on different new building designs and the designs then ranked on the basis of total life-cycle cost.

(2) The determination of the cost effectiveness of an energy-conserving retrofit option on an existing building. Competing options can be ranked on the basis of one or more of the economic statistics that are calculated by the program.

Plant equipment capital costs, plant maintenance costs, and energy costs are calculated in the PLANT program. Costs for non-plant items -- which can include the building itself, secondary systems, insulation, solar collectors, etc. -- are calculated in the ECONOMICS program. The ECONOMICS program adds plant costs and non-plant costs to arrive at the total life-cycle cost of a building.

In addition to calculating total costs, ECONOMICS computes the following economic measures or ``investment statistics:''

- cost saving
- ratio of cost savings to investment
- ratio of energy savings to investment
- payback period.

These statistics are calculated by comparing costs and energy use for the retrofitted building with those input by the user for a baseline case.

B Examples

The examples below show how ECONOMICS can be used to rank design or retrofit alternatives. In the first example, the life-cycle cost of the Example Building with a ceiling-bypass system is compared to the life-cycle cost for the same building with a multi-zone system. In the second example the cost-effectiveness of retrofitting the Example Building (with ceiling-bypass system) by shading the windows during the

cooling season is determined.

B.1 Life-Cycle Cost Comparison of Ceiling-Bypass vs. Multi-Zone System

Description of Problem

It is desired to calculate the life-cycle cost of the Example Building with a ceiling-bypass (CBVAV) system. The purchase price of the system is $25,000, and installation costs $20,000. The system costs $750 a year to maintain. The lifetime of the building is 25 years. The discount rate is 10%.

The next step is to calculate the cost of the same building with an alternative multi-zone (MZS) system that has a purchase price of $15,000, an installation cost of $12,000, and a cost of $750 per year for maintenance.

ECONOMICS Input for CBVAV System

The first instruction follows the pattern of the first three DOE-1 simulation subprograms:

```
INPUT ECONOMICS                                          ..
```

The computer now expects the data that follow to be appropriate for the ECONOMICS program.

The next instruction

```
COMPONENT-RATES   DISCOUNT-RATE=10 PROJECT-LIFE=25    ..
```

sets the discount rate to be 10% per year and the project life (the period over which life-cycle costs will be calculated) to be 25 years. Since these are the default values, this instruction could have been omitted. In any case the values here should agree with the corresponding values in the PLANT simulation.

```
CBVAVCST-1   =COMPONENT-COST   FIRST-COST=25000 INSTALL-COST=20000
                               MAINT-COST=750                    ..
```

Here the cost data for the CBVAV system are defined. The purchase price is $25,000, installation costs are an additional $20,000 and maintenance is $750 per year. (The lifetime of the CBVAV system, given by the keyword **COMPONENT-LIFE**, has been allowed to default to 999 years. This means the system lasts as long as the building and does not have to be replaced. If, on the other hand, the system lasts only ten years, for example, then setting **COMPONENT-LIFE** = 10 would cause the program to compute the replacement cost in year 10 and again in year 20.) The **COMPONENT-COST** command may be used up to 15 times, so that cost data for several different items may be specified.

The last three instructions are now familiar:

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

except that the last is now required since there can be no more input.

Output for CBVAV System

The first report, E01, simply echoes the input cost data for the CBVAV system. It is displayed in Appendix 2 as the illustrative example for the first ECONOMICS report.

The second report, E02, is also reproduced in Appendix 2 and gives the life-cycle cost of the **CBVAV** system as 51.8K$. This cost is the sum of the first cost of $25,000, the installation cost of $20,000 and a life-cycle maintenance cost of $6,810. Note that the total maintenance cost is not simply the annual maintenance cost ($750) times the project lifetime (25 years), which would give $750 x 25 = $18,750. It is instead the present value (PV) of the life-cycle maintenance cost, which is given by

$$PV = \sum_{n=1}^{25} \$750 \left(\frac{1+.01i}{1+.01d}\right)^n,$$

where d, the discount rate, is 10%, and i, the labor cost inflation rate relative to general inflation, is zero (the default value). Thus

$$PV = 750 \sum_{n=1}^{25} \left(\frac{1}{1.10}\right)^n = 750 \times 9.077 = \$6,808.$$

The E02 report also gives the overall life-cycle cost, $256,300, which is the sum of

(1) Non-plant items, $51.8K

This is the sum of the life-cycle costs for all items entered using the **COMPONENT-COST** instruction in ECONOMICS. In this case it is the cost of the **CBVAV** system.

(2) Plant cost, $112.5K

This is the life-cycle cost for central plant equipment, including maintenance and overhauls. This number is calculated in the PLANT program, and should be the same as that given in the PLANT reports: "Central Plant Life Cycle Equipment Cost Summary" and "Life-Cycle Plant Cost Summary" (see Appendix 3).

(3) Fuel Cost, $92.0K

This is the life-cycle cost for fuel and electricity. This number is also calculated in PLANT and should be the same as that given in the PLANT report "Life-Cycle Plant Cost Summary" (See Appendix 3).

Input for Alternate System (Multi-Zone)

To calculate the life-cycle cost of the multi-zone (MZS) system, it is necessary to run the SYSTEMS simulation with the **PLANT-ASSIGNMENT** value changed from **CEILBYPS-1** to **MULTIZON-1**. The same PLANT input was used on this system as was for the CBVAV system, and the following specific cost data were input to ECONOMICS:

```
            INPUT ECONOMICS                                          ..
            COMPONENT-RATES     DISCOUNT-RATE=10 PROJECT-LIFE=25     ..
MZSCST-1    =COMPONENT-COST     FIRST-COST=15000 INSTALL-COST=12000
                                MAINT-COST=750                       ..
            END                                                      ..
            COMPUTE ECONOMICS                                        ..
            STOP                                                     ..
```

The results are in Appendix 3 and show that the total life-cycle cost for the MZS system is $244,000, compared to $256,300 for the CBVAV system. The MZS system, therefore, gives a lower life-cycle cost, but its life-cycle fuel cost, $97,100, is higher than that for the CBVAV system, $92,000.

B.2 Retrofit Cost-Effectiveness Analysis

Description of Problem

The second application of ECONOMICS is to determine the cost effectiveness of an energy conserving retrofit to an existing building. The approach is similar to that in Section 8.B.1; however, in this case the **BASELINE** command is used to enter equipment cost and fuel data for the pre-retrofit (baseline) building.

The baseline will be the Example Building with a CBVAV system. This building is retrofitted by closing the blinds on the windows from April 1 through October 31. This is accomplished in the LOADS input by changing

```
WINGLS-1        =GLASS-TYPE        PANES=2 GLASS-SHADING=.86        ..
```

to

```
SHADSC-1        =SCH              THRU MAR 31 (ALL) (1,24) 1
                                  THRU OCT 31 (ALL) (1,24) 0
                                  THRU DEC 31 (ALL) (1,24) 1        ..

WINGLS-1        =GLASS-TYPE       PANES=2 GLASS-SHADING=.86
                                  SHADING-SCHEDULE=SHADSC-1         ..
```

The SYSTEMS and PLANT input are unchanged.

Economics input for retrofit analysis

```
                INPUT ECONOMICS                                     ..
                COMPONENT-RATES     DISCOUNT-RATE=10 PROJECT-LIFE=25  ..
SHADSKED-1      =COMPONENT-COST     UNIT-NAME=SHADE
                                    NUMBER-OF-UNITS=16
                                    FC-PER-UNIT=20
                                    IC-PER-UNIT=5                   ..
                BASELINE            PLANT-COST=112.5
                                    FUEL-COST=92.0
                                    FUEL-USE=11.9                   ..
                END                                                 ..
                COMPUTE ECONOMICS                                   ..
                STOP                                                ..
```

The **COMPONENT-COST** instruction has been used to specify the costs of adding window shades. Keywords have been chosen which assign costs on a ``per unit'' basis. The unit in question is a single shade. The building has 16 windows, so the **NUMBER-OF-UNITS** = 16. The purchase price of a shade (**FC-PER-UNIT**) is given as $20 each, and the installation cost (**IC-PER-UNIT**) is $5 for each window.

The program will add **FC-PER-UNIT** and **IC-PER-UNIT**, and then multiply by **NUMBER-OF-UNITS** to arrive at the total initial cost of the shades: (20 + 5) x 16 = $400. The **UNIT-NAME** value (**SHADE** in this case) is an arbitrary u-name, which is printed on the output reports as a mnemonic to remind the user what units were used.

The baseline data, which are entered with the **BASELINE** command, have been taken from the PLANT report ``Life-Cycle Plant Cost Summary'' for the baseline run, Appendix 3. The baseline life-cycle plant equipment cost is $112.5K, the fuel cost is $92.0K, and the fuel use (including electricity) at the building boundary is 11.9 GBTU.

Output of retrofit analysis

In Appendix 3, the E01 report for the retrofit analysis shows that the first cost of the shades is $320 and the installation cost is $80. The E02 report shows that the life-cycle cost of the shades is $0.4K. Since all costs occur at the start of the project (i.e., there are no costs for maintenance, overhauls, etc.), the life-cycle cost is the same

as the initial cost.

The E03 report compares the baseline and present-run quantities and gives the savings-to-investment statistics. The investment is the sum of the life-cycle cost of all items entered with **COMPONENT-COST** commands. In this case the investment is $400, the cost of the shades. Primary equipment costs are $109.19K for the retrofit run vs. $112.50K for the baseline, a savings of $3.31K resulting from a lessened operating time under the retrofit conditions. Energy costs now are $88.20K vs. $92.00K for the baseline, an additional savings of $3.80K. The net cost savings due to the retrofit is therefore $7.11K. The energy use is 11.61 GBTU vs. 11.90 GBTU for the baseline; an energy savings of .29 GBTU over the project life.

The dollars saved per dollar invested (the savings-to-investment ratio must be greater than 1.0 for the retrofit to be cost-effective) is in this case 7.1/.4 or 17.8.

The fuel saved per dollar invested (fuel-savings-to-investment ratio) is 286.2×10^6Btu/$3600 = $.72 \times 10^6$Btu/$.

Finally, the payback period — the number of years it takes the accumulated cost savings to equal the investment — is 1.4 years.

B.3 Retrofit of Central Plant

If the retrofit involves adding or replacing central plant equipment, then this will be part of the investment, and these costs must be specified by using the **COMPONENT-COST** command in ECONOMICS. To avoid double counting, the corresponding costs in PLANT must be set to zero, as shown in the example below.

Suppose the retrofit consists of installing an additional boiler with a capacity of 0.16 MBTUH to a plant with an existing 0.45 MBTUH boiler. The input for PLANT and ECONOMICS will be as follows, where only the relevant commands are shown:

```
         INPUT PLANT                                                    ..
            .
            .
            .
OLDBLR-1 =EQUIPMENT          TYPE=STMB NUMBER=1
                             AVAILABLE=1 SIZE=0.45                      ..
         COST-OF-EQUIPMENT FOR OLDBLR-1 COST=35 INSTALLATION=1.2
                             EQUIPMENT-LIFE=200000 HOURS-USED=50000     ..
NEWBLR-1 =EQUIPMENT          TYPE=STMB NUMBER=1
                             AVAILABLE=1 SIZE=0.16                      ..
         COST-OF-EQUIPMENT FOR NEWBLR-1 COST=0 CONSUMABLES=0
                             MAINTENANCE=0 MINOR-OVHL-COST=0
                             MAJOR-OVHL-COST=0                          ..
            .
            .
            .
         END                                                            ..
         COMPUTE PLANT                                                  ..
         INPUT-ECONOMICS                                                ..
            .
            .
            .
NEWBLR-1 =COMPONENT-COST     FIRST-COST=8000 INSTALL-COST=1600
                             ANNUAL-COST=300 /*MAINT & CONSUM COST*/
                             CYCLICAL-COST=400 /*ANNUAL OVERHAUL COST*/
                             COMPONENT-LIFE=10 /*USEFUL LIFE IN YEARS*/
            .
            .
            .
         END                                                            ..
         COMPUTE ECONOMICS                                              ..
         STOP                                                           ..
```

In this example **NEWBLR-1**, the additional boiler, is considered as an investment. Consequently its costs have been specified in ECONOMICS using **COMPONENT-COST** and have been set equal to zero in PLANT to avoid calculating the cost twice. ECONOMICS will calculate the investment as the overall life-cycle cost of the additional boiler, including purchase price, installation, maintenance, overhauls, and replacement.

C Summary

The two examples above illustrate how to use DOE-1 to compare alternative designs and to determine the cost effectiveness of a retrofit. These procedures are summarized below:

1. Procedure for cost comparison of alternative new building designs.

   a. Enter cost data for each building design.

i. Enter central plant costs (except solar collector systems) using **COST-OF-EQUIPMENT** in PLANT.

ii. Enter fuel costs using **ENERGY-COST** in PLANT.

iii. Enter project lifetime, discount rate, etc., using **LIFE-CYCLE-RATES** and **LIFE-CYCLE-COSTS** in PLANT, and **COMPONENT-RATES** in ECONOMICS.

iv. Enter all other cost data in ECONOMICS using **COMPONENT-COST** instructions. These costs can include the building, itself, distribution systems, solar collectors, control systems, etc.

b. Run DOE-1 on each building design. ECONOMICS report E02 gives the total life-cycle cost.

c. Compare life-cycle costs. The building design with the lowest total life-cycle cost has the highest ranking.

Note

Solar collector costs should be entered in ECONOMICS using the **COMPONENT-COST** commands.

2. Procedure for cost analysis of energy conserving retrofits to an existing building.

a. For each retrofit option

i. Enter cenral plant costs (except solar collector systems) using **COST-OF-EQUIPMENT** in PLANT

ii. Enter fuel costs using **ENERGY-COST** in PLANT.

iii. Enter project lifetime, discount rate, etc., using **LIFE-CYCLE-RATES** and **LIFE-CYCLE-COSTS** in PLANT, and **COMPONENT-RATES** in ECONOMICS.

iv. Enter costs of modifications using **COMPONENT-COST** in ECONOMICS.

v. Enter baseline costs using the **BASELINE** command in ECONOMICS (It is assumed that DOE-1 has already been run on the unmodified building to determine the baseline costs).

vi. Run DOE-1

vii. ECONOMICS report E03 gives economic statistics such as savings-to-investment ratio and fuel savings per investment dollar.

b. Compare economic measures: the option with the most favorable economic measures has the highest ranking.

Notes

(1) The cost of a retrofit, i.e., the investment is calculated by the program as the life-cycle cost of all the items specified with **COMPONENT-COST** commands. Examples of such costs are: additinal insulation, modifications to a constant volume system to make it variable volume, replacing an existing boiler with a more efficient one, adding controls for night-time temperature setback, and adding a solar heating system.

(2) Cost for existing central plant equipment are specified as usual in PLANT. Since the existing equipment is not likely to be new, the user should be careful to specify the number of operating hours already accumulated on each piece of existing equipment using the **HOURS-USED** keyword of the **EQUIPMENT-COST** command.

(3) The present program can accommodate only very simple electric rate structures. Therefore the user must at present calculate the electric costs by hand whenever complex rate structures influence the analysis.

D Life Cycle Cost Minimization Using Parametric Analysis

The example below illustrates how DOE-1 can be used to do a cost minimization by making a series of parametric runs.

Object

Find the solar collector area which minimizes the overall life-cycle cost.

Procedure

(1) Enter cost data

(a) Enter central plant costs (except solar collector system) using **COST-OF-EQUIPMENT** in PLANT.

(b) Enter fuel costs using **ENERGY-COST** in PLANT.

(c) Enter project lifetime, discount rate, etc., using **LIFE-CYCLE-RATES** and **LIFE-CYCLE-COSTS** in PLANT and **COMPONENT-RATES** in ECONOMICS.

(d) Solar-related costs

(i) Enter cost data for solar collectors, storage tanks, controls, heat exchangers, etc., in ECONOMICS using **COMPONENT-COST** instructions.

(ii) Enter other costs (the building itself, secondary HVAC systems, etc.) using **COMPONENT-COST**. If these costs are independent of collector size, they can be omitted.

(2) Run DOE-1.

(3) Repeat steps (1) and (2) for different collector areas.

(4) Plot the total life-cycle cost (from the ECONOMICS report E02) vs. the collector area. Draw a smooth curve through the points. The area at which the curve reachest its minimum is the optimum area.

Notes

(1) Since the solar system data are input in PLANT, the output of SYSTEMS will be the same in each run. It is to the advantage of the designer to save the SYSTEMS output and only run PLANT and ECONOMICS. The only exception to this occurs when the shading of the building by the collector has a significant effect on the loads. In this case the orientation and size of the collector should be specified in LOADS using the **BUILDING-SHADE** command and LOADS, SYSTEMS, PLANT and ECONOMICS should be rerun for each value of the collector area.

(2) Non-solar plant equipment can either be resized for each choice of collector area, or held fixed in size, depending on the application.

(3) For each run the collector costs given in ECONOMICS should correspond to the collector size given in PLANT. It is, therefore, convenient to specify collector cost on a per square foot basis. If shading by the collector is taken into account, the collector area in PLANT and ECONOMICS should match that in the **BUILDING-SHADE** instruction in LOADS.

Input example

Let the plant consist of a boiler and a solar heating system. Only plant and solar system costs are entered; other (non-solar) costs are assumed to be independent of the collector area. The first run has a collector area of 1000 sq. ft.

```
            INPUT PLANT                                                 ..
SBOIL-S1    =EQUIPMENT            TYPE=STMB NUMBER=1
                                  AVAILABLE=1 SIZE=0.16                 ..
            COST-OF-EQUIPMENT     FOR SBOIL-S1 COST=5                   ..
            /*ALL OTHER BOILER COSTS ARE DEFAULTED*/
            ENERGY-COST           RESOURCE=BOILER UNIT=100000
                                  COST=0.22 ESCALATION=10               ..
            ENERGY-COST           RESOURCE=BOILER UNIT=3413
                                  COST=0.045 ESCALATION=6               ..
            LIFE-CYCLE-RATES      DISCOUNT-RATE=10                      ..
            LIFE-CYCLE-COSTS      PROJECT-LIFE=25 LABOR=25              ..
            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-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                                                         ..
            COMPUTE PLANT                                               ..

            INPUT ECONOMICS                                             ..
COLLECT-1   =COMPONENT-COST       UNIT-NAME=SQFT
                                  NUMBER-OF-UNITS=1000
                                  FC-PER-UNIT=20 INSTALL-COST=5000
                                  MC-PER-UNIT=0.5 COMPONENT-LIFE=30     ..
/* THE OTHER SOLAR COSTS BELOW ARE ASSUMED TO BE
INDEPENDENT OF COLLECTOR AREA AND ARE LUMPED TOGETHER*/
COLLECT-2   =COMPONENT-COST       FIRST-COST=5000 INSTALL-COST=1500
                                  MAINT-COST=250 COMPONENT-LIFE=40      ..
            COMPONENT-RATES       DISCOUNT-RATE=10 PROJECT-LIFE=25      ..
            END                                                         ..
            COMPUTE ECONOMICS                                           ..
            STOP                                                        ..
```

Parametric Study

To run with a different collector size, e.g., 2000 sq. ft., it is necessary to change only a few cards in the PLANT and ECONOMICS input:

(1) In PLANT, change **AREA** =1000 to **AREA** = 2000.

(2) In ECONOMICS, change **NUMBER-OF-UNITS** = 1000 to **NUMBER-OF-UNITS** = 2000.

Section 9 — Running the DOE-1 Program

A Introduction

Having designed the input for DOE-1 and having punched the input deck, the user is now faced with the task of putting the data onto the computer and getting the output of the DOE-1 simulation. This process is described in detail in the report Remote Operation of DOE-1 on the Lawrence Berkeley Laboratory CDC 7600,660 and 6400 Computers (the LBL Site Manual) for users who will be using the LBL computer. Other users should obtain operating instructions from the computer service that they will be using.

In addition the user will have to know how to interpret the output. The description of the output reports is provided in Appendix 2 of this Manual and in the Reference Manual. The diagnostic comments of BDL are described in subsection C of this Section.

B Control Cards at LBL

Each computer center will have its own set of instructions which allows the user to make access with the DOE-1 program. These instructions are called the control cards and the usual structure of an input deck is:

Job Card
[Control Cards]
End-of-Record Card
[DOE-1 Input Deck]
End-of-File Card

The Job Card is required to identify the user and his/her account to the computing center. The End-of-Record Card separates the Control Cards from the data deck generally and in this case the DOE-1 input deck, which has been described earlier in this manual. The End-of-File Card tells the computer that no more data is forthcoming for this job. In that sense it is an End-of-Job Card. The Control Cards are the ones that depend upon the specific operating system of the particular computing center.

At Lawrence Berkeley Laboratory the Control Cards for running DOE-1 are:

```
[1]   <Job Card goes here>
      DISKHOG,5000.
      FBSIZE,BDLABS=220,BDL=160,DBGMAP=6,TAPE94=2,LSPEI=274,LSPE=252.
      FBSIZE,IN=44,LDLKEY=6,SDLKEY=4,PDLKEY=4,EDLKEY=2,TAPE71=10.
      FBSIZE,WEATHR=44,MATLIB=4,LDLLIB=4,PDLLIB=10,CFILE=16,FFILE=2.
      FETCHPS,CALERDA,BDLABS,BDLABST.
[2]   FETCHPS,BDLLIBS,LDLLIB,<your materials library file>.
      FETCHPS,CALERDA,LSPEI,LSPET.
[3]   FETCHPS,WEATHR,IN,<your weather>.
      SCATTER,BDLABS.
[4]   DELETE,MATLIB,PDLLIB.
      RETURN,BDLABS.
      BDL,LC=50000.
      RETURN,LDLKEY,SDLKEY,PDLKEY,EDLKEY,LDLLIB,MATLIB,PDLLIB,BDL.
      RETURN,TAPE81,TAPE82,TAPE83,TAPE84,TAPE71.
      SCATTER,LSPEI.
[5]   SCATTER,IN,,WEATHR.
      RETURN,LSPEI,IN.
      LSPE,LC=100000.
      FILES.
[6]   ------------------------
      END.
```

The bracketed numbers are not part of the control deck, but have been inserted here for reference below. The periods at the end of each card are required, and their omission will cause the program to abort.

[1] This is the position for the Job Card. See the LBL Site Manual for details on the construction of this card.

[2] This card is used <u>only if</u> the user has prepared his/her own materials library as described in the LBL Site Manual and the Reference Manual. If the user is using only the materials library included within DOE-1 and described in the Reference Manual, this card should be removed.

[3] In place of the string <your weather> the user should place the code-word for the weather data desired. The list of stored weather data available to the user in this fashion is given in Chapter III of the Reference Manual.

If the user has prepared his/her own weather tape following the format described in the LBL Site Manual, this card must be replaced by a card which copies the tape onto the file WEATHR <u>and</u> the card numbered [5] in the above list should be removed.

[4] This card should be used <u>only if</u> the user does <u>not</u> intend to use the built-in materials library. If the user will use the built-in materials library, this card should be removed.

[5] This card should be used <u>only if</u> the user is making use of a built-in weather tape as described in [3].

[6] If the user is a DOE contractor and desires assistance from the DOE-1 Users Office in debugging his/her input, a copy of the DOE-1 output will be sent to the Users Office at Lawrence Berkeley Laboratory, if the following cards are inserted in the space indicated:

```
EXIT.
DUMP,0.
FIN.
DDB.
COPY,OUTPUT/RR,USER.
DISPOSE,USER=PR,SC=UC,DT=I,T=[TO THE/ATTENTION OF/DOE-1/USERS OFFICE].
```

Now that the user is prepared to run his/her program, it is important to know how to deal with errors in the input.

C Errors and Diagnostics

``To err is human;'' to have diagnostic messages is a great help. Computers and computer languages have no tolerance for ambiguity and must assume that the user meant precisely what he/she said. When, for example, the user has introduced a u-name as the value of a keyword, but has forgotten previously to define the u-name, BDL cannot assume a value and will abort. Rather than simply aborting, however, BDL has been programmed to tell the user why it found it necessary to do so. Such diagnostic messages are essential in ``debugging'' the input.

To illustrate the above error, consider the following:

```
*  95  *   CEILING1 =INTERIOR-WALL    AREA=1056 NEXT-TO SPACE-1
*  96  *                              CONS=CIEL-1                  ..
-E R R O R ---------------------------------------------------------^--
-E R R O R ------------------------------------------------------------^
       CONSTRUCTION
                        -----PREVIOUSLY UNDEFINED SYMBOL USED------
                        -----REQUIRED KEYWORD NOT SPECIFIED
```

Here is a portion of the computer output of BDL. The number between the stars is supplied by BDL, which numbers each line of input for easy reference. In this sample there are two errors noted. The up-arrow (^) in each error points to the end of the field where BDL discovered something wrong. The ``end of field'' is defined as the last character before the next element or word. The first error suggests something is wrong with the word **CIEL-1** and the message tells us that this is a previously undefined symbol. Looking at the example input, one can see that the word has been misspelled. It should have been **CEIL-1**. The second error is a consequence of the first. **CONS** (or **CONSTRUCTION**) is a required keyword and has not been specified. Note that the up-arrow is at the terminator. BDL has patiently looked through the entire instruction and, only when it came to the end without discovering the required keyword <u>properly</u> valued, did it indicate the error.

C.1 DIAGNOSTIC Command

These messages were indicated by BDL to be **ERROR** level messages, the highest of the levels. There are four levels of messages:

level	meaning
ERROR	Fatal mistake; simulation is not possible.
WARNING	Non-fatal mistake; possible error present.
CAUTION	Non-fatal mistake; suspicious or non-standard input.
COMMENT	Echo of input values and indication of defaults.

These are code-words which can be used with the command **DIAGNOSTIC** to specify what level of message will be issued. In the example input only the ERROR level messages would be printed:

```
DIAGNOSTIC      ERROR      ABORT      ERROR      ..
```

If the instruction had read:

```
DIAGNOSTIC      CAUTION    ABORT      ERROR      ..
```

not only **CAUTION** messages but the higher level **WARNING** and **ERROR** messages would be printed. Generally the code-word selects the lowest level messages to be printed. All higher level messages will also be printed.

Note that the command **DIAGNOSTIC** takes a keyword **ABORT**. This keyword has the code-word values: **CAUTION**, **WARNING**, **ERROR** and controls the message level at which the simulation will be aborted. For example, **ABORT WARNING** will cause the simulation to terminate if there is either a **WARNING** message or an **ERROR** message. The default value for both **DIAGNOSTIC** and **ABORT** is **CAUTION**.

The **COMMENT** code-word produces not only an echo of the user's input, but also the default values for all omitted keywords. In addition, it causes the print-out of the response factors for delayed walls as in Figure 2.

From this example it is clear that BDL does more than simply translate languages; it also makes use of the utility subroutine **PONSFAC** to calculate response factors after looking through the materials library to look up the physical properties of the materials identified by code-words: **RG01**, **BR01** and the like.

The **DIAGNOSTIC** command has one other keyword, namely **SPACING** , which in turn has two code-word values, namely **SINGLE** (the default) and **DOUBLE**. This keyword governs the spacing of the print-out of BDL, i.e., the echo of the user's input deck plus messages. The **DIAGNOSTIC** command may be used anywhere and for as many times as the user chooses. Each

```
 *  38 *  RFLAY-1    =LAYERS              M1=RG01 M2=BR01 M3=IN76
 *  39 *                                  IFR=.76                                         ..
- -INPUT- - - - - - - - - - - - - - - - - - - -+- - - - - - - - - - - - - - - - - - - - - - MATERIAL-1          = RG01
          MATERIAL-2         = BR01              MATERIAL-3        = IN76                  INSIDE-FILM-RES   =          .7600

          LAYER    THICKNESS       CONDUCTIVITY         DENSITY       SPECIFIC HEAT      RESISTANCE

             1         .0417            .8340          55.0000             .4000          0.0000
             2         .0313            .0939          70.0000             .3500          0.0000
             3         .2500            .0300          16.0000             .2000          0.0000
             4        0.0000           0.0000           0.0000            0.0000           .7600


               RESPONSE FACTORS CALCULATED BY PONSFAC
       HOUR           X               Y              Z
         0       1.9223902159     .0076274140     .2861123573
         1      -1.7505104268     .0510176264    -.1425347215
         2       -.0464070096     .0313944454    -.0259669691
         3       -.0135562360     .0105003965    -.0082049155
         4       -.0043392530     .0033809219    -.0026352460

              COMMON RATIO =     .3214174151              U-VALUE =       .1055223356

 *  40 *  EXTW-1     =CONSTRUCTION        LAYERS=WLLAY-1 ABSORPTANCE=.88
 *  41 *                                  ROUGHNESS=2                                     ..
- -INPUT- - - - - - - - - - - - - - - - - - - -+- - - - - - - - - - - - - - - - - - - - - - WALL-TYPE           = WLLAY-1
          ABSORPTANCE       =          .8800         ROUGHNESS        =          2.0000
- DEFAULT - - - - - - - - - - - - - - - - - - - -+- - - - - - - - - - - - - - - - - - - - - - W-INF-FLOW-COEFF =          0.0000
 *  42 *  ROF-1      =CONS                WALL-TYPE=RFLAY-1 ABS=.5 RO=1                   ..
- -INPUT- - - - - - - - - - - - - - - - - - - - - - - - - - - - - -+- - - - - - - - - - - - WALL-TYPE           = RFLAY-1
          ABSORPTANCE       =          .5000         ROUGHNESS        =          1.0000
- DEFAULT - - - - - - - - - - - - - - - - - - - - - - - - - - - - -+- - - - - - - - - - - - W-INF-FLOW-COEFF =          0.0000
 *  43 *  CEIL-1     =CONS                U=.8    /*CONSTRUCTION OF CEILING*/             ..
- -INPUT- - - - - - - - - - - - - - - - - - - + - - - - - - - - - - - - - - - - - - - - - - U-VALUE             =          .8000
- DEFAULT - - - - - - - - - - - - - - - - - - + - - - - - - - - - - - - - - - - - - - - - - WALL-TYPE           = *UNDEFINED*
- DEFAULT - - - - - - - - - - - - - - - - - - + - - - - - - - - - - - - - - - - - - - - - - ABSORPTANCE         =          .7000
```

Figure 9

DIAGNOSTIC command remains in effect until BDL finds a later **DIAGNOSTIC** command. In this way the user may have the spacing vary throughout the print out as well as suppressing messages in portions of the program that have already been debugged.

Users, who are familiar with computer programming, know that the likelihood of writing and punching a program without errors (``bugs'') is very small. Many errors are simply typographical in nature, but others result from unfamiliarity with the language and can serve to be an important learning device. The rest of this section is devoted to exploring some common errors and to interpreting some of the BDL diagnostic messages.

C.2 Common Errors

Undoubtedly the commonest error is illustated below:

```
* 113 *  SPACE-2 =SPACE     LIKE SPACE-1 NOP=5 FA=369 V=3564
* 114 *             EW      LIKE WALL-1 A=90 M=3                    ..
-E R R O R ---------------^-------------------------------------
-E R R O R --------------------^-----------------------------------
-E R R O R ---------------------------^-----------------------------
                  -----PREVIOUSLY UNDEFINED SYMBOL USED -----
                  -----PREVIOUSLY UNDEFINED SYMBOL USED -----
                  -----FOUND SYMBOL WITH NON-NUMERIC VALUE---
```

This error is particularly difficult for the new user to unscramble, since the error flags point to an instruction which is in fact without error. Both the command **EW** and the keyword **LIKE** are flagged as being ``previously undefined symbols'' and **WALL-1** is a proper u-name which is appropriate to the keyword **LIKE**. The problem is not with this instruction at all; it is the missing terminator in the immediately previous instruction which is to blame. BDL came to the end of the line beginning with the u-name **SPACE-2** without finding a terminator and attempted to interpret **EW**, **LIKE** and **WALL-1** as part of the same instruction. The solution to all three errors is to put a terminator after V = 3564.

Another common and difficult error to find arises from the confusion between zero and the letter O.

```
* 21 *   RFLAY-1 =LAYERS     M1=RG01 M2=BR01 M3=IN76 IFR=.76     ..
-E R R O R ------------------------^-------------------------------
--WARNING ------------------------------------------------------^-
                            ----PREVIOUSLY UNDEFINED SYMBOL USED-----
                            ----INSUFFICIENT DATA-------------------
```

Here is an **ERROR** message followed by a **WARNING** . BDL did not recognize the code word assigned to **M1** since inadvertently a zero was replaced by the letter O. Note the distinction between the letter O in **RG01** and the zero in **BR01** . The **WARNING** now informs the user that **M1** is not defined.

A typographical or spelling mistake can give an **ERROR** message as below:

```
* 22 *  EXTW-1  =CONSTRUCTION    LAYERS=WLLAY-1 ABSORBTANCE=.88
-E R R O R-----------------------------------------------^------
                                 ------FOUND VALUE TO LEFT OF EQUAL SIGN
* 23 *                              ROUGHNESS=2                    ..
```

Since BDL does not recognize **ABSORBTANCE** as a misspelling of the keyword **ABSORPTANCE** , it assumes that it is a u-name and then wonders what a number or value is doing on the lefthand side of an equal sign.

Forgetting the proper spelling or the proper abbreviation of a command can produce the following:

```
* 88 *  PLWL-1  =EXT-WALL     HEIGHT=3 WIDTH=100 AZIMUTH=180
-E R R O R-------------------^-----------------------------------
                                 -----BAD COMMAND --------------
* 89 *                        CONS=EXTW-1                       ..
```

The up arrow indicates that **EXT-WALL** is not an appropriate abbreviation of **EXTERIOR-WALL** (EW is the only abbreviation). This error gets propagated later in the program:

```
* 90 *   EW          LIKE PLWL-1 WIDTH=45 AZIMUTH=90          ..
-E R R O R --------------------^-----------------------------------
-E R R O R ---------------------------------------------------^-----
            CONSTRUCTION
                            ----PREVIOUSLY UNDEFINED SYMBOL USED------
                            ----REQUIRED KEYWORD NOT SPECIFIED
```

The first **ERROR** message indicates that BDL does not recognize the u-name **PLWL-1**. The ``bad command'' error wiped out BDL's identification of this u-name. Since the required keyword **CONSTRUCTION** was imbedded in **PLWL-1**, this instruction seems to be lacking a required keyword. Both of these errors will vanish when the correct command is used in the definition of **PLWL-1** . In other words, there is nothing wrong with this instruction. This is another case of guilt by association.

WIND-1 was the u-name assigned to a **WINDOW** command. In the following printout an underground floor (UF) is described as being **LIKE WIND-1** and produced two **ERROR** messages:

```
* 126 *     UF                    LIKE WIND-1              ..
-E R R O R ---------------------------------------------^------
-E R R O R ---------------------------------------------^----
          CONSTRUCTION             FLOOR-AREA
                              -----WRONG DATA TYPE IN LIKE FIELD
                              -----REQUIRED KEYWORD NOT SPECIFIED
```

The first reminds the user that the data summarized by **WIND-1** is not appropriate for the command **UF** (**UNDERGROUND-FLOOR**). The second message then says the obvious that the **UNDERGROUND-FLOOR** has not been defined,

i.e., the required keywords **CONSTRUCTION** and **FLOOR-AREA** have not been specified.

All of these examples have involved fatal errors, i.e., the simulations cannot be made with the data as given. In the following a **WARNING** message tells the user that unless supreme care is taken, the simulation may not work.

```
* 14 *   DEFINE          GLINF=GLASS-INFILTRATION          ..
--WARNING-----------------------------------------------^---
                 ---KEYWORD NAME USED AS PARAMETER VALUE-----
```

The user has chosen to redefine the symbol for a keyword. The intention is to create a new abbreviation **GLINF** for the longer **GLASS-INILTRATION.** Perhaps the purpose was to have a more recognizable abbreviation than GI which is the standard abbreviation. BDL warns the user that if he/she forgets and attempts to use **GLASS-INILTRATION** later in the input, BDL will not recognize this as a keyword.

The final message example involves the **CAUTION** level:

```
* 210 *  CEILBYPS-1=SYSTEM   SYSTEM-TYPE=CBVAV SYSTEM-AIR=SAIR-1
* 211 *                     SYSTEM-TERMINAL=STERM-1
* 212 *                     SYSTEM-FANS=SFAN-1
* 213 *                     SYSTEM-CONTROL=SCON-1
* 214 *                     ECONO-LIMIT-TEMP=72
* 215 *                     RETURN-AIR-PATH=PLENUM-ZONES
* 216 *                     PLENUM-NAMES=PLENU-1
* 217 *                     ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3
* 218 *                        SPACE-4,SPACE-5,PLENU-1          ..
* 219 *
* 220 *  MULTIZON-1=SYSTEM   LIKE CEILBYPS-1 SYSTEM-TYPE=MZS
* 221 *                     HEAT-CONTROL=COLDEST MIN-CFM-RATIO=1
* 222 *                     PLENUM-NAMES=PLENU-1
* 223 *                     ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 224 *                        SPACE-4,SPACE-5,PLENU-1          ..
-WARNING-----------------------------------------------------^---
-CAUTION-----------------------------------------------------^---
                   REHEAT-DELTA-T
                              ---'LIKE'D SYSTEM/ZONE NOT SAME TYPE
                              ---KEYWORD NOT USED BY ZONE/SYSTEM TYPE
```

Here in the SYSTEMS input two systems are defined, the first, **CBVAV**, is a ceiling bypass variable air volume system and the second, **MZS**, is a multizone system. The user has chosen to save input by using the **LIKE** command for the **MZS** system. BDL warns the user that two different systems are being made ``like'' each other. It goes on to give a **CAUTION** message that the keyword **REHEAT-DELTA-T** is not used by multizone systems. This is not fatal and the SYSTEMS simulation will ignore the **REHEAT-DELTA-T** in simulating the multizone system. BDL is simply reminding the user that this is the case.

The complete list of diagnostic messages is given in the Reference Manual along with typical conditions under which the message is delivered. Although these messages are very useful in detecting syntactical mistakes, they cannot indicate poor modeling of a building.

Appendix 1

Building Description Check List

LOADS

- [ ] Run-period desired [RUN-PERIOD]
- [ ] Weather station (must be specified in the control cards)
- [ ] Reports desired [LOADS-REPORT,HOURLY-REPORT]
- [ ] Define variables for parametric studies [DEFINE]
- [ ] Building location [BUILDING-LOCATION]
  - [ ] Latitude
  - [ ] Longitude
  - [ ] Altitude
  - [ ] Time-Zone
  - [ ] Daylight-savings applicable
  - [ ] Holidays normal or different
  - [ ] Building orientation
- [ ] Layers of materials in walls [LAYERS,MATERIAL]
- [ ] Layers of materials in roof [LAYERS,MATERIAL]
- [ ] U-Factor of ceilings [CONSTRUCTION]
- [ ] U-factor of partitions [CONSTRUCTION]
- [ ] U-factor of floors [CONSTRUCTION]
- [ ] Glass type (or shading coefficient) and number of panes [GLASS-TYPE]
- [ ] Schedules (profiles) for people, lights, equipment, infiltration, and shading devices [DAY-SCHEDULE,WEEK-SCHEDULE,SCHEDULE]
- [ ] Surfaces that shade building [BUILDING-SHADE]
- [ ] Building plenums [SPACE]
- [ ] Building zoning [SPACE]

- ☐ Building occupancy [SPACE-CONDITIONS]
- ☐ Lighting fixture types & light heat to space [SPACE-CONDITIONS]
- ☐ Method of calculating infiltration [SPACE-CONDITIONS]
- ☐ Building set point temperature at which the loads calculation will be made [SPACE-CONDITIONS]
- ☐ Floor weight [SPACE-CONDITIONS]
- ☐ Wall dimensions per space [EXTERIOR-WALL]
- ☐ Glass dimensions per space [WINDOW]
- ☐ Roof dimensions per space [EXTERIOR-WALL]

SYSTEMS

- ☐ Type of reports [SYSTEMS-REPORT,HOURLY-REPORT]
- ☐ Fan schedule [SCHEDULE]
- ☐ Heating and cooling equipment schedules if different from fan schedules [SCHEDULE]
- ☐ Heating set point schedules [SCHEDULE]
- ☐ Cooling set point schedules [SCHEDULE]
- ☐ Ventilation air to space [ZONE-AIR or SYSTEM-AIR]
- ☐ Recirculation rate in space - minimum code [ZONE-AIR or SYSTEM-AIR]
- ☐ Type of thermostat and throttling range [ZONE-CONTROL]
- ☐ Space (zone) description [ZONE]
- ☐ Outside air damper control [SYSTEM-AIR,SYSTEM]
- ☐ Air terminal type and delta-T [SYSTEM-TERMINAL]
- ☐ The minimum air rate allowed if VAV system [SYSTEM-TERMINAL]
- ☐ Supply and return fan static pressures and efficiencies [SYSTEM-FANS]
- ☐ Type of cooling coil control [SYSTEM-CONTROL]
- ☐ Design cooling and heating temperatures [ZONE-CONTROL]
- ☐ Humidity control - minimum and/or maximum [SYSTEM-CONTROL]

- ☐ System types [SYSTEM]
- ☐ Zones assigned to systems [SYSTEM]

PLANT

- ☐ Type of plant components [PLANT-EQUIPMENT]
- ☐ Equipment sizing [PLANT-EQUIPMENT]
- ☐ Costs of equipment [EQUIPMENT-COST]
- ☐ Energy costs [ENERGY-COST]

ECONOMICS

- ☐ Costs for non-plant items (solar collector, insulation, building itself, etc.) [COMPONENT-COST]
- ☐ Baseline costs (if retrofit analysis is being done) [BASELINE]

Appendix 2 - DOE-1 Output Reports

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REPORT L01 — SPACE PEAK LOADS SUMMARY

This report echoes the u-names of the spaces and the number of times each space is repeated (MULTIPLIER) on the left of the report.

The individual space peak sensible cooling load with the month, day and hour it occurred is reported in the center. Their sum, which is the non-coincident building peak load is also reported.

The coincident building peak cooling load (the ``block'' load) is reported directly below the non-coincident peak but it does not include the plenum load. The outside dry bulb and wet bulb temperatures are also reported for the time of the peak load in each space, and for the building.

The heating peak loads are treated similarly on the right.

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LOADS

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E03 — LIFE-CYCLE SAVINGS/INVESTMENT STATISTICS.A2-45

REPORT L01 — SPACE PEAK LOADS SUMMARY

This report echoes the u-names of the spaces and the number of times each space is repeated (MULTIPLIER) on the left of the report.

The individual space peak sensible cooling load with the month, day and hour it occurred is reported in the center. Their sum, which is the non-coincident building peak load is also reported.

The coincident building peak cooling load (the ``block'' load) is reported directly below the non-coincident peak but it does not include the plenum load. The outside dry bulb and wet bulb temperatures are also reported for the time of the peak load in each space, and for the building.

The heating peak loads are treated similarly on the right.

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
PLENU-1	1.	18.294	JUL 7 4 PM	88F	73F	-43.416	JAN 12 10 AM	-7F	-7F
SPACE-1	1.	31.283	NOV 7 3 PM	55F	46F	-22.186	MAR 24 5 AM	9F	8F
SPACE-2	1.	10.247	JUL 3 10 AM	87F	74F	-9.514	JAN 1 4 AM	3F	2F
SPACE-3	1.	26.906	JUL 9 5 PM	97F	73F	-26.431	JAN 1 4 AM	3F	2F
SPACE-4	1.	10.356	AUG 19 5 PM	90F	71F	-9.316	JAN 1 4 AM	3F	2F
SPACE-5	1.	24.565	AUG 30 5 PM	80F	66F	-2.030	FEB 25 8 AM	10F	9F
SUM		121.650				-112.893			
BUILDING PEAK		99.241	JUL 9 5 PM	97F	73F	-68.204	JAN 1 4 AM	3F	2F

REPORT LO2 — SPACE PEAK LOAD COMPONENTS

These reports give a breakdown of cooling and heating peak loads by the source of the load in each space. There are several interesting points that the user should be acquainted with.

1) Roof loads are reported as Ceilings; see Report LO2 for **PLENU-1**, p. A2-5.

2) Internal surfaces are partitions and drop ceilings and is negative if heat is leaving the space and positive if heat is entering the space. Note that the contribution to the loads from internal surfaces is zero for all spaces. The reason is that the heat transfer is calculated for each space held at the **TEMPERATURE** selected in LOADS. This was 73° for all the spaces and by the Second Law of Thermodynamics there will occur no net transfer of heat between spaces at the same temperature. Later in SYSTEMS this situation will change as the space temperatures ``float'' from their set points.

3) Note that all sensible loads are calculated delayed in time with weighting factors and it is possible to have heat gains from GLASS SOLAR long after the sun has moved and no longer shines on the exposed walls of the space.

4) UNDERGROUND SURFACES can be basement floors and walls or slab on grade. The user should take care to adjust either the areas or U-factor to approach the heat transfer loss he/she anticipates. For example, the slab-on-grade should ordinarily include only perimeter areas, since the soil under the central part of the building will not significantly conduct heat away from the slab. On the other hand, if the walls and basement floor are below the water table, they should not be adjusted, since water is a good conductor of heat.

SPACE PLENU-1

MULTIPLIER 1

FLOOR AREA 4500 SQFT 418 SQMT
VOLUME 13500 CUFT 382 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 10 AM	
DRY-BULB TEMP	88F	31C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.786	.83	0.000	0.00	-6.006	-6.34
CEILINGS	17.508	18.47	0.000	0.00	-37.409	-39.47
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	18.294	19.30	0.000	0.00	-43.416	-45.81
TOTAL LOAD	18.294 KBTU/H		19.30 MJ/H		-43.416 KBTU/H	-45.81 MJ/H
TOTAL LOAD / AREA	4.07 BTUH/SQFT		.04618 MJ/H/SQMT		9.65 BTUH/SQFT	.10958 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-1

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	NOV 7 3 PM		MAR 24 5 AM	
DRY-BULB TEMP	55F	13C	9F	-13C
WET-BULB TEMP	46F	8C	8F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	-1.831	-1.93	0.000	0.00	-4.054	-4.28
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	-2.455	-2.59	0.000	0.00	-7.727	-8.15
GLASS SOLAR	16.677	17.60	0.000	0.00	1.145	1.21
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-1.109	-1.17	0.000	0.00	-1.795	-1.89
OCCUPANTS TO SPACE	10.237	10.80	5.188	5.47	.028	.03
LIGHT TO SPACE	7.196	7.59	0.000	0.00	.459	.48
EQUIPMENT TO SPACE	2.567	2.71	0.000	0.00	.078	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-10.321	-10.89
TOTAL	31.283	33.00	5.188	5.47	-22.186	-23.41

TOTAL LOAD	36.470 KBTU/H	38.48 MJ/H	-22.186 KBTU/H	-23.41 MJ/H
TOTAL LOAD / AREA	34.54 BTUH/SQFT	.39264 MJ/H/SQMT	21.01 BTUH/SQFT	.23885 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-2

MULTIPLIER 1

FLOOR AREA 396 SQFT 36 SQMT
VOLUME 3564 CUFT 100 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 10 AM		JAN 1 4 AM	
DRY-BULB TEMP	87F	31C	3F	-16C
WET-BULB TEMP	74F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.528	.56	0.000	0.00	-2.599	-2.74
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.571	.60	0.000	0.00	-3.149	-3.32
GLASS SOLAR	5.002	5.28	0.000	0.00	.248	.26
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.238	-.25	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.063	1.12	.576	.61	0.000	0.00
LIGHT TO SPACE	2.386	2.52	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.934	.99	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	10.247	10.81	.576	.61	-9.514	-10.04

TOTAL LOAD	10.823 KBTU/H	11.42 MJ/H	-9.514 KBTU/H	-10.04 MJ/H
TOTAL LOAD / AREA	27.33 BTUH/SQFT	.31720 MJ/H/SQMT	24.03 BTUH/SQFT	.27883 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-3

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	2.915	3.08	0.000	0.00	-10.642	-11.23
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.551	1.64	0.000	0.00	-5.248	-5.54
GLASS SOLAR	2.616	2.76	0.000	0.00	.165	.17
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.634	-.67	0.000	0.00	-1.690	-1.78
OCCUPANTS TO SPACE	10.890	11.49	5.188	5.47	0.000	0.00
LIGHT TO SPACE	7.688	8.11	0.000	0.00	.432	.46
EQUIPMENT TO SPACE	1.880	1.98	0.000	0.00	.072	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-9.520	-10.04
TOTAL	26.906	28.39	5.188	5.47	-26.431	-27.89

TOTAL LOAD	32.094 KBTU/H	33.86 MJ/H	-26.431 KBTU/H	-27.89 MJ/H
TOTAL LOAD / AREA	30.39 BTUH/SQFT	.34552 MJ/H/SQMT	25.03 BTUH/SQFT	.28455 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-4

MULTIPLIER	1			
FLOOR AREA	396	SQFT	36	SQMT
VOLUME	3564	CUFT	100	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 19	5 PM	JAN 1	4 AM
DRY-BULB TEMP	90F	32C	3F	-16C
WET-BULB TEMP	71F	22C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.324	.34	0.000	0.00	-2.557	-2.70
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.626	.66	0.000	0.00	-3.149	-3.32
GLASS SOLAR	4.875	5.14	0.000	0.00	.406	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.198	-.21	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.196	1.26	.576	.61	0.000	0.00
LIGHT TO SPACE	2.839	2.99	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.694	.73	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	10.356	10.93	.576	.61	-9.316	-9.83

TOTAL LOAD	10.932 KBTU/H	11.53 MJ/H	-9.316 KBTU/H	-9.83 MJ/H
TOTAL LOAD / AREA	27.61 BTUH/SQFT	.32040 MJ/H/SQMT	23.53 BTUH/SQFT	.27303 MJ/H/SQMT

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

PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.04.48
DECEMBER 1978
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE-5

MULTIPLIER 1

FLOOR AREA 1596 SQFT 148 SQMT
VOLUME 14364 CUFT 406 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 5 PM		FEB 25 8 AM	
DRY-BULB TEMP	80F	27C	10F	-12C
WET-BULB TEMP	66F	19C	9F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	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	-.798	-.84	0.000	0.00	-2.793	-2.95
OCCUPANTS TO SPACE	10.894	11.49	5.188	5.47	.000	.00
LIGHT TO SPACE	11.626	12.27	0.000	0.00	.654	.69
EQUIPMENT TO SPACE	2.843	3.00	0.000	0.00	.109	.11
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	24.565	25.92	5.188	5.47	-2.030	-2.14
TOTAL LOAD	29.753 KBTU/H		31.39 MJ/H		-2.030 KBTU/H	-2.14 MJ/H
TOTAL LOAD / AREA	18.64 BTUH/SQFT		.21210 MJ/H/SQMT		1.27 BTUH/SQFT	.01447 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

The building coincident peak load does not include plenums or other unconditioned spaces. Although no infiltration is indicated for the peak cooling load for the Example Building, the user should realize how DOE-1 treats infiltration loads. The sensible portion is treated as an instantaneous heat gain or loss. The latent portion is reported in LOADS, but is passed to Systems as a CFM with the calculated humidity ratio for each hour. The contribution of the latent heat (negative or positive in relation to room humidity) is then calculated as a mass balance of moisture in the space, to determine the return air humidity ratio. In dry climates the infiltration may actually result in a decreased space latent load and thus a decreased total SYSTEMS load. The opposite is true in humid climates where infiltration acts to increase the SYSTEMS load.

The heat gain or loss that occurs in plenums, including heat due to lights, is accounted for in the SYSTEMS simulation causing a temperature difference of the return air flowing through the plenum. Therefore the user should not specify plenums unless they are actually return air plenums. Unconditioned, non-return air spaces should be specified in the SPACE command with **ZONE-TYPE = UNCONDITIONED.**

*** BUILDING ***

FLOOR AREA	9000	SQFT	836	SQMT
VOLUME	54000	CUFT	1529	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9	5 PM	JAN 1	4 AM
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	COOLING SENSIBLE (KBTU/H)	COOLING SENSIBLE (MJ/H)	COOLING LATENT (KBTU/H)	COOLING LATENT (MJ/H)	HEATING SENSIBLE (KBTU/H)	HEATING SENSIBLE (MJ/H)
WALLS	5.714	6.03	0.000	0.00	-20.762	-21.90
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	5.908	6.23	0.000	0.00	-19.996	-21.10
GLASS SOLAR	14.458	15.25	0.000	0.00	3.785	3.99
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-2.700	-2.85	0.000	0.00	-7.200	-7.60
OCCUPANTS TO SPACE	35.090	37.02	16.716	17.64	0.000	0.00
LIGHT TO SPACE	32.761	34.56	0.000	0.00	1.843	1.94
EQUIPMENT TO SPACE	8.010	8.45	0.000	0.00	.307	.32
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-26.181	-27.62
TOTAL	99.241	104.70	16.716	17.64	-68.204	-71.96
TOTAL LOAD	115.957 KBTU/H		122.34 MJ/H		-68.204 KBTU/H	-71.96 MJ/H
TOTAL LOAD / AREA	12.88 BTUH/SQFT		.14634 MJ/H/SQMT		7.58 BTUH/SQFT	.08608 MJ/H/SQMT

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

These optional reports are user-designed (see Section 5.B.2.h). What variables are displayed are chosen by the user from the list in Chapter II of the Reference Manual.

At the left is the month, day, and hours of the report. Each successive column is headed by the code-word and code-number of the variable chosen by the user. In DOE-2 the heading will be a mnemonic name of the variable.

In the example shown here the variables are:

BUILDING - ITEM 6: Building load due to solar radiation through window (if net building heating load)
BUILDING - ITEM 23: Building load due to solar radiation through window (if net building cooling load)
GLOBAL - ITEM 6: Cloud amount (0.0 to 10.0)
GLOBAL - ITEM 20: Cloud cover multiplier (0.0 to 1.0)
GLOBAL - ITEM 21: Direct normal solar times Cloud cover multiplier
GLOBAL - ITEM 22: Diffuse solar on horizontal surface times Cloud cover multiplier
DOOR-1 - ITEM 13: Solar energy transmitted through glass
DOOR-1 - ITEM 15: Heat through window by radiation

MMDDHH	BUILDING ITEM 6	BUILDING ITEM 23	GLOBAL ITEM 6	GLOBAL ITEM 20	GLOBAL ITEM 21	GLOBAL ITEM 22	DOOR-1 ITEM 13	DOOR-1 ITEM 15	ITEM
716 1	0.0000	6149.7936	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 2	0.0000	5350.3205	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 3	0.0000	4654.7788	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 4	0.0000	4049.6576	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 5	0.0000	3523.2021	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 6	0.0000	3356.6745	2.0000	.7154	14.5878	2.0807	.9659	43.6067	
716 7	0.0000	4688.9302	3.0000	.7098	105.3042	15.0201	8.3146	373.9075	
716 8	0.0000	5574.6483	7.0000	.6126	127.6457	18.2068	11.7009	528.2472	
716 9	0.0000	6656.0875	6.0000	.6537	155.6851	22.2062	16.5550	746.9809	
71610	0.0000	8941.1707	0.0000	1.0000	254.5798	36.3120	35.7032	1608.9037	
71611	0.0000	10326.3921	3.0000	.9996	263.7741	37.6235	37.6639	1673.2947	
71612	0.0000	11322.3628	3.0000	.9996	268.5693	38.3074	33.8589	1504.6477	
71613	0.0000	12046.8180	3.0000	.9361	252.8455	36.0647	32.2663	1437.4999	
71614	0.0000	12790.3058	3.0000	.9361	251.2855	35.8422	32.0859	1443.4296	
71615	0.0000	13636.3996	2.0000	.9371	246.7650	35.1974	36.0565	1603.2167	
71616	0.0000	14387.0552	1.0000	.9429	239.0980	34.1038	33.4131	1512.2392	
71617	0.0000	15090.0797	0.0000	1.0000	236.3670	33.7142	24.7270	1099.6978	
71618	0.0000	15248.7274	0.0000	1.0000	205.0068	29.2412	18.5872	825.9907	
71619	0.0000	14616.2576	0.0000	1.0000	141.1180	20.1284	10.9961	486.5154	
71620	0.0000	12072.3945	0.0000	1.0000	10.5654	1.5070	.6890	30.7811	
71621	0.0000	10430.7461	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71622	0.0000	9074.7491	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71623	0.0000	7895.0317	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71624	0.0000	6868.6776	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

REPORT SVA — SYSTEMS DESIGN PARAMETERS

This report is called by the user input keyword **VERIFICATION = SV-A**, and serves to echo the user's input in tabular form.

1) Reading the top line from left to right, starting with the heading SYSTEM NAME, the u-name of the system selected by the user is displayed.

2) Under the next item, DESIGN CFM, is the number 4886 which is the calculated system design CFM. If the system selected is a constant volume system, the number will equal the sum of the DESIGN CFMs of the individual spaces. If the system selected is a variable-air-volume system, the number will be calculated from the building coincident peak load, which is less than the sum of the non-coincident peak loads of all the spaces.

3) Under MIN CFM is the number .30. This is the user-specified input for **MIN-CFM-RATIO**. This number states that the minimum ratio of air delivered to the space divided by DESIGN CFM is .30 or 30%. There are programs that use the number of CFM/sq.ft. as the limiting factor to accomplish this purpose.

4) MIN OUTSIDE RATIO of .22 states that 22% of the total supply air is outside air, as calculated from the user-supplied keyword=value pair **OUTSIDE-CFM/PER** = 7.

5) The SUP FAN KW of 3.04 is the peak electric load calculated as a function of the user input for **SUPPLY-STATIC** = 3.5 and **SUPPLY-EFF** = 0.66.

6) The RET FAN KW of .87 is the peak electric load calculated for the return fan in the same manner as for the supply fan.

7) The ALTITUDE MULT of 1.02 is the correction factor to account for the difference of a standard air volume from that at sea level as a function of air pressure.

8) Under the heading ZONE NAME, the u-names of the zones are specified.

9) Under the heading DESIGN CFM are the calculated CFMs for each zone.

10) Under the heading OUTSIDE CFM is the calculated outside air for each zone, using the user-specified value of 7 CFM per person and corrected for altitude after being rounded to the nearest factor of 10 CFM.

11) Under the heading COOL KBTU/HR is the calculated cooling load (sensible only) in 1000's of BTU/HR, excluding outside air and prior to the floating temperature calculation. If the user has assigned a cooling extraction rate, it would be displayed here rather than the calculated rate. Similarly for HEAT KBTU/HR.

12) Under the heading PEOPLE is the user specified **NUMBER-OF-PEOPLE** per zone.

13) Under the heading MULTIPLIER is the user specified number of identical zones.

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.04.50
DECEMBER 1978
REPORT SVA SYSTEM DESIGN PARAMETERS PAGE 1

SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
CEILBYPS-1	4886.	.30	.22	3.04	.87	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	1479.	326.	-22.19	31.28	45.0	1.0
SPACE-2	479.	41.	-9.51	10.25	5.0	1.0
SPACE-3	1275.	326.	-26.43	26.91	45.0	1.0
SPACE-4	490.	41.	-9.32	10.36	5.0	1.0
SPACE-5	1163.	326.	-2.03	24.56	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

Report SSA — SYSTEM LOAD SUMMARY

This report is generated automatically by the program, but the user may use the keyword **SUMMARY** = **SS-A**.

1) The first line of the report gives the u-name of the system and the program keyword **TYPE**, which in this case is **CBVAV**.

2) The second level of headings are divided into four sections. The first lists the months that a system load occurred. These loads are divided into Heating, Cooling, and Electrical with the day of month and the hour that the maximums occurred.

3) The maximum heating loads include the preheating of ventilation air plus the heat for humidification. They also reflect start-up loads which occur after fan shut-down periods. Notice that the Spring and Summer maximums often occur in the seventh hour (6 to 7 am).

4) The maximum cooling loads include both sensible and latent loads, cooling of the ventiltion air, and the start-up loads.

5) The HEATING ENERGY in millions of Btu is the sum of energy delivered to the space for all hours of the month. It does not include plant energy for absorption cooling.

6) The COOLING ENERGY in millions of Btu is the sum of the energy extracted for all hours of the month.

7) The ELECTRICAL ENERGY (KWH) is the total electric consumption for lights, equipment and fans.

8) The MAXIMUM LOAD (KW) is the peak electric load observed for any one hour of the month including lights, equipment and fans.

9) The yearly totals and the maximums observed for the entire year are indicated at the bottom of each column.

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.04.50
DECEMBER 1978
REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM CEILBYPS-1 TYPE CBVAV

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	-18.207	7	8	-133.112	0.000	31	24	0.000	7169.	21.
FEB	-13.438	11	8	-124.720	0.000	28	24	0.000	6329.	21.
MAR	-10.020	25	8	-114.315	0.000	31	24	0.000	7001.	21.
APR	-7.537	10	8	-111.459	3.025	29	18	127.028	7057.	21.
MAY	-4.982	6	7	-119.298	7.021	21	13	157.810	7169.	21.
JUN	-1.751	3	14	-50.972	16.027	20	17	181.700	6721.	21.
JUL	-.685	26	7	-37.413	30.467	3	14	186.095	7169.	21.
AUG	-1.333	20	7	-44.845	27.431	26	16	171.363	7169.	21.
SEP	-1.973	23	7	-78.677	10.494	11	15	155.175	6721.	21.
OCT	-5.628	21	10	-107.239	5.466	30	18	129.095	7337.	21.
NOV	-8.477	18	9	-102.800	0.000	30	24	0.000	6721.	21.
DEC	-11.391	9	8	-113.313	0.000	31	24	0.000	6665.	21.
TOTAL	-85.422				99.931				83229.493	
MAX				-133.112				186.095		21.456

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

Column 1 — MONTH
This column represents January as 1, February as 2, etc.

Columns 2 to 6 — SITE ENERGY
The information in these 5 columns is site energy use before equipment part load efficiencies are taken into account. For electrical energy 1 GBTU = 2.93×10^5kWH.

Column 2 — TOTAL HEAT ENERGY GBTU (10^9Btu)
These values are identical to those in Column 1 in the SYSTEMS SSA report except that the heat energy delivered to an absorption chiller is included, if one has been assigned to the plant. The contribution of solar heating by solar plants is subtracted from the values in Column 2.

Column 3 — TOTAL ELECTRICAL ENERGY (GBTU)
This is the total electrical energy consumed by lights, equipment, and system fans plus the additional energy consumed by chiller motors, pumps, cooling towers and any other electrical site use.

Column 4 - COOLING ENERGY (GBTU)
These values are the same as the values reported in the SSA Report and represent the total energy used for cooling in each month.

Column 5 - RCVRED ENERGY (GBTU)
The values in this column are for the recovered heat that is used to reduce heating loads. The recovered heat is the waste heat from turbines, diesels, and double bundle chillers. Recovered heat does not affect the TOTAL HEAT ENERGY reported in Colunn 2, unless there is solar heating.

Column 6 — WASTED RCVRABL ENERGY (GBTU)
The values in this column represent the heat that was recovered but not used and thus rejected to the cooling tower. The sum of the values in Column 5 plus Column 6 represent the total heat rejection of the equipment.

Columns 7 to 12 — SOURCE ENERGY
The information in these columns is the energy use at the source and therefore represents the actual energy consumption resulting from the performance characteristics of the plant equipment. The energy consumed at the generating station to produce electricity is calculated by dividing the electrical consumption at the site by the value of TOTUEF, whose default is 0.333, i.e., it requires 10,239 Btu to generate 1 kWH of electricity.

Column 7 — HEAT EN INPUT COOLING (GBTU)
This column reports the source energy used to drive cooling equipment such as absorption chillers as a function of their part load characteristics.

Column 8 — ELECTRIC EN INPUT COOLING (GBTU)
This column reports the electric source energy used to drive refrigeration units as a function of their part load characteristics.

Column 9 - ENERGY INPUT HEATING (GBTU)
This column reports the source energy used for heating by the boiler as a function of its part load characteristics and combustion efficiency.

Column 10 — ENERGY INPUT ELECTRIC (GBTU)
This column reports the source energy of the utility generating plant
or, for on-site equipment, the energy used by gas turbines or diesels. (Steam turbines are always considered as driven by waste heat from the TE plants).

Colunn 11 — TOTAL FUEL INPUT (GBTU)
This column reports the sum of all the users of fossil fuels in a single column.

Column 12 — TOTAL ENERGY INPUT (GBTU)
This column reports the sum of fossil fuel and electric source energy.

Column 13 — AVERAGE PLANT EFFIC - PERC
This column reports the average plant efficiency as computed through the following equation:

$$\text{Plant Efficiency} = (100) \times \frac{\text{Total Heat(Col. 2)} + \text{Total Electric(Col. 3)}}{\text{Total Energy Input(Col. 12)}}.$$

In the case that the user has attempted to simulate an electric boiler, the results printed should be ignored and the following equation should be calculated by hand:

Plant Efficiency =

$$(100) \times \frac{\text{Total Heat(Col. 2)} + \text{Total Electric(Col. 3)}}{\frac{\text{Total Fuel Input(Col. 11)}}{\text{TOTUEF}} + \text{Total Electric Input(Col. 10)}}.$$

CENTRAL PLANT ENERGY UTILIZATION SUMMARY

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	.018	.025	0.000	0.000	0.000	0.000	0.000	.029	.074	.029	.103	41.
2	.013	.022	0.000	0.000	0.000	0.000	0.000	.022	.065	.022	.087	40.
3	.010	.024	0.000	0.000	0.000	0.000	0.000	.017	.072	.017	.089	38.
4	.008	.027	.003	0.000	0.000	0.000	.006	.012	.082	.012	.094	37.
5	.005	.029	.007	0.000	0.000	0.000	.009	.008	.086	.008	.094	36.
6	.002	.030	.016	0.000	0.000	0.000	.017	.003	.090	.003	.093	34.
7	.001	.036	.030	0.000	0.000	0.000	.029	.001	.108	.001	.110	34.
8	.001	.035	.027	0.000	0.000	0.000	.026	.003	.106	.003	.108	34.
9	.002	.028	.010	0.000	0.000	0.000	.012	.004	.084	.004	.088	34.
10	.006	.029	.005	0.000	0.000	0.000	.008	.010	.087	.010	.096	36.
11	.008	.023	0.000	0.000	0.000	0.000	0.000	.015	.069	.015	.084	38.
12	.011	.023	0.000	0.000	0.000	0.000	0.000	.019	.068	.019	.088	39.
	.085	.330	.100	0.000	0.000	0.000	.108	.144	.991	.144	1.134	37.

EQUIPMENT USE STATISTICS

This report gives the user an assessment of the appropriateness of the equipment selected.

1) AVG OPER RATIO is the point on the average at which the equipment operates on its part load curve.

2) MAX LOAD (MBTU) — MON-DAY-HR gives the maximum loading and the time of occurrence. This value should compare favorably with the size of the equipment selected.

3) SIZE (MBTU) is the equipment size selected either automatically by the program or as input by the user.

4) OPER HRS is the total number of hours the equipment was ``on.'' If more than one unit is involved there is space to report four more units by size and operating hours.

E Q U I P M E N T U S E S T A T I S T I C S

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
STEAM BOILER	.157	.133	1	7	8	.150	3629								
RECIPROCATING CHILR	.298	.186	7	3	14	.240	1398								
COOLING TOWER	.324	.240	7	3	14	.300	1398								

CENTRAL PLANT LIFE CYCLE EQUIPMENT COST SUMMARY

For each piece of equipment the report generates information as follows:

1) Nominal Size

2) Number Installed

3) First Cost of Equipment

4) Annual Cost of Operating and Maintenance Costs

5) Cyclical Costs are the total costs of major and minor overhauls over the operating life. The user must review TABLE V5 in the Reference Manual to make sure that the default values assigned are appropriate. Otherwise the information in this report will be of little value.

CENTRAL PLANT LIFE CYCLE EQUIPMENT COST SUMMARY

EQUIPMENT	TOTALS		
STEAM BOILER	84.6		
NOMINAL SIZE (MBTU)			.150
NUMBER INSTALLED			1
FIRST COST (K$)		2.8	2.8
ANNUAL COST (K$)		79.4	79.4
CYCLICAL COST (K$)		2.4	2.4
----TOTAL---- (K$)			84.6
RECIPROCATING CHILR	10.6		
NOMINAL SIZE (MBTU)			.240
NUMBER INSTALLED			1
FIRST COST (K$)		8.7	8.7
ANNUAL COST (K$)		1.7	1.7
CYCLICAL COST (K$)		.2	.2
----TOTAL---- (K$)			10.6
COOLING TOWER	17.4		
NOMINAL SIZE (MBTU)			.300
NUMBER INSTALLED			1
FIRST COST (K$)		6.6	6.6
ANNUAL COST (K$)		8.7	8.7
CYCLICAL COST (K$)		2.1	2.1
----TOTAL---- (K$)			17.4
EQUIPMENT TOTAL	112.5		

MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY

The information reported treats the electric utility, the diesel, the gas turbine and the boiler as prime energy users. All other types of plant equipment are considered as auxiliaries, (i.e., storage, heat recovery, pumps, towers, etc.). Therefore, the report shows these four types of equipment whether or not they are part of the equipment for each month, plus the peak energy demand and the day and hour it occurred. Note that the values are net or at the building boundary. Therefore, to calculate the peak electrical demand, the user should divide PEAK in MBTU by 3413 Btu/kW.

MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY

MO	UTILITY>	ELECT	DIESEL	GASTUR	BOILER
	TOTAL(MBTU)	24.570	0.000	0.000	29.488
1	PEAK(MBTU)	.074	0.000	0.000	.178
	DY/HR	7/11	31/24	31/24	7/ 8
	TOTAL(MBTU)	21.675	0.000	0.000	22.300
2	PEAK(MBTU)	.074	0.000	0.000	.167
	DY/HR	4/11	28/24	28/24	11/ 8
	TOTAL(MBTU)	23.948	0.000	0.000	17.124
3	PEAK(MBTU)	.074	0.000	0.000	.153
	DY/HR	25/11	31/24	31/24	25/ 8
	TOTAL(MBTU)	27.165	0.000	0.000	12.136
4	PEAK(MBTU)	.119	0.000	0.000	.149
	DY/HR	29/16	30/24	30/24	10/ 8
	TOTAL(MBTU)	28.633	0.000	0.000	8.387
5	PEAK(MBTU)	.129	0.000	0.000	.159
	DY/HR	21/10	31/24	31/24	6/ 7
	TOTAL(MBTU)	29.930	0.000	0.000	3.284
6	PEAK(MBTU)	.132	0.000	0.000	.080
	DY/HR	20/15	30/24	30/24	3/14
	TOTAL(MBTU)	36.143	0.000	0.000	1.348
7	PEAK(MBTU)	.136	0.000	0.000	.063
	DY/HR	3/10	31/24	31/24	26/ 7
	TOTAL(MBTU)	35.287	0.000	0.000	2.604
8	PEAK(MBTU)	.132	0.000	0.000	.073
	DY/HR	20/10	31/24	31/24	20/ 7
	TOTAL(MBTU)	28.082	0.000	0.000	3.551
9	PEAK(MBTU)	.128	0.000	0.000	.112
	DY/HR	11/14	30/24	30/24	23/ 7
	TOTAL(MBTU)	28.922	0.000	0.000	9.592
10	PEAK(MBTU)	.123	0.000	0.000	.144
	DY/HR	31/11	31/24	31/24	21/10
	TOTAL(MBTU)	22.984	0.000	0.000	14.785
11	PEAK(MBTU)	.073	0.000	0.000	.140
	DY/HR	29/11	30/24	30/24	18/ 9
	TOTAL(MBTU)	22.811	0.000	0.000	19.350
12	PEAK(MBTU)	.074	0.000	0.000	.152
	DY/HR	9/11	31/24	31/24	9/ 8
	ONE YEAR	330.149	0.000	0.000	143.949
	USE/PEAK (MBTU)	.136	0.000	0.000	.178
	YEAR COST (K$)	3.4	0.0	0.0	.3
	COST ESCLTN (PCT)	6.0	5.0	5.0	10.0

TOTAL USE (MBTU) 474.098

TOTAL COST (K$) 3.7

NOTES TO ABOVE TABLE
(1) ALL ENERGY USE VALUES ARE NET, I.E., AT BUILDING BOUNDARY

EQUIPMENT OPERATION AND PART LOAD REPORT

This report is self-explanatory and shows the hours at percent part load ratios in increments of 10%. If equipment is oversized, the equipment will never indicate any hours in the 100% range. The chiller is sized by the program in units of 10 tons (.120 MBTUH). In this case the maximum load reported in the EQUIPMENT USE STATISTICS report was .186 MBTUH and thus the chiller was sized at 20 tons or .240 MBTUH. The boiler was purposely oversized by the user at .150 MBTUH.

The TOTAL HOURS entry differs from the total hours in other reports. In this report, TOTAL HOURS refers to the total hours of the day during which one or more units of a given equipment type are operating. This sum is independent of the number of units operating. If three boilers are operating during a given hour, TOTAL HOURS is increased by one rather than three.

ANNUAL LOAD is the useful load handled by the equipment. A FALSE LOAD occurs when, due to **MIN-RATIO** setting (the minimum load on the part load curve), the equipment outputs more than the plant requests. The excess load over demand is the FALSE LOAD. The total load is the sum of the annual and false loads.

(2) PEAK VALUES ARE IN MBTUH
(3) YEAR COST IS LIFE-CYCLE COST DIVIDED BY PROJECT LIFETIME

E Q U I P M E N T O P E R A T I O N A N D P A R T L O A D R E P O R T

NAME	HOURS AT PERCENT PART LOAD RATIO												TOTAL HOURS	ANNUAL LOAD (GBTU)	FALSE LOAD (GBTU)	TOTAL LOAD (GBTU)
	0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110	- 120+				
STMB	1555	1235	416	167	82	52	74	31	17	0	0	0	3629	.085	0.000	.085
	1555	1235	416	167	82	52	74	31	17	0	0	0				
COMPR	558	122	65	67	113	276	152	45	0	0	0	0	1398	.100	.007	.107
	558	122	65	67	113	276	152	45	0	0	0	0				
CTOWR	504	162	66	60	70	284	184	68	0	0	0	0	1398	.136	0.000	.136
	504	162	66	60	70	284	184	68	0	0	0	0				

NOTES TO TABLE
1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE HOURLY OPERATING CAPACITY (UNITS OPERATING THAT HOUR)
2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE TOTAL INSTALLED CAPACITY

PLANT DEMANDS SATISFIED REPORT

Again, this report is self-explanatory with the exception that under ELECTRICAL DEMANDS the intent is to report electric loads ``not met'' by a Total Energy Plant (TE) and does not refer to a utility which is always considered able to meet its demand.

P L A N T D E M A N D S S A T I S F I E D R E P O R T

HEATING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
STEAM BOILER	.085	100.0
DEMAND SATISFIED	.085	100.0
TOTAL DEMAND ON PLANT	.085	

COOLING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
RECIPROCATING CHILR	.100	100.0
DEMAND SATISFIED	.100	100.0
TOTAL DEMAND ON PLANT	.100	

ELECTRICAL DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
DEMAND SATISFIED	0.000	0.0
TOTAL DEMAND ON PLANT	.330	

REJECTED HEAT	GBTU SUPPLIED	PCT OF TOTAL DEMAND
COOLING TOWER	.136	100.0
DEMAND SATISFIED	.136	100.0
TOTAL DEMAND ON PLANT	.136	

SUMMARY OF LOADS MET

The intent of this report is to flag those situations where the plant is not able to meet the loads imposed by both SYSTEMS and other plant and equipment. This is of special importance in those cases where equipment is intentionally undersized in order to improve part load performance.

SUMMARY OF LOADS MET

TYPE OF DEMAND	TOTAL DEMAND (GBTU)	DEMAND SATISFIED (GBTU)	TOTAL OVERLOAD (GBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING DEMANDS	.085	.085	0.000	0.000	0
COOLING DEMANDS	.100	.100	0.000	0.000	0
REJECTED HEAT	.136	.136	0.000	0.000	0

ELECTRICAL DEMAND SCATTER PLOT

In this scatter plot the ordinate shown in the left most column is the electrical demand divided into 13 blocks ranging from zero to just above the peak electrical demand. The abscissa shown at the top is the hour of the day. Entered in each cell of the plot is the number of days during the year for which the electrical demand was less than the ordinate shown but larger than the next lower ordinate at that hour of the day. Thus there were 365 days (i.e., every day) of the year when the electrical demand between midnight and 1:00 A.M. was between 6.475 and 3.238 kWH. Similarly there were 17 days in the year when the electrical demand was between 35.615 and 32.377 kWH in the 8th hour between 7:00 A.M. and 8:00 A.M.

The right most column is the sum of the entries in each row and shows the relative frequency of the electrical demand throughout the year.

The bottom row is the frequency of the electrical demnd for each hour of the average day.

The chart at the bottom is a breakdown of the peak electrical demand into the contributing components. The SYSTEM LOAD includes the lighting and equipment electrical loads from LOADS as well as that from system fans.

ELECTRICAL DEMAND SCATTER PLOT

TOTAL HOURS AT DEMAND AND TIME OF DAY

	HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
	42.090	0	0	0	0	0	0	0	0	0	5	2	0	0	4	3	0	0	0	0	0	0	0	0	0	14
	38.853	0	0	0	0	0	0	0	1	26	40	29	5	28	44	37	26	23	0	0	0	0	0	0	0	259
	35.615	0	0	0	0	0	0	0	26	17	14	32	34	31	19	29	39	45	3	0	0	0	0	0	0	289
	32.377	0	0	0	0	0	0	0	17	9	4	6	25	12	9	9	9	4	0	0	0	0	0	0	0	104
D	29.139	0	0	0	0	0	0	0	7	13	24	12	10	5	6	10	11	15	0	0	0	0	0	0	0	113
E K	25.902	0	0	0	0	0	0	0	7	36	37	60	71	68	61	52	59	55	15	0	0	0	0	0	0	521
M W	22.664	0	0	0	0	0	0	0	25	42	128	111	102	5	109	112	108	110	105	0	0	0	0	0	0	957
A H	19.426	0	0	0	0	0	0	1	46	109	0	0	5	103	0	0	0	0	0	0	0	0	0	0	0	264
N	16.189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	129	123	0	0	0	0	0	252
D	12.951	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	9.713	0	0	0	0	0	0	43	13	0	0	0	0	0	0	0	0	0	0	129	252	123	0	0	0	560
	6.475	365	365	365	365	365	365	319	222	113	113	113	113	113	113	113	113	113	113	113	113	242	365	365	365	5424
	3.238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PERCENT TOTAL DEMAND		1.8	1.8	1.8	1.8	1.8	1.8	2.0	4.5	6.7	7.3	7.4	7.1	7.0	7.4	7.5	7.3	7.2	4.9	3.3	2.5	2.0	1.8	1.8	1.8	

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KWH	PCT
SYSTEMS LOAD	21.450	54.0
COMPRESSION CHILLERS	15.316	38.5
COOLING TOWER	2.043	5.1
CIRCULATION PUMPS	.946	2.4
TOTAL	39.755	

LIFE-CYCLE PLANT COST SUMMARY

This report is self-explanatory. The annual ENERGY COST and ENERGY USE are taken from the data at the bottom of the MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY and multiplied by the user-specified lifetime. The PLANT EQUIPMENT COST includes overhauls and replacement costs which are prorated per year for the annual cost.

LIFE-CYCLE PLANT COST SUMMARY

	ANNUAL	LIFETIME(25 YRS)
PLANT EQUIPMENT COST	4.5	112.5 K$
ENERGY COST	3.7	92.0 K$
ENERGY USE (NET)	.5	11.9 GBTU

PLANT EQUIPMENT PLUS ENERGY LIFE CYCLE COST FOR 25 YEARS = .2045 (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

Report E01 — ECONOMICS VERIFICATION

This report echoes the non-plant cost data input with the **COMPONENT-RATES** instruction and with each **COMPONENT-COST** instruction.

COMPONENT-RATES data

DISCOUNT RATE is the rate in percent used in calculating present values.

LABOR INFL-RATE is the annual inflation rate (relative to general inflation) of labor costs, in percent.

MATERIALS INFL-RATE is the annual inflation rate (relative to the general inflation) of material costs, in percent.

PROJECT LIFETIME is the period, in years, over which the life-cycle cost analysis is performed.

COMPONENT-COST data

COST-NAME is the u-name of the component.

NO. OF UNITS is the multiplier by which all costs specified on a per-unit basis, such as UNIT FIRST COST, UNIT INSTALL COST, etc., are multiplied.

UNIT NAME is the name assigned to the unit (such as SQFT or CUFT) by the user to identify the size of the unit. The name is arbitrary and optional and is for user convenience only.

LIFE is the life expectancy of the component, in years, and is used in calculating replacement costs.

FIRST COST, UNIT FIRST COST, etc., are defined in the Reference Manual under the corresponding keywords, **FIRST-COST**, **FC-PER-UNIT**, etc.

REPORT- E01 ECONOMICS VERIFICATION (NON-PLANT COST ITEMS) CAL-ERDA 1.3 15 JAN 1979 20.13.32

DISCOUNT RATE (PCT)	LABOR INFL-RATE (PCT)	MATERIALS INFL-RATE (PCT)	PROJECT LIFETIME (YRS)
10.0	0.0	0.0	25.0

COST-NAME CBVAVCST-1 NO. OF UNITS 1.0 UNIT-NAME 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
25000.	0.00	20000.	0.00	750.	0.00	750.	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

This report has two parts:

(1) PRESENT-VALUE OF NON-PLANT LIFE-CYCLE COSTS gives the present value, in $1000 units, of the different contributions to each component cost.

COST-NAME Same as in E01

UNIT-NAME Same as in E01

FIRST COST Initial cost, excluding installation

INSTALLATION Installation cost, both initially and for replacement(s)

TOTAL ANNUAL Life-cycle value of annual costs as specified by the keywords **ANNUAL-COST** or **AC-PER-UNIT**. If neither of these was specified, TOTAL ANNUAL is the sum of the next two columns, TOTAL MAINT and TOTAL CONSUM (see below).

TOTAL MAINT life-cycle value of maintenance costs as specified by the keywords **MAINT-COST** or **MC-PER-UNIT**.

TOTAL CONSUM Life-cycle value of consumable costs, as specified by the keywords **CONSUM-COST** or **CONSC-PER-UNIT**.

TOTAL CYCLIC Life-cycle vale of cyclical costs as specified by the keywords **CYCLICAL-COST** or **CC-PER-UNIT**. If neither of these was specified, TOTAL CYCLIC is the sum of the next two columns, MINOR OVHLS and MAJOR OVHLS (see below).

MINOR OVHLS Life-cycle costs for minor overhauls as specified via the keywords **MIN-OVERH-INT** and **MIN-OVERH-COST** (or **MINOC-PER-UNIT**).

MAJOR OVHLS Life-cycle cost for major overhauls as specified via the keywords **MAJ-OVERH-INT** and **MAJ-OVERH-COST** (or **MAJOC-PER-UNIT**).

REPLACEMENTS Life-cycle cost (including re-installation) for all replacements of a component. Replacement costs are calculated only if the expected useful life of a component (given by the keyword **COMPONENT-LIFE**) is less than the project life.

TOTAL (right hand column) Sum of FIRST COST, INSTALLATION, TOTAL ANNUAL, TOTAL CYCLIC and REPLACEMENTS. The quantities in parentheses are not included in this sum.

(2) OVERALL LIFE-CYCLE COSTS (in $1000 units)

NON-PLANT Total life-cycle cost for non-plant components

(i.e., all components entered using the **COMPONENT-COST** command).

PLANT Total life-cycle cost for plant equipment and plant operation and maintenance (excluding energy costs), as specified in PDL.

FUEL Total life-cycle cost for purchased fuel and electricity.

TOTAL Grand total life-cycle cost (sum of above three items).

REPORT- E02 LIFE-CYCLE COSTS SUMMARY CAL-ERDA 1.3 15 JAN 1979 20.13.32

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
CBVAVCST-1	1.		25.00	20.00	6.81 (	6.81	0.00)	0.00 (	0.00	0.00)	0.00	51.81
		TOTAL	25.00	20.00	6.81 (	6.81	0.00)	0.00 (	0.00	0.00)	0.00	51.81

OVERALL LIFE-CYCLE COSTS (K$)

NON-PLANT	PLANT	FUEL	T O T A L
51.8	112.5	92.0	256.3

Report E03 -- LIFE-CYCLE SAVINGS/INVESTMENT STATISTICS

This report has two parts:

(1) LIFE-CYCLE COMPARISON -- THIS RUN VS BASELINE

This compares costs and energy use for the baseline case (entered using the **BASELINE** instruction) with those for the present run.

INVESTMENT Sum of life-cycle costs of all items entered with the **COMPONENT-COST** instruction.

PLANT-EQUIP COST Total life-cycle cost for plant equipment and plant operation and maintenance (excluding energy costs).

ENERGY COST Total life-cycle cost of purchased fuel and electricity.

PLANT-EQUIP + ENERGY COST Sum of two previous costs.

ENERGY USE Life-cycle energy use, in units of 10^9Btu.

SAVINGS Cost and energy use differences, baseline minus present run.

(2) SAVINGS/INVESTMENT STATISTICS

COST-SAVINGS The dollar savings relative to baseline. Repeated from part (1) above.

INVESTMENT Repeated from part (1) above.

SAVINGS-TO-INVESTMENT RATIO (SIR) Dollars saved per dollar invested (ratio of two previous values).

FUEL SAVINGS Energy use savings relative to baseline, in units of 10^6 Btu; repeated from part (1).

FUEL-SAVINGS-TO-INVESTMENT RATIO Energy saved (in Btu) per dollar invested.

PAYBACK PERIOD Project life divided by SIR. In DOE-1 the present value of total savings is averaged over the project life and is considered uniform for each year. The payback period is the number of years of these uniform savings which would equal the investment. See Reference Manual, Chapter VI.A.1.b.

REPORT- E03 LIFE-CYCLE SAVINGS/INVESTMENT STATISTICS CAL-ERDA 1.3 15 JAN 1979 11.19.59

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		112.50	92.00	204.50	11.90
THIS RUN	.40	109.19	88.20	197.39	11.61
SAVINGS		3.31	3.80	7.11	.29

SAVINGS/INVESTMENT STATISTICS

COST SAVINGS (K$)	INVESTMENT (K$)	SAVINGS-TO-INVESTMENT RATIO	FUEL SAVINGS (MBTU)	FUEL-SAVINGS-TO-INVESTMENT RATIO(MBTU/$)	PAYBACK PERIOD (YRS)
7.1	.4	17.8	286.2	.72	1.4

Appendix 3 — Example Building Output

Table of Contents

CBVAV System Type.....A3-2
MZS System Type.....A3-38
Retrofit with CBVAV System Type.....A3-74

Example Building with CBVAV System

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C A L - E R D A   E N E R G Y   A N A L Y S I S   P R O G R A M   V E R S I O N   1.4
      B U I L D I N G   D E S I G N   L A N G U A G E   P R O C E S S O R

*  1 *          INPUT LOADS                                          ..
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L D L P R O C E S S O R I N P U T D A T A

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*   2 *  TITLE      USERS GUIDE EXAMPLE BUILDING
*   3 *  TITLE      LAWRENCE BERKELEY LABORATORY
*   4 *  TITLE
*   5 *  TITLE      JANUARY 1979
*   6 *
*   7 *  /* [1] THE BUILDING IS A SINGLE STORY OFFICE BUILDING LOCATED IN CHICAGO.
*   8 *     [2] THE WEATHER DATA WILL BE FOR 1974.
*   9 *     [3] THE WALLS ARE OF FACE BRICK AND CONCRETE CONSTRUCTION WITH 1 INCH OF
*  10 *         EXPANDED POLYSTYRENE INSULATION (R-4) UNDER THE BRICK.
*  11 *     [4] THE ROOF IS A BUILT-UP ROOF OVER 3 INCHES OF PREFORMED ROOF          */
*  12 *  /*     INSULATION (R-8)                                                      */
*  13 *  /* [5] THERE ARE 16 4 FEET BY 6 FEET WINDOWS, DOUBLE PANED WITH AN ASHRAE
*  14 *         SHADING COEFFICIENT OF .86 AND SETBACK 6 INCHES FROM THE WALL SURFACE.
*  15 *     [6] THE FRONT DOOR IS .25 INCH PLATE GLASS; THE BACK DOOR IS ONE INCH WOOD.
*  16 *     [7] THE FLOOR IS 6 INCHES THICK CONCRETE IN CONTACT WITH THE SOIL.
*  17 *     [8] A DROP CEILING SERVES AS A PLENUM.                                    */
*  18 *  /* [9] THE LIGHTING FIXTURES HAVE FLUORESCENT LAMPS AND RETURN AIR PASSES
*  19 *         THROUGH THE FIXTURE.  THE MAXIMUM ENERGY OF THE LIGHTING IS 3 W/SQ.FT.
*  20 *    [10] THE ENERGY USED BY EQUIPMENT IS 1 W/SQ.FT. AT A MAXIMUM.
*  21 *    [11] THE NUMBER OF PEOPLE IS 145; 45 IN THREE SPACES AND 5 IN TWO SPACES.
*  22 *    [12] THE INFILTRATION DURING OCCUPIED HOURS IS .5 AIR CHANGES PER HOUR.    */
*  23 *
*  24 *           DIAGNOSTIC          ERROR     ABORT     ERROR                 ..
*  25 *           RUN-PERIOD          JAN 1 1974 THRU DEC 31 1974               ..
*  26 *           LOADS-REPORT        L02                                       ..
*  27 *           BUILDING-LOCATION   LATITUDE=42 LONGITUDE=88
*  28 *                               ALTITUDE=610 TIME-ZONE=6
*  29 *                               BUILDING-AZIMUTH=0                        ..
*  30 *
*  31 *
*  32 *
*  33 *             /*-----BUILDING CONSTRUCTION MATERIALS-----*/
*  34 *
*  35 *  WLLAY-1   =LAYERS            MATERIAL-1=BK05 M2=IN33
*  36 *                               M3=CB46 M4=AL11 M5=GP01
*  37 *                               INSIDE-FILM-RES=.68                       ..
*  38 *  RFLAY-1   =LAYERS            M1=RG01 M2=BR01 M3=IN76
*  39 *                               IFR=.76                                   ..
*  40 *  EXTW-1    =CONSTRUCTION       LAYERS=WLLAY-1 ABSORPTANCE=.88
*  41 *                               ROUGHNESS=2                               ..
*  42 *  ROF-1     =CONS               WALL-TYPE=RFLAY-1 ABS=.5 RO=1             ..
*  43 *  CEIL-1    =CONS               U=.8   /*CONSTRUCTION OF CEILING*/        ..
*  44 *  PART-1    =CONS               U=10   /*FALSE PARTITIONS*/                ..
*  45 *  FLOR-1    =CONS               U=.05  /*SLAB ON GROUND*/                  ..
*  46 *  DOR-1     =CONS               U=1.0 ROUGHNESS=6   /*BACK DOOR*/         ..
*  47 *  WINGLS-1  =GLASS-TYPE         PANES=2 GLASS-SHADING=.86                 ..
*  48 *  DORGLS-1  =GT                 GTC=3   /*FRONT DOOR*/                    ..
*  49 *
*  50 *
*  51 *                     /*-----SCHEDULES-----*/
*  52 *
*  53 *  DAYSC-1   =DAY-SCHEDULE       (1,8) 0 (9,11) 1 (12,14) .8,.4,.8
*  54 *                               (15,18) 1 (19,21) .5,.1,.1 (22,24) 0      ..
*  55 *  DAYSC-2   =DS                 (1,24) 0                                  ..
*  56 *
*  57 *  WKPEOP-1  =WEEK-SCHEDULE      (MON,FRI) DAYSC-1 (WEH) DAYSC-2           ..
```

```
*  58 *
*  59 *  PEOPSC-1  =SCHEDULE          THRU DEC 31 WKPEOP-1                    ..
*  60 *
*  61 *  WKLITE-1  =WS                (MON,FRI) (1,8) .05 (9,14) .9,.95,1,.95,.8,.9
*  62 *                                        (15,18) 1 (19,21) .6,.2,.2
*  63 *                                        (22,24) .05
*  64 *                             (WEH)      (1,24) .05                       ..
*  65 *
*  66 *  LITESC-1  =SCH               THRU DEC 31 WKLITE-1                    ..
*  67 *
*  68 *  WKEQUP-1  =WS                (MON,FRI) (1,8) .02 (9) .4 (10,14) .9
*  69 *                                        (15,20) .8,.7,.5,.5,.3,.3
*  70 *                                        (21,24) .02
*  71 *                             (WEH)      (1,24) .02                      ..
*  72 *
*  73 *  EQUIPSC-1 =SCH               THRU DEC 31 WKEQUP-1                    ..
*  74 *
*  75 *  INFLSC-1  =SCH               THRU DEC 31 (MON,FRI) (1,7) 1 (8,18) 0
*  76 *                                                     (19,24) 1
*  77 *                                        (WEH)      (1,24) 1             ..
*  78 *
*  79 *
*  80 *            /*-----BUILDING SHADE SPECIFICATION-----*/
*  81 *
*  82 *           BUILDING-SHADE      HEIGHT=5 WIDTH=10 TRANSMITTANCE=0
*  83 *                               X-BUILDING=52.5 Y-BUILDING=0 Z-BUILDING=9
*  84 *                               SURFACE-AZIMUTH=180 TILT=180            ..
*  85 *
*  86 *
*  87 *                   /*-----SETTING DEFAULTS-----*/
*  88 *
*  89 *
*  90 *           SET-DEFAULT         FLOOR-WEIGHT=70 GLASS-HEIGHT=4
*  91 *                               GLASS-WIDTH=6 GLASS-TYPE=WINGLS-1
*  92 *                               SETBACK=0.5 TEMPERATURE=73              ..
*  93 *
*  94 *
*  95 *                     /*-----SPACE DESCRIPTIONS-----*/
*  96 *
*  97 *  COND-1    =SPACE-CONDITIONS  NUMBER-OF-PEOPLE=45
*  98 *                               PEOPLE-ACTIVITY=400
*  99 *                               PEOPLE-SCHEDULE=PEOPSC-1
* 100 *                               LIGHTING-TYPE=2
* 101 *                               LIGHT-TO-SPACE=80
* 102 *                               LIGHTING-W/SQFT=3
* 103 *                               LIGHTING-SCHEDULE=LITESC-1
* 104 *                               EQUIPMENT-W/SQFT=1
* 105 *                               EQUIPMENT-SCHEDULE=EQUIPSC-1
* 106 *                               AIR-CHANGES/HR=.5
* 107 *                               INF-METHOD=1
* 108 *                               INF-SCHEDULE=INFLSC-1                   ..
* 109 *
* 110 *  PLENU-1   =SPACE             FLOOR-AREA=4500 SPACE-HEIGHT=3
* 111 *                               VOLUME=13500 FLOOR-WEIGHT=5
* 112 *                               ZONE-TYPE=UNCONDITIONED                 ..
* 113 *  PLWL-1       =EXTERIOR-WALL  HEIGHT=3 WIDTH=100 AZIMUTH=180
* 114 *                               CONS=EXTW-1                             ..
* 115 *                EW             LIKE PLWL-1 WIDTH=45 AZIMUTH=90         ..
* 116 *                EW             LIKE PLWL-1 A=0                         ..
* 117 *                EW             LIKE PLWL-1 W=45 A=270                  ..
* 118 *  ROOF-1       =ROOF           HEIGHT=45 WIDTH=100 AZIMUTH=180 TILT=0
* 119 *                               CONS=ROOF-1 GND-REFLECTANCE=0           ..
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* 120 *  CEILING-1   =INTERIOR-WALL     AREA=1056 NEXT-TO SPACE-1 CONS=CEIL-1   ..
* 121 *  CEILING-2   =IW               AREA=396 NEXT-TO SPACE-2 CONS=CEIL-1    ..
* 122 *                IW               LIKE CEILING-1 NEXT-TO SPACE-3          ..
* 123 *                IW               LIKE CEILING-2 NEXT-TO SPACE-4          ..
* 124 *                IW               AREA=1596 NEXT-TO SPACE-5 CONS=CEIL-1   ..
* 125 *
* 126 *
* 127 *  SPACE-1    =SPACE              SPACE-CONDITIONS=COND-1 FA=1056 SH=9
* 128 *                                 V=9504                                  ..
* 129 *  WALL-1      =EW                HEIGHT=9 WIDTH=15 AZIMUTH=180
* 130 *                                 CONS=EXTW-1 MULTIPLIER=5                ..
* 131 *  WIND-1        =WINDOW                                                  ..
* 132 *  WALL-2      =EW                LIKE WALL-1 WIDTH=25 X=45 M=1           ..
* 133 *  DOOR-1        =WI              GLASS-HEIGHT=7 GLASS-WIDTH=6 SETBACK=0
* 134 *                                 GLASS-TYPE=DORGLS-1 J=9.5               ..
* 135 *  FLOOR-1     =UNDERGROUND-FLOOR AREA=1056 CONS=FLOR-1                   ..
* 136 *
* 137 *
* 138 *  SPACE-2    =SPACE              LIKE SPACE-1 NOP=5 FA=396 V=3564        ..
* 139 *               EW                LIKE WALL-1 A=90 M=3                    ..
* 140 *                 WINDOW                                                  ..
* 141 *  INWALL-1     =IW               AREA=161.8 NEXT-TO SPACE-1 CONS=PART-1  ..
* 142 *  INWALL-2     =IW               LIKE INWALL-1 NEXT-TO SPACE-3           ..
* 143 *  FLOOR-2     =UF                AREA=396 CONS=FLOR-1                    ..
* 144 *
* 145 *
* 146 *  SPACE-3    =SPACE              LIKE SPACE-1                            ..
* 147 *               EW                LIKE WALL-1 A=0                         ..
* 148 *                 WINDOW                                                  ..
* 149 *               EW                LIKE WALL-2 A=0                         ..
* 150 *                 WI              LIKE DOOR-1 GLASS-WIDTH=10
* 151 *                                 GLASS-HEIGHT=9 M=0                      ..
* 152 *                 EW              WIDTH=10 HEIGHT=9 A=0 CONS=DOR-1        ..
* 153 *               UF                LIKE FLOOR-1                            ..
* 154 *
* 155 *
* 156 *  SPACE-4    =SPACE              LIKE SPACE-2                            ..
* 157 *               EW                LIKE WALL-1 A=270 M=3                   ..
* 158 *                 WINDOW                                                  ..
* 159 *               IW               LIKE INWALL-1                           ..
* 160 *               IW               LIKE INWALL-2                           ..
* 161 *               UF                LIKE FLOOR-2                            ..
* 162 *
* 163 *
* 164 *  SPACE-5    =SPACE              LIKE SPACE-1 FA=1596 V=14364
* 165 *                                 INF-METHOD=0                            ..
* 166 *  INWALL-3    =IW               AREA=684 NEXT-TO SPACE-1 CONS=PART-1    ..
* 167 *  INWALL-4    =IW               LIKE INWALL-3 AREA=189 NEXT-TO SPACE-2  ..
* 168 *               IW                LIKE INWALL-3 NEXT-TO SPACE-3           ..
* 169 *               IW                LIKE INWALL-4 NEXT-TO SPACE-4           ..
* 170 *               UF                LIKE FLOOR-1 AREA=1596                  ..
* 171 *
* 172 *  REPTSCHD-1=SCHEDULE            THRU JUL 15 (ALL) (1,24) 0
* 173 *                                 THRU JUL 16 (ALL) (1,24) 1
* 174 *                                 THRU DEC 31 (ALL) (1,24) 0              ..
* 175 *  REPTBLK-1 =REPORT-BLOCK        VARIABLE-TYPE=BUILDING
* 176 *                                 VARIABLE-LIST=6,23                      ..
* 177 *  REPTBLK-2 =REPORT-BLOCK        VARIABLE-TYPE=GLOBAL
* 178 *                                 VARIABLE-LIST=6,20,21,22                ..
* 179 *  REPTBLK-3 =R-B                 V-TYPE=DOOR-1 V-L=13,15                 ..
* 180 *  SOLAR      =HOURLY-REPORT      REPORT-SCHEDULE=REPTSCHD-1
* 181 *                                 R-B=REPTBLK-1,REPTBLK-2,REPTBLK-3       ..
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* 182 *
* 183 *          END                                          ..
* 184 *          COMPUTE LOADS                                ..
* 185 *          INPUT SYSTEMS                                ..
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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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* 186 *
* 187 *  /* [1] FANS SHALL OPERATE CONTINUOUSLY FROM JANUARY 1 THROUGH MARCH AND FROM
* 188 *         NOVEMBER 1 THROUGH DECEMBER.  FROM APRIL 1 THROUGH OCTOBER THE FANS
* 189 *         SHALL OPERATE ONLY FROM 7 A.M. THROUGH 6 P.M. ON WEEKDAYS.
* 190 *     [2] THE HEATING WILL BE AVAILABLE WHENEVER THE FANS ARE OPERATING WITH
* 191 *         NIGHT AND WEEKEND SETBACK FROM 70 DEG TO 50 DEG.                    */
* 192 *  /* [3] THE COOLING WILL BE AVAILABLE ONLY FROM APRIL 1 THROUGH OCTOBER WITH
* 193 *         A COOLING SETPOINT OF 76 DEG.
* 194 *     [4] THE MINIMUM OUTSIDE AIR WILL BE SET AT 7 CFM PER PERSON.
* 195 *     [5] THE THROTTLING RANGE OF THE PROPORTIONAL THERMOSTAT WILL BE 2 DEG.
* 196 *     [6] THE CEILING PLENUM WILL BE USED FOR RETURN AIR.                     */
* 197 *  /* [7] THE SUPPLY AIR WILL HAVE A MINIMUM TEMPERATURE OF 55 DEG.
* 198 *     [8] THE MAXIMUM TEMPERATURE OF THE HEATING COILS WILL BE 105 DEG.
* 199 *     [9] THE SUPPLY AIR WILL BE RESET TO SATISFY THE WARMEST ZONE.
* 200 *    [10] THE HUMIDITY WILL BE HELD BETWEEN .006 AND .01 LB WATER/LB AIR.
* 201 *    [11] THERE WILL BE AN ENTHALPY CONTROLLED ECONOMIZER SET TO RETURN TO     */
* 202 *  /*      MINIMUM OUTSIDE AIR AT 72 DEG.
* 203 *    [12] THE FANS WILL OPERATE AT 66 PERCENT EFFICIENCY WITH A STATIC PRESSURE
* 204 *         OF THE SUPPLY FAN OF 3.5 INCHES AND THAT OF THE RETURN FAN OF 1.0 INCH.
* 205 *    [13] THE REHEAT COIL WILL HAVE A RANGE OF 50 DEG.
* 206 *    [14] THE MINIMUM RECIRCULATION RATE OF SUPPLY AIR WILL BE 30 PERCENT.    */
* 207 *  /*[15] THE SYSTEM WILL BE A CEILING BYPASS VARIABLE VOLUME SYSTEM.
* 208 *    [16] THE SYSTEM WILL BE COMPARED WITH A MULTI-ZONE SYSTEM.                */
* 209 *
* 210 *            SYSTEMS-REPORT      VERIFICATION=SV-A SUMMARY=SS-A          ..
* 211 *
* 212 *
* 213 *                      /*-----SCHEDULES-----*/
* 214 *
* 215 *
* 216 *  FAN-1      =SCHEDULE           THRU MAR 31 (ALL)      (1,24) 1
* 217 *                                 THRU OCT 31 (WD)       (1,7) 0 (8,18) 1
* 218 *                                                        (19,24) 0
* 219 *                                            (WEH)       (1,24) 0
* 220 *                                 THRU DEC 31 (ALL)      (1,24) 1          ..
* 221 *
* 222 *  HEATWK-1   =WEEK-SCHEDULE      (WD)       (1,7) 50 (8,18) 70
* 223 *                                            (19,24) 50
* 224 *                                 (WEH)      (1,24) 60                    ..
* 225 *
* 226 *  HTEMP-1    =SCH                THRU DEC 31 HEATWK-1                     ..
* 227 *
* 228 *  COOL-1     =SCH                THRU MAR 31 (ALL) (1,24) 0
* 229 *                                 THRU OCT 31 (ALL) (1,24) 1
* 230 *                                 THRU DEC 31 (ALL) (1,24) 0               ..
* 231 *
* 232 *  COOLWK-1   =WS                 (MON,FRI) (1,7) 99 (8,18) 75 (19,24) 99
* 233 *                                 (WEH)      (1,24) 99                          ..
* 234 *
* 235 *  CTEMP-1    =SCH                THRU MAR 31 (ALL) (1,24) 99
* 236 *                                 THRU OCT 31 COOLWK-1
* 237 *                                 THRU DEC 31 (ALL) (1,24) 99              ..
* 238 *
* 239 *
* 240 *                    /*-----ZONE DESCRIPTIONS-----*/
* 241 *
```

```
* 242 *  ZNAIR-1    =ZONE-AIR            OUTSIDE-CFM/PER=7                        ..
* 243 *
* 244 *  ZNCON-1    =ZONE-CONTROL        DESIGN-HEAT-TEMP=70
* 245 *                                  DESIGN-COOL-TEMP=75
* 246 *                                  HEAT-TEMP-SCHED=HTEMP-1
* 247 *                                  COOL-TEMP-SCHED=CTEMP-1
* 248 *                                  THERMOSTAT-TYPE=PROPORTIONAL             ..
* 249 *
* 250 *  PLENU-1    =ZONE                ZONE-TYPE=PLENUM                         ..
* 251 *  SPACE-1    =ZONE                ZONE-AIR=ZNAIR-1 ZONE-CONTROL=ZNCON-1    ..
* 252 *  SPACE-2    =ZONE                LIKE SPACE-1                             ..
* 253 *  SPACE-3    =ZONE                LIKE SPACE-1                             ..
* 254 *  SPACE-4    =ZONE                LIKE SPACE-1                             ..
* 255 *  SPACE-5    =ZONE                LIKE SPACE-1                             ..
* 256 *
* 257 *
* 258 *                  /*-----SYSTEMS DESCRIPTIONS-----*/
* 259 *
* 260 *  SCON-1     =SYSTEM-CONTROL      COOLING-SCHEDULE=COOL-1
* 261 *                                  HEATING-SCHEDULE=FAN-1
* 262 *                                  MIN-SUPPLY-TEMP=55
* 263 *                                  MAX-SUPPLY-TEMP=105
* 264 *                                  COOL-CONTROL=WARMEST
* 265 *                                  MIN-HUMIDITY=.006
* 266 *                                  MAX-HUMIDITY=.01       ..
* 267 *
* 268 *  SAIR-1     =SYSTEM-AIR          OUTSIDE-CONTROL=ENTHALPY                 ..
* 269 *
* 270 *  SFAN-1     =SYSTEM-FANS         SUPPLY-STATIC=3.5 SUPPLY-EFF=.66
* 271 *                                  RETURN-STATIC=1.0 RETURN-EFF=.66
* 272 *                                  FAN-SCHEDULE=FAN-1                       ..
* 273 *
* 274 *  STERM-1    =SYSTEM-TERMINAL     REHEAT-DELTA-T=50
* 275 *                                  MIN-CFM-RATIO=.3                         ..
* 276 *
* 277 *  CEILBYPS-1=SYSTEM               SYSTEM-TYPE=CBVAV
* 278 *                                  SYSTEM-CONTROL=SCON-1
* 279 *                                  SYSTEM-AIR=SAIR-1
* 280 *                                  SYSTEM-FANS=SFAN-1
* 281 *                                  SYSTEM-TERMINAL=STERM-1
* 282 *                                  ECONO-LIMIT-TEMP=72
* 283 *                                  RETURN-AIR-PATH=PLENUM-ZONES
* 284 *                                  PLENUM-NAMES=PLENU-1
* 285 *                                  ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 286 *                                             SPACE-4,SPACE-5,PLENU-1       ..
* 287 *
* 288 *  MULTIZON-1=SYSTEM               LIKE CEILBYPS-1  SYSTEM-TYPE=MZS
* 289 *                                  HEAT-CONTROL=COLDEST MIN-CFM-RATIO=1
* 290 *                                  PLENUM-NAMES=PLENU-1
* 291 *                                  ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 292 *                                             SPACE-4,SPACE-5,PLENU-1       ..
* 293 *
* 294 *  PLANT-1    =PLANT-ASSIGNMENT    SYSTEM-NAMES=CEILBYPS-1                  ..
* 295 *  PLANT-2    =PLANT-ASSIGNMENT    SYSTEM-NAMES=MULTIZON-1                  ..
* 296 *
* 297 *             END                                                           ..
* 298 *             COMPUTE SYSTEMS                                               ..
* 299 *             INPUT PLANT                                                   ..
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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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* 300 *  /* [1] COOLING WILL BE PROVIDED BY A RECIPROCATING CHILLER CONNECTED TO A
* 301 *         COOLING TOWER, AND THE SIZING WILL BE PERFORMED AUTOMATICALLY
* 302 *         BY THE PROGRAM.
* 303 *     [2] HEATING WILL BE PROVIDED BY A 0.15 MBTUH STEAM BOILER.
* 304 *     [3] THE COSTS OF THE CHILLER AND COOLING TOWER WILL BE TAKEN FROM THE   */
* 305 *  /*     DEFAULT VALUES OF THE PROGRAM.
* 306 *     [4] THE INITIAL BOILER COST IS $2000 AND THE COST OF INSTALLATION $800.
* 307 *     [5] MAINTENANCE COSTS FOR THE BOILER ARE $350/YEAR.
* 308 *     [6] THE ELECTRIC UTILITY RATE IS $.045/KWH AND THE NATURAL GAS RATE IS
* 309 *         $. 22/THERM.                                                        */
* 310 *
* 311 *  SBOIL-1    =EQUIPMENT          TYPE=STMB NUMBER=1
* 312 *                                 AVAILABLE=1 SIZE=.15                    ..
* 313 *  CHILL-1    =EQUIPMENT          TYPE=COMPR NUMBER=1
* 314 *                                 AVAILABLE=1 SIZE=-999.                  ..
* 315 *  CTOW-1     =EQUIPMENT          TYPE=CTOWR NUMBER=1
* 316 *                                 AVAILABLE=1 SIZE=-999.                  ..
* 317 *             COST-OF-EQUIPMENT   FOR SBOIL-1
* 318 *                                 COST=2 INSTALLATION=1.4
* 319 *                                 MAINTENANCE=350 LIFE=2000J0
* 320 *                                 MINOR-OVHL-COST=200
* 321 *                                 MINOR-OVHL-INVL=4000
* 322 *                                 MAJOR-OVHL-COST=700
* 323 *                                 MAJOR-OVHL-INVL=20000                   ..
* 324 *             ENERGY-COST         RESOURCE=BOILER  UNIT=100000
* 325 *                                 COST=.22 ESCALATION=10                  ..
* 326 *             ENERGY-COST         RESOURCE=ELECT   UNIT=3413
* 327 *                                 COST=.045 ESCALATION=6                  ..
* 328 *             LIFE-CYCLE-RATES    DISCOUNT-RATE=10 LABOR-INFLTN=0         ..
* 329 *             LIFE-CYCLE-COSTS    LABOR=25 PROJECT-LIFE=25                ..
* 330 *             END                                                         ..
* 331 *             COMPUTE PLANT                                               ..
* 332 *             INPUT ECONOMICS                                             ..
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E D L P R O C E S S O R I N P U T D A T A

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* 333 *
* 334 *  /* [1] THE PURCHASE COST OF THE CBVAV SYSTEM IS $25,000 AND THE COST OF
* 335 *         INSTALLATION IS $20,000.
* 336 *     [2] MAINTENANCE OF THE SYSTEM WILL COST $750/YEAR.
* 337 *     [3] IT IS ASSUMED THAT THE SYSTEM WILL LAST AS LONG AS THE BUILDING.    */
* 338 *
* 339 *            COMPONENT-RATES     DISCOUNT-RATE=10 PROJECT-LIFE=25        ..
* 340 *  CBVAVCST-1=COMPONENT-COST     FIRST-COST=25000 INSTALL-COST=20000
* 341 *                                MAINT-COST=750                          ..
* 342 *            END                                                         ..
* 343 *            COMPUTE ECONOMICS                                           ..
* 344 *            STOP                                                        ..
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PROJECT- JSERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.28.37
JANUARY 1979
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
PLENU-1	1.	18.294	JUL 7 4 PM	88F	73F	-43.416	JAN 12 10 AM	-7F	-7F
SPACE-1	1.	31.283	NOV 7 3 PM	55F	46F	-22.186	MAR 24 5 AM	9F	8F
SPACE-2	1.	10.247	JUL 3 10 AM	87F	74F	-9.514	JAN 1 4 AM	3F	2F
SPACE-3	1.	26.906	JUL 9 5 PM	97F	73F	-26.431	JAN 1 4 AM	3F	2F
SPACE-4	1.	10.356	AUG 19 5 PM	90F	71F	-9.316	JAN 1 4 AM	3F	2F
SPACE-5	1.	24.565	AUG 30 5 PM	80F	66F	-2.030	FEB 25 8 AM	10F	9F
SUM		121.650				-112.893			
BUILDING PEAK		99.241	JUL 9 5 PM	97F	73F	-68.204	JAN 1 4 AM	3F	2F

SPACE PLENU-1

MULTIPLIER 1

FLOOR AREA 4500 SQFT 418 SQMT
VOLUME 13500 CUFT 382 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 10 AM	
DRY-BULB TEMP	88F	31C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.786	.83	0.000	0.00	-6.006	-6.34
CEILINGS	17.508	18.47	0.000	0.00	-37.409	-39.47
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	18.294	19.30	0.000	0.00	-43.416	-45.81

TOTAL LOAD	18.294 KBTU/H	19.30 MJ/H	-43.416 KBTU/H	-45.81 MJ/H
TOTAL LOAD / AREA	4.07 BTUH/SQFT	.04618 MJ/H/SQMT	9.65 BTUH/SQFT	.10958 MJ/H/SQMT

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*************************************************************
*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
*************************************************************
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PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.28.37
JANUARY 1979
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE-1

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	NOV 7 3 PM		MAR 24 5 AM	
DRY-BULB TEMP	55F	13C	9F	-13C
WET-BULB TEMP	46F	8C	8F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	-1.831	-1.93	0.000	0.00	-4.054	-4.28
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	-2.455	-2.59	0.000	0.00	-7.727	-8.15
GLASS SOLAR	16.677	17.60	0.000	0.00	1.145	1.21
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-1.109	-1.17	0.000	0.00	-1.795	-1.89
OCCUPANTS TO SPACE	10.237	10.80	5.188	5.47	.028	.03
LIGHT TO SPACE	7.196	7.59	0.000	0.00	.459	.48
EQUIPMENT TO SPACE	2.567	2.71	0.000	0.00	.078	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-10.321	-10.89
TOTAL	31.283	33.00	5.188	5.47	-22.186	-23.41

TOTAL LOAD	36.470 KBTU/H	38.48 MJ/H	-22.186 KBTU/H	-23.41 MJ/H
TOTAL LOAD / AREA	34.54 BTUH/SQFT	.39264 MJ/H/SQMT	21.01 BTUH/SQFT	.23885 MJ/H/SQMT

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

MULTIPLIER 1

FLOOR AREA 396 SQFT 36 SQMT
VOLUME 3564 CUFT 100 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 10 AM		JAN 1 4 AM	
DRY-BULB TEMP	87F	31C	3F	-16C
WET-BULB TEMP	74F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.528	.56	0.000	0.00	-2.599	-2.74
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.571	.60	0.000	0.00	-3.149	-3.32
GLASS SOLAR	5.002	5.28	0.000	0.00	.248	.26
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.238	-.25	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.063	1.12	.576	.61	0.000	0.00
LIGHT TO SPACE	2.386	2.52	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.934	.99	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	10.247	10.81	.576	.61	-9.514	-10.04
TOTAL LOAD	10.823 KBTU/H		11.42 MJ/H		-9.514 KBTU/H	-10.04 MJ/H
TOTAL LOAD / AREA	27.33 BTUH/SQFT		.31720 MJ/H/SQMT		24.03 BTUH/SQFT	.27883 MJ/H/SQMT

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*************************************************************
*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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SPACE SPACE-3

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	2.915	3.08	0.000	0.00	-10.642	-11.23
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.551	1.64	0.000	0.00	-5.248	-5.54
GLASS SOLAR	2.616	2.76	0.000	0.00	.165	.17
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.634	-.67	0.000	0.00	-1.690	-1.78
OCCUPANTS TO SPACE	10.890	11.49	5.188	5.47	0.000	0.00
LIGHT TO SPACE	7.688	8.11	0.000	0.00	.432	.46
EQUIPMENT TO SPACE	1.880	1.98	0.000	0.00	.072	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-9.520	-10.04
TOTAL	26.906	28.39	5.188	5.47	-26.431	-27.89

TOTAL LOAD	32.094 KBTU/H	33.86 MJ/H	-26.431 KBTU/H	-27.89 MJ/H
TOTAL LOAD / AREA	30.39 BTUH/SQFT	.34552 MJ/H/SQMT	25.03 BTUH/SQFT	.28455 MJ/H/SQMT

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*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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SPACE SPACE-4

MULTIPLIER 1

FLOOR AREA 396 SQFT 36 SQMT
VOLUME 3564 CUFT 100 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 19 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	90F	32C	3F	-16C
WET-BULB TEMP	71F	22C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.324	.34	0.000	0.00	-2.557	-2.70
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.626	.66	0.000	0.00	-3.149	-3.32
GLASS SOLAR	4.875	5.14	0.000	0.00	.404	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.198	-.21	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.196	1.26	.576	.61	0.000	0.00
LIGHT TO SPACE	2.839	2.99	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.694	.73	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	10.356	10.93	.576	.61	-9.316	-9.83
TOTAL LOAD	10.932 KBTU/H		11.53 MJ/H		-9.316 KBTU/H	-9.83 MJ/H
TOTAL LOAD / AREA	27.61 BTUH/SQFT		.32040 MJ/H/SQMT		23.53 BTUH/SQFT	.27303 MJ/H/SQMT

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*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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SPACE SPACE-5

MULTIPLIER 1

FLOOR AREA 1596 SQFT 148 SQMT
VOLUME 14364 CUFT 406 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 5 PM		FEB 25 8 AM	
DRY-BULB TEMP	80F	27C	10F	-12C
WET-BULB TEMP	66F	19C	9F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	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	-.798	-.84	0.000	0.00	-2.793	-2.95
OCCUPANTS TO SPACE	10.894	11.49	5.188	5.47	.000	.00
LIGHT TO SPACE	11.626	12.27	0.000	0.00	.654	.69
EQUIPMENT TO SPACE	2.843	3.00	0.000	0.00	.109	.11
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	24.565	25.92	5.188	5.47	-2.030	-2.14

TOTAL LOAD	29.753 KBTU/H	31.39 MJ/H	-2.030 KBTU/H	-2.14 MJ/H
TOTAL LOAD / AREA	18.64 BTUH/SQFT	.21210 MJ/H/SQMT	1.27 BTUH/SQFT	.01447 MJ/H/SQMT

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

FLOOR AREA	9000	SQFT	836	SQMT
VOLUME	54000	CUFT	1529	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9	5 PM	JAN 1	4 AM
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	5.714	6.03	0.000	0.00	-20.762	-21.90
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	5.908	6.23	0.000	0.00	-19.996	-21.10
GLASS SOLAR	14.458	15.25	0.000	0.00	3.785	3.99
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-2.700	-2.85	0.000	0.00	-7.200	-7.60
OCCUPANTS TO SPACE	35.090	37.02	16.716	17.64	0.000	0.00
LIGHT TO SPACE	32.761	34.56	0.000	0.00	1.843	1.94
EQUIPMENT TO SPACE	8.010	8.45	0.000	0.00	.307	.32
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-26.181	-27.62
TOTAL	99.241	104.70	16.716	17.64	-68.204	-71.96
TOTAL LOAD	115.957 KBTU/H		122.34 MJ/H		-68.204 KBTU/H	-71.96 MJ/H
TOTAL LOAD / AREA	12.88 BTUH/SQFT		.14634 MJ/H/SQMT		7.58 BTUH/SQFT	.08608 MJ/H/SQMT

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*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----    LOADS                                            *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.28.37
JANUARY 1979
SOLAR = HOURLY REPORT PAGE 1-1

MMDDHH	BUILDING ITEM 6	BUILDING ITEM 23	GLOBAL ITEM 6	GLOBAL ITEM 20	GLOBAL ITEM 21	GLOBAL ITEM 22	DOOR-1 ITEM 13	DOOR-1 ITEM 15	ITEM
716 1	0.0000	6149.7936	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 2	0.0000	5350.3205	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 3	0.0000	4654.7788	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 4	0.0000	4049.6576	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 5	0.0000	3523.2021	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 6	0.0000	3356.6745	2.0000	.7154	14.5878	2.0807	.9659	43.6067	
716 7	0.0000	4688.9302	3.0000	.7098	105.3042	15.0201	8.3146	373.9075	
716 8	0.0000	5574.6483	7.0000	.6126	127.6457	18.2068	11.7009	528.2472	
716 9	0.0000	6656.0875	6.0000	.6537	155.6851	22.2062	16.5550	746.9809	
71610	0.0000	8941.1707	0.0000	1.0000	254.5798	36.3120	35.7032	1608.9037	
71611	0.0000	10326.3921	3.0000	.9996	263.7741	37.6235	37.6639	1673.2947	
71612	0.0000	11322.3628	3.0000	.9996	268.5693	38.3074	33.8589	1504.6477	
71613	0.0000	12046.8180	3.0000	.9361	252.8455	36.0647	32.2663	1437.4999	
71614	0.0000	12790.3058	3.0000	.9361	251.2855	35.8422	32.0859	1443.4296	
71615	0.0000	13636.3996	2.0000	.9371	246.7650	35.1974	36.0565	1603.2167	
71616	0.0000	14387.0552	1.0000	.9429	239.0980	34.1038	33.4131	1512.2392	
71617	0.0000	15090.0797	0.0000	1.0000	236.3670	33.7142	24.7270	1099.6978	
71618	0.0000	15248.7274	0.0000	1.0000	205.0068	29.2412	18.5872	825.9907	
71619	0.0000	14616.2576	0.0000	1.0000	141.1180	20.1284	10.9961	486.5154	
71620	0.0000	12072.3945	0.0000	1.0000	10.5654	1.5070	.6890	30.7811	
71621	0.0000	10430.7461	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71622	0.0000	9074.7491	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71623	0.0000	7895.0317	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71624	0.0000	6868.6776	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
CEILBYPS-1	4886.	.30	.22	3.04	.87	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	1479.	326.	-22.19	31.28	45.0	1.0
SPACE-2	479.	41.	-9.51	10.25	5.0	1.0
SPACE-3	1275.	326.	-26.43	26.91	45.0	1.0
SPACE-4	490.	41.	-9.32	10.36	5.0	1.0
SPACE-5	1163.	326.	-2.03	24.56	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.29.46
JANUARY 1979
REPORT SVA SYSTEM DESIGN PARAMETERS PAGE 1

SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
MULTIZON-1	4886.	1.00	.22	3.04	.87	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	1479.	326.	-22.19	31.28	45.0	1.0
SPACE-2	479.	41.	-9.51	10.25	5.0	1.0
SPACE-3	1275.	326.	-26.43	26.91	45.0	1.0
SPACE-4	490.	41.	-9.32	10.36	5.0	1.0
SPACE-5	1163.	326.	-2.03	24.56	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.29.46
JANUARY 1979
REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM CEILBYPS-1 TYPE CBVAV

MONTH	HEATING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	COOLING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM LOAD (KW)
JAN	-18.207	7	8	-133.112	0.000	31	24	0.000	7169.	21.
FEB	-13.438	11	8	-124.720	0.000	28	24	0.000	6329.	21.
MAR	-10.020	25	8	-114.315	0.000	31	24	0.000	7001.	21.
APR	-7.537	10	8	-111.459	3.025	29	18	127.028	7057.	21.
MAY	-4.982	6	7	-119.298	7.021	21	13	157.810	7169.	21.
JUN	-1.751	3	14	-50.972	16.027	20	17	181.700	6721.	21.
JUL	-.685	26	7	-37.413	30.467	3	14	186.095	7169.	21.
AUG	-1.333	20	7	-44.845	27.431	26	16	171.363	7169.	21.
SEP	-1.973	23	7	-78.677	10.494	11	15	155.175	6721.	21.
OCT	-5.628	21	10	-107.239	5.466	30	18	129.095	7337.	21.
NOV	-8.477	18	9	-102.800	0.000	30	24	0.000	6721.	21.
DEC	-11.391	9	8	-113.313	0.000	31	24	0.000	6665.	21.
TOTAL	-85.422				99.931				83229.493	
MAX				-133.112				186.095		21.456

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.29.46
JANUARY 1979
REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM MULTIZON-1 TYPE MZS

MONTH	HEATING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	COOLING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM LOAD (KW)
JAN	-61.301	7	8	-178.795	0.000	31	24	0.000	7169.	21.
FEB	-52.187	11	8	-169.494	0.000	28	24	0.000	6329.	21.
MAR	-51.434	25	8	-158.926	0.000	31	24	0.000	7001.	21.
APR	-8.564	8	12	-136.385	1.734	29	18	59.947	5190.	21.
MAY	-4.315	6	7	-104.211	4.527	29	7	113.527	5208.	21.
JUN	-.113	24	9	-29.752	13.776	20	17	152.661	4768.	21.
JUL	-.020	5	7	-1.893	28.676	9	13	180.599	5208.	21.
AUG	-.039	5	7	-13.359	24.808	16	10	163.754	5208.	21.
SEP	-1.459	23	10	-65.317	9.148	11	9	151.311	4768.	21.
OCT	-4.109	21	9	-136.412	3.884	31	8	116.439	5419.	21.
NOV	-51.443	2	6	-124.081	0.000	30	24	0.000	6721.	21.
DEC	-51.063	9	8	-157.497	0.000	31	24	0.000	6665.	21.
TOTAL	-286.046				86.553				69656.114	
MAX				-178.795				180.599		21.456

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	.018	.025	0.000	0.000	0.000	0.000	0.000	.029	.074	.029	.103	41.
2	.013	.022	0.000	0.000	0.000	0.000	0.000	.022	.065	.022	.087	40.
3	.010	.024	0.000	0.000	0.000	0.000	0.000	.017	.072	.017	.089	38.
4	.008	.027	.003	0.000	0.000	0.000	.006	.012	.082	.012	.094	37.
5	.005	.029	.007	0.000	0.000	0.000	.009	.008	.086	.008	.094	36.
6	.002	.030	.016	0.000	0.000	0.000	.017	.003	.090	.003	.093	34.
7	.001	.036	.030	0.000	0.000	0.000	.029	.001	.108	.001	.110	34.
8	.001	.035	.027	0.000	0.000	0.000	.026	.003	.106	.003	.108	34.
9	.002	.028	.010	0.000	0.000	0.000	.012	.004	.084	.004	.088	34.
10	.006	.029	.005	0.000	0.000	0.000	.008	.010	.087	.010	.096	36.
11	.008	.023	0.000	0.000	0.000	0.000	0.000	.015	.069	.015	.084	38.
12	.011	.023	0.000	0.000	0.000	0.000	0.000	.019	.068	.019	.088	39.
	.085	.330	.100	0.000	0.000	0.000	.108	.144	.991	.144	1.134	37.

EQUIPMENT USE STATISTICS

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
STEAM BOILER	.157	.133	1	7	8	.150	3629								
RECIPROCATING CHILR	.298	.186	7	3	14	.240	1398								
COOLING TOWER	.324	.240	7	3	14	.300	1398								

CENTRAL PLANT LIFE CYCLE EQUIPMENT COST SUMMARY

EQUIPMENT	TOTALS		
STEAM BOILER	84.6		
NOMINAL SIZE (MBTU)			.150
NUMBER INSTALLED			1
FIRST COST (K$)		2.8	2.8
ANNUAL COST (K$)		79.4	79.4
CYCLICAL COST (K$)		2.4	2.4
-----TOTAL----(K$)			84.6
RECIPROCATING CHILR	10.6		
NOMINAL SIZE (MBTU)			.240
NUMBER INSTALLED			1
FIRST COST (K$)		8.7	8.7
ANNUAL COST (K$)		1.7	1.7
CYCLICAL COST (K$)		.2	.2
-----TOTAL----(K$)			10.6
COOLING TOWER	17.4		
NOMINAL SIZE (MBTU)			.300
NUMBER INSTALLED			1
FIRST COST (K$)		6.6	6.6
ANNUAL COST (K$)		8.7	8.7
CYCLICAL COST (K$)		2.1	2.1
-----TOTAL----(K$)			17.4
EQUIPMENT TOTAL	112.5		

MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY

MO	UTILITY>	ELECT	DIESEL	GASTUR	BOILER
	TOTAL (MBTU)	24.570	0.000	0.000	29.488
1	PEAK (MBTU)	.074	0.000	0.000	.178
	DY/HR	7/11	31/24	31/24	7/ 8
	TOTAL (MBTU)	21.675	0.000	0.000	22.300
2	PEAK (MBTU)	.074	0.000	0.000	.167
	DY/HR	4/11	28/24	28/24	11/ 8
	TOTAL (MBTU)	23.948	0.000	0.000	17.124
3	PEAK (MBTU)	.074	0.000	0.000	.153
	DY/HR	25/11	31/24	31/24	25/ 8
	TOTAL (MBTU)	27.165	0.000	0.000	12.136
4	PEAK (MBTU)	.119	0.000	0.000	.149
	DY/HR	29/16	30/24	30/24	10/ 8
	TOTAL (MBTU)	28.633	0.000	0.000	8.387
5	PEAK (MBTU)	.129	0.000	0.000	.159
	DY/HR	21/10	31/24	31/24	6/ 7
	TOTAL (MBTU)	29.930	0.000	0.000	3.284
6	PEAK (MBTU)	.132	0.000	0.000	.080
	DY/HR	20/15	30/24	30/24	3/14
	TOTAL (MBTU)	36.143	0.000	0.000	1.348
7	PEAK (MBTU)	.136	0.000	0.000	.063
	DY/HR	3/10	31/24	31/24	26/ 7
	TOTAL (MBTU)	35.287	0.000	0.000	2.604
8	PEAK (MBTU)	.132	0.000	0.000	.073
	DY/HR	20/10	31/24	31/24	20/ 7
	TOTAL (MBTU)	28.082	0.000	0.000	3.551
9	PEAK (MBTU)	.128	0.000	0.000	.112
	DY/HR	11/14	30/24	30/24	23/ 7
	TOTAL (MBTU)	28.922	0.000	0.000	9.592
10	PEAK (MBTU)	.123	0.000	0.000	.144
	DY/HR	31/11	31/24	31/24	21/10
	TOTAL (MBTU)	22.984	0.000	0.000	14.785
11	PEAK (MBTU)	.073	0.000	0.000	.140
	DY/HR	29/11	30/24	30/24	18/ 9
	TOTAL (MBTU)	22.811	0.000	0.000	19.350
12	PEAK (MBTU)	.074	0.000	0.000	.152
	DY/HR	9/11	31/24	31/24	9/ 8
		==========	==========	==========	==========
	ONE YEAR	330.149	0.000	0.000	143.949
	USE/PEAK (MBTU)	.136	0.000	0.000	.178
	YEAR COST (K$)	3.4	0.0	0.0	.3
	COST ESCLTN (PCT)	6.0	5.0	5.0	10.0

TOTAL USE (MBTU) 474.098

TOTAL COST (K$) 3.7

NOTES TO ABOVE TABLE
(1) ALL ENERGY USE VALUES ARE NET, I.E., AT BUILDING BOUNDARY

(2) PEAK VALUES ARE IN MBTUH
(3) YEAR COST IS LIFE-CYCLE COST DIVIDED BY PROJECT LIFETIME

E Q U I P M E N T O P E R A T I O N A N D P A R T L O A D R E P O R T

NAME	HOURS AT PERCENT PART LOAD RATIO												TOTAL HOURS	ANNUAL LOAD (GBTU)	FALSE LOAD (GBTU)	TOTAL LOAD (GBTU)
	0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110	- 120+				
STMB	1555	1235	416	167	82	52	74	31	17	0	0	0	3629	.085	0.000	.085
	1555	1235	416	167	82	52	74	31	17	0	0	0				
COMPR	558	122	65	67	113	276	152	45	0	0	0	0	1398	.100	.007	.107
	558	122	65	67	113	276	152	45	0	0	0	0				
CTOWR	504	162	66	60	70	284	184	68	0	0	0	0	1398	.136	0.000	.136
	504	162	66	60	70	284	184	68	0	0	0	0				

NOTES TO TABLE
1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE HOURLY OPERATING CAPACITY (UNITS OPERATING THAT HOUR)
2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE TOTAL INSTALLED CAPACITY

PLANT DEMANDS SATISFIED REPORT

HEATING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
STEAM BOILER	.085	100.0
DEMAND SATISFIED	.085	100.0
TOTAL DEMAND ON PLANT	.085	

COOLING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
RECIPROCATING CHILR	.100	100.0
DEMAND SATISFIED	.100	100.0
TOTAL DEMAND ON PLANT	.100	

ELECTRICAL DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
DEMAND SATISFIED	0.000	0.0
TOTAL DEMAND ON PLANT	.330	

REJECTED HEAT	GBTU SUPPLIED	PCT OF TOTAL DEMAND
COOLING TOWER	.136	100.0
DEMAND SATISFIED	.136	100.0
TOTAL DEMAND ON PLANT	.136	

SUMMARY OF LOADS MET

TYPE OF DEMAND	TOTAL DEMAND (GBTU)	DEMAND SATISFIED (GBTU)	TOTAL OVERLOAD (GBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING DEMANDS	.085	.085	0.000	0.000	0
COOLING DEMANDS	.100	.100	0.000	0.000	0
REJECTED HEAT	.136	.136	0.000	0.000	0

ELECTRICAL DEMAND SCATTER PLOT

TOTAL HOURS AT DEMAND AND TIME OF DAY

DEMAND KWH	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
42.090	0	0	0	0	0	0	0	0	0	5	2	0	0	4	3	0	0	0	0	0	0	0	0	0	14
38.853	0	0	0	0	0	0	0	1	26	40	29	5	28	44	37	26	23	0	0	0	0	0	0	0	259
35.615	0	0	0	0	0	0	0	26	17	14	32	34	31	19	29	39	45	3	0	0	0	0	0	0	289
32.377	0	0	0	0	0	0	0	17	9	4	6	25	12	9	9	9	4	0	0	0	0	0	0	0	104
29.139	0	0	0	0	0	0	0	7	13	24	12	10	5	6	10	11	15	0	0	0	0	0	0	0	113
25.902	0	0	0	0	0	0	0	7	36	37	60	71	68	61	52	59	55	15	0	0	0	0	0	0	521
22.664	0	0	0	0	0	0	0	25	42	128	111	102	5	109	112	108	110	105	0	0	0	0	0	0	957
19.426	0	0	0	0	0	0	1	46	109	0	0	5	103	0	0	0	0	0	0	0	0	0	0	0	264
16.189	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	129	123	0	0	0	0	0	252
12.951	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
9.713	0	0	0	0	0	0	43	13	0	0	0	0	0	0	0	0	0	0	129	252	123	0	0	0	560
6.475	365	365	365	365	365	365	319	222	113	113	113	113	113	113	113	113	113	113	113	113	242	365	365	365	5424
3.238	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PERCENT TOTAL DEMAND	1.8	1.8	1.8	1.8	1.8	1.8	2.0	4.5	6.7	7.3	7.4	7.1	7.0	7.4	7.5	7.3	7.2	4.9	3.3	2.5	2.0	1.8	1.8	1.8	

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KWH	PCT
SYSTEMS LOAD	21.450	54.0
COMPRESSION CHILLERS	15.316	38.5
COOLING TOWER	2.043	5.1
CIRCULATION PUMPS	.946	2.4
TOTAL	39.755	

L I F E - C Y C L E P L A N T C O S T S U M M A R Y

	ANNUAL	LIFETIME(25 YRS)
PLANT EQUIPMENT COST	4.5	112.5 K$
ENERGY COST	3.7	92.0 K$
ENERGY USE (NET)	.5	11.9 GBTU

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- PLANT EQUIPMENT PLUS ENERGY                 -
- LIFE CYCLE COST FOR 25 YEARS =    .2045 (M$) -
-                                             -
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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

REPORT- E01 ECONOMICS VERIFICATION (NON-PLANT COST ITEMS) CAL-ERDA 1.3 11 JAN 1979 14.36.11

DISCOUNT RATE (PCT)	LABOR INFL-RATE (PCT)	MATERIALS INFL-RATE (PCT)	PROJECT LIFETIME (YRS)
10.0	0.0	0.0	25.0

COST-NAME CBVAVCST-1 NO. OF UNITS 1.0 UNIT-NAME 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
25000.	0.00	20000.	0.00	750.	0.00	750.	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 11 JAN 1979 14.36.11

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
CBVAVCST-1	1.		25.00	20.00	6.81 (	6.81	0.00)	0.00 (	0.00	0.00)	0.00	51.81
		TOTAL	25.00	20.00	6.81 (	6.81	0.00)	0.00 (	0.00	0.00)	0.00	51.81

OVERALL LIFE-CYCLE COSTS (K$)

NON-PLANT	PLANT	FUEL	T O T A L
51.8	112.5	92.0	256.3

REPORT- E03 LIFE-CYCLE SAVINGS/INVESTMENT STATISTICS CAL-ERDA 1.3 11 JAN 1979 14.36.11

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		0.00	0.00	0.00	0.00
THIS RUN	51.81	112.54	91.98	204.52	11.85
SAVINGS		-112.54	-91.98	-204.52	-11.85

SAVINGS/INVESTMENT STATISTICS

COST SAVINGS (K$)	INVESTMENT (K$)	SAVINGS-TO-INVESTMENT RATIO	FUEL SAVINGS (MBTU)	FUEL-SAVINGS-TO-INVESTMENT RATIO(MBTU/$)	PAYBACK PERIOD (YRS)
-204.5	51.8	-3.9	-11852.4	-.23	0.0

Example Building with MZS System

```
C A L - E R D A   E N E R G Y   A N A L Y S I S   P R O G R A M   V E R S I O N   1.4
      B U I L D I N G   D E S I G N   L A N G U A G E   P R O C E S S O R

*  1 *          INPUT LOADS                                          ..
```

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

*   2 *  TITLE      USERS GUIDE EXAMPLE BUILDING
*   3 *  TITLE      LAWRENCE BERKELEY LABORATORY
*   4 *  TITLE
*   5 *  TITLE      JANUARY 1979
*   6 *
*   7 *  /* [1] THE BUILDING IS A SINGLE STORY OFFICE BUILDING LOCATED IN CHICAGO.
*   8 *     [2] THE WEATHER DATA WILL BE FOR 1974.
*   9 *     [3] THE WALLS ARE OF FACE BRICK AND CONCRETE CONSTRUCTION WITH 1 INCH OF
*  10 *         EXPANDED POLYSTYRENE INSULATION (R-4) UNDER THE BRICK.
*  11 *     [4] THE ROOF IS A BUILT-UP ROOF OVER 3 INCHES OF PREFORMED ROOF          */
*  12 *  /*      INSULATION (R-8)                                                     */
*  13 *  /* [5] THERE ARE 16 4 FEET BY 6 FEET WINDOWS, DOUBLE PANED WITH AN ASHRAE
*  14 *         SHADING COEFFICIENT OF .86 AND SETBACK 6 INCHES FROM THE WALL SURFACE.
*  15 *     [6] THE FRONT DOOR IS .25 INCH PLATE GLASS; THE BACK DOOR IS ONE INCH WOOD.
*  16 *     [7] THE FLOOR IS 6 INCHES THICK CONCRETE IN CONTACT WITH THE SOIL.
*  17 *     [8] A DROP CEILING SERVES AS A PLENUM.                                   */
*  18 *  /* [9] THE LIGHTING FIXTURES HAVE FLUORESCENT LAMPS AND RETURN AIR PASSES
*  19 *         THROUGH THE FIXTURE.  THE MAXIMUM ENERGY OF THE LIGHTING IS 3 W/SQ.FT.
*  20 *    [10] THE ENERGY USED BY EQUIPMENT IS 1 W/SQ.FT. AT A MAXIMUM.
*  21 *    [11] THE NUMBER OF PEOPLE IS 145; 45 IN THREE SPACES AND 5 IN TWO SPACES.
*  22 *    [12] THE INFILTRATION DURING OCCUPIED HOURS IS .5 AIR CHANGES PER HOUR.    */
*  23 *
*  24 *            DIAGNOSTIC          ERROR     ABORT     ERROR                  ..
*  25 *            RUN-PERIOD          JAN 1 1974 THRU DEC 31 1974                ..
*  26 *            LOADS-REPORT        LO2                                        ..
*  27 *            BUILDING-LOCATION   LATITUDE=42 LONGITUDE=88
*  28 *                                ALTITUDE=610 TIME-ZONE=6
*  29 *                                BUILDING-AZIMUTH=0                         ..
*  30 *
*  31 *
*  32 *
*  33 *              /*-----BUILDING CONSTRUCTION MATERIALS-----*/
*  34 *
*  35 *  WLLAY-1    =LAYERS             MATERIAL-1=BK05 M2=IN33
*  36 *                                M3=CB46 M4=AL11 M5=GP01
*  37 *                                INSIDE-FILM-RES=.68                        ..
*  38 *  RFLAY-1    =LAYERS             M1=RG01 M2=BR01 M3=IN76
*  39 *                                IFR=.76                                    ..
*  40 *  EXTW-1     =CONSTRUCTION       LAYERS=WLLAY-1 ABSORPTANCE=.88
*  41 *                                ROUGHNESS=2                                ..
*  42 *  ROF-1      =CONS               WALL-TYPE=RFLAY-1 ABS=.5 RO=1              ..
*  43 *  CEIL-1     =CONS               U=.8    /*CONSTRUCTION OF CEILING*/        ..
*  44 *  PART-1     =CONS               U=10    /*FALSE PARTITIONS*/                ..
*  45 *  FLOR-1     =CONS               U=.05   /*SLAB ON GROUND*/                  ..
*  46 *  DOR-1      =CONS               U=1.0 ROUGHNESS=6    /*BACK DOOR*/          ..
*  47 *  WINGLS-1   =GLASS-TYPE         PANES=2 GLASS-SHADING=.86                  ..
*  48 *  DORGLS-1   =GT                 GTC=3    /*FRONT DOOR*/                     ..
*  49 *
*  50 *
*  51 *                      /*-----SCHEDULES-----*/
*  52 *
*  53 *  DAYSC-1    =DAY-SCHEDULE       (1,8) 0 (9,11) 1 (12,14) .8,.4,.8
*  54 *                                (15,18) 1 (19,21) .5,.1,.1 (22,24) 0       ..
*  55 *  DAYSC-2    =DS                 (1,24) 0                                   ..
*  56 *
*  57 *  WKPEOP-1   =WEEK-SCHEDULE      (MON,FRI) DAYSC-1 (WEH) DAYSC-2            ..
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*  58 *
*  59 *  PEOPSC-1  =SCHEDULE          THRU DEC 31 WKPEOP-1                    ..
*  60 *
*  61 *  WKLITE-1  =WS                (MON,FRI) (1,8) .05 (9,14) .9,.95,1,.95,.8,.9
*  62 *                                        (15,18) 1 (19,21) .6,.2,.2
*  63 *                                        (22,24) .05
*  64 *                             (WEH)      (1,24) .05                       ..
*  65 *
*  66 *  LITESC-1  =SCH               THRU DEC 31 WKLITE-1                    ..
*  67 *
*  68 *  WKEQUP-1  =WS                (MON,FRI) (1,8) .02 (9) .4 (10,14) .9
*  69 *                                        (15,20) .8,.7,.5,.5,.3,.3
*  70 *                                        (21,24) .02
*  71 *                             (WEH)      (1,24) .02                      ..
*  72 *
*  73 *  EQUIPSC-1 =SCH               THRU DEC 31 WKEQUP-1                    ..
*  74 *
*  75 *  INFLSC-1  =SCH               THRU DEC 31 (MON,FRI) (1,7) 1 (8,18) 0
*  76 *                                                     (19,24) 1
*  77 *                                        (WEH)      (1,24) 1             ..
*  78 *
*  79 *
*  80 *            /*-----BUILDING SHADE SPECIFICATION-----*/
*  81 *
*  82 *          BUILDING-SHADE       HEIGHT=5 WIDTH=10 TRANSMITTANCE=0
*  83 *                               X-BUILDING=52.5 Y-BUILDING=0 Z-BUILDING=9
*  84 *                               SURFACE-AZIMUTH=180 TILT=180            ..
*  85 *
*  86 *
*  87 *                    /*-----SETTING DEFAULTS-----*/
*  88 *
*  89 *
*  90 *          SET-DEFAULT          FLOOR-WEIGHT=70 GLASS-HEIGHT=4
*  91 *                               GLASS-WIDTH=6 GLASS-TYPE=SINGLS-1
*  92 *                               SETBACK=0.5 TEMPERATURE=73              ..
*  93 *
*  94 *
*  95 *                      /*-----SPACE DESCRIPTIONS-----*/
*  96 *
*  97 *  COND-1    =SPACE-CONDITIONS  NUMBER-OF-PEOPLE=45
*  98 *                               PEOPLE-ACTIVITY=400
*  99 *                               PEOPLE-SCHEDULE=PEOPSC-1
* 100 *                               LIGHTING-TYPE=2
* 101 *                               LIGHT-TO-SPACE=80
* 102 *                               LIGHTING-W/SQFT=3
* 103 *                               LIGHTING-SCHEDULE=LITESC-1
* 104 *                               EQUIPMENT-W/SQFT=1
* 105 *                               EQUIPMENT-SCHEDULE=EQUIPSC-1
* 106 *                               AIR-CHANGES/HR=.5
* 107 *                               INF-METHOD=1
* 108 *                               INF-SCHEDULE=INFLSC-1                   ..
* 109 *
* 110 *  PLENU-1   =SPACE             FLOOR-AREA=4500 SPACE-HEIGHT=3
* 111 *                               VOLUME=13500 FLOOR-WEIGHT=5
* 112 *                               ZONE-TYPE=UNCONDITIONED                 ..
* 113 *  PLWL-1       =EXTERIOR-WALL  HEIGHT=3 WIDTH=100 AZIMUTH=180
* 114 *                               CONS=EXTW-1                             ..
* 115 *                EW             LIKE PLWL-1 WIDTH=45 AZIMUTH=90         ..
* 116 *                EW             LIKE PLWL-1 A=0                         ..
* 117 *                EW             LIKE PLWL-1 W=45 A=270                  ..
* 118 *  ROOF-1      =ROOF            HEIGHT=45 WIDTH=100 AZIMUTH=180 TILT=0
* 119 *                               CONS=ROF-1 GND-REFLECTANCE=0            ..
```

```
* 120 *  CEILING-1    =INTERIOR-WALL     AREA=1056 NEXT-TO SPACE-1 CONS=CEIL-1   ..
* 121 *  CEILING-2    =IW                AREA=396 NEXT-TO SPACE-2 CONS=CEIL-1    ..
* 122 *                IW                LIKE CEILING-1 NEXT-TO SPACE-3          ..
* 123 *                IW                LIKE CEILING-2 NEXT-TO SPACE-4          ..
* 124 *                IW                AREA=1596 NEXT-TO SPACE-5 CONS=CEIL-1   ..
* 125 *
* 126 *
* 127 *  SPACE-1    =SPACE               SPACE-CONDITIONS=COND-1 FA=1056 SH=9
* 128 *                                  V=9504                                  ..
* 129 *  WALL-1      =EW                HEIGHT=9 WIDTH=15 AZIMUTH=180
* 130 *                                  CONS=EXTW-1 MULTIPLIER=5                ..
* 131 *  WIND-1        =WINDOW                                                   ..
* 132 *  WALL-2      =EW                LIKE WALL-1 WIDTH=25 X=45 M=1           ..
* 133 *  DOOR-1        =WI              GLASS-HEIGHT=7 GLASS-WIDTH=6 SETBACK=0
* 134 *                                  GLASS-TYPE=DORGLS-1 J=9.5               ..
* 135 *  FLOOR-1     =UNDERGROUND-FLOOR AREA=1056 CONS=FLOR-1                   ..
* 136 *
* 137 *
* 138 *  SPACE-2    =SPACE               LIKE SPACE-1 NOP=5 FA=396 V=3564        ..
* 139 *                EW                LIKE WALL-1 A=90 M=3                    ..
* 140 *                  WINDOW                                                  ..
* 141 *  INWALL-1    =IW                AREA=161.8 NEXT-TO SPACE-1 CONS=PART-1  ..
* 142 *  INWALL-2    =IW                LIKE INWALL-1 NEXT-TO SPACE-3           ..
* 143 *  FLOOR-2     =UF                AREA=396 CONS=FLOR-1                    ..
* 144 *
* 145 *
* 146 *  SPACE-3    =SPACE               LIKE SPACE-1                            ..
* 147 *                EW                LIKE WALL-1 A=0                         ..
* 148 *                  WINDOW                                                  ..
* 149 *                EW                LIKE WALL-2 A=0                         ..
* 150 *                  WI              LIKE DOOR-1 GLASS-WIDTH=10
* 151 *                                  GLASS-HEIGHT=9 M=0                      ..
* 152 *                  EW              WIDTH=10 HEIGHT=9 A=0 CONS=DOR-1        ..
* 153 *                UF                LIKE FLOOR-1                            ..
* 154 *
* 155 *
* 156 *  SPACE-4    =SPACE               LIKE SPACE-2                            ..
* 157 *                EW                LIKE WALL-1 A=270 M=3                   ..
* 158 *                  WINDOW                                                  ..
* 159 *                IW               LIKE INWALL-1                           ..
* 160 *                IW               LIKE INWALL-2                           ..
* 161 *                UF                LIKE FLOOR-2                            ..
* 162 *
* 163 *
* 164 *  SPACE-5    =SPACE               LIKE SPACE-1 FA=1596 V=14364
* 165 *                                  INF-METHOD=0                            ..
* 166 *  INWALL-3    =IW                AREA=684 NEXT-TO SPACE-1 CONS=PART-1    ..
* 167 *  INWALL-4    =IW                LIKE INWALL-3 AREA=189 NEXT-TO SPACE-2  ..
* 168 *                IW                LIKE INWALL-3 NEXT-TO SPACE-3           ..
* 169 *                IW                LIKE INWALL-4 NEXT-TO SPACE-4           ..
* 170 *                UF                LIKE FLOOR-1 AREA=1596                  ..
* 171 *
* 172 *  REPTSCHD-1=SCHEDULE             THRU JUL 15 (ALL) (1,24) 0
* 173 *                                  THRU JUL 16 (ALL) (1,24) 1
* 174 *                                  THRU DEC 31 (ALL) (1,24) 0              ..
* 175 *  REPTBLK-1 =REPORT-BLOCK         VARIABLE-TYPE=BUILDING
* 176 *                                  VARIABLE-LIST=6,23                      ..
* 177 *  REPTBLK-2 =REPORT-BLOCK         VARIABLE-TYPE=GLOBAL
* 178 *                                  VARIABLE-LIST=6,20,21,22                ..
* 179 *  REPTBLK-3 =R-B                  V-TYPE=DOOR-1 V-L=13,15                 ..
* 180 *  SOLAR      =HOURLY-REPORT       REPORT-SCHEDULE=REPTSCHD-1
* 181 *                                  R-B=REPTBLK-1,REPTBLK-2,REPTBLK-3       ..
```

```
* 182 *
* 183 *          END                                          ..
* 184 *          COMPUTE LOADS                                ..
* 185 *          INPUT SYSTEMS                                ..
```

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

 186 *
 187 *  /* [1] FANS SHALL OPERATE CONTINUOUSLY FROM JANUARY 1 THROUGH MARCH AND FROM
 188 *         NOVEMBER 1 THROUGH DECEMBER.  FROM APRIL 1 THROUGH OCTOBER THE FANS
 189 *         SHALL OPERATE ONLY FROM 7 A.M. THROUGH 6 P.M. ON WEEKDAYS.
 190 *     [2] THE HEATING WILL BE AVAILABLE WHENEVER THE FANS ARE OPERATING WITH
 191 *         NIGHT AND WEEKEND SETBACK FROM 70 DEG TO 50 DEG.                    */
 192 *  /* [3] THE COOLING WILL BE AVAILABLE ONLY FROM APRIL 1 THROUGH OCTOBER WITH
 193 *         A COOLING SETPOINT OF 76 DEG.
 194 *     [4] THE MINIMUM OUTSIDE AIR WILL BE SET AT 7 CFM PER PERSON.
 195 *     [5] THE THROTTLING RANGE OF THE PROPORTIONAL THERMOSTAT WILL BE 2 DEG.
 196 *     [6] THE CEILING PLENUM WILL BE USED FOR RETURN AIR.                     */
 197 *  /* [7] THE SUPPLY AIR WILL HAVE A MINIMUM TEMPERATURE OF 55 DEG.
 198 *     [8] THE MAXIMUM TEMPERATURE OF THE HEATING COILS WILL BE 105 DEG.
 199 *     [9] THE SUPPLY AIR WILL BE RESET TO SATISFY THE WARMEST ZONE.
 200 *    [10] THE HUMIDITY WILL BE HELD BETWEEN .006 AND .01 LB WATER/LB AIR.
 201 *    [11] THERE WILL BE AN ENTHALPY CONTROLLED ECONOMIZER SET TO RETURN TO     */
 202 *  /*      MINIMUM OUTSIDE AIR AT 72 DEG.
 203 *    [12] THE FANS WILL OPERATE AT 66 PERCENT EFFICIENCY WITH A STATIC PRESSURE
 204 *         OF THE SUPPLY FAN OF 3.5 INCHES AND THAT OF THE RETURN FAN OF 1.0 INCH.
 205 *    [13] THE REHEAT COIL WILL HAVE A RANGE OF 50 DEG.
 206 *    [14] THE MINIMUM RECIRCULATION RATE OF SUPPLY AIR WILL BE 30 PERCENT.    */
 207 *  /*[15] THE SYSTEM WILL BE A MULTI-ZONE SYSTEM.                              */
 208 *
 209 *            SYSTEMS-REPORT      VERIFICATION=SV-A SUMMARY=SS-A          ..
 210 *
 211 *
 212 *                      /*-----SCHEDULES-----*/
 213 *
 214 *
 215 *  FAN-1      =SCHEDULE           THRU MAR 31 (ALL)      (1,24) 1
 216 *                                 THRU OCT 31 (WD)       (1,7) 0 (8,18) 1
 217 *                                                        (19,24) 0
 218 *                                             (WEH)      (1,24) 0
 219 *                                 THRU DEC 31 (ALL)      (1,24) 1          ..
 220 *
 221 *  HEATWK-1   =WEEK-SCHEDULE      (WD)       (1,7) 50 (8,18) 70
 222 *                                            (19,24) 50
 223 *                                 (WEH)      (1,24) 60                    ..
 224 *
 225 *  HTEMP-1    =SCH                THRU DEC 31 HEATWK-1                     ..
 226 *
 227 *  COOL-1     =SCH                THRU MAR 31 (ALL) (1,24) 0
 228 *                                 THRU OCT 31 (ALL) (1,24) 1
 229 *                                 THRU DEC 31 (ALL) (1,24) 0               ..
 230 *
 231 *  COOLWK-1   =WS                 (MON,FRI) (1,7) 99 (8,18) 75 (19,24) 99
 232 *                                 (WEH)      (1,24) 99                        ..
 233 *
 234 *  CTEMP-1    =SCH                THRU MAR 31 (ALL) (1,24) 99
 235 *                                 THRU OCT 31 COOLWK-1
 236 *                                 THRU DEC 31 (ALL) (1,24) 99              ..
 237 *
 238 *
 239 *                    /*-----ZONE DESCRIPTIONS-----*/
 240 *
 241 *  ZNAIR-1    =ZONE-AIR           OUTSIDE-CFM/PER=7                        ..
```

```
* 242 *
* 243 *  ZNCON-1    =ZONE-CONTROL        DESIGN-HEAT-TEMP=70
* 244 *                                  DESIGN-COOL-TEMP=75
* 245 *                                  HEAT-TEMP-SCHED=HTEMP-1
* 246 *                                  COOL-TEMP-SCHED=CTEMP-1
* 247 *                                  THERMOSTAT-TYPE=PROPORTIONAL              ..
* 248 *
* 249 *  PLENU-1    =ZONE                ZONE-TYPE=PLENUM                          ..
* 250 *  SPACE-1    =ZONE                ZONE-AIR=ZNAIR-1 ZONE-CONTROL=ZNCON-1     ..
* 251 *  SPACE-2    =ZONE                LIKE SPACE-1                              ..
* 252 *  SPACE-3    =ZONE                LIKE SPACE-1                              ..
* 253 *  SPACE-4    =ZONE                LIKE SPACE-1                              ..
* 254 *  SPACE-5    =ZONE                LIKE SPACE-1                              ..
* 255 *
* 256 *
* 257 *                  /*-----SYSTEMS DESCRIPTIONS-----*/
* 258 *
* 259 *  SCON-1     =SYSTEM-CONTROL      COOLING-SCHEDULE=COOL-1
* 260 *                                  HEATING-SCHEDULE=FAN-1
* 261 *                                  MIN-SUPPLY-TEMP=55
* 262 *                                  MAX-SUPPLY-TEMP=105
* 263 *                                  COOL-CONTROL=WARMEST
* 264 *                                  MIN-HUMIDITY=.006
* 265 *                                  MAX-HUMIDITY=.01       ..
* 266 *
* 267 *  SAIR-1     =SYSTEM-AIR          OUTSIDE-CONTROL=ENTHALPY                  ..
* 268 *
* 269 *  SFAN-1     =SYSTEM-FANS         SUPPLY-STATIC=3.5 SUPPLY-EFF=.66
* 270 *                                  RETURN-STATIC=1.0 RETURN-EFF=.66
* 271 *                                  FAN-SCHEDULE=FAN-1                        ..
* 272 *
* 273 *  STERM-1    =SYSTEM-TERMINAL     REHEAT-DELTA-T=50
* 274 *                                  MIN-CFM-RATIO=.3                          ..
* 275 *
* 276 *  CEILBYPS-1=SYSTEM               SYSTEM-TYPE=CBVAV
* 277 *                                  SYSTEM-CONTROL=SCON-1
* 278 *                                  SYSTEM-AIR=SAIR-1
* 279 *                                  SYSTEM-FANS=SFAN-1
* 280 *                                  SYSTEM-TERMINAL=STERM-1
* 281 *                                  ECONO-LIMIT-TEMP=72
* 282 *                                  RETURN-AIR-PATH=PLENUM-ZONES
* 283 *                                  PLENUM-NAMES=PLENU-1
* 284 *                                  ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 285 *                                             SPACE-4,SPACE-5,PLENU-1        ..
* 286 *
* 287 *  MULTIZON-1=SYSTEM               LIKE CEILBYPS-1  SYSTEM-TYPE=MZS
* 288 *                                  HEAT-CONTROL=COLDEST MIN-CFM-RATIO=1
* 289 *                                  PLENUM-NAMES=PLENU-1
* 290 *                                  ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 291 *                                             SPACE-4,SPACE-5,PLENU-1        ..
* 292 *
* 293 *  PLANT-2    =PLANT-ASSIGNMENT    SYSTEM-NAMES=MULTIZON-1                   ..
* 294 *
* 295 *             END                                                            ..
* 296 *             COMPUTE SYSTEMS                                                ..
* 297 *             INPUT PLANT                                                    ..
```

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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                1         2         3         4         5         6         7         8
       12345678901234567890123456789012345678901234567890123456789012345678901234567890

* 298 *  /* [1] COOLING WILL BE PROVIDED BY A RECIPROCATING CHILLER CONNECTED TO A
* 299 *         COOLING TOWER, AND THE SIZING WILL BE PERFORMED AUTOMATICALLY
* 300 *         BY THE PROGRAM.
* 301 *     [2] HEATING WILL BE PROVIDED BY A 0.15 MBTUH STEAM BOILER.
* 302 *     [3] THE COSTS OF THE CHILLER AND COOLING TOWER WILL BE TAKEN FROM THE   */
* 303 *  /*     DEFAULT VALUES OF THE PROGRAM.
* 304 *     [4] THE INITIAL BOILER COST IS $2000 AND THE COST OF INSTALLATION $800.
* 305 *     [5] MAINTENANCE COSTS FOR THE BOILER ARE $350/YEAR.
* 306 *     [6] THE ELECTRIC UTILITY RATE IS $.045/KWH AND THE NATURAL GAS RATE IS
* 307 *         $. 22/THERM.                                                        */
* 308 *
* 309 *  SBOIL-1    =EQUIPMENT          TYPE=STMB NUMBER=1
* 310 *                                 AVAILABLE=1 SIZE=.15                    ..
* 311 *  CHILL-1    =EQUIPMENT          TYPE=COMPR NUMBER=1
* 312 *                                 AVAILABLE=1 SIZE=-999.                  ..
* 313 *  CTOW-1     =EQUIPMENT          TYPE=CTOWR NUMBER=1
* 314 *                                 AVAILABLE=1 SIZE=-999.                  ..
* 315 *             COST-OF-EQUIPMENT   FOR SBOIL-1
* 316 *                                 COST=2 INSTALLATION=1.4
* 317 *                                 MAINTENANCE=350 LIFE=200000
* 318 *                                 MINOR-OVHL-COST=200
* 319 *                                 MINOR-OVHL-INVL=4000
* 320 *                                 MAJOR-OVHL-COST=700
* 321 *                                 MAJOR-OVHL-INVL=20000                   ..
* 322 *             ENERGY-COST         RESOURCE=BOILER  UNIT=100000
* 323 *                                 COST=.22 ESCALATION=10                  ..
* 324 *             ENERGY-COST         RESOURCE=ELECT   UNIT=3413
* 325 *                                 COST=.045 ESCALATION=6                  ..
* 326 *             LIFE-CYCLE-RATES    DISCOUNT-RATE=10 LABOR-INFLTN=0         ..
* 327 *             LIFE-CYCLE-COSTS    LABOR=25 PROJECT-LIFE=25                ..
* 328 *             END                                                         ..
* 329 *             COMPUTE PLANT                                               ..
* 330 *             INPUT ECONOMICS                                             ..
```

F 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

* 331 *
* 332 *  /* [1] THE PURCHASE COST OF THE MZS SYSTEM IS $15,000 AND THE COST OF
* 333 *         INSTALLATION IS $12,000.
* 334 *     [2] MAINTENANCE OF THE SYSTEM WILL COST $750/YEAR.
* 335 *     [3] IT IS ASSUMED THAT THE SYSTEM WILL LAST AS LONG AS THE BUILDING.    */
* 336 *
* 337 *            COMPONENT-RATES     DISCOUNT-RATE=10 PROJECT-LIFE=25          ..
* 338 *  MZSCST-1   =COMPONENT-COST    FIRST-COST=15000 INSTALL-COST=12000
* 339 *                               MAINT-COST=750                            ..
* 340 *            END                                                           ..
* 341 *            COMPUTE ECONOMICS                                             ..
* 342 *            STOP                                                          ..
```

PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.16.33
JANUARY 1979
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	D - BULB	WET-BULB
PLENU-1	1.	18.294	JUL 7 4 PM	88F	73F	-43.416	JAN 12 10 AM	-7F	-7F
SPACE-1	1.	31.283	NOV 7 3 PM	55F	46F	-22.186	MAR 24 5 AM	9F	8F
SPACE-2	1.	10.247	JUL 3 10 AM	87F	74F	-9.514	JAN 1 4 AM	3F	2F
SPACE-3	1.	26.906	JUL 9 5 PM	97F	73F	-26.431	JAN 1 4 AM	3F	2F
SPACE-4	1.	10.356	AUG 19 5 PM	90F	71F	-9.316	JAN 1 4 AM	3F	2F
SPACE-5	1.	24.565	AUG 30 5 PM	80F	66F	-2.030	FEB 25 8 AM	10F	9F
SUM		121.650				-112.893			
BUILDING PEAK		99.241	JUL 9 5 PM	97F	73F	-68.204	JAN 1 4 AM	3F	2F

SPACE PLENU-1

MULTIPLIER 1

FLOOR AREA 4500 SQFT 418 SQMT
VOLUME 13500 CUFT 382 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 10 AM	
DRY-BULB TEMP	88F	31C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.786	.83	0.000	0.00	-6.006	-6.34
CEILINGS	17.508	18.47	0.000	0.00	-37.409	-39.47
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	18.294	19.30	0.000	0.00	-43.416	-45.81

TOTAL LOAD	18.294 KBTU/H	19.30 MJ/H	-43.416 KBTU/H	-45.81 MJ/H
TOTAL LOAD / AREA	4.07 BTUH/SQFT	.04618 MJ/H/SQMT	9.65 BTUH/SQFT	.10958 MJ/H/SQMT

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

PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.16.33
JANUARY 1979
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE-1

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	NOV 7 3 PM		MAR 24 5 AM	
DRY-BULB TEMP	55F	13C	9F	-13C
WET-BULB TEMP	46F	8C	8F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	-1.831	-1.93	0.000	0.00	-4.054	-4.28
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	-2.455	-2.59	0.000	0.00	-7.727	-8.15
GLASS SOLAR	16.677	17.60	0.000	0.00	1.145	1.21
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-1.109	-1.17	0.000	0.00	-1.795	-1.89
OCCUPANTS TO SPACE	10.237	10.80	5.188	5.47	.028	.03
LIGHT TO SPACE	7.196	7.59	0.000	0.00	.459	.48
EQUIPMENT TO SPACE	2.567	2.71	0.000	0.00	.078	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-10.321	-10.89
TOTAL	31.283	33.00	5.188	5.47	-22.186	-23.41

TOTAL LOAD	36.470 KBTU/H	38.48 MJ/H	-22.186 KBTU/H	-23.41 MJ/H
TOTAL LOAD / AREA	34.54 BTUH/SQFT	.39264 MJ/H/SQMT	21.01 BTUH/SQFT	.23885 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-2

MULTIPLIER 1

FLOOR AREA 396 SQFT 36 SQMT
VOLUME 3564 CUFT 100 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 3 10 AM		JAN 1 4 AM	
DRY-BULB TEMP	87F	31C	3F	-16C
WET-BULB TEMP	74F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.528	.56	0.000	0.00	-2.599	-2.74
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.571	.60	0.000	0.00	-3.149	-3.32
GLASS SOLAR	5.002	5.28	0.000	0.00	.248	.26
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROJND SURFACES	-.238	-.25	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.063	1.12	.576	.61	0.000	0.00
LIGHT TO SPACE	2.386	2.52	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.934	.99	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	10.247	10.81	.576	.61	-9.514	-10.04

TOTAL LOAD	10.823 KBTU/H	11.42 MJ/H	-9.514 KBTU/H	-10.04 MJ/H
TOTAL LOAD / AREA	27.33 BTUH/SQFT	.31720 MJ/H/SQMT	24.03 BTUH/SQFT	.27883 MJ/H/SQMT

```
*************************************************************
*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
*************************************************************
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PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.16.33
JANUARY 1979
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE-3

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	2.915	3.08	0.000	0.00	-10.642	-11.23
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.551	1.64	0.000	0.00	-5.248	-5.54
GLASS SOLAR	2.616	2.76	0.000	0.00	.165	.17
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.634	-.67	0.000	0.00	-1.690	-1.78
OCCUPANTS TO SPACE	10.890	11.49	5.188	5.47	0.000	0.00
LIGHT TO SPACE	7.688	8.11	0.000	0.00	.432	.46
EQUIPMENT TO SPACE	1.880	1.98	0.000	0.00	.072	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-9.520	-10.04
TOTAL	26.906	28.39	5.188	5.47	-26.431	-27.89

TOTAL LOAD	32.094 KBTU/H	33.86 MJ/H	-26.431 KBTU/H	-27.89 MJ/H
TOTAL LOAD / AREA	30.39 BTUH/SQFT	.34552 MJ/H/SQMT	25.03 BTUH/SQFT	.28455 MJ/H/SQMT

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*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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SPACE SPACE-4

MULTIPLIER 1

FLOOR AREA 396 SQFT 36 SQMT
VOLUME 3564 CUFT 100 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 19 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	90F	32C	3F	-16C
WET-BULB TEMP	71F	22C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.324	.34	0.000	0.00	-2.557	-2.70
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.626	.66	0.000	0.00	-3.149	-3.32
GLASS SOLAR	4.875	5.14	0.000	0.00	.404	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.198	-.21	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.196	1.26	.576	.61	0.000	0.00
LIGHT TO SPACE	2.839	2.99	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.694	.73	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	10.356	10.93	.576	.61	-9.316	-9.83

TOTAL LOAD	10.932 KBTU/H	11.53 MJ/H	-9.316 KBTU/H	-9.83 MJ/H
TOTAL LOAD / AREA	27.61 BTUH/SQFT	.32040 MJ/H/SQMT	23.53 BTUH/SQFT	.27303 MJ/H/SQMT

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*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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SPACE SPACE-5

MULTIPLIER 1

FLOOR AREA 1596 SQFT 148 SQMT
VOLUME 14364 CUFT 406 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 5 PM		FEB 25 8 AM	
DRY-BULB TEMP	80F	27C	10F	-12C
WET-BULB TEMP	66F	19C	9F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	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	-.798	-.84	0.000	0.00	-2.793	-2.95
OCCUPANTS TO SPACE	10.894	11.49	5.188	5.47	.000	.00
LIGHT TO SPACE	11.626	12.27	0.000	0.00	.654	.69
EQUIPMENT TO SPACE	2.843	3.00	0.000	0.00	.109	.11
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	24.565	25.92	5.188	5.47	-2.030	-2.14

TOTAL LOAD	29.753 KBTU/H	31.39 MJ/H	-2.030 KBTU/H	-2.14 MJ/H
TOTAL LOAD / AREA	18.64 BTUH/SQFT	.21210 MJ/H/SQMT	1.27 BTUH/SQFT	.01447 MJ/H/SQMT

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

FLOOR AREA	9000	SQFT	836	SQMT
VOLUME	54000	CUFT	1529	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9	5 PM	JAN 1	4 AM
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	5.714	6.03	0.000	0.00	-20.762	-21.90
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	5.908	6.23	0.000	0.00	-19.996	-21.10
GLASS SOLAR	14.458	15.25	0.000	0.00	3.785	3.99
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-2.700	-2.85	0.000	0.00	-7.200	-7.60
OCCUPANTS TO SPACE	35.090	37.02	16.716	17.64	0.000	0.00
LIGHT TO SPACE	32.761	34.56	0.000	0.00	1.843	1.94
EQUIPMENT TO SPACE	8.010	8.45	0.000	0.00	.307	.32
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-26.181	-27.62
TOTAL	99.241	104.70	16.716	17.64	-68.204	-71.96
TOTAL LOAD	115.957 KBTU/H		122.34 MJ/H		-68.204 KBTU/H	-71.96 MJ/H
TOTAL LOAD / AREA	12.88 BTUH/SQFT		.14634 MJ/H/SQMT		7.58 BTUH/SQFT	.08608 MJ/H/SQMT

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*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.16.33
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MMDDHH	BUILDING ITEM 6	BUILDING ITEM 23	GLOBAL ITEM 6	GLOBAL ITEM 20	GLOBAL ITEM 21	GLOBAL ITEM 22	DOOR-1 ITEM 13	DOOR-1 ITEM 15	ITEM
716 1	0.0000	6149.7936	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 2	0.0000	5350.3205	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 3	0.0000	4654.7788	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 4	0.0000	4049.6576	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 5	0.0000	3523.2021	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 6	0.0000	3356.6745	2.0000	.7154	14.5878	2.0807	.9659	43.6067	
716 7	0.0000	4688.9302	3.0000	.7098	105.3042	15.0201	8.3146	373.9075	
716 8	0.0000	5574.6483	7.0000	.6126	127.6457	18.2068	11.7009	528.2472	
716 9	0.0000	6656.0875	6.0000	.6537	155.6851	22.2062	16.5550	746.9809	
71610	0.0000	8941.1707	0.0000	1.0000	254.5798	36.3120	35.7032	1608.9037	
71611	0.0000	10326.3921	3.0000	.9996	263.7741	37.6235	37.6639	1673.2947	
71612	0.0000	11322.3628	3.0000	.9996	268.5693	38.3074	33.8589	1504.6477	
71613	0.0000	12046.8180	3.0000	.9361	252.8455	36.0647	32.2663	1437.4999	
71614	0.0000	12790.3058	3.0000	.9361	251.2855	35.8422	32.0859	1443.4296	
71615	0.0000	13636.3996	2.0000	.9371	246.7650	35.1974	36.0565	1603.2167	
71616	0.0000	14387.0552	1.0000	.9429	239.0980	34.1038	33.4131	1512.2392	
71617	0.0000	15090.0797	0.0000	1.0000	236.3670	33.7142	24.7270	1099.6978	
71618	0.0000	15248.7274	0.0000	1.0000	205.0068	29.2412	18.5872	825.9907	
71619	0.0000	14616.2576	0.0000	1.0000	141.1180	20.1284	10.9961	486.5154	
71620	0.0000	12072.3945	0.0000	1.0000	10.5654	1.5070	.6890	30.7811	
71621	0.0000	10430.7461	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71622	0.0000	9074.7491	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71623	0.0000	7895.0317	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71624	0.0000	6868.6776	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
CEILBYPS-1	0.	.30	0.00	.66	.66	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	0.	0.	0.00	0.00	45.0	1.0
SPACE-2	0.	0.	0.00	0.00	5.0	1.0
SPACE-3	0.	0.	0.00	0.00	45.0	1.0
SPACE-4	0.	0.	0.00	0.00	5.0	1.0
SPACE-5	0.	0.	0.00	0.00	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.17.34
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SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
MULTIZON-1	4886.	1.00	.22	3.04	.87	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	1479.	326.	-22.19	31.28	45.0	1.0
SPACE-2	479.	41.	-9.51	10.25	5.0	1.0
SPACE-3	1275.	326.	-26.43	26.91	45.0	1.0
SPACE-4	490.	41.	-9.32	10.36	5.0	1.0
SPACE-5	1163.	326.	-2.03	24.56	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.17.34
JANUARY 1979
REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM CEILBYPS-1 TYPE CBVAV

MONTH	HEATING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	COOLING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM LOAD (KW)
JAN	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
FEB	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
MAR	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
APR	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
MAY	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
JUN	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
JUL	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
AUG	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
SEP	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
OCT	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
NOV	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
DEC	0.000	0	0	0.000	0.000	0	0	0.000	0.	0.
TOTAL	0.000				0.000				0.000	
MAX				0.000				0.000		0.000

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 11 JAN 1979 14.17.34
JANUARY 1979
REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM MULTIZON-1 TYPE MZS

MONTH	HEATING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	COOLING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM LOAD (KW)
JAN	-60.970	7	8	-179.167	0.000	31	24	0.000	7169.	21.
FEB	-51.927	11	8	-170.959	0.000	28	24	0.000	6329.	21.
MAR	-51.454	25	8	-159.135	0.000	31	24	0.000	7001.	21.
APR	-9.561	8	12	-140.857	1.799	29	18	82.808	5190.	21.
MAY	-5.307	6	7	-142.248	4.737	21	13	114.187	5208.	21.
JUN	-.414	3	7	-69.180	14.280	20	17	173.515	4768.	21.
JUL	-.051	24	7	-9.172	29.634	3	14	180.250	5208.	21.
AUG	-.106	29	7	-13.019	25.579	26	16	165.098	5208.	21.
SEP	-1.938	23	7	-99.195	9.701	11	16	149.118	4768.	21.
OCT	-6.524	21	10	-139.736	3.969	30	18	95.375	5419.	21.
NOV	-51.390	25	8	-115.245	0.000	30	24	0.000	6721.	21.
DEC	-50.951	9	8	-157.944	0.000	31	24	0.000	6665.	21.
TOTAL	-290.591				89.700				69656.114	
MAX				-179.167				180.250		21.456

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	.061	.025	0.000	0.000	0.000	0.000	0.000	.086	.074	.086	.161	53.
2	.052	.022	0.000	0.000	0.000	0.000	0.000	.074	.066	.074	.140	53.
3	.051	.024	0.000	0.000	0.000	0.000	0.000	.075	.073	.075	.147	51.
4	.010	.020	.002	0.000	0.000	0.000	.005	.014	.061	.014	.076	40.
5	.005	.021	.005	0.000	0.000	0.000	.007	.008	.064	.008	.071	37.
6	.000	.023	.014	0.000	0.000	0.000	.015	.001	.069	.001	.069	34.
7	.000	.029	.030	0.000	0.000	0.000	.028	.000	.088	.000	.088	33.
8	.000	.028	.026	0.000	0.000	0.000	.025	.000	.085	.000	.085	33.
9	.002	.021	.010	0.000	0.000	0.000	.011	.003	.064	.003	.067	35.
10	.007	.022	.004	0.000	0.000	0.000	.007	.010	.066	.010	.076	38.
11	.051	.023	0.000	0.000	0.000	0.000	0.000	.074	.070	.074	.144	52.
12	.051	.023	0.000	0.000	0.000	0.000	0.000	.075	.069	.075	.144	51.
	.291	.282	.090	0.000	0.000	0.000	.100	.420	.847	.420	1.267	43.

EQUIPMENT USE STATISTICS

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
STEAM BOILER	.453	.150	12	9	8	.150	4273								
RECIPROCATING CHILR	.270	.180	7	3	14	.240	1385								
COOLING TOWER	.296	.233	7	3	14	.300	1385								

CENTRAL PLANT LIFE CYCLE EQUIPMENT COST SUMMARY

EQUIPMENT	TOTALS		
STEAM BOILER	85.1		
NOMINAL SIZE (MBTU)			.150
NUMBER INSTALLED			1
FIRST COST (K$)		2.8	2.8
ANNUAL COST (K$)		79.4	79.4
CYCLICAL COST (K$)		2.9	2.9
-----TOTAL----(K$)			85.1
RECIPROCATING CHILR	10.6		
NOMINAL SIZE (MBTU)			.240
NUMBER INSTALLED			1
FIRST COST (K$)		8.7	8.7
ANNUAL COST (K$)		1.7	1.7
CYCLICAL COST (K$)		.2	.2
-----TOTAL----(K$)			10.6
COOLING TOWER	17.3		
NOMINAL SIZE (MBTU)			.300
NUMBER INSTALLED			1
FIRST COST (K$)		6.6	6.6
ANNUAL COST (K$)		8.7	8.7
CYCLICAL COST (K$)		2.1	2.1
-----TOTAL----(K$)			17.3
EQUIPMENT TOTAL	113.1		

MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY

MO	UTILITY>	ELECT	DIESEL	GASTUR	BOILER
	TOTAL(MBTU)	24.827	0.000	0.000	86.152
1	PEAK(MBTU)	.074	0.000	0.000	.201
	DY/HR	2/11	31/24	31/24	7/ 8
	TOTAL(MBTU)	21.906	0.000	0.000	74.208
2	PEAK(MBTU)	.074	0.000	0.000	.201
	DY/HR	25/11	28/24	28/24	11/ 8
	TOTAL(MBTU)	24.197	0.000	0.000	74.751
3	PEAK(MBTU)	.074	0.000	0.000	.200
	DY/HR	25/11	31/24	31/24	25/ 8
	TOTAL(MBTU)	20.437	0.000	0.000	14.199
4	PEAK(MBTU)	.104	0.000	0.000	.186
	DY/HR	29/18	30/24	30/24	8/12
	TOTAL(MBTU)	21.177	0.000	0.000	7.817
5	PEAK(MBTU)	.116	0.000	0.000	.188
	DY/HR	22/14	31/24	31/24	6/ 7
	TOTAL(MBTU)	22.855	0.000	0.000	.704
6	PEAK(MBTU)	.130	0.000	0.000	.101
	DY/HR	20/15	30/24	30/24	3/ 7
	TOTAL(MBTU)	29.379	0.000	0.000	.107
7	PEAK(MBTU)	.135	0.000	0.000	.019
	DY/HR	3/10	31/24	31/24	24/ 7
	TOTAL(MBTU)	28.245	0.000	0.000	.219
8	PEAK(MBTU)	.131	0.000	0.000	.026
	DY/HR	20/10	31/24	31/24	29/ 7
	TOTAL(MBTU)	21.234	0.000	0.000	3.088
9	PEAK(MBTU)	.127	0.000	0.000	.135
	DY/HR	11/14	30/24	30/24	23/ 7
	TOTAL(MBTU)	21.873	0.000	0.000	10.035
10	PEAK(MBTU)	.111	0.000	0.000	.185
	DY/HR	31/15	31/24	31/24	21/10
	TOTAL(MBTU)	23.241	0.000	0.000	74.257
11	PEAK(MBTU)	.074	0.000	0.000	.154
	DY/HR	5/11	30/24	30/24	25/ 8
	TOTAL(MBTU)	23.048	0.000	0.000	74.574
12	PEAK(MBTU)	.074	0.000	0.000	.200
	DY/HR	9/11	31/24	31/24	9/ 8
		==========	==========	==========	==========
	ONE YEAR	282.420	0.000	0.000	420.108
	USE/PEAK (MBTU)	.135	0.000	0.000	.201
	YEAR COST (K$)	3.0	0.0	0.0	.9
	COST ESCLTN (PCT)	6.0	5.0	5.0	10.0

TOTAL USE (MBTU) 702.528

TOTAL COST (K$) 3.9

NOTES TO ABOVE TABLE
(1) ALL ENERGY USE VALUES ARE NET, I.E., AT BUILDING BOUNDARY

(2) PEAK VALUES ARE IN MBTUH
(3) YEAR COST IS LIFE-CYCLE COST DIVIDED BY PROJECT LIFETIME

E Q U I P M E N T O P E R A T I O N A N D P A R T L O A D R E P O R T

NAME	HOURS AT PERCENT PART LOAD RATIO												TOTAL HOURS	ANNUAL LOAD (GBTU)	FALSE LOAD (GBTU)	TOTAL LOAD (GBTU)
	0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110	- 120+				
STMB	303	66	211	898	966	1061	499	210	27	15	17	0	4273	.290	0.000	.290
	303	66	211	898	966	1061	499	210	27	15	17	0				
COMPR	515	138	109	158	187	145	100	33	0	0	0	0	1385	.090	.008	.098
	515	138	109	158	187	145	100	33	0	0	0	0				
CTOWR	466	161	105	142	177	159	124	51	0	0	0	0	1385	.123	0.000	.123
	466	161	105	142	177	159	124	51	0	0	0	0				

NOTES TO TABLE
1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE HOURLY OPERATING CAPACITY (UNITS OPERATING THAT HOUR)
2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE TOTAL INSTALLED CAPACITY

PLANT DEMANDS SATISFIED REPORT

HEATING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
STEAM BOILER	.290	99.9
DEMAND SATISFIED	.290	99.9
TOTAL DEMAND ON PLANT	.291	

COOLING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
RECIPROCATING CHILR	.090	100.0
DEMAND SATISFIED	.090	100.0
TOTAL DEMAND ON PLANT	.090	

ELECTRICAL DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
DEMAND SATISFIED	0.000	0.0
TOTAL DEMAND ON PLANT	.282	

REJECTED HEAT	GBTU SUPPLIED	PCT OF TOTAL DEMAND
COOLING TOWER	.123	100.0
DEMAND SATISFIED	.123	100.0
TOTAL DEMAND ON PLANT	.123	

SUMMARY OF LOADS MET

TYPE OF DEMAND	TOTAL DEMAND (GBTU)	DEMAND SATISFIED (GBTU)	TOTAL OVERLOAD (GBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING DEMANDS	.291	.290	.000	.029	17
COOLING DEMANDS	.090	.090	0.000	0.000	0
REJECTED HEAT	.123	.123	0.000	0.000	0

E L E C T R I C A L D E M A N D S C A T T E R P L O T

TOTAL HOURS AT DEMAND AND TIME OF DAY

	HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
	42.140	0	0	0	0	0	0	0	0	0	4	0	0	0	1	0	0	0	0	0	0	0	0	0	0	5
	38.899	0	0	0	0	0	0	0	0	16	23	21	3	12	26	27	20	18	0	0	0	0	0	0	0	166
	35.657	0	0	0	0	0	0	0	16	18	17	21	20	28	31	32	36	34	0	0	0	0	0	0	0	253
	32.416	0	0	0	0	0	0	0	14	12	14	22	29	26	18	17	19	21	3	0	0	0	0	0	0	195
D	29.174	0	0	0	0	0	0	0	11	16	22	11	15	10	7	12	13	17	0	0	0	0	0	0	0	134
E K	25.933	0	0	0	0	0	0	0	18	36	38	56	67	58	57	52	52	53	17	0	0	0	0	0	0	504
M W	22.691	0	0	0	0	0	0	15	20	44	134	121	108	8	112	112	112	109	103	0	0	0	0	0	0	998
A H	19.449	0	0	0	0	0	0	11	50	110	0	0	10	110	0	0	0	0	0	0	0	0	0	0	0	291
N	16.208	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	101	0	0	0	0	0	112
D	12.966	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
	9.725	0	0	0	0	0	0	33	14	0	0	0	0	0	0	0	0	0	129	22	101	101	0	0	0	400
	6.483	151	151	151	151	151	151	199	159	50	50	50	50	50	50	50	50	50	50	179	72	50	151	151	151	2518
	3.242	214	214	214	214	214	214	85	63	63	63	63	63	63	63	63	63	63	63	63	192	214	214	214	214	3173
PERCENT TOTAL DEMAND		1.1	1.1	1.1	1.1	1.1	1.1	2.5	4.8	7.4	8.1	8.2	7.8	7.8	8.2	8.3	8.2	8.0	4.9	2.9	1.9	1.4	1.1	1.1	1.1	

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KWH	PCT
SYSTEMS LOAD	21.450	54.4
COMPRESSION CHILLERS	15.058	38.2
COOLING TOWER	2.022	5.1
CIRCULATION PUMPS	.922	2.3
TOTAL	39.453	

L I F E - C Y C L E P L A N T C O S T S U M M A R Y

	ANNUAL	LIFETIME(25 YRS)
PLANT EQUIPMENT COST	4.5	113.1 K$
ENERGY COST	3.9	97.1 K$
ENERGY USE (NET)	.7	17.6 GBTU

```
-----------------------------------------
- PLANT EQUIPMENT PLUS ENERGY           -
- LIFE CYCLE COST FOR 25 YEARS =   .2102 (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

REPORT- E01 ECONOMICS VERIFICATION (NON-PLANT COST ITEMS) CAL-ERDA 1.3 11 JAN 1979 14.21.34

DISCOUNT RATE (PCT)	LABOR INFL-RATE (PCT)	MATERIALS INFL-RATE (PCT)	PROJECT LIFETIME (YRS)
10.0	0.0	0.0	25.0

COST-NAME MZSCST-1 NO. OF UNITS 1.0 UNIT-NAME 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
15000.	0.00	12000.	0.00	750.	0.00	750.	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 11 JAN 1979 14.21.34

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
MZSCST-1	1.		15.00	12.00	6.81 (	6.81	0.00)	0.00 (	0.00	0.00)	0.00	33.81
		TOTAL	15.00	12.00	6.81 (	6.81	0.00)	0.00 (	0.00	0.00)	0.00	33.81

OVERALL LIFE-CYCLE COSTS (K$)

NON-PLANT	PLANT	FUEL	T O T A L
33.8	113.1	97.1	244.0

REPORT- E03 LIFE-CYCLE SAVINGS/INVESTMENT STATISTICS CAL-ERDA 1.3 11 JAN 1979 14.21.34

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		0.00	0.00	0.00	0.00
THIS RUN	33.81	113.05	97.10	210.15	17.56
SAVINGS		-113.05	-97.10	-210.15	-17.56

SAVINGS/INVESTMENT STATISTICS

COST SAVINGS (K$)	INVESTMENT (K$)	SAVINGS-TO-INVESTMENT RATIO	FUEL SAVINGS (MBTU)	FUEL-SAVINGS-TO-INVESTMENT RATIO(MBTU/$)	PAYBACK PERIOD (YRS)
-210.2	33.8	-6.2	-17563.2	-.52	0.0

Example Building with CBVAV System Retrofit with Seasonal Shading

```
CAL-ERDA ENERGY ANALYSIS PROGRAM VERSION 1.4
BUILDING DESIGN LANGUAGE PROCESSOR

*  1 *        INPUT LOADS                                    ..
```

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
12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789 0

 2  TITLE     USERS GUIDE EXAMPLE BUILDING
 3  TITLE     LAWRENCE BERKELEY LABORATORY
 4  TITLE
 5  TITLE     DECEMBER 1978
 6
 7  /* [1] THE BUILDING IS A SINGLE STORY OFFICE BUILDING LOCATED IN CHICAGO.
 8     [2] THE WEATHER DATA WILL BE FOR 1974.
 9     [3] THE WALLS ARE OF FACE BRICK AND CONCRETE CONSTRUCTION WITH 1 INCH OF
10         EXPANDED POLYSTYRENE INSULATION (R-4) UNDER THE BRICK.
11     [4] THE ROOF IS A BUILT-UP ROOF OVER 3 INCHES OF PREFORMED ROOF */
12  /*     INSULATION (R-8)                                                  */
13  /* [5] THERE ARE 16 4 FEET BY 6 FEET WINDOWS, DOUBLE PANED WITH AN ASHRAE
14         SHADING COEFFICIENT OF .86 AND SETBACK 6 INCHES FROM THE WALL SURFACE.
15     [6] THE FRONT DOOR IS .25 INCH PLATE GLASS; THE BACK DOOR IS ONE INCH WOOD.
16     [7] THE FLOOR IS 6 INCHES THICK CONCRETE IN CONTACT WITH THE SOIL.
17     [8] A DROP CEILING SERVES AS A PLENUM.                                */
18  /* [9] THE LIGHTING FIXTURES HAVE FLUORESCENT LAMPS AND RETURN AIR PASSES
19         THROUGH THE FIXTURE.  THE MAXIMUM ENERGY OF THE LIGHTING IS 3 W/SQ.FT.
20    [10] THE ENERGY USED BY EQUIPMENT IS 1 W/SQ.FT. AT A MAXIMUM.
21    [11] THE NUMBER OF PEOPLE IS 145; 45 IN THREES SPACES AND 5 IN TWO SPACES.
22    [12] THE INFILTRATION DURING OCCUPIED HOURS IS .5 AIR CHANGES PER HOUR.   */
23  /*[13] AS A RETROFIT THE WINDOWS WILL BE COMPLETELY SHADED FROM APRIL 1
24         THROUGH OCTOBER.                                                    */
25             DIAGNOSTIC          ERROR     ABORT     ERROR                 ..
26             RUN-PERIOD          JAN 1 1974 THRU DEC 31 1974               ..
27             LOADS-REPORT        L02                                       ..
28             BUILDING-LOCATION   LATITUDE=42 LONGITUDE=88
29                                 ALTITUDE=610 TIME-ZONE=6
30                                 BUILDING-AZIMUTH=0                        ..
31
32
33
34               /*-----BUILDING CONSTRUCTION MATERIALS-----*/
35
36  WLLAY-1    =LAYERS             MATERIAL-1=BK05 M2=IN33
37                                 M3=CB46 M4=AL11 M5=GP01
38                                 INSIDE-FILM-RES=.68                       ..
39  RFLAY-1    =LAYERS             M1=RG01 M2=BR01 M3=IN76
40                                 IFR=.76                                   ..
41  EXTW-1     =CONSTRUCTION       LAYERS=WLLAY-1 ABSORPTANCE=.88
42                                 ROUGHNESS=2                               ..
43  ROF-1      =CONS               WALL-TYPE=RFLAY-1 ABS=.5 RO=1             ..
44  CEIL-1     =CONS               U=.8   /*CONSTRUCTION OF CEILING*/        ..
45  PART-1     =CONS               U=10   /*FALSE PARTITIONS*/               ..
46  FLOR-1     =CONS               U=.05  /*SLAB ON GROUND*/                 ..
47  DOR-1      =CONS               U=1.0 ROUGHNESS=6   /*BACK DOOR*/         ..
48  SHADSC-1   =SCH                THRU MAR 31 (ALL) (1,24) 1
49                                 THRU OCT 31 (ALL) (1,24) 0
50                                 THRU DEC 31 (ALL) (1,24) 1                ..
51  WINGLS-1   =GLASS-TYPE         PANES=2 GLASS-SHADING=.86
52                                 SHADING-SCHEDULE=SHADSC-1                 ..
53  DORGLS-1   =GT                 GTC=3   /*FRONT DOOR*/                    ..
54
55
56                       /*-----SCHEDULES-----*/
57
```

```
*  58 *  DAYSC-1    =DAY-SCHEDULE       (1,8) 0 (9,11) 1 (12,14) .8,.4,.8
*  59 *                                (15,18) 1 (19,21) .5,.1,.1 (22,24) 0    ..
*  60 *  DAYSC-2    =DS                 (1,24) 0                                ..
*  61 *
*  62 *  WKPEOP-1   =WEEK-SCHEDULE      (MON,FRI) DAYSC-1 (WEH) DAYSC-2         ..
*  63 *
*  64 *  PEOPSC-1   =SCHEDULE           THRU DEC 31 WKPEOP-1                    ..
*  65 *
*  66 *  WKLITE-1   =WS                 (MON,FRI) (1,8) .05 (9,14) .9,.95,1,.95,.8,.9
*  67 *                                           (15,18) 1 (19,21) .6,.2,.2
*  68 *                                           (22,24) .05
*  69 *                                (WEH)     (1,24) .05                     ..
*  70 *
*  71 *  LITESC-1   =SCH                THRU DEC 31 WKLITE-1                    ..
*  72 *
*  73 *  WKEQUP-1   =WS                 (MON,FRI) (1,8) .02 (9) .4 (10,14) .9
*  74 *                                           (15,20) .8,.7,.5,.5,.3,.3
*  75 *                                           (21,24) .02
*  76 *                                (WEH)     (1,24) .02                      ..
*  77 *
*  78 *  EQUIPSC-1  =SCH                THRU DEC 31 WKEQUP-1                    ..
*  79 *
*  80 *  INFLSC-1   =SCH                THRU DEC 31 (MON,FRI) (1,7) 1 (8,18) 0
*  81 *                                                       (19,24) 1
*  82 *                                           (WEH)     (1,24) 1            ..
*  83 *
*  84 *
*  85 *            /*-----BUILDING SHADE SPECIFICATION-----*/
*  86 *
*  87 *            BUILDING-SHADE      HEIGHT=5 WIDTH=10 TRANSMITTANCE=0
*  88 *                                X-BUILDING=52.5 Y-BUILDING=0 Z-BUILDING=9
*  89 *                                SURFACE-AZIMUTH=180 TILT=180            ..
*  90 *
*  91 *
*  92 *                    /*-----SETTING DEFAULTS-----*/
*  93 *
*  94 *
*  95 *            SET-DEFAULT         FLOOR-WEIGHT=70 GLASS-HEIGHT=4
*  96 *                                GLASS-WIDTH=6 GLASS-TYPE=WINGLS-1
*  97 *                                SETBACK=0.5 TEMPERATURE=73              ..
*  98 *
*  99 *
* 100 *                      /*-----SPACE DESCRIPTIONS-----*/
* 101 *
* 102 *  COND-1     =SPACE-CONDITIONS   NUMBER-OF-PEOPLE=45
* 103 *                                PEOPLE-ACTIVITY=400
* 104 *                                PEOPLE-SCHEDULE=PEOPSC-1
* 105 *                                LIGHTING-TYPE=2
* 106 *                                LIGHT-TO-SPACE=80
* 107 *                                LIGHTING-W/SQFT=3
* 108 *                                LIGHTING-SCHEDULE=LITESC-1
* 109 *                                EQUIPMENT-W/SQFT=1
* 110 *                                EQUIPMENT-SCHEDULE=EQUIPSC-1
* 111 *                                AIR-CHANGES/HR=.5
* 112 *                                INF-METHOD=1
* 113 *                                INF-SCHEDULE=INFLSC-1                   ..
* 114 *
* 115 *  PLENU-1    =SPACE              FLOOR-AREA=4500 SPACE-HEIGHT=3
* 116 *                                VOLUME=13500 FLOOR-WEIGHT=5
* 117 *                                ZONE-TYPE=UNCONDITIONED                 ..
* 118 *  PLWL-1        =EXTERIOR-WALL  HEIGHT=3 WIDTH=100 AZIMUTH=180
* 119 *                                CONS=EXTW-1                             ..
```

```
* 120 *                EW                LIKE PLWL-1 WIDTH=45 AZIMUTH=90          ..
* 121 *                EW                LIKE PLWL-1 A=0                          ..
* 122 *                EW                LIKE PLWL-1 W=45 A=270                   ..
* 123 *  ROOF-1       =ROOF              HEIGHT=45 WIDTH=100 AZIMUTH=180 TILT=0
* 124 *                                  CONS=ROF-1 GND-REFLECTANCE=0             ..
* 125 *  CEILING-1    =INTERIOR-WALL     AREA=1056 NEXT-TO SPACE-1 CONS=CEIL-1    ..
* 126 *  CEILING-2    =IW                AREA=396 NEXT-TO SPACE-2 CONS=CEIL-1     ..
* 127 *                IW                LIKE CEILING-1 NEXT-TO SPACE-3           ..
* 128 *                IW                LIKE CEILING-2 NEXT-TO SPACE-4           ..
* 129 *                IW                AREA=1596 NEXT-TO SPACE-5 CONS=CEIL-1    ..
* 130 *
* 131 *
* 132 *  SPACE-1    =SPACE               SPACE-CONDITIONS=COND-1 FA=1056 SH=9
* 133 *                                  V=9504                                   ..
* 134 *  WALL-1      =EW                HEIGHT=9 WIDTH=15 AZIMUTH=180
* 135 *                                  CONS=EXTW-1 MULTIPLIER=5                 ..
* 136 *  WIND-1        =WINDOW                                                    ..
* 137 *  WALL-2      =EW                LIKE WALL-1 WIDTH=25 X=45 M=1            ..
* 138 *  DOOR-1        =WI              GLASS-HEIGHT=7 GLASS-WIDTH=6 SETBACK=0
* 139 *                                  GLASS-TYPE=DORGLS-1 J=9.5                ..
* 140 *  FLOOR-1     =UNDERGROUND-FLOOR AREA=1056 CONS=FLOR-1                    ..
* 141 *
* 142 *
* 143 *  SPACE-2    =SPACE               LIKE SPACE-1 NOP=5 FA=396 V=3564         ..
* 144 *                EW                LIKE WALL-1 A=90 M=3                     ..
* 145 *                  WINDOW                                                   ..
* 146 *  INWALL-1     =IW                AREA=161.8 NEXT-TO SPACE-1 CONS=PART-1   ..
* 147 *  INWALL-2     =IW                LIKE INWALL-1 NEXT-TO SPACE-3            ..
* 148 *  FLOOR-2     =UF                AREA=396 CONS=FLOR-1                     ..
* 149 *
* 150 *
* 151 *  SPACE-3    =SPACE               LIKE SPACE-1                             ..
* 152 *                EW                LIKE WALL-1 A=0                          ..
* 153 *                  WINDOW                                                   ..
* 154 *                EW                LIKE WALL-2 A=0                          ..
* 155 *                  WI              LIKE DOOR-1 GLASS-WIDTH=10
* 156 *                                  GLASS-HEIGHT=9 M=0                       ..
* 157 *                  EW              WIDTH=10 HEIGHT=9 A=0 CONS=DOR-1         ..
* 158 *                UF                LIKE FLOOR-1                             ..
* 159 *
* 160 *
* 161 *  SPACE-4    =SPACE               LIKE SPACE-2                             ..
* 162 *                EW                LIKE WALL-1 A=270 M=3                    ..
* 163 *                  WINDOW                                                   ..
* 164 *                IW                LIKE INWALL-1                            ..
* 165 *                IW                LIKE INWALL-2                            ..
* 166 *                UF                LIKE FLOOR-2                             ..
* 167 *
* 168 *
* 169 *  SPACE-5    =SPACE               LIKE SPACE-1 FA=1596 V=14364
* 170 *                                  INF-METHOD=0                             ..
* 171 *  INWALL-3     =IW                AREA=684 NEXT-TO SPACE-1 CONS=PART-1     ..
* 172 *  INWALL-4     =IW                LIKE INWALL-3 AREA=189 NEXT-TO SPACE-2   ..
* 173 *                IW                LIKE INWALL-3 NEXT-TO SPACE-3            ..
* 174 *                IW                LIKE INWALL-4 NEXT-TO SPACE-4            ..
* 175 *                UF                LIKE FLOOR-1 AREA=1596                   ..
* 176 *
* 177 *  REPTSCHD-1=SCHEDULE             THRU JUL 15 (ALL) (1,24) 0
* 178 *                                  THRU JUL 16 (ALL) (1,24) 1
* 179 *                                  THRU DEC 31 (ALL) (1,24) 0               ..
* 180 *  REPTBLK-1 =REPORT-BLOCK         VARIABLE-TYPE=BUILDING
* 181 *                                  VARIABLE-LIST=6,23                       ..
```

```
* 182 *  REPTBLK-2 =REPORT-BLOCK        VARIABLE-TYPE=GLOBAL
* 183 *                                 VARIABLE-LIST=6,20,21,22                  ..
* 184 *  REPTBLK-3 =R-B                 V-TYPE=DOOR-1 V-L=13,15                   ..
* 185 *  SOLAR     =HOURLY-REPORT       REPORT-SCHEDULE=REPTSCHD-1
* 186 *                                 R-B=REPTBLK-1,REPTBLK-2,REPTBLK-3         ..
* 187 *
* 188 *            END                                                            ..
* 189 *            COMPUTE LOADS                                                  ..
* 190 *            INPUT SYSTEMS                                                  ..
```

S 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

* 191 *
* 192 *  /* [1] FANS SHALL OPERATE CONTINUOUSLY FROM JANUARY 1 THROUGH MARCH AND FROM
* 193 *         NOVEMBER 1 THROUGH DECEMBER.  FROM APRIL 1 THROUGH OCTOBER THE FANS
* 194 *         SHALL OPERATE ONLY FROM 7:00 A.M. THROUGH 6:00 P.M. ON WEEKDAYS.
* 195 *     [2] THE HEATING WILL BE AVAILABLE WHENEVER THE FANS ARE OPERATING WITH
* 196 *         NIGHT AND WEEKEND SETBACK FROM 70 DEG TO 50 DEG.                    */
* 197 *  /* [3] THE COOLING WILL BE AVAILABLE ONLY FROM APRIL 1 THROUGH OCTOBER WITH
* 198 *         A COOLING SETPOINT OF 76 DEG.
* 199 *     [4] THE MINIMUM OUTSIDE AIR WILL BE SET AT 7 CFM PER PERSON.
* 200 *     [5] THE THROTTLING RANGE OF THE PROPORTIONAL THERMOSTAT WILL BE 2 DEG.
* 201 *     [6] THE CEILING PLENUM WILL BE USED FOR RETURN AIR.                     */
* 202 *  /* [7] THE SUPPLY AIR WILL HAVE A MINIMUM TEMPERATURE OF 55 DEG.
* 203 *     [8] THE MAXIMUM TEMPERATURE OF THE HEATING COILS WILL BE 105 DEG.
* 204 *     [9] THE SUPPLY AIR WILL BE RESET TO SATISFY THE WARMEST ZONE.
* 205 *    [10] THE HUMIDITY WILL BE HELD BETWEEN .006 AND .01 LB WATER/LB AIR.
* 206 *    [11] THERE WILL BE AN ENTHALPY CONTROLLED ECONOMIZER SET TO RETURN TO     */
* 207 *  /*      MINIMUM OUTSIDE AIR AT 72 DEG.
* 208 *    [12] THE FANS WILL OPERATE AT 66% EFFICIENCY WITH A STATIC PRESSURE OF
* 209 *         THE SUPPLY FAN OF 3.5 INCHES AND THAT OF THE RETURN FAN OF 1.0 INCH.
* 210 *    [13] THE REHEAT COIL WILL HAVE A RANGE OF 50 DEG.
* 211 *    [14] THE MINIMUM RECIRCULATION RATE OF SUPPLY AIR WILL BE 30%.            */
* 212 *  /*[15] THE SYSTEM WILL BE A CEILING BYPASS VARIABLE VOLUME SYSTEM.
* 213 *    [16] THE SYSTEM WILL BE COMPARED WITH A MULTI-ZONE SYSTEM.                */
* 214 *            SYSTEMS-REPORT      VERIFICATION=SV-A SUMMARY=SS-A          ..
* 215 *
* 216 *
* 217 *                      /*-----SCHEDULES-----*/
* 218 *
* 219 *
* 220 *  FAN-1      =SCHEDULE           THRU MAR 31 (ALL)     (1,24) 1
* 221 *                                 THRU OCT 31 (WD)      (1,7) 0 (8,18) 1
* 222 *                                                       (19,24) 0
* 223 *                                            (WEH)      (1,24) 0
* 224 *                                 THRU DEC 31 (ALL)     (1,24) 1          ..
* 225 *
* 226 *  HEATWK-1   =WEEK-SCHEDULE      (WD)       (1,7) 50 (8,18) 70
* 227 *                                             (19,24) 50
* 228 *                                 (WEH)      (1,24) 60                    ..
* 229 *
* 230 *  HTEMP-1    =SCH                THRU DEC 31 HEATWK-1                     ..
* 231 *
* 232 *  COOL-1     =SCH                THRU MAR 31 (ALL) (1,24) 0
* 233 *                                 THRU OCT 31 (ALL) (1,24) 1
* 234 *                                 THRU DEC 31 (ALL) (1,24) 0               ..
* 235 *
* 236 *  COOLWK-1   =WS                 (MON,FRI) (1,7) 99 (8,18) 75 (19,24) 99
* 237 *                                 (WEH)      (1,24) 99                        ..
* 238 *
* 239 *  CTEMP-1    =SCH                THRU MAR 31 (ALL) (1,24) 99
* 240 *                                 THRU OCT 31 COOLWK-1
* 241 *                                 THRU DEC 31 (ALL) (1,24) 99              ..
* 242 *
* 243 *
* 244 *                      /*-----ZONE DESCRIPTIONS-----*/
* 245 *
* 246 *  ZNAIR-1    =ZONE-AIR           OUTSIDE-CFM/PER=7                        ..
```

```
* 247 *
* 248 *  ZNCON-1    =ZONE-CONTROL        DESIGN-HEAT-TEMP=70
* 249 *                                  DESIGN-COOL-TEMP=75
* 250 *                                  HEAT-TEMP-SCHED=HTEMP-1
* 251 *                                  COOL-TEMP-SCHED=CTEMP-1
* 252 *                                  THERMOSTAT-TYPE=PROPORTIONAL            ..
* 253 *
* 254 *  PLENU-1    =ZONE                ZONE-TYPE=PLENUM                        ..
* 255 *  SPACE-1    =ZONE                ZONE-AIR=ZNAIR-1 ZONE-CONTROL=ZNCON-1   ..
* 256 *  SPACE-2    =ZONE                LIKE SPACE-1                            ..
* 257 *  SPACE-3    =ZONE                LIKE SPACE-1                            ..
* 258 *  SPACE-4    =ZONE                LIKE SPACE-1                            ..
* 259 *  SPACE-5    =ZONE                LIKE SPACE-1                            ..
* 260 *
* 261 *
* 262 *                  /*-----SYSTEMS DESCRIPTIONS-----*/
* 263 *
* 264 *  SCON-1     =SYSTEM-CONTROL      COOLING-SCHEDULE=COOL-1
* 265 *                                  HEATING-SCHEDULE=FAN-1
* 266 *                                  MIN-SUPPLY-TEMP=55
* 267 *                                  MAX-SUPPLY-TEMP=105
* 268 *                                  COOL-CONTROL=WARMEST
* 269 *                                  MIN-HUMIDITY=.006
* 270 *                                  MAX-HUMIDITY=.01       ..
* 271 *
* 272 *  SAIR-1     =SYSTEM-AIR          OUTSIDE-CONTROL=ENTHALPY                ..
* 273 *
* 274 *  SFAN-1     =SYSTEM-FANS         SUPPLY-STATIC=3.5 SUPPLY-EFF=.66
* 275 *                                  RETURN-STATIC=1.0 RETURN-EFF=.66
* 276 *                                  FAN-SCHEDULE=FAN-1                      ..
* 277 *
* 278 *  STERM-1    =SYSTEM-TERMINAL     REHEAT-DELTA-T=50
* 279 *                                  MIN-CFM-RATIO=.3                        ..
* 280 *
* 281 *  CEILBYPS-1=SYSTEM               SYSTEM-TYPE=CBVAV
* 282 *                                  SYSTEM-CONTROL=SCON-1
* 283 *                                  SYSTEM-AIR=SAIR-1
* 284 *                                  SYSTEM-FANS=SFAN-1
* 285 *                                  SYSTEM-TERMINAL=STERM-1
* 286 *                                  ECONO-LIMIT-TEMP=72
* 287 *                                  RETURN-AIR-PATH=PLENUM-ZONES
* 288 *                                  PLENUM-NAMES=PLENU-1
* 289 *                                  ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 290 *                                             SPACE-4,SPACE-5,PLENU-1      ..
* 291 *
* 292 *  MULTIZON-1=SYSTEM               LIKE CEILBYPS-1  SYSTEM-TYPE=MZS
* 293 *                                  HEAT-CONTROL=COLDEST MIN-CFM-RATIO=1
* 294 *                                  PLENUM-NAMES=PLENU-1
* 295 *                                  ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
* 296 *                                             SPACE-4,SPACE-5,PLENU-1      ..
* 297 *
* 298 *  PLANT-1    =PLANT-ASSIGNMENT    SYSTEM-NAMES=CEILBYPS-1                 ..
* 299 *  PLANT-2    =PLANT-ASSIGNMENT    SYSTEM-NAMES=MULTIZON-1                 ..
* 300 *
* 301 *             END                                                          ..
* 302 *             COMPUTE SYSTEMS                                              ..
* 303 *             INPUT PLANT                                                  ..
```

P 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

* 304 *  /* [1] COOLING WILL BE PROVIDED BY A RECIPROCATING CHILLER CONNECTED TO A
* 305 *         COOLING TOWER, AND THE SIZING WILL BE PERFORMED AUTOMATICALLY
* 306 *         BY THE PROGRAM.
* 307 *     [2] HEATING WILL BE PROVIDED BY A 0.15 MBTUH STEAM BOILER.
* 308 *     [3] THE COSTS OF THE CHILLER AND COOLING TOWER WILL BE TAKEN FROM THE   */
* 309 *  /*     DEFAULT VALUES OF THE PROGRAM.
* 310 *     [4] THE INITIAL BOILER COST IS $2000 AND THE COST OF INSTALLATION $800.
* 311 *     [5] MAINTENANCE COSTS FOR THE BOILER ARE $350/YEAR.
* 312 *     [6] THE ELECTRIC UTILITY RATE IS $.045/KWH AND THE NATURAL GAS RATE IS
* 313 *         $. 22/THERM.                                                        */
* 314 *
* 315 *  SBOIL-1    =EQUIPMENT          TYPE=STMB NUMBER=1
* 316 *                                 AVAILABLE=1 SIZE=.15                    ..
* 317 *  CHILL-1    =EQUIPMENT          TYPE=COMPR NUMBER=1
* 318 *                                 AVAILABLE=1 SIZE=-999.                  ..
* 319 *  CTOW-1     =EQUIPMENT          TYPE=CTOWR NUMBER=1
* 320 *                                 AVAILABLE=1 SIZE=-999.                  ..
* 321 *             COST-OF-EQUIPMENT   FOR SBOIL-1
* 322 *                                 COST=2 INSTALLATION=1.4
* 323 *                                 MAINTENANCE=350 LIFE=200000
* 324 *                                 MINOR-OVHL-COST=200
* 325 *                                 MINOR-OVHL-INVL=4000
* 326 *                                 MAJOR-OVHL-COST=700
* 327 *                                 MAJOR-OVHL-INVL=20000                   ..
* 328 *             ENERGY-COST         RESOURCE=BOILER  UNIT=100000
* 329 *                                 COST=.22 ESCALATION=10                  ..
* 330 *             ENERGY-COST         RESOURCE=ELECT   UNIT=3413
* 331 *                                 COST=.045 ESCALATION=6                  ..
* 332 *             LIFE-CYCLE-RATES    DISCOUNT-RATE=10 LABOR-INFLTN=0         ..
* 333 *             LIFE-CYCLE-COSTS    LABOR=25 PROJECT-LIFE=25                ..
* 334 *             END                                                         ..
* 335 *             COMPUTE PLANT                                               ..
* 336 *             INPUT ECONOMICS                                             ..
```

E 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

* 337 *  /* [1] WINDOW SHADES HAVE A PURCHASE COST OF $20 EACH AND AN INSTALLATION
* 338 *        COST OF $5 EACH.  THERE ARE 16 WINDOWS.
* 339 *     [2] THE BASELINE RUN WITHOUT SCHEDULED SHADING HAD A LIFE-CYCLE PLANT
* 340 *        COST OF $112.5K$, A LIFE-CYCLE FUEL COST OF 92.0K$, AND A LIFE-CYCLE
* 341 *        FUEL USAGE OF 11.9 GBTU.                                          */
* 342 *
* 343 *           COMPONENT-RATES     DISCOUNT-RATE=10 PROJECT-LIFE=25        ..
* 344 *  ADDSHADE-1=COMPONENT-COST    UNIT-NAME=SHADE
* 345 *                               NUMBER-OF-UNITS=16
* 346 *                               FC-PER-UNIT=20
* 347 *                               IC-PER-UNIT=5                           ..
* 348 *           BASELINE            PLANT-COST=112.5
* 349 *                               FUEL-COST=92.0
* 350 *                               FUEL-USE=11.9                           ..
* 351 *           END                                                         ..
* 352 *           COMPUTE ECONOMICS                                           ..
* 353 *           STOP                                                        ..
```

PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.05.02
DECEMBER 1978
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
PLENU-1	1.	18.294	JUL 7 4 PM	88F	73F	-43.416	JAN 12 10 AM	-7F	-7F
SPACE-1	1.	31.283	NOV 7 3 PM	55F	46F	-22.186	MAR 24 5 AM	9F	8F
SPACE-2	1.	6.366	JUL 9 5 PM	97F	73F	-9.514	JAN 1 4 AM	3F	2F
SPACE-3	1.	24.290	JUL 9 5 PM	97F	73F	-26.431	JAN 1 4 AM	3F	2F
SPACE-4	1.	6.397	NOV 1 4 PM	72F	59F	-9.316	JAN 1 4 AM	3F	2F
SPACE-5	1.	24.565	AUG 30 5 PM	80F	66F	-2.030	FEB 25 8 AM	10F	9F
SUM		111.194				-112.893			
BUILDING PEAK		85.827	JUL 9 5 PM	97F	73F	-68.204	JAN 1 4 AM	3F	2F

SPACE PLENU-1

MULTIPLIER 1

FLOOR AREA	4500	SQFT	418	SQMT
VOLUME	13500	CUFT	382	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 7 4 PM		JAN 12 10 AM	
DRY-BULB TEMP	88F	31C	-7F	-22C
WET-BULB TEMP	73F	23C	-7F	-22C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.786	.83	0.000	0.00	-6.006	-6.34
CEILINGS	17.508	18.47	0.000	0.00	-37.409	-39.47
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	18.294	19.30	0.000	0.00	-43.416	-45.81

TOTAL LOAD	18.294 KBTU/H	19.30 MJ/H	-43.416 KBTU/H	-45.81 MJ/H
TOTAL LOAD / AREA	4.07 BTUH/SQFT	.04618 MJ/H/SQMT	9.65 BTUH/SQFT	.10958 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-1

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	NOV 7 3 PM		MAR 24 5 AM	
DRY-BULB TEMP	55F	13C	9F	-13C
WET-BULB TEMP	46F	8C	8F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	-1.831	-1.93	0.000	0.00	-4.054	-4.28
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	-2.455	-2.59	0.000	0.00	-7.727	-8.15
GLASS SOLAR	16.677	17.60	0.000	0.00	1.145	1.21
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-1.109	-1.17	0.000	0.00	-1.795	-1.89
OCCUPANTS TO SPACE	10.237	10.80	5.188	5.47	.028	.03
LIGHT TO SPACE	7.196	7.59	0.000	0.00	.459	.48
EQUIPMENT TO SPACE	2.567	2.71	0.000	0.00	.078	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-10.321	-10.89
TOTAL	31.283	33.00	5.188	5.47	-22.186	-23.41

TOTAL LOAD	36.470 KBTU/H	38.48 MJ/H	-22.186 KBTU/H	-23.41 MJ/H
TOTAL LOAD / AREA	34.54 BTUH/SQFT	.39264 MJ/H/SQMT	21.01 BTUH/SQFT	.23885 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-2

MULTIPLIER 1

FLOOR AREA 396 SQFT 36 SQMT
VOLUME 3564 CUFT 100 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	.875	.92	0.000	0.00	-2.599	-2.74
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	.931	.98	0.000	0.00	-3.149	-3.32
GLASS SOLAR	.000	.00	0.000	0.00	.248	.26
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.238	-.25	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.210	1.28	.576	.61	0.000	0.00
LIGHT TO SPACE	2.883	3.04	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.705	.74	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	6.366	6.72	.576	.61	-9.514	-10.04

TOTAL LOAD	6.942 KBTU/H	7.32 MJ/H	-9.514 KBTU/H	-10.04 MJ/H
TOTAL LOAD / AREA	17.53 BTUH/SQFT	.20345 MJ/H/SQMT	24.03 BTUH/SQFT	.27883 MJ/H/SQMT

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

SPACE SPACE-3

MULTIPLIER 1

FLOOR AREA 1056 SQFT 98 SQMT
VOLUME 9504 CUFT 269 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9 5 PM		JAN 1 4 AM	
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	2.915	3.08	0.000	0.00	-10.642	-11.23
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	1.551	1.64	0.000	0.00	-5.248	-5.54
GLASS SOLAR	.000	.00	0.000	0.00	.165	.17
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.634	-.67	0.000	0.00	-1.690	-1.78
OCCUPANTS TO SPACE	10.890	11.49	5.188	5.47	0.000	0.00
LIGHT TO SPACE	7.688	8.11	0.000	0.00	.432	.46
EQUIPMENT TO SPACE	1.880	1.98	0.000	0.00	.072	.08
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-9.520	-10.04
TOTAL	24.290	25.63	5.188	5.47	-26.431	-27.89

TOTAL LOAD 29.478 KBTU/H 31.10 MJ/H -26.431 KBTU/H -27.89 MJ/H

TOTAL LOAD / AREA 27.91 BTUH/SQFT .31736 MJ/H/SQMT 25.03 BTUH/SQFT .28455 MJ/H/SQMT

```
*************************************************************
*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----    LOADS                                            *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
*************************************************************
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SPACE SPACE-4

MULTIPLIER 1

FLOOR AREA	396	SQFT	36	SQMT
VOLUME	3564	CUFT	100	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	NOV 1	4 PM	JAN 1	4 AM
DRY-BULB TEMP	72F	22C	3F	-16C
WET-BULB TEMP	59F	15C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	-.174	-.18	0.000	0.00	-2.557	-2.70
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	-.112	-.12	0.000	0.00	-3.149	-3.32
GLASS SOLAR	2.273	2.40	0.000	0.00	.404	.43
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-.410	-.43	0.000	0.00	-.634	-.67
OCCUPANTS TO SPACE	1.165	1.23	.576	.61	0.000	0.00
LIGHT TO SPACE	2.769	2.92	0.000	0.00	.162	.17
EQUIPMENT TO SPACE	.886	.93	0.000	0.00	.027	.03
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-3.570	-3.77
TOTAL	6.397	6.75	.576	.61	-9.316	-9.83

TOTAL LOAD	6.973 KBTU/H	7.36 MJ/H	-9.316 KBTU/H	-9.83 MJ/H
TOTAL LOAD / AREA	17.61 BTUH/SQFT	.20436 MJ/H/SQMT	23.53 BTUH/SQFT	.27303 MJ/H/SQMT

```
*************************************************************
*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
*************************************************************
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PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.05.02
DECEMBER 1978
REPORT- L02 SPACE PEAK LOAD COMPONENTS

SPACE SPACE-5

MULTIPLIER 1

FLOOR AREA 1596 SQFT 148 SQMT
VOLUME 14364 CUFT 406 CUMT

	COOLING LOAD		HEATING LOAD	
TIME	AUG 30 5 PM		FEB 25 8 AM	
DRY-BULB TEMP	80F	27C	10F	-12C
WET-BULB TEMP	66F	19C	9F	-13C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	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	-.798	-.84	0.000	0.00	-2.793	-2.95
OCCUPANTS TO SPACE	10.894	11.49	5.188	5.47	.000	.00
LIGHT TO SPACE	11.626	12.27	0.000	0.00	.654	.69
EQUIPMENT TO SPACE	2.843	3.00	0.000	0.00	.109	.11
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	24.565	25.92	5.188	5.47	-2.030	-2.14

TOTAL LOAD	29.753 KBTU/H	31.39 MJ/H	-2.030 KBTU/H	-2.14 MJ/H
TOTAL LOAD / AREA	18.64 BTUH/SQFT	.21210 MJ/H/SQMT	1.27 BTUH/SQFT	.01447 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	9000	SQFT	836	SQMT
VOLUME	54000	CUFT	1529	CUMT

	COOLING LOAD		HEATING LOAD	
TIME	JUL 9	5 PM	JAN 1	4 AM
DRY-BULB TEMP	97F	36C	3F	-16C
WET-BULB TEMP	73F	23C	2F	-17C

	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)	LATENT (KBTU/H)	LATENT (MJ/H)	SENSIBLE (KBTU/H)	SENSIBLE (MJ/H)
WALLS	5.714	6.03	0.000	0.00	-20.762	-21.90
CEILINGS	0.000	0.00	0.000	0.00	0.000	0.00
GLASS CONDUCTION	5.908	6.23	0.000	0.00	-19.996	-21.10
GLASS SOLAR	1.043	1.10	0.000	0.00	3.785	3.99
INTERNAL SURFACES	0.000	0.00	0.000	0.00	0.000	0.00
UNDERGROUND SURFACES	-2.700	-2.85	0.000	0.00	-7.200	-7.60
OCCUPANTS TO SPACE	35.090	37.02	16.716	17.64	0.000	0.00
LIGHT TO SPACE	32.761	34.56	0.000	0.00	1.843	1.94
EQUIPMENT TO SPACE	8.010	8.45	0.000	0.00	.307	.32
PROCESS TO SPACE	0.000	0.00	0.000	0.00	0.000	0.00
INFILTRATION	0.000	0.00	0.000	0.00	-26.181	-27.62
TOTAL	85.827	90.55	16.716	17.64	-68.204	-71.96
TOTAL LOAD	102.543 KBTU/H		108.19 MJ/H		-68.204 KBTU/H	-71.96 MJ/H
TOTAL LOAD / AREA	11.39 BTUH/SQFT		.12941 MJ/H/SQMT		7.58 BTUH/SQFT	.08608 MJ/H/SQMT

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*************************************************************
*                                                           *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR  *
*  ----     LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION    *
*          IN CONSIDERATION                                 *
*                                                           *
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PROJECT- USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.05.02
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MMDDHH	BUILDING ITEM 6	BUILDING ITEM 23	GLOBAL ITEM 6	GLOBAL ITEM 20	GLOBAL ITEM 21	GLOBAL ITEM 22	DOOR-1 ITEM 13	DOOR-1 ITEM 15	ITEM
716 1	0.0000	398.2169	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 2	0.0000	346.4487	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 3	0.0000	301.4104	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 4	0.0000	262.2270	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 5	0.0000	228.1375	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
716 6	0.0000	207.0701	2.0000	.7154	14.5878	2.0807	.9659	43.6067	
716 7	0.0000	250.8892	3.0000	.7098	105.3042	15.0201	8.3146	373.9075	
716 8	0.0000	297.2865	7.0000	.6126	127.6457	18.2068	11.7009	528.2472	
716 9	0.0000	370.4019	6.0000	.6537	155.6851	22.2062	16.5550	746.9809	
71610	0.0000	589.1560	0.0000	1.0000	254.5798	36.3120	35.7032	1608.9037	
71611	0.0000	734.4082	3.0000	.9996	263.7741	37.6235	37.6639	1673.2947	
71612	0.0000	823.2400	3.0000	.9996	268.5693	38.3074	33.8589	1504.6477	
71613	0.0000	898.5949	3.0000	.9361	252.8455	36.0647	32.2663	1437.4999	
71614	0.0000	969.8207	3.0000	.9361	251.2855	35.8422	32.0859	1443.4296	
71615	0.0000	1062.8679	2.0000	.9371	246.7650	35.1974	36.0565	1603.2167	
71616	0.0000	1115.1907	1.0000	.9429	239.0980	34.1038	33.4131	1512.2392	
71617	0.0000	1085.5363	0.0000	1.0000	236.3670	33.7142	24.7270	1099.6978	
71618	0.0000	1033.4570	0.0000	1.0000	205.0068	29.2412	18.5872	825.9907	
71619	0.0000	939.6098	0.0000	1.0000	141.1180	20.1284	10.9961	486.5154	
71620	0.0000	790.9278	0.0000	1.0000	10.5654	1.5070	.6890	30.7811	
71621	0.0000	686.0449	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71622	0.0000	596.8590	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71623	0.0000	519.2674	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	
71624	0.0000	451.7626	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	

SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
CEILBYPS-1	4386.	.30	.24	2.73	.78	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	1479.	326.	-22.19	31.28	45.0	1.0
SPACE-2	296.	41.	-9.51	6.37	5.0	1.0
SPACE-3	1142.	326.	-26.43	24.29	45.0	1.0
SPACE-4	306.	41.	-9.32	6.40	5.0	1.0
SPACE-5	1163.	326.	-2.03	24.56	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.05.04
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SYSTEM NAME	DESIGN CFM	MIN CFM	MIN OUTSIDE RATIO	SUP FAN KW	RET FAN KW	ALTITUDE MULT
MULTIZON-1	4386.	1.00	.24	2.73	.78	1.02

ZONE NAME	DESIGN CFM	OUTSIDE CFM	HEAT KBTU/HR	COOL KBTU/HR	PEOPLE	MULTIPLIER
SPACE-1	1479.	326.	-22.19	31.28	45.0	1.0
SPACE-2	296.	41.	-9.51	6.37	5.0	1.0
SPACE-3	1142.	326.	-26.43	24.29	45.0	1.0
SPACE-4	306.	41.	-9.32	6.40	5.0	1.0
SPACE-5	1163.	326.	-2.03	24.56	45.0	1.0
PLENU-1	0.	0.	0.00	0.00	0.0	1.0

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.05.04
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REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM CEILBYPS-1 TYPE CBVAV

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	-19.469	7	8	-135.339	0.000	31	24	0.000	6872.	21.
FEB	-14.436	11	8	-127.119	0.000	28	24	0.000	6061.	21.
MAR	-10.151	25	8	-116.598	0.000	31	24	0.000	6704.	21.
APR	-8.607	24	8	-116.449	2.661	29	18	116.229	6769.	21.
MAY	-5.826	20	7	-118.191	6.122	21	13	147.877	6872.	21.
JUN	-2.097	4	10	-45.239	13.485	20	17	171.212	6433.	21.
JUL	-1.303	23	9	-33.233	26.577	9	11	169.055	6872.	21.
AUG	-1.911	26	8	-50.707	24.146	26	16	160.480	6872.	21.
SEP	-2.547	23	7	-100.749	8.680	11	15	144.804	6433.	21.
OCT	-6.541	21	12	-115.644	4.797	30	18	119.876	7040.	21.
NOV	-8.246	18	9	-105.972	0.000	30	24	0.000	6433.	21.
DEC	-11.780	9	8	-115.890	0.000	31	24	0.000	6368.	21.
TOTAL	-92.913				86.467				79729.253	
MAX				-135.339				171.212		21.057

PROJECT - USERS GUIDE EXAMPLE BUILDING LAWRENCE BERKELEY LABORATORY CAL-ERDA 1.4 15 JAN 1979 20.05.04
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REPORT SSA SYSTEM LOAD SUMMARY

SYSTEM MULTIZON-1 TYPE MZS

MONTH	HEATING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	COOLING ENERGY (MBTU)	TIME OF MAXIMUM DAY	HOUR	MAXIMUM LOAD (KBTU/HR)	ELECTRICAL ENERGY (KWH)	MAXIMUM LOAD (KW)
JAN	-60.079	7	8	-178.283	0.000	31	24	0.000	6872.	21.
FEB	-51.651	11	8	-169.068	0.000	28	24	0.000	6061.	21.
MAR	-49.454	25	8	-158.292	0.000	31	24	0.000	6704.	21.
APR	-10.867	9	8	-136.307	.830	29	18	38.166	5093.	21.
MAY	-5.758	6	7	-134.924	3.318	16	16	96.433	5112.	21.
JUN	-.691	3	7	-58.660	10.900	20	17	137.472	4680.	21.
JUL	-.021	1	7	-2.629	23.899	3	10	163.861	5112.	21.
AUG	-.041	5	8	-6.290	20.699	16	9	143.941	5112.	21.
SEP	-2.203	23	7	-89.677	6.956	11	8	130.528	4680.	21.
OCT	-6.475	21	11	-138.906	2.713	31	8	97.705	5318.	21.
NOV	-48.592	2	6	-111.806	0.000	30	24	0.000	6433.	21.
DEC	-49.857	9	8	-156.221	0.000	31	24	0.000	6368.	21.
TOTAL	-285.689				69.315				67544.383	
MAX				-178.283				163.861		21.057

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	.019	.024	0.000	0.000	0.000	0.000	0.000	.031	.071	.031	.102	42.
2	.014	.021	0.000	0.000	0.000	0.000	0.000	.024	.062	.024	.086	41.
3	.010	.023	0.000	0.000	0.000	0.000	0.000	.017	.069	.017	.086	38.
4	.009	.025	.003	0.000	0.000	0.000	.005	.014	.076	.014	.090	38.
5	.006	.027	.006	0.000	0.000	0.000	.007	.010	.080	.010	.090	36.
6	.002	.028	.013	0.000	0.000	0.000	.013	.004	.083	.004	.086	34.
7	.001	.033	.027	0.000	0.000	0.000	.024	.003	.099	.003	.102	34.
8	.002	.032	.024	0.000	0.000	0.000	.022	.004	.097	.004	.101	34.
9	.003	.026	.009	0.000	0.000	0.000	.009	.005	.078	.005	.082	35.
10	.007	.027	.005	0.000	0.000	0.000	.007	.011	.081	.011	.092	36.
11	.008	.022	0.000	0.000	0.000	0.000	0.000	.014	.066	.014	.080	38.
12	.012	.022	0.000	0.000	0.000	0.000	0.000	.020	.065	.020	.085	39.
	.093	.309	.086	0.000	0.000	0.000	.087	.155	.928	.155	1.083	37.

EQUIPMENT USE STATISTICS

EQUIPMENT	AVG OPER RATIO	MAX LOAD (MBTU)	MON	DAY	HR	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS	SIZE (MBTU)	OPER HRS
STEAM BOILER	.161	.135	1	7	8	.150	3840								
RECIPROCATING CHILR	.349	.171	6	20	17	.180	1378								
COOLING TOWER	.373	.216	6	20	17	.225	1378								

CENTRAL PLANT LIFE CYCLE EQUIPMENT COST SUMMARY

EQUIPMENT	TOTALS		
STEAM BOILER	84.8		
NOMINAL SIZE (MBTU)			.150
NUMBER INSTALLED			1
FIRST COST (K$)		2.8	2.8
ANNUAL COST (K$)		79.4	79.4
CYCLICAL COST (K$)		2.5	2.5
-----TOTAL----(K$)			84.8
RECIPROCATING CHILR	9.0		
NOMINAL SIZE (MBTU)			.180
NUMBER INSTALLED			1
FIRST COST (K$)		7.2	7.2
ANNUAL COST (K$)		1.6	1.6
CYCLICAL COST (K$)		.2	.2
-----TOTAL----(K$)			9.0
COOLING TOWER	15.5		
NOMINAL SIZE (MBTU)			.225
NUMBER INSTALLED			1
FIRST COST (K$)		5.4	5.4
ANNUAL COST (K$)		8.2	8.2
CYCLICAL COST (K$)		1.8	1.8
-----TOTAL----(K$)			15.5
EQUIPMENT TOTAL	109.2		

MONTHLY PEAK AND TOTAL ENERGY USE SUMMARY

MO	UTILITY>	ELECT	DIESEL	GASTUR	BOILER
	TOTAL(MBTU)	23.563	0.000	0.000	31.231
1	PEAK(MBTU)	.073	0.000	0.000	.181
	DY/HR	7/11	31/24	31/24	7/ 8
	TOTAL(MBTU)	20.765	0.000	0.000	23.805
2	PEAK(MBTU)	.073	0.000	0.000	.170
	DY/HR	11/11	28/24	28/24	11/ 8
	TOTAL(MBTU)	22.935	0.000	0.000	17.250
3	PEAK(MBTU)	.072	0.000	0.000	.156
	DY/HR	25/11	31/24	31/24	25/ 8
	TOTAL(MBTU)	25.416	0.000	0.000	13.538
4	PEAK(MBTU)	.110	0.000	0.000	.155
	DY/HR	29/16	30/24	30/24	24/ 8
	TOTAL(MBTU)	26.737	0.000	0.000	9.533
5	PEAK(MBTU)	.120	0.000	0.000	.157
	DY/HR	21/10	31/24	31/24	20/ 7
	TOTAL(MBTU)	27.515	0.000	0.000	3.924
6	PEAK(MBTU)	.122	0.000	0.000	.073
	DY/HR	20/15	30/24	30/24	4/10
	TOTAL(MBTU)	33.055	0.000	0.000	2.547
7	PEAK(MBTU)	.125	0.000	0.000	.057
	DY/HR	3/10	31/24	31/24	23/ 9
	TOTAL(MBTU)	32.438	0.000	0.000	3.707
8	PEAK(MBTU)	.122	0.000	0.000	.080
	DY/HR	26/14	31/24	31/24	26/ 8
	TOTAL(MBTU)	25.933	0.000	0.000	4.517
9	PEAK(MBTU)	.120	0.000	0.000	.137
	DY/HR	11/14	30/24	30/24	23/ 7
	TOTAL(MBTU)	27.109	0.000	0.000	10.943
10	PEAK(MBTU)	.115	0.000	0.000	.154
	DY/HR	31/11	31/24	31/24	21/12
	TOTAL(MBTU)	22.001	0.000	0.000	14.378
11	PEAK(MBTU)	.072	0.000	0.000	.143
	DY/HR	29/11	30/24	30/24	18/ 9
	TOTAL(MBTU)	21.799	0.000	0.000	19.912
12	PEAK(MBTU)	.072	0.000	0.000	.155
	DY/HR	9/11	31/24	31/24	9/ 8
	ONE YEAR	309.266	0.000	0.000	155.284
	USE/PEAK (MBTU)	.125	0.000	0.000	.181
	YEAR COST (K$)	3.2	0.0	0.0	.3
	COST ESCLTN (PCT)	6.0	5.0	5.0	10.0

TOTAL USE (MBTU) 464.550

TOTAL COST (K$) 3.5

NOTES TO ABOVE TABLE
(1) ALL ENERGY USE VALUES ARE NET, I.E., AT BUILDING BOUNDARY

(2) PEAK VALUES ARE IN MBTUH
(3) YEAR COST IS LIFE-CYCLE COST DIVIDED BY PROJECT LIFETIME

E Q U I P M E N T O P E R A T I O N A N D P A R T L O A D R E P O R T

NAME	HOURS AT PERCENT PART LOAD RATIO												TOTAL HOURS	ANNUAL LOAD (GBTU)	FALSE LOAD (GBTU)	TOTAL LOAD (GBTU)
	0 -- 10	-- 20	-- 30	-- 40	-- 50	-- 60	-- 70	-- 80	-- 90	-- 100	- 110	- 120+				
STMB	1613	1301	429	163	111	65	96	38	22	2	0	0	3840	.093	0.000	.093
	1613	1301	429	163	111	65	96	38	22	2	0	0				
COMPR	510	166	60	61	45	72	230	140	82	12	0	0	1378	.086	.004	.091
	510	166	60	61	45	72	230	140	82	12	0	0				
CTOWR	463	204	57	58	44	47	205	168	109	23	0	0	1378	.116	0.000	.116
	463	204	57	58	44	47	205	168	109	23	0	0				

NOTES TO TABLE
1) THE FIRST PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE HOURLY OPERATING CAPACITY (UNITS OPERATING THAT HOUR)
2) THE SECOND PART LOAD ENTRY FOR EACH PIECE OF EQUIPMENT IS A FUNCTION OF THE TOTAL INSTALLED CAPACITY

PLANT DEMANDS SATISFIED REPORT

HEATING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
STEAM BOILER	.093	100.0
DEMAND SATISFIED	.093	100.0
TOTAL DEMAND ON PLANT	.093	

COOLING DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
RECIPROCATING CHILR	.086	100.0
DEMAND SATISFIED	.086	100.0
TOTAL DEMAND ON PLANT	.086	

ELECTRICAL DEMANDS	GBTU SUPPLIED	PCT OF TOTAL DEMAND
DEMAND SATISFIED	0.000	0.0
TOTAL DEMAND ON PLANT	.309	

REJECTED HEAT	GBTU SUPPLIED	PCT OF TOTAL DEMAND
COOLING TOWER	.116	100.0
DEMAND SATISFIED	.116	100.0
TOTAL DEMAND ON PLANT	.116	

SUMMARY OF LOADS MET

TYPE OF DEMAND	TOTAL DEMAND (GBTU)	DEMAND SATISFIED (GBTU)	TOTAL OVERLOAD (GBTU)	PEAK OVERLOAD (MBTU)	HOURS OVERLOADED
HEATING DEMANDS	.093	.093	0.000	0.000	0
COOLING DEMANDS	.086	.086	0.000	0.000	0
REJECTED HEAT	.116	.116	0.000	0.000	0

ELECTRICAL DEMAND SCATTER PLOT

TOTAL HOURS AT DEMAND AND TIME OF DAY

	HOUR	1AM	2	3	4	5	6	7	8	9	10	11	12	1PM	2	3	4	5	6	7	8	9	10	11	12	TOTAL
	36.761	0	0	0	0	0	0	0	0	13	31	15	0	10	31	26	8	8	0	0	0	0	0	0	0	142
	33.934	0	0	0	0	0	0	0	11	28	21	37	21	40	31	35	52	51	3	0	0	0	0	0	0	330
	31.106	0	0	0	0	0	0	0	26	6	8	11	33	11	6	10	8	7	0	0	0	0	0	0	0	126
	28.278	0	0	0	0	0	0	0	6	10	14	7	12	9	9	9	9	11	0	0	0	0	0	0	0	96
D	25.450	0	0	0	0	0	0	0	5	43	52	66	33	57	64	61	28	11	1	0	0	0	0	0	0	421
E K	22.622	0	0	0	0	0	0	0	26	42	126	116	149	17	14	111	141	54	14	0	0	0	0	0	0	810
M W	19.795	0	0	0	0	0	0	0	55	110	0	0	4	108	97	0	6	110	105	0	0	0	0	0	0	595
A H	16.967	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
N	14.139	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	129	123	0	0	0	0	0	252
D	11.311	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
	8.483	0	0	0	0	0	0	40	12	0	0	0	0	0	0	0	0	0	0	129	252	123	0	0	0	556
	5.656	365	365	365	365	365	365	322	223	113	113	113	113	113	113	113	113	113	113	113	113	242	365	365	365	5428
	2.828	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PERCENT TOTAL DEMAND		1.7	1.7	1.7	1.7	1.7	1.7	1.9	4.4	6.8	7.4	7.5	7.1	7.1	7.4	7.5	7.3	7.2	5.1	3.4	2.5	2.0	1.7	1.7	1.7	

PEAK ELECTRICAL LOAD BREAKDOWN

SOURCE	KWH	PCT
SYSTEMS LOAD	21.050	57.6
COMPRESSION CHILLERS	13.087	35.8
COOLING TOWER	1.528	4.2
CIRCULATION PUMPS	.881	2.4
TOTAL	36.547	

L I F E - C Y C L E P L A N T C O S T S U M M A R Y

	ANNUAL	LIFETIME(25 YRS)
PLANT EQUIPMENT COST	4.4	109.2 K$
ENERGY COST	3.5	88.2 K$
ENERGY USE (NET)	.5	11.6 GBTU

- PLANT EQUIPMENT PLUS ENERGY -
- LIFE CYCLE COST FOR 25 YEARS = .1974 (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

REPORT- E01 ECONOMICS VERIFICATION (NON-PLANT COST ITEMS) CAL-ERDA 1.3 15 JAN 1979 20.07.57

DISCOUNT RATE (PCT)	LABOR INFL-RATE (PCT)	MATERIALS INFL-RATE (PCT)	PROJECT LIFETIME (YRS)
10.0	0.0	0.0	25.0

COST-NAME ADDSHADE-1 NO. OF UNITS 16.0 UNIT-NAME SHADE 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
320.	20.00	80.	5.00	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 15 JAN 1979 20.07.57

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
ADDSHADE-1	16.	SHADE	.32	.08	0.00 (	0.00	0.00)	0.00 (	0.00	0.00)	0.00	.40
		TOTAL	.32	.08	0.00 (	0.00	0.00)	0.00 (	0.00	0.00)	0.00	.40

OVERALL LIFE-CYCLE COSTS (K$)

NON-PLANT	PLANT	FUEL	T O T A L
.4	109.2	88.2	197.8

REPORT- E03 LIFE-CYCLE SAVINGS/INVESTMENT STATISTICS CAL-ERDA 1.3 15 JAN 1979 20.07.57

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		112.50	92.00	204.50	11.90
THIS RUN	.40	109.19	88.20	197.39	11.61
SAVINGS		3.31	3.80	7.11	.29

SAVINGS/INVESTMENT STATISTICS

COST SAVINGS (K$)	INVESTMENT (K$)	SAVINGS-TO-INVESTMENT RATIO	FUEL SAVINGS (MBTU)	FUEL-SAVINGS-TO-INVESTMENT RATIO(MBTU/$)	PAYBACK PERIOD (YRS)
7.1	.4	17.8	286.2	.72	1.4

Appendix 4 — Example Building Input

```
          INPUT LOADS                                                    ..
TITLE     USERS GUIDE EXAMPLE BUILDING
TITLE     LAWRENCE BERKELEY LABORATORY
TITLE
TITLE     DECEMBER 1978

/* [1] THE BUILDING IS A SINGLE STORY OFFICE BUILDING LOCATED IN CHICAGO.
   [2] THE WEATHER DATA WILL BE FOR 1974.
   [3] THE WALLS ARE OF FACE BRICK AND CONCRETE CONSTRUCTION WITH 1 INCH OF
       EXPANDED POLYSTYRENE INSULATION (R-4) UNDER THE BRICK.
   [4] THE ROOF IS A BUILT-UP ROOF OVER 3 INCHES OF PREFORMED ROOF */
/*     INSULATION (R-8)                                                  */
/* [5] THERE ARE 16 4 FEET BY 6 FEET WINDOWS, DOUBLE PANED WITH AN ASHRAE
       SHADING COEFFICIENT OF .86 AND SETBACK 6 INCHES FROM THE WALL SURFACE.
   [6] THE FRONT DOOR IS .25 INCH PLATE GLASS; THE BACK DOOR IS ONE INCH WOOD.
   [7] THE FLOOR IS 6 INCHES THICK CONCRETE IN CONTACT WITH THE SOIL.
   [8] A DROP CEILING SERVES AS A PLENUM.                                */
/* [9] THE LIGHTING FIXTURES HAVE FLUORESCENT LAMPS AND RETURN AIR PASSES
       THROUGH THE FIXTURE.  THE MAXIMUM ENERGY OF THE LIGHTING IS 3 W/SQ.FT.
  [10] THE ENERGY USED BY EQUIPMENT IS 1 W/SQ.FT. AT A MAXIMUM.
  [11] THE NUMBER OF PEOPLE IS 145; 45 IN THREES SPACES AND 5 IN TWO SPACES.
  [12] THE INFILTRATION DURING OCCUPIED HOURS IS .5 AIR CHANGES PER HOUR.   */
          DIAGNOSTIC          ERROR     ABORT     ERROR
                              SPACING DOUBLE                           ..
          RUN-PERIOD          JAN 1 1974 THRU DEC 31 1974              ..
          LOADS-REPORT        LO2                                      ..
          BUILDING-LOCATION   LATITUDE=42 LONGITUDE=88
                              ALTITUDE=610 TIME-ZONE=6
                              BUILDING-AZIMUTH=0                       ..


            /*-----BUILDING CONSTRUCTION MATERIALS-----*/

WLLAY-1   =LAYERS             MATERIAL-1=BK05 M2=IN33
                              M3=CB46 M4=AL11 M5=GP01
                              INSIDE-FILM-RES=.68                      ..
RFLAY-1   =LAYERS             M1=RG01 M2=BR01 M3=IN76
                              IFR=.76                                  ..
EXTW-1    =CONSTRUCTION       LAYERS=WLLAY-1 ABSORPTANCE=.88
                              ROUGHNESS=2                              ..
ROF-1     =CONS               WALL-TYPE=RFLAY-1 ABS=.5 RO=1            ..
CEIL-1    =CONS               U=.8   /*CONSTRUCTION OF CEILING*/       ..
PART-1    =CONS               U=10   /*FALSE PARTITIONS*/               ..
FLOR-1    =CONS               U=.05  /*SLAB ON GROUND*/                 ..
DOR-1     =CONS               U=1.0 ROUGHNESS=6   /*BACK DOOR*/         ..
WINGLS-1  =GLASS-TYPE         PANES=2 GLASS-SHADING=.86                ..
DORGLS-1  =GT                 GTC=3   /*FRONT DOOR*/                   ..


                    /*-----SCHEDULES-----*/

DAYSC-1   =DAY-SCHEDULE       (1,8) 0 (9,11) 1 (12,14) .8,.4,.8
                              (15,18) 1 (19,21) .5,.1,.1 (22,24) 0     ..
DAYSC-2   =DS                 (1,24) 0                                 ..

WKPEOP-1  =WEEK-SCHEDULE      (MON,FRI) DAYSC-1 (WEH) DAYSC-2          ..

PEOPSC-1  =SCHEDULE           THRU DEC 31 WKPEOP-1                     ..

WKLITE-1  =WS                 (MON,FRI) (1,8) .05 (9,14) .9,.95,1,.95,.8,.9
```

```
                                        (15,18) 1 (19,21) .6,.2,.2
                                        (22,24) .05
                                (WEH)   (1,24) .05                          ..

LITESC-1   =SCH                 THRU DEC 31 WKLITE-1                        ..

WKEQUP-1   =WS                  (MON,FRI) (1,8) .02 (9) .4 (10,14) .9
                                        (15,20) .8,.7,.5,.5,.3,.3
                                        (21,24) .02
                                (WEH)   (1,24) .02                          ..

EQUIPSC-1  =SCH                 THRU DEC 31 WKEQUP-1                        ..

INFLSC-1   =SCH                 THRU DEC 31 (MON,FRI) (1,7) 1 (8,18) 0
                                                      (19,24) 1
                                          (WEH)       (1,24) 1              ..

          /*-----BUILDING SHADE SPECIFICATION-----*/

          BUILDING-SHADE        HEIGHT=5 WIDTH=10 TRANSMITTANCE=0
                                X-BUILDING=52.5 Y-BUILDING=0 Z-BUILDING=9
                                SURFACE-AZIMUTH=180 TILT=180                ..

                /*-----SETTING DEFAULTS-----*/

          SET-DEFAULT           FLOOR-WEIGHT=70 GLASS-HEIGHT=4
                                GLASS-WIDTH=6 GLASS-TYPE=WINGLS-1
                                SETBACK=0.5 TEMPERATURE=73                  ..

                  /*-----SPACE DESCRIPTIONS-----*/

COND-1     =SPACE-CONDITIONS    NUMBER-OF-PEOPLE=45
                                PEOPLE-ACTIVITY=400
                                PEOPLE-SCHEDULE=PEOPSC-1
                                LIGHTING-TYPE=2
                                LIGHT-TO-SPACE=80
                                LIGHTING-W/SQFT=3
                                LIGHTING-SCHEDULE=LITESC-1
                                EQUIPMENT-W/SQFT=1
                                EQUIPMENT-SCHEDULE=EQUIPSC-1
                                AIR-CHANGES/HR=.5
                                INF-METHOD=1
                                INF-SCHEDULE=INFLSC-1                       ..

PLENU-1    =SPACE               FLOOR-AREA=4500 SPACE-HEIGHT=3
                                VOLUME=13500 FLOOR-WEIGHT=5
                                ZONE-TYPE=UNCONDITIONED                     ..
PLWL-1       =EXTERIOR-WALL     HEIGHT=3 WIDTH=100 AZIMUTH=180
                                CONS=EXTW-1                                 ..
             EW                 LIKE PLWL-1 WIDTH=45 AZIMUTH=90             ..
             EW                 LIKE PLWL-1 A=0                             ..
             EW                 LIKE PLWL-1 W=45 A=270                      ..
ROOF-1      =ROOF               HEIGHT=45 WIDTH=100 AZIMUTH=180 TILT=0
                                CONS=ROF-1 GND-REFLECTANCE=0                ..
CEILING-1   =INTERIOR-WALL      AREA=1056 NEXT-TO SPACE-1 CONS=CEIL-1       ..
CEILING-2   =IW                 AREA=396 NEXT-TO SPACE-2 CONS=CEIL-1        ..
             IW                 LIKE CEILING-1 NEXT-TO SPACE-3              ..
             IW                 LIKE CEILING-2 NEXT-TO SPACE-4              ..
```

```
            IW                  AREA=1596 NEXT-TO SPACE-5 CONS=CEIL-1    ..

SPACE-1    =SPACE               SPACE-CONDITIONS=COND-1 FA=1056 SH=9
                                V=9504                                   ..
WALL-1      =EW                 HEIGHT=9 WIDTH=15 AZIMUTH=180
                                CONS=EXTW-1 MULTIPLIER=5                 ..
WIND-1        =WINDOW                                                    ..
WALL-2      =EW                 LIKE WALL-1 WIDTH=25 X=45 M=1            ..
DOOR-1        =WI               GLASS-HEIGHT=7 GLASS-WIDTH=6 SETBACK=0
                                GLASS-TYPE=DORGLS-1 J=9.5                ..
FLOOR-1     =UNDERGROUND-FLOOR  AREA=1056 CONS=FLOR-1                    ..

SPACE-2    =SPACE               LIKE SPACE-1 NOP=5 FA=396 V=3564         ..
             EW                 LIKE WALL-1 A=90 M=3                     ..
               WINDOW                                                    ..
INWALL-1     =IW                AREA=161.8 NEXT-TO SPACE-1 CONS=PART-1   ..
INWALL-2     =IW                LIKE INWALL-1 NEXT-TO SPACE-3            ..
FLOOR-2     =UF                 AREA=396 CONS=FLOR-1                     ..

SPACE-3    =SPACE               LIKE SPACE-1                             ..
             EW                 LIKE WALL-1 A=0                          ..
               WINDOW                                                    ..
             EW                 LIKE WALL-2 A=0                          ..
               WI               LIKE DOOR-1 GLASS-WIDTH=10
                                GLASS-HEIGHT=9 M=0                       ..
               EW               WIDTH=10 HEIGHT=9 A=0 CONS=DOR-1         ..
             UF                 LIKE FLOOR-1                             ..

SPACE-4    =SPACE               LIKE SPACE-2                             ..
             EW                 LIKE WALL-1 A=270 M=3                    ..
               WINDOW                                                    ..
             IW                LIKE INWALL-1                            ..
             IW                LIKE INWALL-2                            ..
             UF                 LIKE FLOOR-2                             ..

SPACE-5    =SPACE               LIKE SPACE-1 FA=1596 V=14364
                                INF-METHOD=0                             ..
INWALL-3     =IW                AREA=684 NEXT-TO SPACE-1 CONS=PART-1     ..
INWALL-4     =IW                LIKE INWALL-3 AREA=189 NEXT-TO SPACE-2   ..
             IW                 LIKE INWALL-3 NEXT-TO SPACE-3            ..
             IW                 LIKE INWALL-4 NEXT-TO SPACE-4            ..
             UF                 LIKE FLOOR-1 AREA=1596                   ..

REPTSCHD-1=SCHEDULE             THRU JUL 15 (ALL) (1,24) 0
                                THRU JUL 16 (ALL) (1,24) 1
                                THRU DEC 31 (ALL) (1,24) 0               ..
REPTBLK-1 =REPORT-BLOCK         VARIABLE-TYPE=BUILDING
                                VARIABLE-LIST=6,23                       ..
REPTBLK-2 =REPORT-BLOCK         VARIABLE-TYPE=GLOBAL
                                VARIABLE-LIST=6,20,21,22                 ..
REPTBLK-3 =R-B                  V-TYPE=DOOR-1 V-L=13,15                  ..
SOLAR     =HOURLY-REPORT        REPORT-SCHEDULE=REPTSCHD-1
                                R-B=REPTBLK-1,REPTBLK-2,REPTBLK-3        ..

           END                                                           ..
           COMPUTE LOADS                                                 ..
           INPUT SYSTEMS                                                 ..
```

```
/* [1] FANS SHALL OPERATE CONTINUOUSLY FROM JANUARY 1 THROUGH MARCH AND FROM
       NOVEMBER 1 THROUGH DECEMBER.  FROM APRIL 1 THROUGH OCTOBER THE FANS
       SHALL OPERATE ONLY FROM 7:00 A.M. THROUGH 6:00 P.M. ON WEEKDAYS.
   [2] THE HEATING WILL BE AVAILABLE WHENEVER THE FANS ARE OPERATING WITH
       NIGHT AND WEEKEND SETBACK FROM 70 DEG TO 50 DEG.                    */
/* [3] THE COOLING WILL BE AVAILABLE ONLY FROM APRIL 1 THROUGH OCTOBER WITH
       A COOLING SETPOINT OF 76 DEG.
   [4] THE MINIMUM OUTSIDE AIR WILL BE SET AT 7 CFM PER PERSON.
   [5] THE THROTTLING RANGE OF THE PROPORTIONAL THERMOSTAT WILL BE 2 DEG.
   [6] THE CEILING PLENUM WILL BE USED FOR RETURN AIR.                     */
/* [7] THE SUPPLY AIR WILL HAVE A MINIMUM TEMPERATURE OF 55 DEG.
   [8] THE MAXIMUM TEMPERATURE OF THE HEATING COILS WILL BE 105 DEG.
   [9] THE SUPPLY AIR WILL BE RESET TO SATISFY THE WARMEST ZONE.
  [10] THE HUMIDITY WILL BE HELD BETWEEN .006 AND .01 LB WATER/LB AIR.
  [11] THERE WILL BE AN ENTHALPY CONTROLLED ECONOMIZER SET TO RETURN TO    */
/*      MINIMUM OUTSIDE AIR AT 72 DEG.
  [12] THE FANS WILL OPERATE AT 66% EFFICIENCY WITH A STATIC PRESSURE OF
       THE SUPPLY FAN OF 3.5 INCHES AND THAT OF THE RETURN FAN OF 1.0 INCH.
  [13] THE REHEAT COIL WILL HAVE A RANGE OF 50 DEG.
  [14] THE MINIMUM RECIRCULATION RATE OF SUPPLY AIR WILL BE 30%.          */
/*[15] THE SYSTEM WILL BE A CEILING BYPASS VARIABLE VOLUME SYSTEM.
  [16] THE SYSTEM WILL BE COMPARED WITH A MULTI-ZONE SYSTEM.              */
         SYSTEMS-REPORT      VERIFICATION=SV-A SUMMARY=SS-A          ..


                  /*-----SCHEDULES-----*/

FAN-1      =SCHEDULE           THRU MAR 31 (ALL)      (1,24) 1
                               THRU OCT 31 (WD)       (1,7) 0 (8,18) 1
                                                      (19,24) 0
                                           (WEH)      (1,24) 0
                               THRU DEC 31 (ALL)      (1,24) 1          ..

HEATWK-1   =WEEK-SCHEDULE      (WD)       (1,7) 50 (8,18) 70
                                          (19,24) 50
                               (WEH)      (1,24) 60                    ..

HTEMP-1    =SCH                THRU DEC 31 HEATWK-1                    ..

COOL-1     =SCH                THRU MAR 31 (ALL) (1,24) 0
                               THRU OCT 31 (ALL) (1,24) 1
                               THRU DEC 31 (ALL) (1,24) 0              ..

COOLWK-1   =WS                 (MON,FRI) (1,7) 99 (8,18) 75 (19,24) 99
                               (WEH)      (1,24) 99                        ..

CTEMP-1    =SCH                THRU MAR 31 (ALL) (1,24) 99
                               THRU OCT 31 COOLWK-1
                               THRU DEC 31 (ALL) (1,24) 99             ..


                /*-----ZONE DESCRIPTIONS-----*/

ZNAIR-1    =ZONE-AIR           OUTSIDE-CFM/PER=7                       ..

ZNCON-1    =ZONE-CONTROL       DESIGN-HEAT-TEMP=70
                               DESIGN-COOL-TEMP=75
                               HEAT-TEMP-SCHED=HTEMP-1
                               COOL-TEMP-SCHED=CTEMP-1
                               THERMOSTAT-TYPE=PROPORTIONAL            ..
```

```
PLENU-1    =ZONE                ZONE-TYPE=PLENUM                                  ..
SPACE-1    =ZONE                ZONE-AIR=ZNAIR-1 ZONE-CONTROL=ZNCON-1             ..
SPACE-2    =ZONE                LIKE SPACE-1                                      ..
SPACE-3    =ZONE                LIKE SPACE-1                                      ..
SPACE-4    =ZONE                LIKE SPACE-1                                      ..
SPACE-5    =ZONE                LIKE SPACE-1                                      ..

                /*-----SYSTEMS DESCRIPTIONS-----*/

SCON-1     =SYSTEM-CONTROL      COOLING-SCHEDULE=COOL-1
                                HEATING-SCHEDULE=FAN-1
                                MIN-SUPPLY-TEMP=55
                                MAX-SUPPLY-TEMP=105
                                COOL-CONTROL=WARMEST
                                MIN-HUMIDITY=.006
                                MAX-HUMIDITY=.01        ..

SAIR-1     =SYSTEM-AIR          OUTSIDE-CONTROL=ENTHALPY                          ..

SFAN-1     =SYSTEM-FANS         SUPPLY-STATIC=3.5 SUPPLY-EFF=.66
                                RETURN-STATIC=1.0 RETURN-EFF=.66
                                FAN-SCHEDULE=FAN-1                                ..

STERM-1    =SYSTEM-TERMINAL     REHEAT-DELTA-T=50
                                MIN-CFM-RATIO=.3                                  ..

CEILBYPS-1=SYSTEM               SYSTEM-TYPE=CBVAV
                                SYSTEM-CONTROL=SCON-1
                                SYSTEM-AIR=SAIR-1
                                SYSTEM-FANS=SFAN-1
                                SYSTEM-TERMINAL=STERM-1
                                ECONO-LIMIT-TEMP=72
                                RETURN-AIR-PATH=PLENUM-ZONES
                                PLENUM-NAMES=PLENU-1
                                ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
                                           SPACE-4,SPACE-5,PLENU-1                ..

MULTIZON-1=SYSTEM               LIKE CEILBYPS-1  SYSTEM-TYPE=MZS
                                HEAT-CONTROL=COLDEST MIN-CFM-RATIO=1
                                PLENUM-NAMES=PLENU-1
                                ZONE-NAMES=SPACE-1,SPACE-2,SPACE-3,
                                           SPACE-4,SPACE-5,PLENU-1                ..

PLANT-1    =PLANT-ASSIGNMENT    SYSTEM-NAMES=CEILBYPS-1                           ..
PLANT-2    =PLANT-ASSIGNMENT    SYSTEM-NAMES=MULTIZON-1                           ..

           END                                                                    ..
           COMPUTE SYSTEMS                                                        ..
           INPUT PLANT                                                            ..
/* [1] COOLING WILL BE PROVIDED BY A RECIPROCATING CHILLER CONNECTED TO A
       COOLING TOWER, AND THE SIZING WILL BE PERFORMED AUTOMATICALLY
       BY THE PROGRAM.
   [2] HEATING WILL BE PROVIDED BY A 0.15 MBTUH STEAM BOILER.
   [3] THE COSTS OF THE CHILLER AND COOLING TOWER WILL BE TAKEN FROM THE   */
/*     DEFAULT VALUES OF THE PROGRAM.
   [4] THE INITIAL BOILER COST IS $2000 AND THE COST OF INSTALLATION $800.
   [5] MAINTENANCE COSTS FOR THE BOILER ARE $350/YEAR.
   [6] THE ELECTRIC UTILITY RATE IS $.045/KWH AND THE NATURAL GAS RATE IS
       $. 22/THERM.                                                            */
```

```
SBOIL-1     =EQUIPMENT          TYPE=STMB NUMBER=1
                                AVAILABLE=1 SIZE=.15                    ..
CHILL-1     =EQUIPMENT          TYPE=COMPR NUMBER=1
                                AVAILABLE=1 SIZE=-999.                  ..
CTOW-1      =EQUIPMENT          TYPE=CTOWR NUMBER=1
                                AVAILABLE=1 SIZE=-999.                  ..
            COST-OF-EQUIPMENT   FOR SBOIL-1
                                COST=2 INSTALLATION=1.4
                                MAINTENANCE=350 LIFE=200000
                                MINOR-OVHL-COST=200
                                MINOR-OVHL-INVL=4000
                                MAJOR-OVHL-COST=700
                                MAJOR-OVHL-INVL=20000                   ..
            ENERGY-COST         RESOURCE=BOILER  UNIT=100000
                                COST=.22 ESCALATION=10                  ..
            ENERGY-COST         RESOURCE=ELECT   UNIT=3413
                                COST=.045 ESCALATION=6                  ..
            LIFE-CYCLE-RATES    DISCOUNT-RATE=10 LABOR-INFLTN=0         ..
            LIFE-CYCLE-COSTS    LABOR=25 PROJECT-LIFE=25                ..
            END                                                         ..
            COMPUTE PLANT                                               ..
            INPUT ECONOMICS                                             ..

/* [1] THE PURCHASE COST OF THE CBVAV SYSTEM IS $25,000 AND THE COST OF
       INSTALLATION IS $20,000.
   [2] MAINTENANCE OF THE SYSTEM WILL COST $750/YEAR.
   [3] IT IS ASSUMED THAT THE SYSTEM WILL LAST AS LONG AS THE BUILDING.    */
            COMPONENT-RATES     DISCOUNT-RATE=10 PROJECT-LIFE=25        ..
CBVAVCST-1=COMPONENT-COST       FIRST-COST=25000 INSTALL-COST=20000
                                MAINT-COST=750                          ..
            END                                                         ..
            COMPUTE ECONOMICS                                           ..
            STOP                                                        ..
```

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