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Building Energy Analysis with BLAST and CEL-1

Stephen J. Treado
Douglas B. Holland
William E. Remmert

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Building Technology
Gaithersburg, MD 20899

William Pierpoint

Naval Civil Engineering Laboratory
Port Hueneme, California

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, ***Secretary***
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, ***Director***

Abstract

This report describes the capabilities of the BLAST and CEL-1 computer programs and the procedures for using a hybrid version which incorporates both programs into a single design and analysis tool. Details on assembling the required information for development of the input files and the actual execution of the hybrid program are covered. The program allows detailed simulation of actual lighting systems using CEL-1 including daylighting effects while providing BLAST with lighting energy modifiers on an hourly basis.

The procedure is demonstrated using a sample building.

Keywords: daylighting, energy simulation, lighting, solar radiation.

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1. INTRODUCTION

The purpose of this report is to describe the techniques for using the BLAST and CEL-1 computer programs together to analyze building heating, cooling, and lighting loads and energy requirements. The BLAST (Building Loads and System Thermodynamics) [1] program accommodates the simulation of heat gains, heat losses, heat storage, and heat transfer throughout the building. HVAC equipment and central plants can also be simulated.

Lighting is included in the BLAST simulation, but only in a general manner. It is expressed as lighting power for each building space or zone. The percentage of lighting system output energy which is radiant, the percentage which is visible, and the percentage which goes directly into the return air can be specified. The effects of dimming or switching due to daylight utilization for interior illumination are modeled as simple constant coefficients relating interior electric lighting levels to the levels of direct and diffuse solar radiation entering the zone. The determination of the appropriate values to be used for the percent usable direct and diffuse irradiance parameters can require considerable effort. Lighting energy would not be expected to vary in direct proportion to the total irradiance entering the zone, due to angular effects and controller nonlinearity, so the constant coefficients must be chosen for an average condition.

Motivated by a desire to model the performance of lighting systems in a more realistic manner, and also to integrate the lighting and thermal analyses into a single comprehensive package, the CEL-1 (Conservation of Electric Lighting) [2,3] program has been modified to operate as a lighting simulation subprogram of BLAST. Together, the hybrid program (BLAST/CEL-1) can perform detailed lighting and thermal modeling of buildings.

This report describes some of the techniques for performing building energy computer analysis using BLAST/CEL-1. The capabilities of BLAST/CEL-1 are discussed and a sample building evaluation is presented. The appendices list the details of the hybrid BLAST/CEL-1 interface routines.

2. COMPUTER TECHNIQUES FOR BUILDING ENERGY ANALYSIS

Computer programs for building energy analysis have been developed in response to the need of the design and engineering community for tools to enable the design of energy efficient buildings [4]. Due to the many energy and economic tradeoffs associated with building design options, it is difficult to determine the optimum ranges for design parameters based on intuition alone. The interactions between the building envelope, building heating and cooling loads, and HVAC system performance are complex, creating difficulties in evaluating the relative performance of design options [5,6,7,8]. For example, varying window size will influence solar heat gains, thermal heat transfer, and interior daylight levels [9]. The solar heat gains are beneficial in the heating season and detrimental during the cooling season. Thermal heat transfer is usually not beneficial, causing a heat loss in winter and a heat gain in summer. Interior daylight is beneficial, but only at levels up to the required illumination set-point. At any time, the net effect of the combination of these three factors is dependent upon the weather conditions, whether the building is in a heating or cooling mode, and occupant factors such as scheduling and internal energy usage for equipment. Over a typical year, these conditions and the associated net effects vary considerably. The annual net effect is simply the sum of each of the incremental amounts.

The building model may include heat transfer and energy performance components related to the building envelope, HVAC system and occupant loads. Hourly time increments are usually used for this type of analysis, although shorter time steps are sometimes required for detailed simulation of controls. Weather tapes have been generated to provide hourly values for important weather parameters.

The basic procedure for performing building energy analysis with BLAST/CEL-1 is as follows:

- establish baseline building
- simulate baseline building
- evaluate the design performance
- redesign
- resimulate
- repeat until optimum determined

This section of the report describes some of the background for building energy simulations, including an analysis of simulation requirements and objectives at various stages of design.

2.1 LOADS, SYSTEMS, AND PLANT

The sequencing of building energy simulation computer programs such as BLAST, mirrors the general breakdown of the problem into its major components. Building energy or thermal loads represent the energy which must be added to or extracted from the building to maintain the desired conditions. A lighting load is energy added to the space to provide for illumination. A heating load is energy which must be added to the space to maintain the desired temperature conditions. A cooling load is energy which must be removed from the space to meet comfort conditions.

These loads are determined from heat balance considerations, including the effects of solar heat gains, thermal heat transfer, internal equipment, occupancy schedules, and temperature control criteria. In many cases, the loads calculations are all that are required for a particular simulation. An attempt can be made to minimize loads, and then design the best system to meet those loads. While the HVAC system is not modeled during the loads computations, its effect is implicitly included in the specification of the temperature control strategy. That is, the heat balance calculations used to determine the loads are dependent upon the desired building space air temperatures, as specified by a temperature control profile. The temperature control profile should be chosen to match the temperature control performance of the HVAC system proposed for the building.

This might be dead-band control, proportional control or some other typical control profile. If the system type has not been determined, a standard temperature control profile should be specified, usually from the BLAST library.

Once the loads are calculated they can be converted into energy by the user through the use of an assumed heating efficiency and cooling coefficient of performance. Dividing heating loads by heating efficiency determines heating energy, while dividing cooling loads by the coefficient of performance determines cooling energy. Lighting and other electrical loads are equivalent to energy without conversion. However, if more detailed system performance information is required, BLAST can be used to simulate the HVAC system and plant.

During the systems portion of the calculations, BLAST can simulate fan system performance, deck and outside air controls, coil performance, and heat recovery systems. The central plant calculations include equipment performance and load scheduling. In addition, an economic analysis can be included in the plant section.

2.2 DESIGN PHASES

The simulation requirements and outputs are dependent on the objectives of the analysis, which in turn are dependent upon the stage of the design and motivation for the evaluation. This issue is discussed in the following sections.

2.2.1 Predesign Stage

The predesign category includes two general classes of design. First, for the case of an actual proposed building, the predesign stage of analysis usually is intended to determine general building characteristics. Second, there may not be an actual proposed building under consideration, but rather generalized design guidelines for a typical generic category of buildings. In either case, specific building information is not available, so the simulation must be based on general considerations. Performing only the loads calculations and not considering system or plant performance may be most appropriate for the predesign stage. The loads output is more directly sensitive to envelope design than systems output, which provides information directly linked to a particular system, which might not be the appropriate system for the load patterns.

Many critical design decisions must be made very early in the design process. Items such as fenestration type and size cannot be easily altered once the building design has reached an advanced stage, without severely disrupting other elements of the design (structural, electrical, etc.). As a result, the predesign stage analysis should focus on those design options which potentially will have the most impact on building loads, using a fairly simple building model, and a variation of parameters technique. For example, varying window size and location or comparing windows to skylights of various sizes will enable initial determination of fenestration design. Once the initial design has been determined, more detailed modeling can be used to fine-tune the design options over a smaller range, including more specific design details.

2.2.2 Preliminary Design Stage

The preliminary design stage occurs during the initial planning stages for the building. Typically, some information related to building usage and site constraints is available. For example, the number of building floors, required floor area, and general site layout are usually determined fairly early in the design of a building. However, considerable latitude remains in determining other design parameters, such as envelope construction components, heating, cooling, and lighting systems, and design of interior spaces. If passive or hybrid solar strategies or other innovative design concepts are to be included in the list of design alternatives, they must be considered at this stage of design. This is due to the interactions between building structural and envelope requirements, building orientation, and the building thermal and lighting systems.

During the preliminary design stage, loads calculations may still suffice, although a simple system model may allow easier comparison of the net energy impacts of design alternatives. Since it is probable that a significant number of simulations could be required to enable evaluation of the various design options, an elaborate simulation model at this stage could be costly. The more detailed modeling should be done during the advanced and final design phases.

It is easy to see how a series of simulations with multiple variation of parameters can mushroom into an excessively large set. As an example, consider a typical office space with one exterior wall. Let's say that we would like to compare annual energy requirements for the space for two different wall types, two insulation levels, three sizes of single-pane and double-pane windows, and three different window shading coefficients. The total number of required simulations, determined by the product of the number of variations of each variable, is 72. If more than one system were to be simulated, this number would increase in direct proportion. Thus, the simulation efforts during the preliminary design stages should be directed towards general envelope design issues, consistent with the objectives of initial building design.

2.2.3 Advanced Design Stage

The user will probably have passed through the preliminary design simulation stage before reaching the advanced stage. This means that the simulation input files are in existence, although they may be simplified geometrically, and lacking detail, particularly regarding system design. However, the initial simulations should have allowed identification of the most effective envelope design on the basis of building loads and/or energy.

During the advanced design stage the building simulation input file can be expanded to include more explicit detail than was required during the initial simulations. Envelope parameters can be held constant, with emphasis placed on system performance, for various system options. Once the system design has been basically determined, both the building envelope and systems can be adjusted for optimum performance. This might involve slight adjustments in glazing area or transmittance or changes in fan sizing or in other system parameters.

2.2.4. Retrofit Analysis

Building energy simulation for retrofit analysis differs from the previously discussed phases, both in its scope and objective. Retrofit analysis concerns existing buildings, and the evaluation of the impact of proposed or potential changes on building performance. These changes are usually small compared to alternatives in new building design. For example, they might involve the addition of insulation or replacement of part of the HVAC system.

For retrofit analysis, the existing building must be modeled first to establish a baseline condition. Then the simulation input file is modified to simulate the retrofit activity, and the output of the simulation compared to the baseline building. The energy or dollar savings, if any, are compared to the cost of the retrofit to determine cost effectiveness. The retrofit alternative with the greatest savings-to-investment ratio is usually selected if it meets other design criteria.

Sometimes it is more useful to simulate retrofit options using a variation of parameters technique rather than to simulate actual retrofit strategies. In this manner, the optimum retrofit characteristics can be determined and the actual retrofit strategy can be selected to match the optimum characteristics. For example, window transmittance can be varied in steps of 0.1 to determine the best value for a fixed window size.

3. THE BLAST/CEL-1 COMPUTER PROGRAM

3.1. BLAST/CEL-1 CAPABILITIES

The hybrid version of BLAST/CEL-1 contains all of the capabilities of both programs. A complete understanding of the capabilities and their implementation can only be gained from the respective user's guides [1,3]. However, a general description is provided here, along with a step-by-step description of the procedure for using the program, illustrated by a sample building analysis.

3.2. INPUT INFORMATION AND FILE FORMATION

The first step in using BLAST/CEL-1 is to obtain access to a computing system which has both the programs. Appendix B of this report describes access information. Assuming that access has been established, we can examine the details of performing building energy analysis with the hybrid program.

Many factors can influence building energy performance and usage. These include internal and external loads, HVAC system design and operation, control types and strategies, plant type and efficiency, and economic considerations. External loads are associated with weather and solar conditions while internal loads are due to lights, equipment, and people. In order to have a valid simulation, accurate information must be used to assemble the input files.

Some of the information can be provided by BLAST/CEL-1, but most is provided by the user. The program will provide default values for some required parameters, but these are not always appropriate for a specific design. Weather tape information is available, and other information is contained in the BLAST and CEL-1 libraries, and can be selected by the user.

Thus the first stage of a BLAST/CEL-1 analysis is the data gathering phase. Building data must be obtained to enable the development of the input files. For an existing building, the plans and specifications can usually be obtained. For a new building design, proposed specifications can be used, if available. If not, choices of materials and layout must be made (i.e., preliminary design stage). For a full-fledged simulation, the following types of input information are required:

- architectural plans
- sections and details for walls, ceilings, etc.
- mechanical plans - air systems
- mechanical plans - central plant
- lighting plans
- schedules
  - lighting
  - heating
  - cooling
  - occupancy
  - equipment
- economic data
  - equipment costs
  - energy costs
  - cost of capital

Once the information has been assembled, it must be organized, and put into the BLAST/CEL-1 input format. Choices must be made concerning the number of thermal zones into which the building will be divided for the simulation. The geometric data is usually simplified when assembling the input files from the actual drawings.

There are a few points which should be addressed before proceeding with the development of the BLAST input file. These points are:

- use and abuse of default values
- temperature control profiles
- punctuation and spacing
- concept of thermal zone
- multiple effective solution paths

Some BLAST input parameters are optional, but take on default values if not set explicitly in the input file. It is important that these default values be examined to ensure that they are appropriate for the simulation. Don't blindly accept default values without checking the BLAST user's guide.

The operation of the building heating and cooling system is simulated during the loads calculations by a temperature control profile. The temperature control profile should be selected to match the operation of the HVAC system, if that system is known. Otherwise, a typical control profile should be specified.

Following the indicated punctuation is essential, although spacing is flexible and commands can be stretched over several lines. Indenting can be useful for organizing file structure.

Within BLAST, a thermal zone is defined as a space with uniform air temperature conditions. During the heat balance calculations, air temperature is assumed to be uniform throughout each zone. While this is not exactly true in an actual zone, it is a good approximation if the zones are chosen carefully. Care should be exercised so that zones are not specified such that loads cancellation occurs. That is, if two rooms are actually exposed to significantly different thermal conditions, they should not be combined as a single thermal zone. However, a row of adjacent identical rooms can be simulated as a single zone with a multiplier.

The concept of multiple effective solution paths means simply that there is more than one way to accomplish the effective simulation of a building using BLAST/CEL-1. Attempting to describe all the acceptable variations would be fruitless; rather what is needed is a consistent approach towards assembling the input file. Once a typical zone input file has been established, other similar files can be generated and modified using the system editor. Preprocessor programs are available to assist in input file generation. These may be particularly useful for beginning users, but do require familiarization with the format and content of user responses to the questions from the preprocessor. In many ways, assembling the input file using the system editor may be more efficient since the user has direct contact with the file.

3.3 THE BLAST INPUT FILE

Blast input files are assembled according to the rules listed in the BLAST users guides, using an English-language type of high level computer code. Every complete BLAST run has the following structure:

```
BEGIN INPUT;

   (lead input block)
   (building description block)
   (fan description block) optional
   (central plant description block) optional

END INPUT;
```

Each of the parenthesized blocks are described separately.

Lead Input Block

This block contains:
(run control block)
(library modification block)
(project description block)

The RUN CONTROL block contains the instructions concerning what simulations and reports are requested, and what system of units should be used for input and output. The format of the RUN CONTROL block is:

```
RUN CONTROL:
     NEW ZONES,
     NEW SYSTEMS,
     PLANT,
     PRINT LIBRARY,
     REPORTS (         ),
     UNITS (IN =    , OUT =       );
```

NEW ZONES tells BLAST to calculate loads for any zone in the building description block. Any previous load calculation are ignored. If the prefix NEW is replaced by ADD, NEW ZONE loads will be added to previously calculated zones which had been saved. All zones must have unique zone numbers. REPLACE instead of NEW tells BLAST that the user has saved previously calculated loads data, but wants to recalculate some of the zones. Zone numbers must match the zone numbers for the zones being replaced. A similar convention holds for the NEW SYSTEMS command.

If no zones or systems run control commands are given, no simulations will occur, but the input deck will be processed and checked.

The PLANT parameter causes BLAST to simulate the user-described central plant using either the results of newly-generated or saved fan system simulations.

The REPORTS parameter allows the user to request optional reports, in addition to the default output reports. Units can be specified as ENGLISH or METRIC, and may not be mixed within one input file. PRINT LIBRARY causes the BLAST library to be printed alphabetically by subset.

Library Modification Block

The BLAST library contains a substantial amount of information about building materials, components, and elements. This information can be used very readily, simply by specifying a library name, enabling rapid development of an input file for a building using standard components. For example, specifying the library name EXTWALL28 is equivalent to inputting a layer-by-layer description of an insulated metal-siding exterior wall. The BLAST library contains similar information on materials, interior wall, roofs, floors, locations, windows, doors, schedules and temperature control profiles. It is frequently useful, particularly during the initial design stages, to use library elements in the simulation input file. This avoids the potential problem of incorrectly modeling a building component or material. However, the user can specify building elements which are not found in the BLAST library in several ways. If the new element is likely to be used frequently, it can be added to the BLAST library using the DEFINE parameter. Old data can be replaced with new data using the REDEFINE parameter. If the new element is only selected for the current simulation, the TEMPORARY command should be used. The DELETE command erases both the name and the data from the library.

Materials are defined using their basic properties, and components are defined as consisting of layers of materials. See the user's guide for format details.

Locations can be defined according to:

```
        DEFINE LOCATION:

            ANY PLACE = (LAT =          , LONG =          , TZ =      ),

        END LOCATION;
```

However, if a weather data tape is specified, the latitude (LAT), longitude (LONG), and time zone (TZ) will be taken from the tape.

Design days are used to calculate peak heating and cooling loads. In addition, they provide a chance to check the output for reasonableness and consistency, before more expensive annual simulations are run. It is advisable that a design day simulation be performed before any long time period simulations, perhaps with detailed hourly reports, to verify and validate the accuracy of the simulation.

Design days can be defined in a manner similar to other library parameters. See the user's guide for format details.

Schedules and controls are two important BLAST input parameters. Schedules are used to tell BLAST when things occur, and more importantly, when they don't. An occupancy schedule specifies the normalized percentage of people in the building for each hour of the day. The lighting schedule defines the profile of lighting energy usage. Similar schedules can be defined, or specified from the BLAST library, concerning equipment usage, air infiltration, and any other parameters. Room temperature control strategies are defined as profiles, with the ability to mix profiles for different days of the week and different times of the year. This allows for night setback and different heating and cooling control profiles. Using BLAST library profiles and schedules is very helpful since most typical profiles are available.

<u>Project Description Block</u>

The last portion of the lead input:

1) gives the project title

2) extracts design day and location information from the BLAST library

3) indicates simulation time period (if weather tapes are being used)

4) provides ground temperatures

In BLAST syntax these take the form

```
PROJECT = "SAMPLE";
LOCATION = ANYPLACE;
DESIGN DAYS = username 1, username 2, .....;
WEATHER TAPE FROM userdate THRU userdate;
GROUND TEMPERATURES = (usn 1, usn 2, ...usn 12);
```

where:

username N = names of design days from BLAST library
userdate = starting and ending simulation dates
usn N = average ground temperature for each month

It should be noted that ground temperature information may be difficult to obtain. Measurements have shown that assuming a constant ground temperature of 55°F (the default value) may be significantly in error. In addition, the ground temperature which is needed is that which is adjacent to the building surface (usually floor or wall), not the undisturbed earth temperature. One method of estimating ground temperature adjacent to a building surface is to average the interior air temperature and the undisturbed earth temperature.

Earth temperature information can be found in the BLAST Users Guide and several other references [10,11].

Building Description Block

This section of the input file contains all of the information concerning the construction, orientation, and usage of the building. The generalized format of the block is

```
BEGIN BUILDING DESCRIPTION; BUILDING = "usname";
     DIMENSION: usname 1 = usn 1, usname 2 = usn 2, ...;
     NORTH AXIS = usn;

DETACHED  SHADING "usname": (usn 1 BY usn 2)
                         or ((usn 1, usn 1'),
                            (usn 2, usn 2'),....)

     STARTING AT (usn, usn, usn)
     FACING (usn)
     TILTED (usn);

ZONE usn "usname":
     DIMENSION: usname 1 = usn 1, usname 2 = usn 2,...;
     ORIGIN:  (usn, usn, usn);
     NORTH AXIS = usn;
     surface type:
        STARTING AT (usn, usn, usn)
        FACING (usn)
        TILTED (usn)
        surface-name (usn 1 BY usn 2)
                  or ((usn 1, usn 1'), (usn 2, usn 2'),...)
            OTHER SIDE COEFFICIENTS (usn 1, usn 2, usn 3,
                                     usn 4, usn 5, usn 6,
                                     usn 7)
            WITH subsurface-type OF TYPE subsurface-name
                                     (usn 1 BY usn 2)

                   REVEAL (usn)
                AT (usn 1, usn 2)
                   AND (usn 1, usn 2)

            WITH subsurface-type OF TYPE subsurface-name
                                         (usn 1 BY usn 2)
            .
            .
            .
         STARTING AT (usn, usn, usn)
         .
         .
         .
```

```
          surface-type:
          •
          •
          •

          PEOPLE = usn 1, schedule-name, AT ACTIVITY LEVEL
                   usn 2, usn 3 PERCENT RADIANT FROM date 1 THRU date 2;

          LIGHTS = usn 1, schedule-name, usn 2 PERCENT RADIANT,
                   usn 3 PERCENT RETURN AIR, usn 4 PERCENT, VISIBLE,
                   usn 5 PERCENT REPLACEABLE, FROM date 1 THRU date 2;

          ELECTRIC EQUIPMENT = usn 1, schedule-name, usn 2 PERCENT RADIANT,
                               usn 3 PERCENT LATENT,
                               usn 4 PERCENT LOST, FROM date 1 THRU date 2;

          GAS EQUIPMENT = usn 1, schedule-name, usn 2 PERCENT RADIANT,
                          Usn 3 PERCENT LATENT,
                          usn 4 PERCENT LOST, FROM date 1 THRU date 2;

          INFILTRATION = usn 1, schedule-name,
                         WITH COEFFICIENTS, (usn 2, usn 3,
                         usn 4, usn 5), FROM date 1 THRU date 2;

          CONTROLS = control-schedule-name, usn 1 HEATING,
                     usn 2 COOLING, usn 3 PERCENT RADIANT,
                     FROM date 1 thru date 2;

          BASEBOARD HEATING = (usn 1 AT usn 2, usn 3 AT usn 4),
                              Schedule-name,
                              usn 5 PERCENT RADIANT,
                              FROM date 1 THRU date 2;

     END ZONE;
        •
        •  other zones
        •
END BUILDING DESCRIPTION;
```

In the above block, the lowercase parameters are user-selected names or values. The BLAST User's Guide should be consulted to determine default values and other detailed information.

The system and plant blocks are developed in a similar manner. Specific information on the system and plant input and simulation should be obtained from the user's guides, as they are beyond the scope of this report. There are no changes in the system or plant sections of BLAST due to the incorporation of CEL-1.

3.4 THE CEL-1 INPUT FILE

The CEL-1 package actually consists of twenty separate programs. Any single simulation will involve a particular subset of these programs. The input file must contain all of the information required to carry out the requested program operations. Some of the CEL-1 capabilities are mutually exclusive, while other sets may be mandatory or optional. For example, use of the DIMMING block requires both FENESTRATION and LUMINAIRES blocks, but does not allow the DESIGN block, while the FURNITURE block is optional. The user specifies the type of simulation desired using the CEL-1 control structure. See the user's guide for more detailed information.

The CEL-1 input file consists of several blocks of information, headed by a keyword that describes the type of information. The keyword is followed by one or more lines of data values, as appropriate. The various blocks are as follows:

1) ROOM - room dimensions, reflectances
2) TASK - define target points
3) INSERTS - doors, objects on walls, etc.
4) SENSORS - lighting control
5) FENESTRATION - windows, skylights, etc.
6) FURNITURE - objects in room
7) PROFILE - parameters for energy profile
8) ANALYSIS - simulation information
9) LUMINAIRES - type of location
10) DIMMING - control strategy
11) DESIGN - selects luminaire locations
12) CALCULATE - specifies metrics to be computed

Sub-blocks may follow block headings containing information required for the block.

CEL-1 allows the calculation of several lighting metrics, including:

Illuminance
Equivalent Sphere Illuminance (ESI)
Task Luminance
Background Luminance
Contrast Rendering Factor (CRF)
Lighting Effectiveness Factor (LEF)
Luminance on Room Surfaces
Illuminance on Room Surfaces
Visual Comfort Probability (VCP)

The CEL-1 program possesses the following capabilities:

- luminaires may have any orientation
- rooms are assumed to be rectangular with opposite surfaces parallel
- inserts, partitions, obstructions, and furniture may be present

• various fenestration types can be modeled
• the external environment may be specified

The surfaces of the room being modeled are designated by their nominal compass orientation (i.e., north, south). The relation between room north and true north can be specified. Room surfaces are numbered as follows:

1. west wall
2. north wall
3. east wall
4. south wall
5. floor
6. ceiling

A rectangular coordinate system is established with its axes parallel to the room surfaces and its origin (0,0,0) located at the southwest corner of the room. Thus the positive x-direction is room east, positive y is room north, and positive z is up. Angles are listed according to the convention of zero degrees for room north, 90 degrees for east, 180 degrees for south, and -90 or 270 degrees for west.

Input data elements can be either alphabetic, like keywords and file names, real numeric (decimal point optional), and/or integer numeric. Spaces or commas must be used to separate numeric inputs. Keywords must start in column 1. Numeric input data can start in any column and must be separated by at least one blank. The sequencing of input data blocks and parameters is critical. Any input data block, when used, must appear in the order listed above.

For the purpose of creating a CEL-1 input file to use for a BLAST simulation, the CEL-1 input file should contain the request to calculate BLS, along with the appropriate DIMMING block, the PROFILE block and the LUMINAIRES block. While the complete details of CEL-1 input file generation should be obtained from the user's guides [3], a general description is given below.

In addition, a sample building simulation file is described in the following section.

The ROOM block always begins each CEL-1 input file followed by five user comment lines. These lines must be included even if they are left blank. Other blocks and sub-blocks follow containing information related to room, fenestration, lighting, and simulation characteristics.

Some of the input information is determined explicitly by the building design, while other input parameters are chosen by the user. Room dimensions and reflectances are examples of the first catagory of input data. User-chosen input parameters include the specification of task locations and the sub-division of room surfaces into small zones for the inter-reflected light calculations. If task locations are not known, the UNKNOWN sub-block can be used to specify that illuminance calculations be performed over a grid of target points, otherwise, the actual task location can be specified using the KNOWN sub-block.

The subdivision of room surfaces into subareas deserves special attention. Specifying smaller subareas improves simulation accuracy at the expense of increasing simulation time and cost. The user must determine the level of accuracy which is acceptable for a particular application. For initial simulations, larger subareas may be appropriate, while the number of subareas can be increased for more detailed subsequent simulation. In most cases, the minimum subarea dimension should not exceed one-half of the smallest room dimension. In addition, subareas of 2 by 2 feet or larger should provide sufficient accuracy for all but extreme cases.

For the simulation of lighting performance, the luminaire type, power consumption, lumen output, and location must be specified. For the simulation of daylight performance with lighting controls, the required illuminance level and control parameters must be specified. This initially presents a problem since it is impossible to specify the illumination set-point and lumen output independently. This problem is overcome by initially simulating the lighting system without daylighting, and computing the horizontal illuminance over a grid of target points or known task locations, using the HOR calculation keyword. This procedure causes the generation of a matrix of illuminance levels, along with a listing of extreme and average values. The lighting design (i.e., number, type of luminaire) can be varied to provide the required illumination conditions. Once the lighting system design is determined, the resulting illuminance conditions can be used to provide the lighting control criterion. That is, if a 50 fc minimum illuminance level is required, the lighting system can be simulated and adjusted until that minimum level is obtained. Then an illuminance level of 50 fc can be specified as the lighting control criteria.

It is important that consistency be maintained between the lighting power and lumen output in the CEL-1 input file and the lighting power in the BLAST input file. The two lighting power inputs must be identical and the lumen output must be appropriate for the power consumption. For example, the CEL-1 input file for zone 1 (Table 3) shows six 90 watt luminaires for a zone total of 540 watts. The BLAST input file (Table 2) for zone 1 shows the lighting power in the LIGHTS statement to be 1.843k BTU/hr which is the same as 540 watts. Care must be taken to use the appropriate units in each input file.

4. SAMPLE BUILDING ANALYSIS

In order to demonstrate the techniques for developing the input files, a sample building will be considered (see figure 3). It will be assumed that it is desired to design a new building, according to the proposed general building plans, although an existing building would be analyzed in a similar manner using actual building drawings. This sample building has been chosen from the Naval Facilities Engineering Command's publication entitled, Definitive Designs for Naval Shore Facilities (NAVFAC P-272), Sept. 1983. The particular structure, a delivery retraining detachment building, was chosen because it allows the illustration of several points.

The building consists of two classrooms, an office, mechanical equipment and equipment maintenance rooms, a bathroom, a lobby, and storage areas. The floor area of the single-story building is approximately 1590 ft^2 (148 m^2). The definitive drawings do not specify the components of the building structure, envelope, or systems. However, limits on maximum heating, cooling, and lighting energy usage are delineated. Of course, it will not be known if the building meets these performance criteria until a proposed building design is established and simulated. The best procedure is to specify standard components from the BLAST library, according to standard energy and building codes and practices.

While the building actually consists of nine distinct rooms, the energy performance of the building can be adequately simulated using six thermal zones. Each of the five major rooms with exterior walls constitute an individual zone. The sixth zone is composed of the lobby and the adjacent storage and bathroom areas. Combining adjacent interior zones is beneficial because it reduces the complexity of the input files and the cost of the simulation while not significantly degrading the accuracy of the building thermal performance calculations. In addition, since daylighting will not be used in any of the sixth zone rooms, separate CEL-1 input files will not be needed for those rooms. In fact, no CEL-1 input file will be needed for zone six, since CEL-1 analysis is not required. The lighting system for zone six can be adequately modeled using only the BLAST input file.

Table 1 lists information for each zone size, lighting system design, and window design.

4.1. SAMPLE BLAST INPUT FILE

Like all BLAST input files, the first line is:

```
BEGIN INPUT;
```

Since this is the first simulation and no previously calculated loads are to be used, the next lines are:

Table 1. Sample Building Information

Room	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Name	West Classroom	East Classroom	Office	Equipment and Maintenance	Mechanical Equipment	Lobby
Dimensions	17x30x9 ft (5.2x9.1x2.7 m)	17x30x9 ft (5.2x9.1x2.7 m)	10.5x10x9 ft (3.2x3.0x2.7 m)	10.5x8.5x9 ft (3.2x2.6x2.7 m)	8.5x8.5x9 ft (2.6x2.6x2.7 m)	19x11.5x9ft 8.5x10x9 ft
Floor Area	510 ft^2 (47 m^2)	510 ft^2 (47 m^2)	105 ft^2 (10 m^2)	89 ft^2 (8 m^2)	72 ft^2 (7 m^2)	219 ft^2 (20 m^2)
Window Area	120 ft^2 (11 m^2)	120 ft^2 (11 m^2)	48 ft^2 (4 m^2)	30 ft^2 (3 m^2)	N/A	N/A
No. of Luminaires	6	6	2	2	2	2
Lighting Power	540 W	540 W	180 W	180 W	180 W	180 W
Daylighting	Yes	Yes	Yes	Yes	No	No
Equipment	293 W	293 W	106 W	161 W	293 W	161 W

```
RUN CONTROL:  NEW ZONES,
REPORTS (ZONE LOADS, 26),
```

The ZONE LOADS report gives a monthly breakdown of zone loads by type for the simulation period. Asking for report 26 is the cue that CEL-1 simulation is requested. This means that the appropriate CEL-1 input files have been created (see the following section for information on developing the CEL-1 input files for use with BLAST/CEL-1). To specify English units for input and output:

```
UNITS (ENGLISH);
```

For this simulation no library modifications are needed so the building description block is next. For the sample building, located in Norfolk, if an annual simulation is desired the next block would be:

```
PROJECT  = "SAMPLE BUILDING TEST";
LOCATION = NORFOLK;
WEATHER TAPE FROM 01 JAN 51 THRU 31 DEC 51;
GROUND TEMPERATURES = (55,55, 55, 58, 64,71,73,74,71,67,61,57);
```

This completes the lead input for the simulation. The next section of the input is the building description block. This block contains the building data and zone information for each zone.

The building information is at the head of the block:

```
BEGIN BUILDING DESCRIPTION;
    BUILDING = "DELIVERY RETRAINING DETACHMENT BUILDING";
    DIMENSIONS: W = 53, L = 30, H = 11;
    NORTH AXIS = 0;
    SOLAR DISTRIBUTION = -1;
```

The building name is chosen by the user. The dimension statement is used to assign numerical values to variables. If subsequent dimensions are listed as variables (i.e., W, L, etc.) the numerical values can be changed quickly and easily by changing only the DIMENSION parameters. The NORTH AXIS command orients the building north-south axis (and coordinate system) with true north, allowing rotation of the entire building. By convention the lower southwest corner of the building is designated the origin of the building coordinate system. All surface locations are relative to the building origin. In contrast, all subsurface locations (i.e., windows, doors, etc.) are relative to the surface origin. Each zone is modeled by specifying the origin of the zone to the building origin, and assembling a series of surfaces to enclose the zone. Zone one has been chosen to be the west-facing classroom.

The origin of zone one, with respect to the building's southwest corner, is (0,0,0). Each of the surfaces of zone one is specified as a surface type, of particular length and height, facing a certain direction. The origin of a surface is its lower left-hand corner, with respect to the zone origin. A subsurface, such as a window, is specified by type, width by height, and the coordinate of its lower left-hand corner with respect to the origin of the surface on which it is located. In this manner, the first zone input begins:

```
ZONE 1 "WEST CLASSROOM":
     ORIGIN: (0,0,0);
     NORTH AXIS = 0;
     EXTERIOR WALLS:

       STARTING AT (0,30,0) FACING (270)
       EXTWALL28 (L BY H)
       WITH WINDOWS OF TYPE
       DOUBLE PANE WINDOW
       (24 BY 5) AT (0,3.5),

       STARTING AT (17,30,0 FACING (0)
       EXTWALL 28 (17 BY H),

       STARTING AT (0,0,0) FACING (180)
       EXTWALL28 (17 BY H);

     PARTITIONS:

       STARTING AT (17,0,0) FACING (90)
       PARTITIONS 23 (L BY H);

     ROOFS:

       STARTING AT (0,0,H) FACING (180)
       ROOF17 (17 BY L);

     SLAB ON GRADE FLOOR:

       STARTING AT (0,30,0) FACING (180)
       FLOOR SLAB 4 IN (17 BY 30);
```

EXTWALL28, DOUBLE PANE WINDOW, PARTITION23, ROOF17, and FLOOR SLAB 4 IN have been selected from the BLAST library, which will provide BLAST with all of the information required for their simulation. The facing directions for horizontal surfaces is determined by rotating them about an axis through the surface origin.

Surface types other than exterior walls, partition walls, roofs, and slab-on-grade floors can be specified. The specification of surface type determines how BLAST treats the surface during the heat balance calculations. Exterior walls separate the building interior from the outdoors. Partition walls separate adjacent interior zones of equal temperature. Slab-on-grade floors are in contact with the ground. Interzone heat transfer can be simulated by defining INTERZONE PARTITION, or similar statements for the ceiling or floor. CEILINGS and FLOORS are used to divide temperature controlled spaces. The experienced user can make use of OTHER SIDE COEFFICIENTS to simulate interzone heat transfer. WINDOWS are the only surfaces which can transmit sunlight; thus any glass surface such as a door should be described as a window.

The STARTING AT command in conjunction with a surface type followed by a length by height specification is used to describe rectangular surfaces. Other shapes can be defined by specifying three vertex points in addition to the STARTING AT command. See user's guide for details.

In this simulation file the classroom exit doors have been ignored, since the doors represent only a small fraction of the exterior wall area. The doors can be added in for later detailed simulations. Notice that substituting a door for a portion of exterior wall influences only thermal heat transfer through that portion of the envelope. Any air infiltration effects must be included in subsequent infiltration parameter values.

The remainder of the zone input file is concerned with occupancy, infiltration lighting, electric equipment, and temperature control. There are many optional alternative ways of specifying these parameters; however, in this sample problem the following commands suffice:

```
        PEOPLE = 15, OFFICE OCCUPANCY;
        INFILTRATION = 200, CONSTANT;
        LIGHTS = 1.843, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
        ELECTRIC EQUIPMENT = 1.00, CONSTANT;
        CONTROLS = DEAD BAND;

   END ZONE;
```

The foregoing parameters instruct BLAST that there will be a maximum of 15 people in the classroom, and occupancy will follow the OFFICE OCCUPANCY schedule selected from the BLAST library. The peak infiltration rate is 200 ft^3/min (note the units). Peak lighting is input in units of KBtu/hr, and the OFFICE LIGHTING schedule is selected from the BLAST library. A positive value must be input with the PERCENT REPLACEABLE parameter for execution of BLAST/CEL-1. Electric equipment is specified in a manner similar to lighting. Temperature control is specified as DEAD BAND, a selection from the BLAST library.

The sections of the input file for the other zones can be assembled using the same format. In this initial simulation, six thermal zones have been defined by combining the lobby, restroom, and storage areas into a single zone in which daylighting will not be used. A complete listing of the six-zone BLAST input file is given in table 2.

4.2. SAMPLE CEL-1 INPUT FILE

If the lighting system design has already been determined, a CEL-1 input file can be assembled for the generation of BLAST lighting power multipliers. In many cases, it may be necessary, or useful, to utilize some of the other CEL-1 capabilities prior to generating the BLAST interface output. This would be true if the lighting system design was undetermined or if analysis of a preliminary lighting design was appropriate. CEL-1 possesses varied capabilities to assess illumination levels, lighting energy performance, and visual quality conditions in luminous environments.

While it would be beyond the scope of this report to investigate all of the possible analysis variations, a typical procedure might be to use CEL-1 to determine luminaire type and location and to evaluate illumination levels at task points. This procedure will usually require several iterations until an acceptable design is determined; however, each of these simulations is simple and inexpensive. Once the lighting system design has been determined, BLAST lighting power multipliers can be generated. These lighting power multipliers can be used repeatedly for BLAST simulations as long as the lighting system design is not subsequently altered. If the lighting system design is significantly changed, a new set of BLAST lighting power multipliers should be generated.

For this sample building analysis, two related CEl-1 input files will be demonstrated. The first file will be used to evaluate a proposed lighting system design and the second file will be used to generate the BLAST lighting power multipliers.

The first CEL-1 input file will be assembled to evaluate the performance of the proposed lighting system, beginning with illuminance levels for electric light only. Either the system editor or the CEL-1 program CEL1FE can be used to assemble the input file. The input file should contain at least the following blocks:

ROOM
TASK
FENESTRATION
ANALYSIS (specifying one time at night)
LUMINAIRES
CALCULATE (request HOR and any other desired metrics)

This input file can be processed using the procedure CEL1II. The output will include a printout of the horizontal illuminance levels, and a summary of maximum, minimum, and average values. These levels can be examined to determine if they meet the design criteria. If the illumination conditions are not acceptable, the input file should be modified and resubmitted for simulation. This process can be repeated as often as is needed until a satisfactory design is obtained. At this point, the design of the lighting system is tentatively fixed and the lighting control criterion can be selected to correspond to the lighting system. That is, if the lighting control system is to maintain a particular minimum or average illuminance level, this level should be specified to match the levels calculated in the initial simulations.

Table 3 presents the initial input file for the sample building. A description of the input file and the simulation results, follows.

Like all CEL-1 input files the first line of the file is ROOM, followed by five lines of user comments. There should be description to enable easy identification of the file and any associated output. The next three lines of the room block define the units convention and room dimensions, as follows:

1 1	All input and output units are English units (feet, footcandle, footlambert). Specifying 2 for either or both entries defines metric units (meters, lux, candela/m^2).
17 4 30 4 9 2	This specifies a room 17 feet (east-west) by 30 feet (north-south) by 9 feet (height). Each of the walls is subdivided into a grid with two sections vertically. The ceiling and floor are each divided into a 4 by 4 grid.
0.5 0.5 0.5 0.5 0.2 0.8	This line specifies the wall reflectances as 50 percent, the floor reflectance as 20 percent and the ceiling reflectance as 80 percent.

The next block is the TASK block. If specific task locations are known, such as the locations of desks, these locations can be explicitly defined using the KNOWN keyword. In the present case, task locations are not known, so the UNKNOWN parameter is used. The target points are the locations for which calculations will be done, such as illumination level, ESI, etc.

```
TASK

UNKNOWN

4   4   3.5   14   6   24   3   4
0
```

These entries signify a 4 by 4 grid of target points. The x-coordinates of the leftmost and rightmost columns are 3.5 and 14, respectively. The corresponding y-coordinate are 6 and 24. Target height is 3. The last parameter, 4, defines eye height for VCP calculations. A number must be coded here, even if VCP calculations are not requested. The single zero defines the number of viewing angles for ESI calculations. An integer between 0-4 must be entered here. If a non-zero entry is made, an additional line must be included specifying the viewing directions.

FENESTRATION

The next block is the FENESTRATION block. This block includes the fenestration description and must also contain the sub-blocks GROUND and BUILDING. These sub-blocks define objects other than the sky which may affect the light available from the fenestration. Fenestration types available are:

WINDOW
CLERESTORY
SAWTOOTH
SKYLIGHT

The WINDOW sub-block has additional parameters to define shades, drapes, blinds, light shelves, and barriers. These allow a very detailed description of the daylighting provided by a window. The FENESTRATION block for zone 1 is as follows:

FENESTRATION

WINDOW

1 0.4	This line specifies the window glazing (1-clear, 2-diffusing) and the transmittance which must be in the range 0 to 1.
24 5	Window width and height.
1	The number of locations of this window.
1 0 3 2.5	The first number is the number of the wall that the window is on (1-west, 2-north, 3-east, 4-south). The next three numbers are the x,y,z coordinates of the corner of the window closest to the room origin.
BUILDING	This sub-block must be included in the FENESTRATION block.
1	The number of buildings. This must always be at least one to include the building which contains the room being modeled.
0 0 -1 53 30 12	The first three numbers are the coordinates of the south-west corner of the building relative to the room origin. The next three numbers are the east-west dimension, the north-south dimension and the height.
0.5 0.5 0.5 0.5 0.2	These are the reflectances of the west, north, east, and south faces and the roof of the building.
0	This is the displacement of the west face from true north. This value must be greater than -45° and less than 45°.

GROUND	This sub-block must be included in the FENESTRATION block.
0.2	Ground reflectance.
0	Number of inserts. If an insert such as a parking lot was needed, another line would be added to define location, size, and reflectance of the insert.

The next block is the LUMINAIRES block. Since we are in the process of designing the lighting system, a luminaire type must be selected. If the luminaire type is already known, it can be directly specified. The CEL-1 library contains photometric information for many standard luminaire types. The user also has the option of creating additional luminaire photometric files using other available information. For this sample problem a two-tube four foot fluorescent luminaire will be selected. Using experience and judgement, an initial specification of six luminaires will be made. Each luminaire has a light output of 6300 lumens, at a power consumption of 90 watts. The luminaire block is as follows:

LUMINAIRES	
4B42	Photometric file for this luminaire type.
6300 0.9	Initial lamp lumens and light loss factor (dirt, losses).
2.0 4.5 0.0 90	Luminaire dimensions are 2 by 4.5. The height is entered as zero because fixture is downlight only. Actual height must be entered if luminaire has both uplight and downlight. The luminaire full power is 90 watts.
0.3 0.0 90 0.0	This information describes the lighting system control characteristics.

The 0.3 is the minimum gain (light output) of the system. The three other parameters are quadratic gain coefficients a, b, and c in the relation:

$$\text{light power(watts)} = a \times \text{gain}^2 + b \times \text{gain} + c$$

6							six luminaires specified
1	5.67	7.5	9.0	0.0	0.0	0.0	luminaire locations
2	5.67	15.0	9.0	0.0	0.0	0.0	and orientation angle
3	5.67	22.5	9.0	0.0	0.0	0.0	
4	11.33	7.5	9.0	0.0	0.0	0.0	
5	11.33	15.0	9.0	0.0	0.0	0.0	
6	11.33	22.5	9.0	0.0	0.0	0.0	

The above values are luminaire number, x-coordinate, y-coordinate, z-coordinate, bearing, tilt, and cant.

DIMMING

The next block is the DIMMING block. The DIMMING block allows luminaires to be controlled by the amount of daylighting available to replace electric lighting. Luminaires can be controlled separately or as a group and they may be controlled by three different methods.

1) On/Off
2) High/Low/Off
3) Continuous dimming from full output to a user specified minimum.

The continuous dimming option allows dimming by minimum or average illuminance over target points or a control target area. The dimming criteria could also be minimum ESI over the target points. The DIMMING block is optional for the ANALYSIS mode but is included in the CEL-1 test data deck to allow easy conversion to the data deck used by BLAST/CEL-1. The DIMMING block is as follows:

DIMMING	
-3	Luminaires will be dimmed continuously. The (-) sign indicates that the luminaires are dimmed separately, not as a group.
1000	This is the control value to be maintained during dimming. The value is set arbitrarily high to ensure that no dimming occurs. This criterion value will be replaced for the BLAST/CEL-1 data deck by a value determined by the CEL-1 output.
1 0 0 0 0	These are the luminaires control criterion selection switches. Only one of the five numbers can be a one. The rest must be zeros. The method selected is minimum illuminance over the user defined target points.
0 0 0 0 0 0 0	This line can be used to define a control target area. The control criterion already chosen does not require a control target area. The points must still be entered as seven zeros.
0	The number of luminaires always off.
6	The number of luminaires in the dimming group.

1 2 3 4 5 6	The list of the six luminaires in the dimming group.

The final block is the CALCULATED block. Since horizontal illuminance levels are required, the HOR calculation will be requested as follows:

```
CALCULATE
HOR
```

To summarize, the above CEL-1 input file defines the room dimensions and reflectances, specifies the breakdown of the room surfaces into subsurfaces, specifies a grid of target points, describes the luminaire and luminaire locations, and requests a printout of horizontal illuminance. Table 4 presents the output from the simulation.

The simulation output begins with a reformatted echo of the input data. The user should examine this information closely to ensure that input data were properly coded. Room dimensions, reflectances, and lighting system characteristics are summarized. Following that, the requested horizontal illuminance output is presented in matrix form showing the calculated illuminances at each target point. Below the illuminance grid, the average, minimum, and maximum illuminance levels are printed along with the computed standard deviation of the calculated values. The user should examine this printout carefully to evaluate absolute illuminance levels, uniformity, and minimum conditions in order to determine if the proposed lighting system design is acceptable.

In this case, the average illuminance at the task locations is 48 fc, with a range of 37 to 60 fc over all of the task locations. Thus, any control criterion chosen for subsequent simulations should be selected to correspond to the appropriate level. Thus, if the lighting system is to be controlled according to the average illuminance level, an average illuminance of 48 fc should be specified in the DIMMING block.

The CEL-1 input files for the remaining building zones are listed in table 5. The outputs from simulations using these files are presented in table 6.

Once the initial simulations are completed, input files must be assembled for the BLAST/CEL-1 simulations. Then CEL-1 input files will be very similar to the initial files, except the ANALYSIS block must be replaced by a PROFILE block and the CALCULATE block must be changed to request BLS. The dimming block should incorporate the control criteria determined during the initial simulations described above. Table 7 presents the CEL-1 input files for the BLAST/CEL-1 simulations for the four zones using CEL-1 lighting control.

The output from the BLAST/CEL-1 simulation of the entire building is presented in table 8. Reports of monthly energy use for all zones are found on pages 119-124. These reports include heating, cooling, electric and other loads. The peak heating and cooling loads and the date when these occured, is also shown. The total building energy budget for the year and the energy budget for the year without daylighting are given on page 131. With daylighting the electric load is reduced by 13 percent. The reduction in electric load causes an 8.6 percent decrease in cooling load and a 2.1 percent increase in the heating load.

5. SUMMARY

The procedure for using a hybrid version of the BLAST and CEL-1 computer programs to analyze building energy performance including daylighting has been described and demonstrated. Techniques for developing the appropriate input files, and performing the simulations have been presented. An analysis of a sample building was described indicating the potential of the hybrid BLAST/CEL-1 Program.

6. REFERENCES

1. Hittle, D., "The Building Loads Analysis and System Thermodynamics (BLAST) Program," Version 2.0, Users Manual Vol. 1 and Vol. 2, Technical Report E-153/ADA072272 and ADA722730, U.S. Army Construction Engineering Research Laboratory, June 1979.

2. CEL-1 Lighting Computer Program - Programmer's Guide, CR 83.009, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043, January 1983.

3. CEL-1 Lighting Computer Program - User's Guide, CR 81.026, Naval Civil Engineering Laboratory, Port Hueneme, CA 93043, September 1981.

4. Kusuda, T., "NBSLD, the Computer Program for Heating and Cooling Loads in Buildings," National Bureau of Standards Building Science Series 69, July 1976.

5. Kusuda, T., Collins, B., "Simplified Analysis of Thermal and Lighting Characteristics of Windows - Two Case Studies," National Bureau of Standards Building Science Series 109, February 1978.

6. Johnson, R., Selkowitz, S., Winkelman, F., Zentner, M., "Glazing Optimization Study for Energy Efficiency in Commercial Office Buildings," Third International Symposium on Energy Conservation in the Built Environment, Dublin, Ireland, March 1982.

7. Jurovics, S., "Daylight, Glazing and Building Energy Minimization," IBM Scientific Center publication, Los Angeles, CA, 1981.

8. Place, W., Fontoynant, M., Bauman, F., Anderson, B., Howard, T., "Commercial Building Daylighting," LBLO-14348, Lawrence Berkeley Laboratory, Berkeley, CA 94720, 1982

9. Treado, S., and Kusuda, T., "Daylighting, Window Management Systems and Lighting Controls," NBSIR 80-2147, December 1980.

10. Kusuda, T., Achenbach, P., Earth Temperature and Thermal Diffusivity at Selected Stations in the United States, ASHRAE Trans., Vol. 71, Part 1, 1965.

11. Kusuda, T., "Least Squares Analysis of Annual Earth Temperature Cycles for Selected Stations in the Contiguous United States," NBS Report 9493, January 1968

12. Gillette, G., Treado, S., Correlations of Solar Irradiance and Daylight Illuminance for Building Energy Analysis, ASHRAE Transaction 1985, Vol. 9, Part 1, Atlanta, GA, 1985.

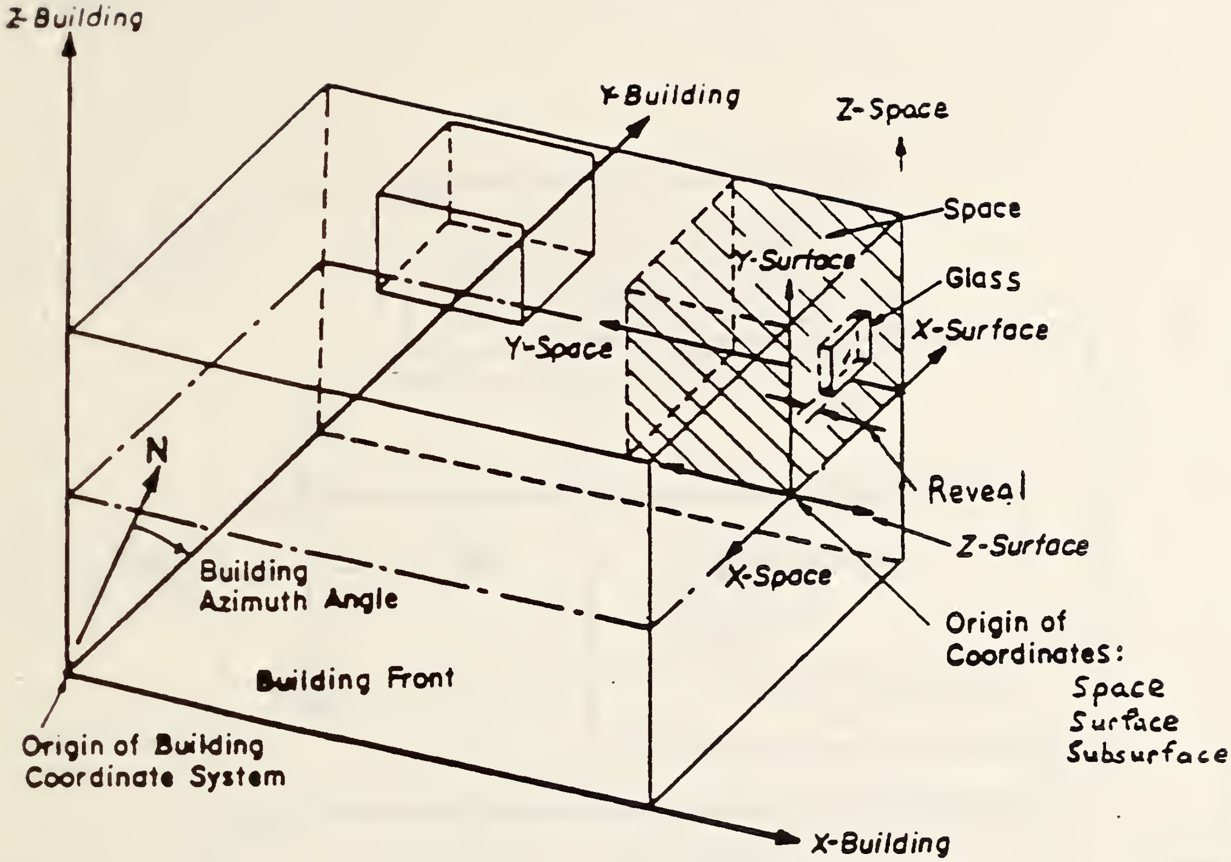

Figure 1 Building and surface coordinate systems in the BLAST environment

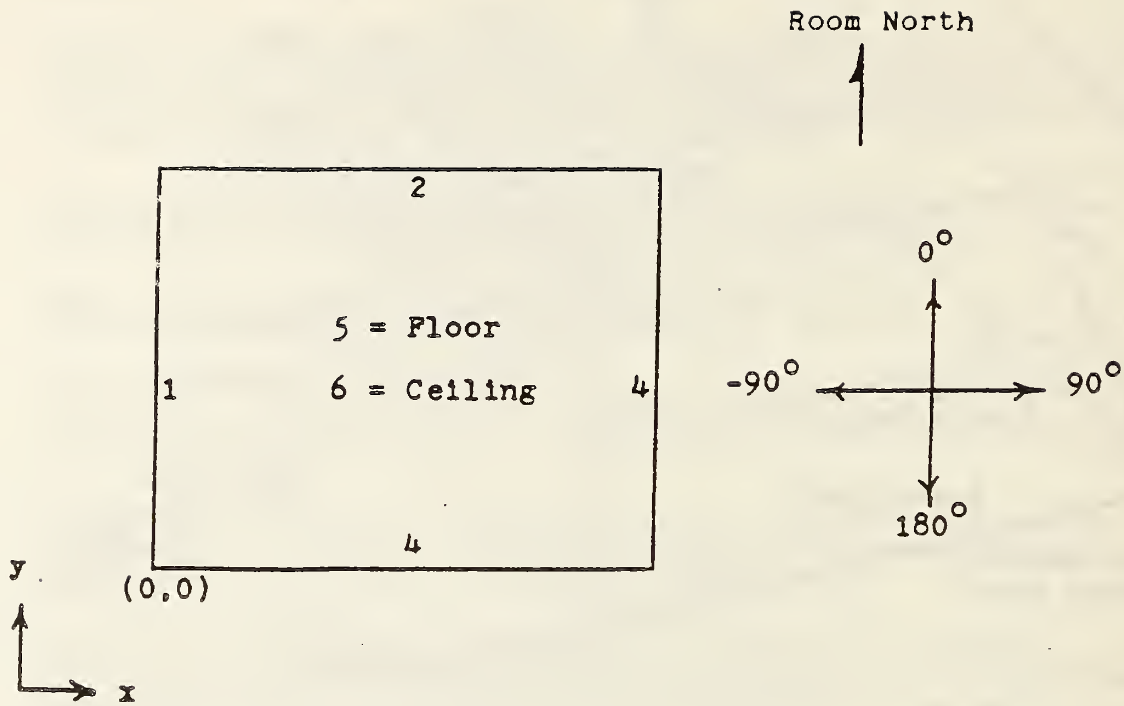

Figure 2 Building and surface coordinate systems in the CEL-1 environment

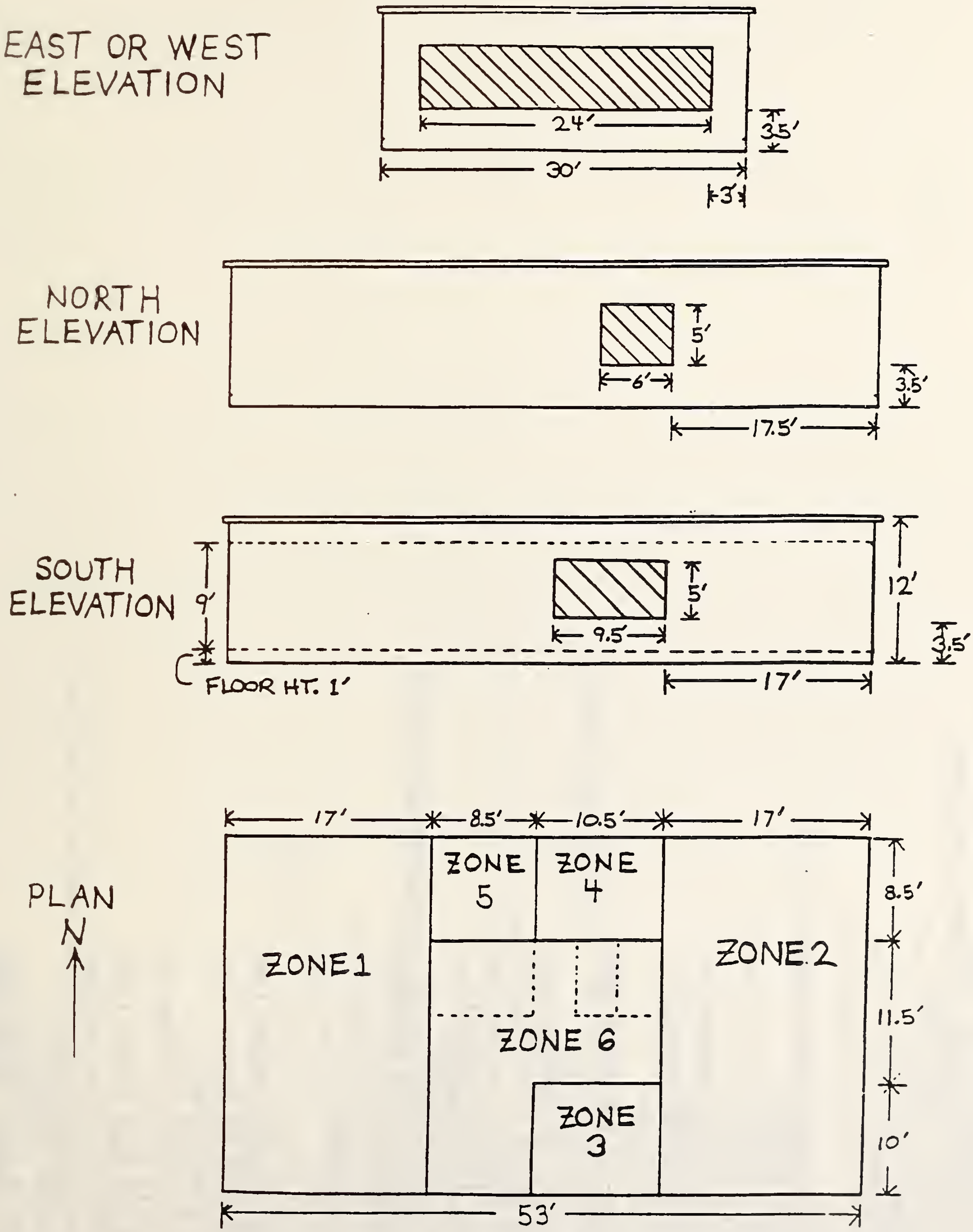

Figure 3 Floor plan of sample building

Table 2. BLAST Input File Listing

```
BEGIN INPUT;
  RUN CONTROL: NEW ZONES,
               REPORTS(ZONE LOADS,26),
               UNITS(ENGLISH);
  PROJECT = "SAMPLE BUILDING TEST";
  LOCATION = NORFOLK;
  WEATHER TAPE FROM 01 JAN 51 THRU 31 DEC 51;
  GROUND TEMPERATURES=(55,55,55,58,64,71,73,74,71,67,61,57);
  BEGIN BUILDING DESCRIPTION;
    BUILDING = "DELIVERY RETRAINING DETACHMENT BUILDING";
    DIMENSIONS: W = 53,L = 30,H = 11;
    NORTH AXIS = 0;
    SOLAR DISTRIBUTION = -1.
    ZONE 1 "WEST CLASSROOM":
      ORIGIN: (0,0,0);
      NORTH AXIS = 0;
      EXTERIOR WALLS:
        STARTING AT (0,30,0) FACING (270)
          EXTWALL28(L BY H)
        WITH WINDOWS OF TYPE
        DOUBLE PANE WINDOW
        (24 BY 5) AT (0,3.5),
        STARTING AT (17,30,0) FACING (0)
          EXTWALL28(17 BY H),
        STARTING AT (0,0,0) FACING (180)
          EXTWALL28(17 BY H);
      PARTITIONS:
        STARTING AT (17,0,0) FACING (90)
          PARTITION23(L BY H);
      ROOFS:
        STARTING AT (0,0,H) FACING (180)
          ROOF17(17 BY L);
      SLAB ON GRADE FLOOR:
        STARTING AT (0,30,0) FACING (180)
          FLOOR SLAB 4 IN (17 BY 30);
      PEOPLE = 15,OFFICE OCCUPANCY;
      INFILTRATION =200, CONSTANT;
      LIGHTS =  1.843, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
      ELECTRIC EQUIPMENT = 1.00,CONSTANT;
      CONTROLS = DEAD BAND;
    END ZONE;
    ZONE 2 "EAST CLASSROOM":
      ORIGIN: (36,0,0);
      NORTH AXIS = 0;
      EXTERIOR WALLS:
        STARTING AT (17,0,0) FACING (90)
          EXTWALL28(L BY H)
            WITH WINDOWS OF TYPE
            DOUBLE PANE WINDOW
            (24 BY 5) AT (0,3.5),
        STARTING AT (17,30,0) FACING (0)
          EXTWALL28(17 BY H),
        STARTING AT (0,0,0) FACING (180)
          EXTWALL28(17 BY H);
      PARTITIONS:
        STARTING AT (0,30,0) FACING (270)
          PARTITION23(L BY H);
      ROOFS:
        STARTING AT (0,0,H) FACING (180)
          ROOF17(17 BY L);
```

```
  SLAB ON GRADE FLOOR:
    STARTING AT (0,30,0) FACING (180)
      FLOOR SLAB 4 IN (17 BY 30);
  PEOPLE = 15,OFFICE OCCUPANCY;
  INFILTRATION =200, CONSTANT;
  LIGHTS =  1.843, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
  ELECTRIC EQUIPMENT = 1.00,CONSTANT;
  CONTROLS = DEAD BAND;
END ZONE;
ZONE 3 "OFFICE":
  ORIGIN: (25.5,0,0);
  NORTH AXIS = 0;
  EXTERIOR WALLS:
    STARTING AT (0,0,0) FACING (180)
      EXTWALL28(10.5 BY H)
    WITH WINDOWS OF TYPE
    DOUBLE PANE WINDOW (9.5 BY 5) AT (0,3.5);
  PARTITIONS:
    STARTING AT (0,10,0) FACING (270)
      PARTITION23(10 BY H),
    STARTING AT (10.5,10,0) FACING (0)
      PARTITION23(10.5 BY H),
    STARTING AT (10.5,0,0) FACING (90)
      PARTITION23(10 BY H);
  ROOFS:
    STARTING AT (0,0,H) FACING (180)
      ROOF17(10.5 BY 10);
  SLAB ON GRADE FLOOR:
    STARTING AT (0,10.0,0) FACING (180)
      FLOOR SLAB 4 IN (10.5 BY 10);
  PEOPLE = 2,OFFICE OCCUPANCY;
  INFILTRATION =50, CONSTANT;
  LIGHTS = 0.614, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
  ELECTRIC EQUIPMENT = 0.36,CONSTANT;
  CONTROLS = DEAD BAND;
END ZONE;
ZONE 4 "EQUIPMENT MAINTAINANCE":
  ORIGIN: (25.5,21.5,0);
  NORTH AXIS = 0;
  EXTERIOR WALLS:
    STARTING AT (10.5,8.5,0) FACING (0)
      EXTWALL28(10.5 BY H)
    WITH WINDOWS OF TYPE
    DOUBLE PANE WINDOW (6 BY 5) AT (0.5,3.5);
  PARTITIONS:
    STARTING AT (10.5,0,0) FACING (90)
      PARTITION23(8.5 BY H),
    STARTING AT (0,0,0) FACING (180)
      PARTITION23(10.5 BY H),
    STARTING AT (0,8.5,0) FACING (270)
      PARTITION23(8.5 BY H);
  ROOFS:
    STARTING AT (0,0,H) FACING (180)
      ROOF17(10.5 BY 8.5);
  SLAB ON GRADE FLOOR:
    STARTING AT (0,8.5,0) FACING (180)
      FLOOR SLAB 4 IN (10.5 BY 8.5);
  PEOPLE = 1,OFFICE OCCUPANCY;
  INFILTRATION =50, CONSTANT;
  LIGHTS = 0.614, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
```

```
  ELECTRIC EQUIPMENT = 0.55,CONSTANT;
  CONTROLS = DEAD BAND;
END ZONE;
ZONE 5 "MECHANICAL EQUIPMENT":
  ORIGIN: (17,21.5,0);
  NORTH AXIS = 0;
  EXTERIOR WALLS:
    STARTING AT (8.5,8.5,0) FACING (0)
      EXTWALL28(8.5 BY H);
  PARTITIONS:
    STARTING AT (8.5,0,0) FACING (90)
      PARTITION23(8.5 BY H),
    STARTING AT (0,0,0) FACING (180)
      PARTITION23(8.5 BY H),
    STARTING AT (0,8.5,0) FACING (270)
      PARTITION23(8.5 BY H);
  ROOFS:
    STARTING AT (0,0,H) FACING (180)
      ROOF17(8.5 BY 8.5);
  SLAB ON GRADE FLOOR:
    STARTING AT (0,8.5,0) FACING (180)
      FLOOR SLAB 4 IN (8.5 BY 8.5);
  PEOPLE = 1,OFFICE OCCUPANCY;
  INFILTRATION =25, CONSTANT;
  LIGHTS = 0.614, OFFICE LIGHTING;
  ELECTRIC EQUIPMENT = 1.00,CONSTANT;
  CONTROLS = DEAD BAND;
END ZONE;
ZONE 6 "LOBBY":
  ORIGIN: (17,0,0);
  NORTH AXIS = 0;
  EXTERIOR WALLS:
    STARTING AT (0,0,0) FACING (180)
      EXTWALL28(8.5 BY H);
  PARTITIONS:
    STARTING AT (0,21.5,0) FACING (270)
      PARTITION23(21.5 BY H),
    STARTING AT (19,21.5,0) FACING (0)
      PARTITION23(19 BY H),
    STARTING AT (19,10,0) FACING (90)
      PARTITION23(11.5 BY H),
    STARTING AT (8.5,10,0) FACING (180)
      PARTITION23(10.5 BY H),
    STARTING AT (8.5,0,0) FACING (90)
      PARTITION23(10 BY H);
  ROOFS:
    STARTING AT (0,0,H) FACING (180)
     ROOF17(8.5 BY 10),
    STARTING AT (0,10,H) FACING (180)
     ROOF17(19 BY 11.5);
  SLAB ON GRADE FLOOR:
    STARTING AT (0,21.5,0) FACING (180)
      FLOOR SLAB 4 IN (19 BY 11.5),
    STARTING AT (0,10,0) FACING (180)
      FLOOR SLAB 4 IN (8.5 BY 10);
  PEOPLE = 2,OFFICE OCCUPANCY;
  INFILTRATION =50, CONSTANT;
  LIGHTS = 0.614, OFFICE LIGHTING;
  ELECTRIC EQUIPMENT = 0.55,CONSTANT;
  CONTROLS = DEAD BAND;
```

```
  END ZONE;
END BUILDING DESCRIPTION;
```

Table 3. CEL-1 Input File for Zone 1

```
ROOM
  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
  CREATED  2/14/85,  UPDATED 2/14/85
********************************************
    1 1
    17 4  30 4  9 2
    0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
    4 4  3.4 13.6  6 24 3 4
    0
FENESTRATION
WINDOW
    1 0.4
    24 5
    1
    1 0 3 2.5
BUILDING
    1
    0 0 -1  53 30 12
    0.5 0.5 0.5 0.5 0.2
    0
GROUND
    0.2
    0
ANALYSIS
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
  1
  12 31 3.00
LUMINAIRES
HB42
   6300 0.9
    2.0 4.5 0.0 90
    0.3 0.0 90 0.0
    6
    1  5.67  7.5 9.0 0.0 0.0 0.0
    2  5.67 15.0 9.0 0.0 0.0 0.0
    3  5.67 22.5 9.0 0.0 0.0 0.0
    4 11.33  7.5 9.0 0.0 0.0 0.0
    5 11.33 15.0 9.0 0.0 0.0 0.0
    6 11.33 22.5 9.0 0.0 0.0 0.0
DIMMING
      -3
    1000
    1 0 0 0 0
    0 0 0 0 0 0 0
    0
    6
    1 2 3 4 5 6
CALCULATE
HOR
```

Table 4. ŒL-1 Output for Zone 1

```
//////////////////////////////
/                            /
/        C E L  -  1         /
/                            /
/ LIGHTING COMPUTER PROGRAM  /
/                            /
//////////////////////////////

               85/03/07.

  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
  CREATED  2/14/85,  UPDATED 2/14/85
********************************************
```

```
          CEL-1 LIGHTING COMPUTER PROGRAM
               INPUT DATA ECHO

PROJECT ID:
  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
  CREATED  2/14/85,  UPDATED 2/14/85
*******************************************

  DIMENSIONS AND (X,Y,Z) COORDINATES ARE GIVEN IN FEET

ROOM DIMENSIONS:
   17.00  WIDTH (E-W)
   30.00  LENGTH (N-S)
    9.00  HEIGHT
ROOM SURFACE REFLECTANCES:     .50   .50   .50   .50   .20   .80


FENESTRATION ENTRY #  1 (WINDOW)   GLAZING IS CLEAR
  TRANSMITTANCE =  .400
  WIDTH =  24.00   HEIGHT =   5.00
 1 LOCATIONS
  SURF.  CORNER NEAREST ORIGIN (X,Y,Z)
    1        0.00    3.00    2.50

BUILDING #  1
  WIDTH=   53.0   LENGTH=   30.0   HEIGHT=   12.0
  SOUTHWEST CORNER (X,Y,Z)=      0.0     0.0    -1.0
  REFLECTANCES=   .500  .500  .500  .500  .200
  WEST WALL DISPLACEMENT FROM TRUE NORTH=   0.0

GROUND REFLECTANCE=  .200

DAYLIGHTING PARAMETERS:
   36.83  LATITUDE
   76.17  LONGITUDE
   75.00  LONGITUDE AT CENTER OF TIME ZONE
     253  WEATHER STATION ID
 0 0 0 0 1 1 1 1 1 1 0 0  DAYLIGHT SAVINGS TIME MAP

LUMINAIRE TYPE # 1
  HB42       PHOTOMETRIC FILE NAME
     6300.   INITIAL LAMP LUMENS
      .900   LIGHT LOSS FACTOR
      2.00   LUMINAIRE WIDTH
      4.50   LUMINAIRE LENGTH
      0.00   LUMINAIRE HEIGHT
 MINIMUM GAIN=   .300    QUADRATIC COEFFICIENTS (WATTS VS. GAIN):
                                   0.0000     90.0000      0.0000
 WATTS PER LUMINAIRE =   90.

    -LUMINAIRE LOCATION DETAILS-
   #     X      Y      Z  BEARING   TILT   CANT
   -     -      -      -  -------   ----   ----
   1    5.67   7.50   9.00    0.0    0.0    0.0
   2    5.67  15.00   9.00    0.0    0.0    0.0
   3    5.67  22.50   9.00    0.0    0.0    0.0
   4   11.33   7.50   9.00    0.0    0.0    0.0
   5   11.33  15.00   9.00    0.0    0.0    0.0
```

6	11.33	22.50	9.00	0.0	0.0	0.0

LUMINAIRE CONTROL METHOD: CONTINUOUS
CONTROL VALUES: 1000.0
CONTROL CRITERION: MINIMUM ILLUM. ON TARGET PTS.

WEATHER STATION NORFOLK, VIRGINIA

```
---------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: OVERCAST

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:       .0
```

```
  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
  CREATED  2/14/85,  UPDATED 2/14/85
********************************************

             HORIZONTAL ILLUMINATION

            UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR


  -Y-

  24.0    39.0  56.1  56.1  38.7

  18.0    47.2  67.6  67.6  47.1

  12.0    47.2  67.6  67.6  47.1

   6.0    39.0  56.1  56.1  38.9

           3.4   6.8  10.2  13.6
                <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.5    67.6    38.7       9.4
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
      HORIZONTAL ILLUMINATION

  75.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE    47.1
  80.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE    47.1
  85.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE    39.0
  90.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE    39.0
  95.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE    38.9
  99.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE    38.9
```

```
------------------------------------------------
MARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: CLEAR

NANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
   0.0     SKY:        .0
```

```
  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
  CREATED  2/14/85,  UPDATED 2/14/85
********************************************

           HORIZONTAL ILLUMINATION

          UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

  24.0   39.0  56.1  56.1  38.7

  18.0   47.2  67.6  67.6  47.1

  12.0   47.2  67.6  67.6  47.1

   6.0   39.0  56.1  56.1  38.9

          3.4   6.8  10.2  13.6
                <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.5    67.6    38.7      9.4
```

--- STATISTICAL OCCURRENCE LEVELS FOR:
HORIZONTAL ILLUMINATION

75.0	OF	16	CALCULATION VALUES ARE AT OR ABOVE	47.1
80.0	OF	16	CALCULATION VALUES ARE AT OR ABOVE	47.1
85.0	OF	16	CALCULATION VALUES ARE AT OR ABOVE	39.0
90.0	OF	16	CALCULATION VALUES ARE AT OR ABOVE	39.0
95.0	OF	16	CALCULATION VALUES ARE AT OR ABOVE	38.9
99.0	OF	16	CALCULATION VALUES ARE AT OR ABOVE	38.9

```
---------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: PARTLY CLDY

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:       .0
```

```
  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
  CREATED  2/14/85,  UPDATED 2/14/85
*********************************************

             HORIZONTAL ILLUMINATION

            UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

  24.0   39.0  56.1  56.1  38.7

  18.0   47.2  67.6  67.6  47.1

  12.0   47.2  67.6  67.6  47.1

   6.0   39.0  56.1  56.1  38.9

          3.4   6.8  10.2  13.6
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.5    67.6    38.7       9.4
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
      HORIZONTAL ILLUMINATION

  75.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE   47.1
  80.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE   47.1
  85.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE   39.0
  90.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE   39.0
  95.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE   38.9
  99.0   OF   16 CALCULATION VALUES ARE AT OR ABOVE   38.9
```

```
ROOM
SAMPLE TEST BUILDING
ZONE 2  EAST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
*********************************************
  1 1
  17 4  30 4  9 2
  0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
  4 4 3.4 13.6 6 24 3 4
  0
FENESTRATION
WINDOW
  1 0.4
  24 5
  1
  3 17 3 2.5
BUILDING
  1
  -36 0 -1 53 30 12
  0.5 0.5 0.5 0.5 0.2
  0
GROUND
  0.2
  0
ANALYSIS
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
  1
  12 31 3.00
LUMINAIRES
HB42
  6300 0.9
  2.0 4.5 0.0 90
  0.3 0.0 90 0.0
  6
  1  5.67  7.5 9.0 0.0 0.0 0.0
  2  5.67 15.0 9.0 0.0 0.0 0.0
  3  5.67 22.5 9.0 0.0 0.0 0.0
  4 11.33  7.5 9.0 0.0 0.0 0.0
  5 11.33 15.0 9.0 0.0 0.0 0.0
  6 11.33 22.5 9.0 0.0 0.0 0.0
DIMMING
  -3
    1000
  1 0 0 0 0
  0 0 0 0 0 0 0
  0
  6
  1 2 3 4 5 6
CALCULATE
HOR
```

```
ROOM
SAMPLE TEST BUILDING
ZONE 3  OFFICE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
********************************************
  1 1
  10.5 3  10 3  9 2
  0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
  3 3 2.6  7.9 2.5 7.5  3 4
  0
FENESTRATION
WINDOW
  1 0.4
  9.5 5
  1
  4 1 0 2.5
BUILDING
  1
  -25.5 0 -1  53 30 12
  0.5 0.5 0.5 0.5 0.2
  0
GROUND
  0.2
  0
ANALYSIS
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
  1
  12 31 3.00
LUMINAIRES
HB42
  6300 0.9
  2.0 4.5 0.0 90
  0.3 0.0 90 0.0
  2
  1 5.25 3.33 9.0 90 0 0
  2 5.25 6.67 9.0 90 0 0
DIMMING
  -3
    1000
  1 0 0 0 0
  0 0 0 0 0 0 0
  0
  2
  1 2
CALCULATE
HOR
```

```
ROOM
SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85,  UPDATED 2/14/85
********************************************
  1 1
  10.5 3  8.5 3  9 2
  0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
  3 3 2.6  7.9 2.1 6.4  3 4
  0
FENESTRATION
WINDOW
  1 0.4
  6.0 5
  1
  2 4.0 8.5 2.5
BUILDING
  1
  -25.5 -21.5 -1  53 30 12
  0.5 0.5 0.5 0.5 0.2
  0
GROUND
  0.2
  0
ANALYSIS
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
  1
  12 31 3.00
LUMINAIRES
HB42
  6300 0.9
  2.0 4.5 0.0 90
  0.3 0.0 90 0.0
  2
  1 5.25 2.83 9.0 90 0 0
  2 5.25 5.67 9.0 90 0 0
DIMMING
  -3
    1000
  1 0 0 0 0
  0 0 0 0 0 0 0
  0
  2
  1 2
CALCULATE
HOR
```

Table 6. ŒL-1 Output for Zones 2 through 4

```
//////////////////////////////
/                            /
/        C E L  -  1         /
/                            /
/ LIGHTING COMPUTER PROGRAM  /
/                            /
//////////////////////////////

          85/03/07.

SAMPLE TEST BUILDING
ZONE 2  EAST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
********************************************
```

```
          CEL-1 LIGHTING COMPUTER PROGRAM
               INPUT DATA ECHO

PROJECT ID:
SAMPLE TEST BUILDING
ZONE 2  EAST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
********************************************

  DIMENSIONS AND (X,Y,Z) COORDINATES ARE GIVEN IN FEET

ROOM DIMENSIONS:
   17.00  WIDTH (E-W)
   30.00  LENGTH (N-S)
    9.00  HEIGHT
ROOM SURFACE REFLECTANCES:     .50   .50   .50   .50   .20   .80


FENESTRATION ENTRY # 1 (WINDOW)   GLAZING IS CLEAR
  TRANSMITTANCE =  .400
  WIDTH =  24.00   HEIGHT =   5.00
 1 LOCATIONS
  SURF.  CORNER NEAREST ORIGIN (X,Y,Z)
    3       17.00    3.00    2.50

BUILDING # 1
  WIDTH=   53.0   LENGTH=   30.0   HEIGHT=   12.0
  SOUTHWEST CORNER (X,Y,Z)=    -36.0     0.0    -1.0
  REFLECTANCES=   .500  .500  .500  .500  .200
  WEST WALL DISPLACEMENT FROM TRUE NORTH=   0.0

GROUND REFLECTANCE=  .200

DAYLIGHTING PARAMETERS:
   36.83  LATITUDE
   76.17  LONGITUDE
   75.00  LONGITUDE AT CENTER OF TIME ZONE
     253  WEATHER STATION ID
 0 0 0 0 1 1 1 1 1 1 0 0  DAYLIGHT SAVINGS TIME MAP

LUMINAIRE TYPE # 1
  HB42        PHOTOMETRIC FILE NAME
     6300.    INITIAL LAMP LUMENS
       .900   LIGHT LOSS FACTOR
       2.00   LUMINAIRE WIDTH
       4.50   LUMINAIRE LENGTH
       0.00   LUMINAIRE HEIGHT
 MINIMUM GAIN=   .300    QUADRATIC COEFFICIENTS (WATTS VS. GAIN):
                                   0.0000      90.0000      0.0000
 WATTS PER LUMINAIRE =   90.

    -LUMINAIRE LOCATION DETAILS-
   #      X       Y       Z  BEARING   TILT   CANT
   -      -       -       -  -------   ----   ----
   1    5.67    7.50   9.00    0.0     0.0    0.0
   2    5.67   15.00   9.00    0.0     0.0    0.0
   3    5.67   22.50   9.00    0.0     0.0    0.0
   4   11.33    7.50   9.00    0.0     0.0    0.0
   5   11.33   15.00   9.00    0.0     0.0    0.0
```

```
  6   11.33  22.50   9.00    0.0     0.0     0.0

LUMINAIRE CONTROL METHOD:  CONTINUOUS
 CONTROL VALUES:  1000.0
 CONTROL CRITERION:  MINIMUM ILLUM. ON TARGET PTS.

WEATHER STATION   NORFOLK, VIRGINIA
```

SUMMARY OF CALCULATIONS FOR: 31 DECEMBER TIME= 3:00 SKIES: OVERCAST

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN: 0.0 SKY: .0

SAMPLE TEST BUILDING
ZONE 2 EAST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85, UPDATED 2/14/85
****

HORIZONTAL ILLUMINATION

UNITS ARE FOOTCANDLES

3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

-Y-				
24.0	38.4	55.7	55.7	38.6
18.0	46.8	67.2	67.3	46.9
12.0	46.8	67.2	67.3	46.9
6.0	38.6	55.7	55.7	38.6
	3.4	6.8	10.2	13.6

<---- X ----

AVERAGE	MAXIMUM	MINIMUM	MEAN DEV.
52.1	67.3	38.4	9.4

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
      HORIZONTAL ILLUMINATION

  75.0    OF    16 CALCULATION VALUES ARE AT OR ABOVE    46.8
  80.0    OF    16 CALCULATION VALUES ARE AT OR ABOVE    46.8
  85.0    OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
  90.0    OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
  95.0    OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
  99.0    OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
```

```
--------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: CLEAR

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:      .0
```

```
SAMPLE TEST BUILDING
ZONE 2  EAST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
*****************************************

          HORIZONTAL ILLUMINATION

         UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

  24.0   38.4  55.7  55.7  38.6

  18.0   46.8  67.2  67.3  46.9

  12.0   46.8  67.2  67.3  46.9

   6.0   38.6  55.7  55.7  38.6

          3.4   6.8  10.2  13.6
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.1    67.3    38.4      9.4
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
      HORIZONTAL ILLUMINATION

 75.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    46.8
 80.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    46.8
 85.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
 90.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
 95.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
 99.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
```

```
--------------------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: PARTLY CLDY

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:      0.0     SKY:       .0
```

```
SAMPLE TEST BUILDING
ZONE 2  EAST CLASSROOM
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
********************************************

             HORIZONTAL ILLUMINATION

            UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

  24.0   38.4  55.7  55.7  38.6

  18.0   46.8  67.2  67.3  46.9

  12.0   46.8  67.2  67.3  46.9

   6.0   38.6  55.7  55.7  38.6

          3.4   6.8  10.2  13.6
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.1    67.3    38.4      9.4
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
      HORIZONTAL ILLUMINATION

  75.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    46.8
  80.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    46.8
  85.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
  90.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
  95.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
  99.0   OF    16 CALCULATION VALUES ARE AT OR ABOVE    38.6
```

```
//////////////////////////////
/                            /
/        C E L  -  1         /
/                            /
/ LIGHTING COMPUTER PROGRAM  /
/                            /
//////////////////////////////

          85/03/07.

SAMPLE TEST BUILDING
ZONE 3  OFFICE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
*********************************************
```

```
            CEL-1 LIGHTING COMPUTER PROGRAM
                  INPUT DATA ECHO

PROJECT ID:
SAMPLE TEST BUILDING
ZONE 3  OFFICE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
********************************************

  DIMENSIONS AND (X,Y,Z) COORDINATES ARE GIVEN IN FEET

ROOM DIMENSIONS:
   10.50  WIDTH (E-W)
   10.00  LENGTH (N-S)
    9.00  HEIGHT
ROOM SURFACE REFLECTANCES:     .50   .50   .50   .50   .20   .80


FENESTRATION ENTRY #  1 (WINDOW)   GLAZING IS CLEAR
  TRANSMITTANCE =  .400
  WIDTH =    9.50   HEIGHT =    5.00
 1 LOCATIONS
  SURF.  CORNER NEAREST ORIGIN (X,Y,Z)
    4        1.00     0.00     2.50

BUILDING #  1
  WIDTH=    53.0   LENGTH=    30.0   HEIGHT=    12.0
  SOUTHWEST CORNER (X,Y,Z)=     -25.5      0.0     -1.0
  REFLECTANCES=   .500  .500  .500  .500  .200
  WEST WALL DISPLACEMENT FROM TRUE NORTH=    0.0

GROUND REFLECTANCE=  .200

DAYLIGHTING PARAMETERS:
   36.83  LATITUDE
   76.17  LONGITUDE
   75.00  LONGITUDE AT CENTER OF TIME ZONE
     253  WEATHER STATION ID
 0 0 0 0 1 1 1 1 1 1 0 0  DAYLIGHT SAVINGS TIME MAP

LUMINAIRE TYPE # 1
  HB42       PHOTOMETRIC FILE NAME
     6300.   INITIAL LAMP LUMENS
      .900   LIGHT LOSS FACTOR
      2.00   LUMINAIRE WIDTH
      4.50   LUMINAIRE LENGTH
      0.00   LUMINAIRE HEIGHT
 MINIMUM GAIN=   .300    QUADRATIC COEFFICIENTS (WATTS VS. GAIN):
                                  0.0000      90.0000      0.0000
 WATTS PER LUMINAIRE =   90.

    -LUMINAIRE LOCATION DETAILS-
  #      X        Y        Z  BEARING   TILT   CANT
  -      -        -        -  -------   ----   ----
  1    5.25     3.33    9.00    90.0     0.0    0.0
  2    5.25     6.67    9.00    90.0     0.0    0.0

LUMINAIRE CONTROL METHOD:  CONTINUOUS
 CONTROL VALUES:  1000.0
```

CONTROL CRITERION: MINIMUM ILLUM. ON TARGET PTS.

WEATHER STATION NORFOLK, VIRGINIA

```
--------------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: OVERCAST

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:      0.0     SKY:       .0
```

```
SAMPLE TEST BUILDING
ZONE 3  OFFICE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
*********************************************

            HORIZONTAL ILLUMINATION

           UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

   7.5   45.8  58.3  45.2

   5.0   53.5  68.8  53.3

   2.5   45.7  58.7  46.0

          2.6   5.3   7.9
                <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.8    68.8    45.2      6.3
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
     HORIZONTAL ILLUMINATION

 75.0    OF      9 CALCULATION VALUES ARE AT OR ABOVE    46.0
 80.0    OF      9 CALCULATION VALUES ARE AT OR ABOVE    45.8
 85.0    OF      9 CALCULATION VALUES ARE AT OR ABOVE    45.8
 90.0    OF      9 CALCULATION VALUES ARE AT OR ABOVE    45.7
 95.0    OF      9 CALCULATION VALUES ARE AT OR ABOVE    45.7
 99.0    OF      9 CALCULATION VALUES ARE AT OR ABOVE    45.7
```

```
--------------------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: CLEAR

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:      .0
```

```
SAMPLE TEST BUILDING
ZONE 3  OFFICE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
****************************************

           HORIZONTAL ILLUMINATION

          UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR


  -Y-

   7.5   45.8  58.3  45.2

   5.0   53.5  68.8  53.3

   2.5   45.7  58.7  46.0

          2.6   5.3   7.9
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.8    68.8    45.2      6.3
```

```
--- STATISTICAL OCCURRENCE LEVEL: FOR:
       HORIZONTAL ILLUMINATION

  75.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    46.0
  80.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    45.8
  85.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    45.8
  90.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    45.7
  95.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    45.7
  99.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    45.7
```

```
-----------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: PARTLY CLDY

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:       .0
```

```
SAMPLE TEST BUILDING
ZONE 3  OFFICE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED  2/14/85,  UPDATED 2/14/85
********************************************

             HORIZONTAL ILLUMINATION

            UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

   7.5   45.8  58.3  45.2

   5.0   53.5  68.8  53.3

   2.5   45.7  58.7  46.0

          2.6   5.3   7.9
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     52.8    68.8    45.2      6.3
```

--- STATISTICAL OCCURRENCE LEVELS FOR:
HORIZONTAL ILLUMINATION

75.0	OF	9 CALCULATION VALUES ARE AT OR ABOVE	46.0
80.0	OF	9 CALCULATION VALUES ARE AT OR ABOVE	45.8
85.0	OF	9 CALCULATION VALUES ARE AT OR ABOVE	45.8
90.0	OF	9 CALCULATION VALUES ARE AT OR ABOVE	45.7
95.0	OF	9 CALCULATION VALUES ARE AT OR ABOVE	45.7
99.0	OF	9 CALCULATION VALUES ARE AT OR ABOVE	45.7

```
//////////////////////////////
/                            /
/        C E L  -  1         /
/                            /
/ LIGHTING COMPUTER PROGRAM  /
/                            /
//////////////////////////////

           85/03/07.

SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85,  UPDATED 2/14/85
********************************************
```

```
            CEL-1 LIGHTING COMPUTER PROGRAM
                 INPUT DATA ECHO

PROJECT ID:
SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85,  UPDATED 2/14/85
*********************************************

  DIMENSIONS AND (X,Y,Z) COORDINATES ARE GIVEN IN FEET

ROOM DIMENSIONS:
   10.50  WIDTH (E-W)
    8.50  LENGTH (N-S)
    9.00  HEIGHT
ROOM SURFACE REFLECTANCES:      .50   .50   .50   .50   .20   .80


FENESTRATION ENTRY #  1 (WINDOW)   GLAZING IS CLEAR
  TRANSMITTANCE =  .400
  WIDTH =   6.00   HEIGHT =   5.00
 1 LOCATIONS
  SURF.  CORNER NEAREST ORIGIN (X,Y,Z)
    2        4.00    8.50    2.50

BUILDING #  1
  WIDTH=   53.0   LENGTH=   30.0   HEIGHT=   12.0
  SOUTHWEST CORNER (X,Y,Z)=     -25.5   -21.5    -1.0
  REFLECTANCES=   .500  .500  .500  .500  .200
  WEST WALL DISPLACEMENT FROM TRUE NORTH=    0.0

GROUND REFLECTANCE=  .200

DAYLIGHTING PARAMETERS:
   36.83  LATITUDE
   76.17  LONGITUDE
   75.00  LONGITUDE AT CENTER OF TIME ZONE
     253  WEATHER STATION ID
 0 0 0 0 1 1 1 1 1 1 0 0  DAYLIGHT SAVINGS TIME MAP

LUMINAIRE TYPE # 1
  HB42       PHOTOMETRIC FILE NAME
     6300.  INITIAL LAMP LUMENS
      .900  LIGHT LOSS FACTOR
      2.00  LUMINAIRE WIDTH
      4.50  LUMINAIRE LENGTH
      0.00  LUMINAIRE HEIGHT
 MINIMUM GAIN=   .300    QUADRATIC COEFFICIENTS (WATTS VS. GAIN):
                                 0.0000      90.0000      0.0000
 WATTS PER LUMINAIRE =   90.

    -LUMINAIRE LOCATION DETAILS-
  #     X      Y      Z  BEARING   TILT   CANT
  -     -      -      -  -------   ----   ----
  1    5.25   2.83   9.00   90.0    0.0    0.0
  2    5.25   5.67   9.00   90.0    0.0    0.0

LUMINAIRE CONTROL METHOD:  CONTINUOUS
 CONTROL VALUES:  1000.0
```

CONTROL CRITERION: MINIMUM ILLUM. ON TARGET PTS.

WEATHER STATION NORFOLK, VIRGINIA

SUMMARY OF CALCULATIONS FOR: 31 DECEMBER TIME= 3:00   SKIES: OVERCAST

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN: 0.0   SKY: .0

```
SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85,  UPDATED 2/14/85
*******************************************

            HORIZONTAL ILLUMINATION

           UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

   6.4   49.2  62.9  49.4

   4.3   55.2  71.4  55.0

   2.1   49.5  62.6  48.7

          2.6   5.3   7.9
                <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     56.0    71.4    48.7      6.4
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
    HORIZONTAL ILLUMINATION

 75.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    49.5
 80.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    49.4
 85.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    49.4
 90.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    49.2
 95.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    49.2
 99.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE    49.2
```

```
-----------------------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: CLEAR

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:       .0
```

```
SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85,  UPDATED 2/14/85
*********************************************

             HORIZONTAL ILLUMINATION

            UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

   6.4   49.2  62.9  49.4

   4.3   55.2  71.4  55.0

   2.1   49.5  62.6  48.7

          2.6   5.3   7.9
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     56.0    71.4    48.7      6.4
```

```
--- STATISTICAL OCCURRENCE LEVELS FOR:
      HORIZONTAL ILLUMINATION

  75.0   OF     9 CALCULATION VALUES ARE AT OR ABOVE    49.5
  80.0   OF     9 CALCULATION VALUES ARE AT OR ABOVE    49.4
  85.0   OF     9 CALCULATION VALUES ARE AT OR ABOVE    49.4
  90.0   OF     9 CALCULATION VALUES ARE AT OR ABOVE    49.2
  95.0   OF     9 CALCULATION VALUES ARE AT OR ABOVE    49.2
  99.0   OF     9 CALCULATION VALUES ARE AT OR ABOVE    49.2
```

```
------------------------------------------------------------
   SUMMARY OF CALCULATIONS FOR:  31 DECEMBER  TIME=  3:00   SKIES: PARTLY CLDY

ILLUMINANCE ON A HORIZONTAL SURFACE FROM UNOBSTRUCTED SKY AND SUN:
SUN:     0.0     SKY:       .0
```

```
SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
HORIZONTAL ILLUM. TEST- WITH FENESTRATION, IN ANALYSIS MODE, AT NIGHT
CREATED 2/14/85,  UPDATED 2/14/85
*******************************************

            HORIZONTAL ILLUMINATION

           UNITS ARE FOOTCANDLES

 3.00 = HEIGHT OF CALCULATION POINTS ABOVE FLOOR

  -Y-

   6.4   49.2  62.9  49.4

   4.3   55.2  71.4  55.0

   2.1   49.5  62.6  48.7

          2.6   5.3   7.9
               <---- X ----

  AVERAGE MAXIMUM MINIMUM  MEAN DEV.
     56.0    71.4    48.7      6.4
```

--- STATISTICAL OCCURRENCE LEVELS FOR:
HORIZONTAL ILLUMINATION

```
75.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE   49.5
80.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE   49.4
85.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE   49.4
90.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE   49.2
95.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE   49.2
99.0   OF    9 CALCULATION VALUES ARE AT OR ABOVE   49.2
```

Table 7. CEL-1 Input Files for BLAST/CEL-1

```
ROOM
  SAMPLE TEST BUILDING
  ZONE 1  WEST CLASSROOM
  BLAST/CEL-1 INPUT DATA DECK
  CREATED  2/14/85,  UPDATED 2/14/85
********************************************
    1 1
    17 4  30 4  9 2
    0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
    4 4  3.4 13.6  6 24 3 4
    0
FENESTRATION
WINDOW
    1 0.4
    24 5
    1
    1 0 3 2.5
BUILDING
    1
    0 0 -1  53 30 12
    0.5 0.5 0.5 0.5 0.2
    0
GROUND
    0.2
    0
PROFILE
    36.83 76.17 75.0 253
    0 0 0 0 1 1 1 1 1 1 0 0
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
LUMINAIRES
HB42
   6300 0.9
    2.0 4.5 0.0 90
    0.3 0.0 90 0.0
    6
    1  5.67  7.5 9.0 0.0 0.0 0.0
    2  5.67 15.0 9.0 0.0 0.0 0.0
    3  5.67 22.5 9.0 0.0 0.0 0.0
    4 11.33  7.5 9.0 0.0 0.0 0.0
    5 11.33 15.0 9.0 0.0 0.0 0.0
    6 11.33 22.5 9.0 0.0 0.0 0.0
DIMMING
       -3
    38.7
    1 0 0 0 0
    0 0 0 0 0 0 0
    0
    6
    1 2 3 4 5 6
CALCULATE
BLS
```

```
ROOM
SAMPLE TEST BUILDING
ZONE 2  EAST CLASSROOM
BLAST/CEL-1 INPUT DATA DECK
CREATED  2/14/85,  UPDATED 2/14/85
********************************************
  1 1
  17 4  30 4  9 2
  0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
  4 4 3.4 13.6 6 24 3 4
  0
FENESTRATION
WINDOW
  1 0.4
  24 5
  1
  3 17 3 2.5
BUILDING
  1
  -36 0 -1 53 30 12
  0.5 0.5 0.5 0.5 0.2
  0
GROUND
  0.2
  0
PROFILE
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
LUMINAIRES
HB42
  6300 0.9
  2.0 4.5 0.0 90
  0.3 0.0 90 0.0
  6
  1  5.67  7.5 9.0 0.0 0.0 0.0
  2  5.67 15.0 9.0 0.0 0.0 0.0
  3  5.67 22.5 9.0 0.0 0.0 0.0
  4 11.33  7.5 9.0 0.0 0.0 0.0
  5 11.33 15.0 9.0 0.0 0.0 0.0
  6 11.33 22.5 9.0 0.0 0.0 0.0
DIMMING
  -3
  38.4
  1 0 0 0 0
  0 0 0 0 0 0 0
  0
  6
  1 2 3 4 5 6
CALCULATE
BLS
```

```
ROOM
SAMPLE TEST BUILDING
ZONE 3  OFFICE
BLAST/CEL-1 INPUT DATA DECK
CREATED  2/14/85,  UPDATED 2/14/85
*******************************************
  1 1
  10.5 3  10 3  9 2
  0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
  3 3 2.6  7.9 2.5 7.5  3 4
  0
FENESTRATION
WINDOW
  1 0.4
  9.5 5
  1
  4 1 0 2.5
BUILDING
  1
  -25.5 0 -1  53 30 12
  0.5 0.5 0.5 0.5 0.2
  0
GROUND
  0.2
  0
PROFILE
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
LUMINAIRES
HB42
  6300 0.9
  2.0 4.5 0.0 90
  0.3 0.0 90 0.0
  2
  1 5.25 3.33 9.0 90 0 0
  2 5.25 6.67 9.0 90 0 0
DIMMING
  -3
  45.2
  1 0 0 0 0
  0 0 0 0 0 0 0
  0
  2
  1 2
CALCULATE
BLS
```

```
ROOM
SAMPLE TEST BUILDING
ZONE 4  EQUIPMENT AND MAINTENANCE
BLAST/CEL-1 RUN
CREATED 2/14/85,  UPDATED 2/14/85
********************************************
  1 1
  10.5 3  8.5 3  9 2
  0.5 0.5 0.5 0.5 0.2 0.8
TASK
UNKNOWN
  3 3 2.6  7.9 2.1 6.4  3 4
  0
FENESTRATION
WINDOW
  1 0.4
  6.0 5
  1
  2 4.0 8.5 2.5
BUILDING
  1
  -25.5 -21.5 -1  53 30 12
  0.5 0.5 0.5 0.5 0.2
  0
GROUND
  0.2
  0
PROFILE
  36.83 76.17 75.0 253
  0 0 0 0 1 1 1 1 1 1 0 0
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0
LUMINAIRES
HB42
  6300 0.9
  2.0 4.5 0.0 90
  0.3 0.0 90 0.0
  2
  1 5.25 2.83 9.0 90 0 0
  2 5.25 5.67 9.0 90 0 0
DIMMING
  -3
  48.7
  1 0 0 0 0
  0 0 0 0 0 0 0
  0
  2
  1 2
CALCULATE
BLS
```

BLAST -- BUILDING LOADS ANALYSIS AND SYSTEM THERMODYNAMICS

TRADEMARK
APPLIED FOR

```
**************************************************
*                                                *
*   A U.S. ARMY CORPS OF ENGINEERS PROGRAM       *
*                                                *
*                     BY                         *
*                                                *
*   CONSTRUCTION ENGINEERING RESEARCH LABORATORY *
*        P.O. BOX 4005                           *
*        CHAMPAIGN, ILLINOIS  61820              *
*                                                *
**************************************************
```

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Table 8. Output from BLAST/CEL-1 Simulation

```
BEGIN INPUT;
  RUN CONTROL: NEW ZONES,
               REPORTS(ZONE LOADS,26),
               UNITS(ENGLISH);
  PROJECT = "SAMPLE BUILDING TEST";
  LOCATION = NORFOLK;
  WEATHER TAPE FROM 01 JAN 51 THRU 31 DEC 51;
  GROUND TEMPERATURES=(55,55,55,58,64,71,73,74,71,67,61,57);
  BEGIN BUILDING DESCRIPTION;
    BUILDING = "DELIVERY RETRAINING DETACHMENT BUILDING";
    DIMENSIONS: W = 53,L = 30,H = 11;
    NORTH AXIS = 0;
    SOLAR DISTRIBUTION = -1;
    ZONE 1 "WEST CLASSROOM":
      ORIGIN: (0,0,0);
      NORTH AXIS = 0;
      EXTERIOR WALLS:
        STARTING AT (0,30,0) FACING (270)
          EXTWALL28(L BY H)
        WITH WINDOWS OF TYPE
        DOUBLE PANE WINDOW
        (24 BY 5) AT (0,3.5),
        STARTING AT (17,30,0) FACING (0)
          EXTWALL28(17 BY H),
        STARTING AT (0,0,0) FACING (180)
          EXTWALL28(17 BY H);
      PARTITIONS:
        STARTING AT (17,0,0) FACING (90)
```

```
          PARTITION23(L BY H);
      ROOFS:
        STARTING AT (0,0,H) FACING (180)
          ROOF17(17 BY L);
      SLAB ON GRADE FLOOR:
        STARTING AT (0,30,0) FACING (180)
          FLOOR SLAB 4 IN (17 BY 30);
      PEOPLE = 15,OFFICE OCCUPANCY;
      INFILTRATION =200, CONSTANT;
      LIGHTS =  1.843, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
      ELECTRIC EQUIPMENT = 1.00,CONSTANT;
      CONTROLS = DEAD BAND;
    END ZONE;
    ZONE 2 "EAST CLASSROOM":
      ORIGIN: (36,0,0);
      NORTH AXIS = 0;
      EXTERIOR WALLS:
        STARTING AT (17,0,0) FACING (90)
          EXTWALL28(L BY H)
            WITH WINDOWS OF TYPE
            DOUBLE PANE WINDOW
            (24 BY 5) AT (0,3.5),
        STARTING AT (17,30,0) FACING (0)
          EXTWALL28(17 BY H),
        STARTING AT (0,0,0) FACING (180)
          EXTWALL28(17 BY H);
      PARTITIONS:
        STARTING AT (0,30,0) FACING (270)
```

```
        PARTITION23(L BY H);
    ROOFS:
      STARTING AT (0,0,H) FACING (180)
        ROOF17(17 BY L);
    SLAB ON GRADE FLOOR:
      STARTING AT (0,30,0) FACING (180)
        FLOOR SLAB 4 IN (17 BY 30);
    PEOPLE = 15,OFFICE OCCUPANCY;
    INFILTRATION =200, CONSTANT;
    LIGHTS =  1.843, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
    ELECTRIC EQUIPMENT = 1.00,CONSTANT;
    CONTROLS = DEAD BAND;
  END ZONE;
  ZONE 3 "OFFICE":
    ORIGIN: (25.5,0,0);
    NORTH AXIS = 0;
    EXTERIOR WALLS:
      STARTING AT (0,0,0) FACING (180)
        EXTWALL28(10.5 BY H)
      WITH WINDOWS OF TYPE
      DOUBLE PANE WINDOW (9.5 BY 5) AT (0,3.5);
    PARTITIONS:
      STARTING AT (0,10,0) FACING (270)
        PARTITION23(10 BY H),
      STARTING AT (10.5,10,0) FACING (0)
        PARTITION23(10.5 BY H),
      STARTING AT (10.5,0,0) FACING (90)
        PARTITION23(10 BY H);
```

```
        ROOFS:
          STARTING AT (0,0,H) FACING (180)
           ROOF17(10.5 BY 10);
      SLAB ON GRADE FLOOR:
          STARTING AT (0,10.0,0) FACING (180)
            FLOOR SLAB 4 IN (10.5 BY 10);
        PEOPLE = 2,OFFICE OCCUPANCY;
        INFILTRATION =50, CONSTANT;
        LIGHTS = 0.614, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
        ELECTRIC EQUIPMENT = 0.36,CONSTANT;
        CONTROLS = DEAD BAND;
      END ZONE;
      ZONE 4 "EQUIPMENT MAINTAINANCE":
        ORIGIN: (25.5,21.5,0);
        NORTH AXIS = 0;
        EXTERIOR WALLS:
          STARTING AT (10.5,8.5,0) FACING (0)
            EXTWALL28(10.5 BY H)
          WITH WINDOWS OF TYPE
          DOUBLE PANE WINDOW (6 BY 5) AT (0.5,3.5);
        PARTITIONS:
          STARTING AT (10.5,0,0) FACING (90)
            PARTITION23(8.5 BY H),
          STARTING AT (0,0,0) FACING (180)
            PARTITION23(10.5 BY H),
          STARTING AT (0,8.5,0) FACING (270)
            PARTITION23(8.5 BY H);
        ROOFS:
```

```
      STARTING AT (0,0,H) FACING (180)
       ROOF17(10.5 BY 8.5);
    SLAB ON GRADE FLOOR:
      STARTING AT (0,8.5,0) FACING (180)
        FLOOR SLAB 4 IN (10.5 BY 8.5);
    PEOPLE = 1,OFFICE OCCUPANCY;
    INFILTRATION =50, CONSTANT;
    LIGHTS = 0.614, OFFICE LIGHTING, 90 PERCENT REPLACEABLE;
    ELECTRIC EQUIPMENT = 0.55,CONSTANT;
    CONTROLS = DEAD BAND;
  END ZONE;
  ZONE 5 "MECHANICAL EQUIPMENT":
    ORIGIN: (17,21.5,0);
    NORTH AXIS = 0;
    EXTERIOR WALLS:
      STARTING AT (8.5,8.5,0) FACING (0)
        EXTWALL28(8.5 BY H);
    PARTITIONS:
      STARTING AT (8.5,0,0) FACING (90)
        PARTITION23(8.5 BY H),
      STARTING AT (0,0,0) FACING (180)
        PARTITION23(8.5 BY H),
      STARTING AT (0,8.5,0) FACING (270)
        PARTITION23(8.5 BY H);
    ROOFS:
      STARTING AT (0,0,H) FACING (180)
        ROOF17(8.5 BY 8.5);
    SLAB ON GRADE FLOOR:
```

```
      STARTING AT (0,8.5,0) FACING (180)
        FLOOR SLAB 4 IN (8.5 BY 8.5);
    PEOPLE = 1,OFFICE OCCUPANCY;
    INFILTRATION =25, CONSTANT;
    LIGHTS = 0.614, OFFICE LIGHTING;
    ELECTRIC EQUIPMENT = 1.00,CONSTANT;
    CONTROLS = DEAD BAND;
  END ZONE;
  ZONE 6 "LOBBY":
    ORIGIN: (17.0,0);
    NORTH AXIS = 0;
    EXTERIOR WALLS:
      STARTING AT (0,0,0) FACING (180)
        EXTWALL28(8.5 BY H);
    PARTITIONS:
      STARTING AT (0,21.5,0) FACING (270)
        PARTITION23(21.5 BY H),
      STARTING AT (19,21.5,0) FACING (0)
        PARTITION23(19 BY H),
      STARTING AT (19,10,0) FACING (90)
        PARTITION23(11.5 BY H),
      STARTING AT (8.5,10,0) FACING (180)
        PARTITION23(10.5 BY H),
      STARTING AT (8.5,0,0) FACING (90)
        PARTITION23(10 BY H);
    ROOFS:
      STARTING AT (0,0,H) FACING (180)
       ROOF17(8.5 BY 10),
```

```
      STARTING AT (0,10,H) FACING (180)
       ROOF17(19 BY 11.5);
    SLAB ON GRADE FLOOR:
      STARTING AT (0,21.5,0) FACING (180)
        FLOOR SLAB 4 IN (19 BY 11.5),
      STARTING AT (0,10,0) FACING (180)
        FLOOR SLAB 4 IN (8.5 BY 10);
    PEOPLE = 2,OFFICE OCCUPANCY;
    INFILTRATION =50, CONSTANT;
    LIGHTS = 0.614, OFFICE LIGHTING;
    ELECTRIC EQUIPMENT = 0.55,CONSTANT;
    CONTROLS = DEAD BAND;
  END ZONE;
END BUILDING DESCRIPTION;
```

```
  REPORTING WILL BE DONE IN UNITS ENGLISH

  SIMULATIONS ARE ALLOWED FOR TYPES% ZONES

         1 BUILDING SIMULATIONS WILL BE ATTEMPTED

       SIMULATIONS WILL BE ATTEMPTED FOR   6 ZONES

NEW BLDFL AND AHLDFL FILES WILL BE CREATED
     FROM USER INPUT, AS NFCESSARY

    LOCATION TAKEN FROM ATTACHED WTHRFL
    TITLE=    NORFOLK, VA   TRY    1951             LAT= 36.83000 LONG= 76.17000 TIME ZONE= 5.0

 * * * * *
 BLDFL FOR
  SAMPLE BUILDING TEST


 LOCATION    NORFOLK, VA   TRY    1951             LAT=  36.83000 LONG=  76.17000 TIME ZONE= 5.0
 DATE OF FILE CREATE/UPDATE  8 MAR 85 NUMBER OF ENVIRONMENTS  1
 NUMBER OF ZONES  6 WITH ZONE NUMBERS
  1    2    3    4    5    6

   ENVIRONMENT NUMBER  1 FOR BLDFL  TITLE IS    NORFOLK, VA   TRY    1951
    WEATHER STATION  13737 START DATE OF  1 JAN 1951 NO. OF DAYS 365
    WITH GROUND TEMPERATURES  JAN =55.00 FEB =55.00 MAR =55.00 APR =58.00 MAY =64.00 JUN =71.00
                              JUL =73.00 AUG =74.00 SEP =71.00 OCT =67.00 NOV =61.00 DEC =57.00
    WITH MAKE UP WATER TEMPERATURES  JAN =55.00 FEB =55.00 MAR =55.00 APR =55.00 MAY =55.00 JUN =55.00
                              JUL =55.00 AUG =55.00 SEP =55.00 OCT =55.00 NOV =55.00 DEC =55.00
```

```
   TEMPERATURE CONTROL PROFILES --

1 --                   40        50        60        70        80        90       100
                        +         +         +         +         +         +         +

( 68.00/ 1.00)   +1.0   XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +1.0
( 68.02/ 0.00)          XXXXXXXXXXXXXXXXXXXXXXXXXXXX
( 78.00/ 0.00)   +0.8   XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +0.8
( 78.02/-1.00)          XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                 +0.6   XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +0.6
                 HEAT   XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   HEAT
                 +0.4   XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +0.4
                        XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                 +0.2   XXXXXXXXXXXXXXXXXXXXXXXXXXXX                                   +0.2
                        XXXXXXXXXXXXXXXXXXXXXXXXXXXX
                  0.0   -------------------------------------------------------------   0.0
                                                               XXXXXXXXXXXXXXXXXXXXXX
                 -0.2                                          XXXXXXXXXXXXXXXXXXXXXX  -0.2
                                                               XXXXXXXXXXXXXXXXXXXXXX
                 -0.4                                          XXXXXXXXXXXXXXXXXXXXXX  -0.4
                 COOL                                          XXXXXXXXXXXXXXXXXXXXXX  COOL
                 -0.6                                          XXXXXXXXXXXXXXXXXXXXXX  -0.6
                                                               XXXXXXXXXXXXXXXXXXXXXX
                 -0.8                                          XXXXXXXXXXXXXXXXXXXXXX  -0.8
                                                               XXXXXXXXXXXXXXXXXXXXXX
                 -1.0                                          XXXXXXXXXXXXXXXXXXXXXX  -1.0
                        +         +         +         +         +         +         +

   GENERAL SCHEDULE PROFILES --

1 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 +                                   XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 + 100
    +                                   XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +
 80 +                                   XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +  80
    +                                   XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +
 60 +                                   XXXXXXXXXXXXXXXX    XXXXXXXXXXXX                                 +  60
    +                               XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
 40 +                               XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  40
    +                               XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
 20 +                               XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  20
    +                           XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

        0   0   0   0   0   0  10  50 100 100 100 100  50 100 100 100  50  10   0   0   0   0   0   0
```

```
3 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX + 100
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 80 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  80
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 60 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  60
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 40 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  40
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
 20 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +  20
    + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

      100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100 100

4 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             + 100
    +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
 80 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  80
    +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +
 60 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                             +  60
    +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
 40 +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +  40
    +                             XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
 20 +                         XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +  20
    +                         XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX                         +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

        5   5   5   5   5   5  20 100 100 100 100 100 100 100 100 100 100  50   5   5   5   5   5   5

5 --    1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24

100 +                                                                                                  + 100
    +                                                                                                  +
 80 +                                                                                                  +  80
    +                                                                                                  +
 60 +                                                                                                  +  60
    +                                                                                                  +
 40 +                                                                                                  +  40
    +                                                                                                  +
 20 +                                                                                                  +  20
    +                                                                                                  +
  0 + XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX +   0

        5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5   5
```

DESCRIPTION OF ZONE 1% WEST CLASSROOM DELIVERY RETRAINING DETACHMENT BUILDING

NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
1	EXTERIOR WALL	210.0	.133	270.0	90.0	EXTWALL28
2	WINDOW	120.0	.553			DOUBLE PANE WINDOW
3	EXTERIOR WALL	187.0	.133	0.0	90.0	EXTWALL28
4	EXTERIOR WALL	187.0	.133	180.0	90.0	EXTWALL28
5	PARTITION	330.0	.389	90.0	90.0	PARTITION23
6	ROOF	510.0	.094	180.0	0.0	ROOF17
7	SLAB ON GRADE FLOOR	510.0	.091	180.0	180.0	FLOOR SLAB 4 IN

EXTERIOR SURFACE AREA = 1214.00 AVERAGE U-VALUE = .158

ZONE FLOOR AREA= 510.00 FT**2

APPROXIMATE ZONE VOLUME = 5837.8 FT**3 AIR HEAT CAPACITY = 112.423 BTU/DEG F

GENERAL SCHEDULES DATA:

		SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE:	1.500E+01 FROM 1JAN THRU 31DEC 4.500E+02 BTUH ACTIVITY LEVEL, 70.0\ RADIANT	2	1	1	1	1	1	2	2	2	2	2	2
INFILTRATION:	2.000E+02 CFM FROM 1JAN THRU 31DEC MODIFIER = .60600 + .02020*DT + .00060*V + 0.00000*V**2	3	3	3	3	3	3	3	3	3	3	3	3
LIGHTS:	1.843E+03 BTUH FROM 1JAN THRU 31DEC 0.0\ RETURN AIR, 20.0\ RADIANT, 20.0\ VISIBLE, 90.0\ REPLACEABLE	5	4	4	4	4	4	5	5	5	5	5	5
ELECTRIC EQUIPMENT:	1.000E+03 BTUH FROM 1JAN THRU 31DEC 0.0\ LATENT, 30.0\ RADIANT, 0.0\ LOST	3	3	3	3	3	3	3	3	3	3	3	3

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.414E+09 BTUH COOLING CAPACITY = 3.414E+09 BTUH 0.0\ RADIANT, FROM 1JAN THRU 31DEC

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MON	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TUE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
THU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FRI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HOL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

DESCRIPTION OF ZONE 2% EAST CLASSROOM DELIVERY RETRAINING DETACHMENT BUILDING

NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
8	EXTERIOR WALL	210.0	.133	90.0	90.0	EXTWALL28
9	WINDOW	120.0	.553			DOUBLE PANE WINDOW
10	EXTERIOR WALL	187.0	.133	0.0	90.0	EXTWALL28
11	EXTERIOR WALL	187.0	.133	180.0	90.0	EXTWALL28
12	PARTITION	330.0	.389	270.0	90.0	PARTITION23
13	ROOF	510.0	.094	180.0	0.0	ROOF17
14	SLAB ON GRADE FLOOR	510.0	.091	180.0	180.0	FLOOR SLAB 4 IN

EXTERIOR SURFACE AREA = 1214.00 AVERAGE U-VALUE = .158

ZONE FLOOR AREA= 510.00 FT**2

APPROXIMATE ZONE VOLUME = 5837.8 FT**3 AIR HEAT CAPACITY = 112.423 BTU/DEG F

GENERAL SCHEDULES DATA:

			SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE:	1.500E+01	FROM 1JAN THRU 31DEC	2	1	1	1	1	1	2	2	2	2	2	2
	4.500E+02 BTUH ACTIVITY LEVEL, 70.0% RADIANT													
INFILTRATION:	2.000E+02 CFM	FROM 1JAN THRU 31DEC	3	3	3	3	3	3	3	3	3	3	3	3
	MODIFIER = .60600 + .02020*DT + .00060*V + 0.00000*V**2													
LIGHTS:	1.843E+03 BTUH	FROM 1JAN THRU 31DEC	5	4	4	4	4	4	5	5	5	5	5	5
	0.0% RETURN AIR, 20.0% RADIANT, 20.0% VISIBLE, 90.0% REPLACEABLE													
ELECTRIC EQUIPMENT:	1.000E+03 BTUH	FROM 1JAN THRU 31DEC	3	3	3	3	3	3	3	3	3	3	3	3
	0.0% LATENT, 30.0% RADIANT, 0.0% LOST													

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.414E+09 BTUH COOLING CAPACITY = 3.414E+09 BTUH 0.0% RADIANT, FROM 1JAN THRU 31DEC

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MON	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TUE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
THU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FRI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HOL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

DESCRIPTION OF ZONE 3% OFFICE DELIVERY RETRAINING DETACHMENT BUILDING

NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
15	EXTERIOR WALL	68.0	.133	180.0	90.0	EXTWALL28
16	WINDOW	47.5	.553			DOUBLE PANE WINDOW
17	PARTITION	110.0	.389	270.0	90.0	PARTITION23
18	PARTITION	115.5	.389	0.0	90.0	PARTITION23
19	PARTITION	110.0	.389	90.0	90.0	PARTITION23
20	ROOF	105.0	.094	180.0	0.0	ROOF17
21	SLAB ON GRADE FLOOR	105.0	.091	180.0	180.0	FLOOR SLAB 4 IN

EXTERIOR SURFACE AREA = 220.50 AVERAGE U-VALUE = .205

ZONE FLOOR AREA= 105.00 FT**2

APPROXIMATE ZONE VOLUME = 1155.3 FT**3 AIR HEAT CAPACITY = 22.250 BTU/DEG F

GENERAL SCHEDULES DATA:

			SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE:	2.000E+00 4.500E+02 BTUH ACTIVITY LEVEL, 70.0\ RADIANT	FROM 1JAN THRU 31DEC	2	1	1	1	1	1	2	2	2	2	2	2
INFILTRATION:	5.000E+01 CFM MODIFIER = .60600 + .02020*DT + .00060*V + 0.00000*V**2	FROM 1JAN THRU 31DEC	3	3	3	3	3	3	3	3	3	3	3	3
LIGHTS:	6.140E+02 BTUH 0.0\ RETURN AIR, 20.0\ RADIANT, 20.0\ VISIBLE, 90.0\ REPLACEABLE	FROM 1JAN THRU 31DEC	5	4	4	4	4	4	5	5	5	5	5	5
ELECTRIC EQUIPMENT:	3.600E+02 BTUH 0.0\ LATENT, 30.0\ RADIANT, 0.0\ LOST	FROM 1JAN THRU 31DEC	3	3	3	3	3	3	3	3	3	3	3	3

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.414E+09 BTUH COOLING CAPACITY = 3.414E+09 BTUH 0.0\ RADIANT, FROM 1JAN THRU 31DEC

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MON	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TUE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
THU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FRI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HOL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

DESCRIPTION OF ZONE 4% EQUIPMENT MAINTAINANCE DELIVERY RETRAINING DETACHMENT BUILDING

NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
22	EXTERIOR WALL	85.5	.133	0.0	90.0	EXTWALL28
23	WINDOW	30.0	.553			DOUBLE PANE WINDOW
24	PARTITION	93.5	.389	90.0	90.0	PARTITION23
25	PARTITION	115.5	.389	180.0	90.0	PARTITION23
26	PARTITION	93.5	.389	270.0	90.0	PARTITION23
27	ROOF	89.3	.094	180.0	0.0	ROOF17
28	SLAB ON GRADE FLOOR	89.3	.091	180.0	180.0	FLOOR SLAB 4 IN

EXTERIOR SURFACE AREA = 204.75 AVERAGE U-VALUE = .177

ZONE FLOOR AREA= 89.25 FT**2

APPROXIMATE ZONE VOLUME = 987.2 FT**3 AIR HEAT CAPACITY = 19.012 BTU/DEG F

GENERAL SCHEDULES DATA:	SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE: 1.000E+00 FROM 1JAN THRU 31DEC 4.500E+02 BTUH ACTIVITY LEVEL, 70.0\ RADIANT	2	1	1	1	1	1	2	2	2	2	2	2
INFILTRATION: 5.000E+01 CFM FROM 1JAN THRU 31DEC MODIFIER = .60600 + .02020*DT + .00060*V + 0.00000*V**2	3	3	3	3	3	3	3	3	3	3	3	3
LIGHTS: 6.140E+02 BTUH FROM 1JAN THRU 31DEC 0.0\ RETURN AIR, 20.0\ RADIANT, 20.0\ VISIBLE, 90.0\ REPLACEABLE	5	4	4	4	4	4	5	5	5	5	5	5
ELECTRIC EQUIPMENT: 5.500E+02 BTUH FROM 1JAN THRU 31DEC 0.0\ LATENT, 30.0\ RADIANT, 0.0\ LOST	3	3	3	3	3	3	3	3	3	3	3	3

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.414E+09 BTUH COOLING CAPACITY = 3.414E+09 BTUH 0.0\ RADIANT, FROM 1JAN THRU 31DEC

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MON	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TUE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
THU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FRI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HOL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

DESCRIPTION OF ZONE 5% MECHANICAL EQUIPMENT DELIVERY RETRAINING DETACHMENT BUILDING

NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
29	EXTERIOR WALL	93.5	.133	0.0	90.0	EXTWALL28
30	PARTITION	93.5	.389	90.0	90.0	PARTITION23
31	PARTITION	93.5	.389	180.0	90.0	PARTITION23
32	PARTITION	93.5	.389	270.0	90.0	PARTITION23
33	ROOF	72.3	.094	180.0	0.0	ROOF17
34	SLAB ON GRADE FLOOR	72.3	.091	180.0	180.0	FLOOR SLAB 4 IN

EXTERIOR SURFACE AREA = 165.75 AVERAGE U-VALUE = .116

ZONE FLOOR AREA= 72.25 FT**2

APPROXIMATE ZONE VOLUME = 794.8 FT**3 AIR HEAT CAPACITY = 15.305 BTU/DEG F

GENERAL SCHEDULES DATA:

		SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE:	1.000E+00 FROM 1JAN THRU 31DEC 4.500E+02 BTUH ACTIVITY LEVEL, 70.0\ RADIANT	2	1	1	1	1	1	2	2	2	2	2	2
INFILTRATION:	2.500E+01 CFM FROM 1JAN THRU 31DEC MODIFIER = .60600 + .02020*DT + .00060*V + 0.00000*V**2	3	3	3	3	3	3	3	3	3	3	3	3
LIGHTS:	6.140E+02 BTUH FROM 1JAN THRU 31DEC 0.0\ RETURN AIR, 20.0\ RADIANT, 20.0\ VISIBLE, 0.0\ REPLACEABLE	5	4	4	4	4	4	5	5	5	5	5	5
ELECTRIC EQUIPMENT:	1.000E+03 BTUH FROM 1JAN THRU 31DEC 0.0\ LATENT, 30.0\ RADIANT, 0.0\ LOST	3	3	3	3	3	3	3	3	3	3	3	3

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.414E+09 BTUH COOLING CAPACITY = 3.414E+09 BTUH 0.0\ RADIANT, FROM 1JAN THRU 31DEC

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MON	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TUE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
THU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FRI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HOL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

DESCRIPTION OF ZONE 6% LOBBY DELIVERY RETRAINING DETACHMENT BUILDING

NUMBER	TYPE OF SURFACE / TYPE OF SUBSURFACE	AREA	U	AZM	TILT	CONSTRUCTION
35	EXTERIOR WALL	93.5	.133	180.0	90.0	EXTWALL28
36	PARTITION	236.5	.389	270.0	90.0	PARTITION23
37	PARTITION	209.0	.389	0.0	90.0	PARTITION23
38	PARTITION	126.5	.389	90.0	90.0	PARTITION23
39	PARTITION	115.5	.389	180.0	90.0	PARTITION23
40	PARTITION	110.0	.389	90.0	90.0	PARTITION23
41	ROOF	85.0	.094	180.0	0.0	ROOF17
42	ROOF	218.5	.094	180.0	0.0	ROOF17
43	SLAB ON GRADE FLOOR	218.5	.091	180.0	180.0	FLOOR SLAB 4 IN
44	SLAB ON GRADE FLOOR	85.0	.091	180.0	180.0	FLOOR SLAB 4 IN

EXTERIOR SURFACE AREA = 397.00 AVERAGE U-VALUE = .103

ZONE FLOOR AREA= 303.50 FT**2

APPROXIMATE ZONE VOLUME = 3880.6 FT**3 AIR HEAT CAPACITY = 74.732 BTU/DEG F

GENERAL SCHEDULES DATA:

		SUN	MON	TUE	WED	THU	FRI	SAT	HOL	SP1	SP2	SP3	SP4
PEOPLE:	2.000E+00 FROM 1JAN THRU 31DEC 4.500E+02 BTUH ACTIVITY LEVEL, 70.0\ RADIANT	2	1	1	1	1	1	2	2	2	2	2	2
INFILTRATION:	5.000E+01 CFM FROM 1JAN THRU 31DEC MODIFIER = .60600 + .02020*DT + .00060*V + 0.00000*V**2	3	3	3	3	3	3	3	3	3	3	3	3
LIGHTS:	6.140E+02 BTUH FROM 1JAN THRU 31DEC 0.0\ RETURN AIR, 20.0\ RADIANT, 20.0\ VISIBLE, 0.0\ REPLACEABLE	5	4	4	4	4	4	5	5	5	5	5	5
ELECTRIC EQUIPMENT:	5.500E+02 BTUH FROM 1JAN THRU 31DEC 0.0\ LATENT, 30.0\ RADIANT, 0.0\ LOST	3	3	3	3	3	3	3	3	3	3	3	3

CONTROL SCHEDULES DATA:

HEATING CAPACITY = 3.414E+09 BTUH COOLING CAPACITY = 3.414E+09 BTUH 0.0\ RADIANT, FROM 1JAN THRU 31DEC

HOUR:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
SUN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MON	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TUE	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
WED	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
THU	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
FRI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SAT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
HOL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SP4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

LPM TABLE INPUT DATA FOR CALCULATED POINTS

SOLAR ALTITUDES AND AZIMUTHS FOR LATITUDE = 36.8

POINT NUMBER	ALTITUDE	AZIMUTH	MAX ALTITUDE	MIN ALTITUDE	MAX AZIMUTH	MIN AZIMUTH
1	75.0	133.0	90.0	60.0	150.0	0.0
2	75.0	165.0	90.0	60.0	180.0	150.0
3	52.0	110.0	60.0	45.0	120.0	0.0
4	52.0	135.0	60.0	45.0	150.0	120.0
5	52.0	165.0	60.0	45.0	180.0	150.0
6	37.0	97.0	45.0	30.0	105.0	0.0
7	37.0	112.0	45.0	30.0	120.0	105.0
8	37.0	127.0	45.0	30.0	135.0	120.0
9	37.0	142.0	45.0	30.0	150.0	135.0
10	37.0	157.0	45.0	30.0	165.0	150.0
11	37.0	172.0	45.0	30.0	180.0	165.0
12	22.0	80.0	30.0	15.0	90.0	0.0
13	22.0	97.0	30.0	15.0	105.0	90.0
14	22.0	112.0	30.0	15.0	120.0	105.0
15	22.0	127.0	30.0	15.0	135.0	120.0
16	22.0	142.0	30.0	15.0	180.0	135.0
17	7.0	75.0	15.0	0.0	80.0	0.0
18	7.0	85.0	15.0	0.0	90.0	80.0
19	7.0	97.0	15.0	0.0	105.0	90.0
20	7.0	112.0	15.0	0.0	180.0	105.0

POINTS 21 - 40 HAVE THE SAME ALTITUDES BUT NEGATIVE AZIMUTHS TO POINTS 1 - 20

ILLUMINATION POINTS CALCULATED (UNITS LUX)

	OVERCAST SKY	CLEAR AND PARTLY CLOUDY SKY	
POINT NO.	DIFFUSE	DIRECT NORMAL	DIFFUSE
1	1.00	22000.00	46000.00
2	13200.00	15200.00	31700.00
3	17520.00	10000.00	20900.00
4	21840.00	68000.00	43700.00
5	27450.00	54600.00	35000.00
6	33060.00	37600.00	24100.00
7	40530.00	24800.00	15900.00
8	48000.00	76900.00	13200.00
9	53940.00	52900.00	9100.00
10	59880.00	35000.00	5980.00

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              ****************************** LIGHTING POWER MULTIPLIER TABLES FOR ZONE  1******************************

                                                              OVERCAST SKY
     POINT NO.        1         2         3         4         5         6         7         8         9        10
     DIFF ILL.        1.     13200.    17520.    21840.    27450.    33060.    40530.    48000.    53940.    59880.
     LPM            1.00       .30       .30       .30       .30       .30       .30       .30       .30       .30

                                                     CLEAR AND PARTLY CLOUDY SKY
                                         ILLUMINATION AT TABLE POINTS(DIRECT NORMAL,DIFFUSE)
          THETA(Q)  (Q=1 IS ALL DIFFUSE)
                1     (     0.,     1.)    (     0.,21840.)    (     0.,33060.)    (     0.,48000.)    (     0.,59880.)
                2     (     0.,     1.)    (10000.,20900.)    (15200.,31700.)    (22000.,46000.)    (68000.,43700.)
                3     (     0.,     1.)    (24800.,15900.)    (37600.,24100.)    (54600.,35000.)    (68000.,43700.)
                4     (     0.,     1.)    (35000., 5980.)    (52900., 9100.)    (76900.,13200.)    (68000.,43700.)
                5     (     0.,     1.)    (35000., 5980.)    (52900., 9100.)    (76900.,13200.)    (68000.,43700.)
                  RADIUS     1                    2                   3                   4                   5

 BOX  1      1 1.00  .30  .30  .30  .30    BOX  2      1 1.00  .30  .30  .30  .30    BOX  3      1 1.00  .30  .30  .30  .30
 ELEV        2 1.00  .37  .30  .30  .30    ELEV        2 1.00  .37  .30  .30  .30    ELEV        2 1.00  .43  .30  .30  .30
 75.0      Q=3 1.00  .40  .30  .30  .30    75.0      Q=3 1.00  .37  .30  .30  .30    52.0      Q=3 1.00  .47  .37  .30  .30
 AZ          4 1.00  .47  .37  .30  .30    AZ          4 1.00  .47  .37  .30  .30    AZ          4 1.00  .57  .48  .37  .30
  133.       5 1.00  .47  .37  .30  .30     165.       5 1.00  .47  .37  .30  .30     110.       5 1.00  .57  .48  .37  .30
               R=1   2    3    4    5                    R=1   2    3    4    5                    R=1   2    3    4    5

 BOX  4      1 1.00  .30  .30  .30  .30    BOX  5      1 1.00  .30  .30  .30  .30    BOX  6      1 1.00  .30  .30  .30  .30
 ELEV        2 1.00  .40  .30  .30  .30    ELEV        2 1.00  .37  .30  .30  .30    ELEV        2 1.00  .43  .33  .30  .30
 52.0      Q=3 1.00  .43  .33  .30  .30    52.0      Q=3 1.00  .38  .30  .30  .30    37.0      Q=3 1.00  .48  .40  .30  .30
 AZ          4 1.00  .55  .47  .33  .30    AZ          4 1.00  .48  .40  .30  .30    AZ          4 1.00  .62  .47  .40  .30
  135.       5 1.00  .55  .47  .33  .30     165.       5 1.00  .48  .40  .30  .30      97.       5 1.00  .62  .47  .40  .30
               R=1   2    3    4    5                    R=1   2    3    4    5                    R=1   2    3    4    5

 BOX  7      1 1.00  .30  .30  .30  .30    BOX  8      1 1.00  .30  .30  .30  .30    BOX  9      1 1.00  .30  .30  .30  .30
 ELEV        2 1.00  .43  .33  .30  .30    ELEV        2 1.00  .43  .32  .30  .30    ELEV        2 1.00  .40  .30  .30  .30
 37.0      Q=3 1.00  .48  .38  .30  .30    37.0      Q=3 1.00  .47  .37  .30  .30    37.0      Q=3 1.00  .43  .35  .30  .30
 AZ          4 1.00  .62  .47  .40  .30    AZ          4 1.00  .60  .47  .40  .30    AZ          4 1.00  .57  .43  .37  .30
  112.       5 1.00  .62  .47  .40  .30     127.       5 1.00  .60  .47  .40  .30     142.       5 1.00  .57  .43  .37  .30
               R=1   2    3    4    5                    R=1   2    3    4    5                    R=1   2    3    4    5

 BOX 10      1 1.00  .30  .30  .30  .30    BOX 11      1 1.00  .30  .30  .30  .30    BOX 12      1 1.00  .30  .30  .30  .30
 ELEV        2 1.00  .38  .30  .30  .30    ELEV        2 1.00  .35  .30  .30  .30    ELEV        2 1.00  .43  .33  .30  .30
 37.0      Q=3 1.00  .43  .32  .30  .30    37.0      Q=3 1.00  .38  .30  .30  .30    22.0      Q=3 1.00  .48  .30  .30  .30
 AZ          4 1.00  .55  .43  .33  .30    AZ          4 1.00  .50  .38  .30  .30    AZ          4 1.00  .58  .47  .40  .30
  157.       5 1.00  .55  .43  .33  .30     172.       5 1.00  .50  .38  .30  .30      80.       5 1.00  .58  .47  .40  .30
               R=1   2    3    4    5                    R=1   2    3    4    5                    R=1   2    3    4    5

 BOX 13      1 1.00  .30  .30  .30  .30    BOX 14      1 1.00  .30  .30  .30  .30    BOX 15      1 1.00  .30  .30  .30  .30
 ELEV        2 1.00  .43  .33  .30  .30    ELEV        2 1.00  .43  .32  .30  .30    ELEV        2 1.00  .42  .30  .30  .30
 22.0      Q=3 1.00  .48  .30  .30  .30    22.0      Q=3 1.00  .48  .30  .30  .30    22.0      Q=3 1.00  .47  .30  .30  .30
 AZ          4 1.00  .58  .47  .40  .30    AZ          4 1.00  .58  .47  .40  .30    AZ          4 1.00  .57  .47  .38  .30
   97.       5 1.00  .58  .47  .40  .30     112.       5 1.00  .58  .47  .40  .30     127.       5 1.00  .57  .47  .38  .30
               R=1   2    3    4    5                    R=1   2    3    4    5                    R=1   2    3    4    5

 BOX 16      1 1.00  .30  .30  .30  .30    BOX 17      1 1.00  .30  .30  .30  .30    BOX 18      1 1.00  .30  .30  .30  .30
 ELEV        2 1.00  .40  .30  .30  .30    ELEV        2 1.00  .30  .30  .30  .30    ELEV        2 1.00  .30  .30  .30  .30
 22.0      Q=3 1.00  .45  .30  .30  .30     7.0      Q=3 1.00  .30  .30  .30  .30     7.0      Q=3 1.00  .30  .30  .30  .30
 AZ          4 1.00  .55  .47  .37  .30    AZ          4 1.00  .52  .43  .35  .30    AZ          4 1.00  .52  .43  .37  .30
  142.       5 1.00  .55  .47  .37  .30      75.       5 1.00  .52  .43  .35  .30      85.       5 1.00  .52  .43  .37  .30
               R=1   2    3    4    5                    R=1   2    3    4    5                    R=1   2    3    4    5
```

```
BOX 19     1 1.00  .30  .30  .30  .30    BOX 20     1 1.00  .30  .30  .30  .30    BOX 21     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .33  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30     7.0     Q=3 1.00  .30  .30  .30  .30    75.0     Q=3 1.00  .33  .30  .30  .30
AZ         4 1.00  .52  .43  .35  .30    AZ         4 1.00  .52  .43  .35  .30    AZ         4 1.00  .43  .33  .30  .30
  97.      5 1.00  .52  .43  .35  .30     112.      5 1.00  .52  .43  .35  .30    -133.      5 1.00  .43  .33  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 22     1 1.00  .30  .30  .30  .30    BOX 23     1 1.00  .30  .30  .30  .30    BOX 24     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .33  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30
75.0     Q=3 1.00  .37  .30  .30  .30    52.0     Q=3 1.00  .30  .30  .30  .30    52.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .43  .35  .30  .30    AZ         4 1.00  .43  .33  .30  .30    AZ         4 1.00  .43  .33  .30  .30
-165.      5 1.00  .43  .35  .30  .30    -110.      5 1.00  .43  .33  .30  .30    -135.      5 1.00  .43  .33  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 25     1 1.00  .30  .30  .30  .30    BOX 26     1 1.00  .30  .30  .30  .30    BOX 27     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .32  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30
52.0     Q=3 1.00  .35  .30  .30  .30    37.0     Q=3 1.00  .30  .30  .30  .30    37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .47  .37  .30  .30    AZ         4 1.00  .40  .30  .30  .30    AZ         4 1.00  .30  .30  .30  .30
-165.      5 1.00  .47  .37  .30  .30     -97.      5 1.00  .40  .30  .30  .30    -112.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 28     1 1.00  .30  .30  .30  .30    BOX 29     1 1.00  .30  .30  .30  .30    BOX 30     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30    37.0     Q=3 1.00  .30  .30  .30  .30    37.0     Q=3 1.00  .32  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30    AZ         4 1.00  .43  .30  .30  .30    AZ         4 1.00  .47  .35  .30  .30
-127.      5 1.00  .30  .30  .30  .30    -142.      5 1.00  .43  .30  .30  .30    -157.      5 1.00  .47  .35  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 31     1 1.00  .30  .30  .30  .30    BOX 32     1 1.00  .30  .30  .30  .30    BOX 33     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .32  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .35  .30  .30  .30    22.0     Q=3 1.00  .30  .30  .30  .30    22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .48  .37  .30  .30    AZ         4 1.00  .30  .30  .30  .30    AZ         4 1.00  .30  .30  .30  .30
-172.      5 1.00  .48  .37  .30  .30     -80.      5 1.00  .30  .30  .30  .30     -97.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 34     1 1.00  .30  .30  .30  .30    BOX 35     1 1.00  .30  .30  .30  .30    BOX 36     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30
22.0     Q=3 1.00  .30  .30  .30  .30    22.0     Q=3 1.00  .30  .30  .30  .30    22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30    AZ         4 1.00  .32  .30  .30  .30    AZ         4 1.00  .38  .30  .30  .30
-112.      5 1.00  .30  .30  .30  .30    -127.      5 1.00  .32  .30  .30  .30    -142.      5 1.00  .38  .30  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 37     1 1.00  .30  .30  .30  .30    BOX 38     1 1.00  .30  .30  .30  .30    BOX 39     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30    ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30     7.0     Q=3 1.00  .30  .30  .30  .30     7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30    AZ         4 1.00  .30  .30  .30  .30    AZ         4 1.00  .30  .30  .30  .30
 -75.      5 1.00  .30  .30  .30  .30     -85.      5 1.00  .30  .30  .30  .30     -97.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5                  R=1    2    3    4    5                  R=1    2    3    4    5

BOX 40     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-112.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5
```

```
*************************** LIGHTING POWER MULTIPLIER TABLES FOR ZONE  2***************************

                                              OVERCAST SKY
   POINT NO.      1        2        3        4        5        6        7        8        9        10
   DIFF ILL.      1.    13200.   17520.   21840.   27450.   33060.   40530.   48000.   53940.   59880.
   LPM          1.00      .30      .30      .30      .30      .30      .30      .30      .30      .30

                                       CLEAR AND PARTLY CLOUDY SKY
                               ILLUMINATION AT TABLE POINTS(DIRECT NORMAL,DIFFUSE)
       THETA(Q)  (Q=1 IS ALL DIFFUSE)
            1    (    0.,     1.)   (    0.,21840.)   (    0.,33060.)   (    0.,48000.)   (    0.,59880.)
            2    (    0.,     1.)   (10000.,20900.)   (15200.,31700.)   (22000.,46000.)   (68000.,43700.)
            3    (    0.,     1.)   (24800.,15900.)   (37600.,24100.)   (54600.,35000.)   (68000.,43700.)
            4    (    0.,     1.)   (35000., 5980.)   (52900., 9100.)   (76900.,13200.)   (68000.,43700.)
            5    (    0.,     1.)   (35000., 5980.)   (52900., 9100.)   (76900.,13200.)   (68000.,43700.)
               RADIUS     1                 2                 3                 4                 5

BOX  1    1 1.00  .30  .30  .30  .30   BOX  2    1 1.00  .30  .30  .30  .30   BOX  3    1 1.00  .30  .30  .30  .30
ELEV      2 1.00  .33  .30  .30  .30   ELEV      2 1.00  .33  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30
75.0    Q=3 1.00  .33  .30  .30  .30   75.0    Q=3 1.00  .37  .30  .30  .30   52.0    Q=3 1.00  .30  .30  .30  .30
AZ        4 1.00  .43  .33  .30  .30   AZ        4 1.00  .43  .33  .30  .30   AZ        4 1.00  .43  .33  .30  .30
 133.     5 1.00  .43  .33  .30  .30    165.     5 1.00  .43  .33  .30  .30    110.     5 1.00  .43  .33  .30  .30
           R=1    2    3    4    5                R=1    2    3    4    5                R=1    2    3    4    5

BOX  4    1 1.00  .30  .30  .30  .30   BOX  5    1 1.00  .30  .30  .30  .30   BOX  6    1 1.00  .30  .30  .30  .30
ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .32  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30
52.0    Q=3 1.00  .30  .30  .30  .30   52.0    Q=3 1.00  .35  .30  .30  .30   37.0    Q=3 1.00  .30  .30  .30  .30
AZ        4 1.00  .43  .33  .30  .30   AZ        4 1.00  .47  .37  .30  .30   AZ        4 1.00  .40  .30  .30  .30
 135.     5 1.00  .43  .33  .30  .30    165.     5 1.00  .47  .37  .30  .30     97.     5 1.00  .40  .30  .30  .30
           R=1    2    3    4    5                R=1    2    3    4    5                R=1    2    3    4    5

BOX  7    1 1.00  .30  .30  .30  .30   BOX  8    1 1.00  .30  .30  .30  .30   BOX  9    1 1.00  .30  .30  .30  .30
ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30
37.0    Q=3 1.00  .30  .30  .30  .30   37.0    Q=3 1.00  .30  .30  .30  .30   37.0    Q=3 1.00  .30  .30  .30  .30
AZ        4 1.00  .30  .30  .30  .30   AZ        4 1.00  .30  .30  .30  .30   AZ        4 1.00  .43  .30  .30  .30
 112.     5 1.00  .30  .30  .30  .30    127.     5 1.00  .30  .30  .30  .30    142.     5 1.00  .43  .30  .30  .30
           R=1    2    3    4    5                R=1    2    3    4    5                R=1    2    3    4    5

BOX 10    1 1.00  .30  .30  .30  .30   BOX 11    1 1.00  .30  .30  .30  .30   BOX 12    1 1.00  .30  .30  .30  .30
ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .32  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30
37.0    Q=3 1.00  .32  .30  .30  .30   37.0    Q=3 1.00  .35  .30  .30  .30   22.0    Q=3 1.00  .30  .30  .30  .30
AZ        4 1.00  .47  .33  .30  .30   AZ        4 1.00  .48  .37  .30  .30   AZ        4 1.00  .30  .30  .30  .30
 157.     5 1.00  .47  .33  .30  .30    172.     5 1.00  .48  .37  .30  .30     80.     5 1.00  .30  .30  .30  .30
           R=1    2    3    4    5                R=1    2    3    4    5                R=1    2    3    4    5

BOX 13    1 1.00  .30  .30  .30  .30   BOX 14    1 1.00  .30  .30  .30  .30   BOX 15    1 1.00  .30  .30  .30  .30
ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30
22.0    Q=3 1.00  .30  .30  .30  .30   22.0    Q=3 1.00  .30  .30  .30  .30   22.0    Q=3 1.00  .30  .30  .30  .30
AZ        4 1.00  .30  .30  .30  .30   AZ        4 1.00  .30  .30  .30  .30   AZ        4 1.00  .32  .30  .30  .30
  97.     5 1.00  .30  .30  .30  .30    112.     5 1.00  .30  .30  .30  .30    127.     5 1.00  .32  .30  .30  .30
           R=1    2    3    4    5                R=1    2    3    4    5                R=1    2    3    4    5

BOX 16    1 1.00  .30  .30  .30  .30   BOX 17    1 1.00  .30  .30  .30  .30   BOX 18    1 1.00  .30  .30  .30  .30
ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30   ELEV      2 1.00  .30  .30  .30  .30
22.0    Q=3 1.00  .30  .30  .30  .30    7.0    Q=3 1.00  .30  .30  .30  .30    7.0    Q=3 1.00  .30  .30  .30  .30
AZ        4 1.00  .38  .30  .30  .30   AZ        4 1.00  .30  .30  .30  .30   AZ        4 1.00  .30  .30  .30  .30
 142.     5 1.00  .38  .30  .30  .30     75.     5 1.00  .30  .30  .30  .30     85.     5 1.00  .30  .30  .30  .30
           R=1    2    3    4    5                R=1    2    3    4    5                R=1    2    3    4    5
```

BOX 19 ELEV 7.0 AZ 97.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.30	.30	.30	.30
Q=3	1.00	.30	.30	.30	.30
4	1.00	.30	.30	.30	.30
5	1.00	.30	.30	.30	.30

BOX 20 ELEV 7.0 AZ 112.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.30	.30	.30	.30
Q=3	1.00	.30	.30	.30	.30
4	1.00	.30	.30	.30	.30
5	1.00	.30	.30	.30	.30

BOX 21 ELEV 75.0 AZ -133.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.37	.30	.30	.30
Q=3	1.00	.40	.30	.30	.30
4	1.00	.47	.37	.30	.30
5	1.00	.47	.37	.30	.30

BOX 22 ELEV 75.0 AZ -165.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.37	.30	.30	.30
Q=3	1.00	.37	.30	.30	.30
4	1.00	.45	.37	.30	.30
5	1.00	.45	.37	.30	.30

BOX 23 ELEV 52.0 AZ -110.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.43	.30	.30	.30
Q=3	1.00	.47	.37	.30	.30
4	1.00	.57	.48	.37	.30
5	1.00	.57	.48	.37	.30

BOX 24 ELEV 52.0 AZ -135.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.40	.30	.30	.30
Q=3	1.00	.43	.33	.30	.30
4	1.00	.55	.47	.33	.30
5	1.00	.55	.47	.33	.30

BOX 25 ELEV 52.0 AZ -165.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.37	.30	.30	.30
Q=3	1.00	.38	.30	.30	.30
4	1.00	.48	.40	.30	.30
5	1.00	.48	.40	.30	.30

BOX 26 ELEV 37.0 AZ -97.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.43	.33	.30	.30
Q=3	1.00	.48	.40	.30	.30
4	1.00	.62	.47	.40	.30
5	1.00	.62	.47	.40	.30

BOX 27 ELEV 37.0 AZ -112.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.43	.33	.30	.30
Q=3	1.00	.48	.38	.30	.30
4	1.00	.62	.47	.38	.30
5	1.00	.62	.47	.38	.30

BOX 28 ELEV 37.0 AZ -127.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.42	.30	.30	.30
Q=3	1.00	.47	.37	.30	.30
4	1.00	.60	.47	.38	.30
5	1.00	.60	.47	.38	.30

BOX 29 ELEV 37.0 AZ -142.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.40	.30	.30	.30
Q=3	1.00	.43	.35	.30	.30
4	1.00	.57	.43	.37	.30
5	1.00	.57	.43	.37	.30

BOX 30 ELEV 37.0 AZ -157.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.38	.30	.30	.30
Q=3	1.00	.42	.32	.30	.30
4	1.00	.55	.43	.33	.30
5	1.00	.55	.43	.33	.30

BOX 31 ELEV 37.0 AZ -172.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.35	.30	.30	.30
Q=3	1.00	.38	.30	.30	.30
4	1.00	.50	.38	.30	.30
5	1.00	.50	.38	.30	.30

BOX 32 ELEV 22.0 AZ -80.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.43	.33	.30	.30
Q=3	1.00	.48	.30	.30	.30
4	1.00	.58	.47	.40	.30
5	1.00	.58	.47	.40	.30

BOX 33 ELEV 22.0 AZ -97.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.43	.33	.30	.30
Q=3	1.00	.48	.30	.30	.30
4	1.00	.58	.47	.40	.30
5	1.00	.58	.47	.40	.30

BOX 34 ELEV 22.0 AZ -112.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.43	.32	.30	.30
Q=3	1.00	.48	.30	.30	.30
4	1.00	.58	.47	.38	.30
5	1.00	.58	.47	.38	.30

BOX 35 ELEV 22.0 AZ -127.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.42	.30	.30	.30
Q=3	1.00	.47	.30	.30	.30
4	1.00	.55	.47	.38	.30
5	1.00	.55	.47	.38	.30

BOX 36 ELEV 22.0 AZ -142.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.40	.30	.30	.30
Q=3	1.00	.45	.30	.30	.30
4	1.00	.55	.47	.37	.30
5	1.00	.55	.47	.37	.30

BOX 37 ELEV 7.0 AZ -75.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.30	.30	.30	.30
Q=3	1.00	.30	.30	.30	.30
4	1.00	.52	.43	.35	.30
5	1.00	.52	.43	.35	.30

BOX 38 ELEV 7.0 AZ -85.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.30	.30	.30	.30
Q=3	1.00	.30	.30	.30	.30
4	1.00	.52	.43	.35	.30
5	1.00	.52	.43	.35	.30

BOX 39 ELEV 7.0 AZ -97.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.30	.30	.30	.30
Q=3	1.00	.30	.30	.30	.30
4	1.00	.52	.43	.35	.30
5	1.00	.52	.43	.35	.30

BOX 40 ELEV 7.0 AZ -112.

Q	R=1	2	3	4	5
1	1.00	.30	.30	.30	.30
2	1.00	.30	.30	.30	.30
Q=3	1.00	.30	.30	.30	.30
4	1.00	.52	.43	.35	.30
5	1.00	.52	.43	.35	.30

```
****************************** LIGHTING POWER MULTIPLIER TABLES FOR ZONE  3******************************

                                                OVERCAST SKY
    POINT NO.       1         2         3         4         5         6         7         8         9         10
    DIFF ILL.       1.     13200.    17520.    21840.    27450.    33060.    40530.    48000.    5[illegible]940.    59880.
    LPM          1.00       .30       .30       .30       .30       .30       .30       .30       .30       .30

                                       CLEAR AND PARTLY CLOUDY SKY
                                 ILLUMINATION AT TABLE POINTS(DIRECT NORMAL,DIFFUSE)
         THETA(Q)  (Q=1 IS ALL DIFFUSE)
              1     (     0.,     1.)     (     0.,21840.)     (     0.,33060.)     (     0.,48000.)     (     0.,59880.)
              2     (     0.,     1.)     (10000.,20900.)     (15200.,31700.)     (22000.,46000.)     (68000.,43700.)
              3     (     0.,     1.)     (24800.,15900.)     (37600.,24100.)     (54600.,35000.)     (68000.,43700.)
              4     (     0.,     1.)     (35000., 5980.)     (52900., 9100.)     (76900.,13200.)     (68000.,43700.)
              5     (     0.,     1.)     (35000., 5980.)     (52900., 9100.)     (76900.,13200.)     (68000.,43700.)
                 RADIUS      1                   2                   3                   4                   5

BOX  1      1 1.00  .30  .30  .30  .30   BOX  2     1 1.00  .30  .30  .30  .30   BOX  3     1 1.00  .30  .30  .30  .30
ELEV        2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30
75.0      Q=3 1.00  .30  .30  .30  .30   75.0     Q=3 1.00  .30  .30  .30  .30   52.0     Q=3 1.00  .30  .30  .30  .30
AZ          4 1.00  .40  .30  .30  .30   AZ         4 1.00  .40  .30  .30  .30   AZ         4 1.00  .45  .30  .30  .30
 133.       5 1.00  .40  .30  .30  .30    165.      5 1.00  .40  .30  .30  .30    110.      5 1.00  .45  .30  .30  .30
             R=1    2    3    4    5                 R=1    2    3    4    5                 R=1    2    3    4    5

BOX  4      1 1.00  .30  .30  .30  .30   BOX  5     1 1.00  .30  .30  .30  .30   BOX  6     1 1.00  .30  .30  .30  .30
ELEV        2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30
52.0      Q=3 1.00  .30  .30  .30  .30   52.0     Q=3 1.00  .30  .30  .30  .30   37.0     Q=3 1.00  .30  .30  .30  .30
AZ          4 1.00  .40  .30  .30  .30   AZ         4 1.00  .35  .30  .30  .30   AZ         4 1.00  .50  .30  .30  .30
 135.       5 1.00  .40  .30  .30  .30    165.      5 1.00  .35  .30  .30  .30     97.      5 1.00  .50  .30  .30  .30
             R=1    2    3    4    5                 R=1    2    3    4    5                 R=1    2    3    4    5

BOX  7      1 1.00  .30  .30  .30  .30   BOX  8     1 1.00  .30  .30  .30  .30   BOX  9     1 1.00  .30  .30  .30  .30
ELEV        2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30
37.0      Q=3 1.00  .30  .30  .30  .30   37.0     Q=3 1.00  .30  .30  .30  .30   37.0     Q=3 1.00  .30  .30  .30  .30
AZ          4 1.00  .45  .30  .30  .30   AZ         4 1.00  .30  .30  .30  .30   AZ         4 1.00  .30  .30  .30  .30
 112.       5 1.00  .45  .30  .30  .30    127.      5 1.00  .30  .30  .30  .30    142.      5 1.00  .30  .30  .30  .30
             R=1    2    3    4    5                 R=1    2    3    4    5                 R=1    2    3    4    5

BOX 10      1 1.00  .30  .30  .30  .30   BOX 11     1 1.00  .30  .30  .30  .30   BOX 12     1 1.00  .30  .30  .30  .30
ELEV        2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30
37.0      Q=3 1.00  .30  .30  .30  .30   37.0     Q=3 1.00  .30  .30  .30  .30   22.0     Q=3 1.00  .30  .30  .30  .30
AZ          4 1.00  .35  .30  .30  .30   AZ         4 1.00  .30  .30  .30  .30   AZ         4 1.00  .55  .40  .30  .30
 157.       5 1.00  .35  .30  .30  .30    172.      5 1.00  .30  .30  .30  .30     80.      5 1.00  .55  .40  .30  .30
             R=1    2    3    4    5                 R=1    2    3    4    5                 R=1    2    3    4    5

BOX 13      1 1.00  .30  .30  .30  .30   BOX 14     1 1.00  .30  .30  .30  .30   BOX 15     1 1.00  .30  .30  .30  .30
ELEV        2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30
22.0      Q=3 1.00  .30  .30  .30  .30   22.0     Q=3 1.00  .30  .30  .30  .30   22.0     Q=3 1.00  .30  .30  .30  .30
AZ          4 1.00  .50  .30  .30  .30   AZ         4 1.00  .40  .30  .30  .30   AZ         4 1.00  .30  .30  .30  .30
  97.       5 1.00  .50  .30  .30  .30    112.      5 1.00  .40  .30  .30  .30    127.      5 1.00  .30  .30  .30  .30
             R=1    2    3    4    5                 R=1    2    3    4    5                 R=1    2    3    4    5

BOX 16      1 1.00  .30  .30  .30  .30   BOX 17     1 1.00  .30  .30  .30  .30   BOX 18     1 1.00  .30  .30  .30  .30
ELEV        2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30   ELEV       2 1.00  .30  .30  .30  .30
22.0      Q=3 1.00  .30  .30  .30  .30    7.0     Q=3 1.00  .30  .30  .30  .30    7.0     Q=3 1.00  .30  .30  .30  .30
AZ          4 1.00  .30  .30  .30  .30   AZ         4 1.00  .60  .40  .30  .30   AZ         4 1.00  .55  .40  .30  .30
 142.       5 1.00  .30  .30  .30  .30     75.      5 1.00  .60  .40  .30  .30     85.      5 1.00  .55  .40  .30  .30
             R=1    2    3    4    5                 R=1    2    3    4    5                 R=1    2    3    4    5
```

```
BOX 19     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .55  .35  .30  .30
  97.      5 1.00  .55  .35  .30  .30
            R=1    2    3    4    5

BOX 20     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
 112.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 21     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
75.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .40  .30  .30  .30
-133.      5 1.00  .40  .30  .30  .30
            R=1    2    3    4    5

BOX 22     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
75.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .40  .30  .30  .30
-165.      5 1.00  .40  .30  .30  .30
            R=1    2    3    4    5

BOX 23     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
52.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .45  .30  .30  .30
-110.      5 1.00  .45  .30  .30  .30
            R=1    2    3    4    5

BOX 24     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
52.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .40  .30  .30  .30
-135.      5 1.00  .40  .30  .30  .30
            R=1    2    3    4    5

BOX 25     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
52.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-165.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 26     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .50  .30  .30  .30
 -97.      5 1.00  .50  .30  .30  .30
            R=1    2    3    4    5

BOX 27     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .45  .30  .30  .30
-112.      5 1.00  .45  .30  .30  .30
            R=1    2    3    4    5

BOX 28     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-127.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 29     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-142.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 30     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-157.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 31     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
37.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-172.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 32     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .55  .40  .30  .30
 -80.      5 1.00  .55  .40  .30  .30
            R=1    2    3    4    5

BOX 33     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .50  .30  .30  .30
 -97.      5 1.00  .50  .30  .30  .30
            R=1    2    3    4    5

BOX 34     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .40  .30  .30  .30
-112.      5 1.00  .40  .30  .30  .30
            R=1    2    3    4    5

BOX 35     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-127.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 36     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
22.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .30  .30  .30  .30
-142.      5 1.00  .30  .30  .30  .30
            R=1    2    3    4    5

BOX 37     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .60  .45  .30  .30
 -75.      5 1.00  .60  .45  .30  .30
            R=1    2    3    4    5

BOX 38     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .55  .40  .30  .30
 -85.      5 1.00  .55  .40  .30  .30
            R=1    2    3    4    5

BOX 39     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .55  .35  .30  .30
 -97.      5 1.00  .55  .35  .30  .30
            R=1    2    3    4    5

BOX 40     1 1.00  .30  .30  .30  .30
ELEV       2 1.00  .30  .30  .30  .30
 7.0     Q=3 1.00  .30  .30  .30  .30
AZ         4 1.00  .35  .30  .30  .30
-112.      5 1.00  .35  .30  .30  .30
            R=1    2    3    4    5
```

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******************************* LIGHTING POWER MULTIPLIER TABLES FOR ZONE  4*******************************

                                                    OVERCAST SKY
     POINT NO.      1          2          3          4          5          6          7          8          9         10
     DIFF ILL.      1.      13200.     17520.     21840.     27450.     33060.     40530.     48000.     53940.     59880.
     LPM          1.00        .30        .30        .30        .30        .30        .30        .30        .30        .30

                                          CLEAR AND PARTLY CLOUDY SKY
                                   ILLUMINATION AT TABLE POINTS(DIRECT NORMAL,DIFFUSE)
          THETA(Q)  (Q=1 IS ALL DIFFUSE)
                 1    (     0.,     1.)    (     0.,21840.)    (     0.,33060.)    (     0.,48000.)    (     0.,59880.)
                 2    (     0.,     1.)    (10000.,20900.)     (15200.,31700.)     (22000.,46000.)     (68000.,43700.)
                 3    (     0.,     1.)    (24800.,15900.)     (37600.,24100.)     (54600.,35000.)     (68000.,43700.)
                 4    (     0.,     1.)    (35000., 5980.)     (52900., 9100.)     (76900.,13200.)     (68000.,43700.)
                 5    (     0.      1.)    (35000., 5980.)     (52900., 9100.)     (76900.,13200.)     (68000.,43700.)
               RADIUS     1                      2                    3                    4                    5

  BOX  1      1 1.00  .30  .30  .30  .30   BOX  2      1 1.00  .30  .30  .30  .30   BOX  3      1 1.00  .30  .30  .30  .30
  ELEV        2 1.00  .40  .30  .30  .30   ELEV        2 1.00  .45  .30  .30  .30   ELEV        2 1.00  .40  .30  .30  .30
  75.0      Q=3 1.00  .45  .30  .30  .30   75.0      Q=3 1.00  .50  .30  .30  .30   52.0      Q=3 1.00  .45  .30  .30  .30
  AZ          4 1.00  .60  .45  .30  .30   AZ          4 1.00  .65  .50  .30  .30   AZ          4 1.00  .65  .55  .35  .30
   133.       5 1.00  .60  .45  .30  .30    165.       5 1.00  .65  .50  .30  .30    110.       5 1.00  .65  .55  .35  .30
                R=1   2    3    4    5                   R=1   2    3    4    5                   R=1   2    3    4    5

  BOX  4      1 1.00  .30  .30  .30  .30   BOX  5      1 1.00  .30  .30  .30  .30   BOX  6      1 1.00  .30  .30  .30  .30
  ELEV        2 1.00  .45  .30  .30  .30   ELEV        2 1.00  .50  .30  .30  .30   ELEV        2 1.00  .30  .30  .30  .30
  52.0      Q=3 1.00  .55  .35  .30  .30   52.0      Q=3 1.00  .55  .40  .30  .30   37.0      Q=3 1.00  .40  .30  .30  .30
  AZ          4 1.00  .75  .60  .45  .30   AZ          4 1.00  .80  .65  .50  .30   AZ          4 1.00  .65  .50  .30  .30
   135.       5 1.00  .75  .60  .45  .30    165.       5 1.00  .80  .65  .50  .30     97.       5 1.00  .65  .50  .30  .30
                R=1   2    3    4    5                   R=1   2    3    4    5                   R=1   2    3    4    5

  BOX  7      1 1.00  .30  .30  .30  .30   BOX  8      1 1.00  .30  .30  .30  .30   BOX  9      1 1.00  .30  .30  .30  .30
  ELEV        2 1.00  .40  .30  .30  .30   ELEV        2 1.00  .45  .30  .30  .30   ELEV        2 1.00  .50  .30  .30  .30
  37.0      Q=3 1.00  .50  .30  .30  .30   37.0      Q=3 1.00  .55  .35  .30  .30   37.0      Q=3 1.00  .55  .40  .30  .30
  AZ          4 1.00  .70  .60  .45  .30   AZ          4 1.00  .75  .65  .50  .30   AZ          4 1.00  .80  .70  .55  .30
   112.       5 1.00  .70  .60  .45  .30    127.       5 1.00  .75  .65  .50  .30    142.       5 1.00  .80  .70  .55  .30
                R=1   2    3    4    5                   R=1   2    3    4    5                   R=1   2    3    4    5

  BOX 10      1 1.00  .30  .30  .30  .30   BOX 11      1 1.00  .30  .30  .30  .30   BOX 12      1 1.00  .30  .30  .30  .30
  ELEV        2 1.00  .50  .30  .30  .30   ELEV        2 1.00  .50  .35  .30  .30   ELEV        2 1.00  .30  .30  .30  .30
  37.0      Q=3 1.00  .60  .45  .30  .30   37.0      Q=3 1.00  .60  .45  .30  .30   22.0      Q=3 1.00  .30  .30  .30  .30
  AZ          4 1.00  .80  .70  .55  .30   AZ          4 1.00  .85  .70  .55  .30   AZ          4 1.00  .60  .45  .30  .30
   157.       5 1.00  .80  .70  .55  .30    172.       5 1.00  .85  .70  .55  .30     80.       5 1.00  .60  .45  .30  .30
                R=1   2    3    4    5                   R=1   2    3    4    5                   R=1   2    3    4    5

  BOX 13      1 1.00  .30  .30  .30  .30   BOX 14      1 1.00  .30  .30  .30  .30   BOX 15      1 1.00  .30  .30  .30  .30
  ELEV        2 1.00  .30  .30  .30  .30   ELEV        2 1.00  .35  .30  .30  .30   ELEV        2 1.00  .45  .30  .30  .30
  22.0      Q=3 1.00  .40  .30  .30  .30   22.0      Q=3 1.00  .50  .30  .30  .30   22.0      Q=3 1.00  .55  .30  .30  .30
  AZ          4 1.00  .65  .55  .35  .30   AZ          4 1.00  .75  .60  .45  .30   AZ          4 1.00  .75  .65  .50  .30
    97.       5 1.00  .65  .55  .35  .30    112.       5 1.00  .75  .60  .45  .30    127.       5 1.00  .75  .65  .50  .30
                R=1   2    3    4    5                   R=1   2    3    4    5                   R=1   2    3    4    5

  BOX 16      1 1.00  .30  .30  .30  .30   BOX 17      1 1.00  .30  .30  .30  .30   BOX 18      1 1.00  .30  .30  .30  .30
  ELEV        2 1.00  .45  .30  .30  .30   ELEV        2 1.00  .30  .30  .30  .30   ELEV        2 1.00  .30  .30  .30  .30
  22.0      Q=3 1.00  .55  .30  .30  .30    7.0      Q=3 1.00  .30  .30  .30  .30    7.0      Q=3 1.00  .30  .30  .30  .30
  AZ          4 1.00  .80  .65  .55  .30   AZ          4 1.00  .30  .30  .30  .30   AZ          4 1.00  .65  .50  .30  .30
   142.       5 1.00  .80  .65  .55  .30     75.       5 1.00  .30  .30  .30  .30     85.       5 1.00  .65  .50  .30  .30
                R=1   2    3    4    5                   R=1   2    3    4    5                   R=1   2    3    4    5
```

```
BOX 19      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
 7.0      Q=3 1.00   .30   .30   .30   .30
AZ          4 1.00   .65   .55   .40   .30
  97.       5 1.00   .65   .55   .40   .30
              R=1    2     3     4     5

BOX 20      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
 7.0      Q=3 1.00   .40   .30   .30   .30
AZ          4 1.00   .75   .60   .45   .30
 112.       5 1.00   .75   .60   .45   .30
              R=1    2     3     4     5

BOX 21      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .45   .30   .30   .30
75.0      Q=3 1.00   .45   .30   .30   .30
AZ          4 1.00   .65   .45   .30   .30
-133.       5 1.00   .65   .45   .30   .30
              R=1    2     3     4     5

BOX 22      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .45   .30   .30   .30
75.0      Q=3 1.00   .50   .30   .30   .30
AZ          4 1.00   .65   .50   .30   .30
-165.       5 1.00   .65   .50   .30   .30
              R=1    2     3     4     5

BOX 23      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .45   .30   .30   .30
52.0      Q=3 1.00   .50   .30   .30   .30
AZ          4 1.00   .70   .55   .35   .30
-110.       5 1.00   .70   .55   .35   .30
              R=1    2     3     4     5

BOX 24      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .50   .30   .30   .30
52.0      Q=3 1.00   .55   .40   .30   .30
AZ          4 1.00   .75   .65   .45   .30
-135.       5 1.00   .75   .65   .45   .30
              R=1    2     3     4     5

BOX 25      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .50   .30   .30   .30
52.0      Q=3 1.00   .60   .40   .30   .30
AZ          4 1.00   .80   .70   .50   .30
-165.       5 1.00   .80   .70   .50   .30
              R=1    2     3     4     5

BOX 26      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .40   .30   .30   .30
37.0      Q=3 1.00   .50   .30   .30   .30
AZ          4 1.00   .70   .50   .35   .30
 -97.       5 1.00   .70   .50   .35   .30
              R=1    2     3     4     5

BOX 27      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .45   .30   .30   .30
37.0      Q=3 1.00   .55   .35   .30   .30
AZ          4 1.00   .80   .60   .45   .30
-112.       5 1.00   .80   .60   .45   .30
              R=1    2     3     4     5

BOX 28      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .50   .30   .30   .30
37.0      Q=3 1.00   .55   .40   .30   .30
AZ          4 1.00   .80   .65   .50   .30
-127.       5 1.00   .80   .65   .50   .30
              R=1    2     3     4     5

BOX 29      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .50   .30   .30   .30
37.0      Q=3 1.00   .60   .45   .30   .30
AZ          4 1.00   .85   .70   .55   .30
-142.       5 1.00   .85   .70   .55   .30
              R=1    2     3     4     5

BOX 30      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .55   .35   .30   .30
37.0      Q=3 1.00   .60   .45   .30   .30
AZ          4 1.00   .85   .70   .55   .30
-157.       5 1.00   .85   .70   .55   .30
              R=1    2     3     4     5

BOX 31      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .55   .35   .30   .30
37.0      Q=3 1.00   .60   .45   .30   .30
AZ          4 1.00   .85   .70   .55   .30
-172.       5 1.00   .85   .70   .55   .30
              R=1    2     3     4     5

BOX 32      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
22.0      Q=3 1.00   .40   .30   .30   .30
AZ          4 1.00   .70   .50   .30   .30
 -80.       5 1.00   .70   .50   .30   .30
              R=1    2     3     4     5

BOX 33      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .40   .30   .30   .30
22.0      Q=3 1.00   .50   .30   .30   .30
AZ          4 1.00   .75   .60   .40   .30
 -97.       5 1.00   .75   .60   .40   .30
              R=1    2     3     4     5

BOX 34      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .45   .30   .30   .30
22.0      Q=3 1.00   .55   .30   .30   .30
AZ          4 1.00   .80   .65   .50   .30
-112.       5 1.00   .80   .65   .50   .30
              R=1    2     3     4     5

BOX 35      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .50   .30   .30   .30
22.0      Q=3 1.00   .60   .30   .30   .30
AZ          4 1.00   .80   .65   .50   .30
-127.       5 1.00   .80   .65   .50   .30
              R=1    2     3     4     5

BOX 36      1 1.00   .30   .30   .30   .30
ELEV        2 1,00   .50   .30   .30   .30
22.0      Q=3 1.00   .60   .30   .30   .30
AZ          4 1.00   .80   .70   .55   .30
-142.       5 1.00   .80   .70   .55   .30
              R=1    2     3     4     5

BOX 37      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
 7.0      Q=3 1.00   .30   .30   .30   .30
AZ          4 1.00   .30   .30   .30   .30
 -75.       5 1.00   .30   .30   .30   .30
              R=1    2     3     4     5

BOX 38      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
 7.0      Q=3 1.00   .30   .30   .30   .30
AZ          4 1.00   .70   .55   .40   .30
 -85.       5 1.00   .70   .55   .40   .30
              R=1    2     3     4     5

BOX 39      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
 7.0      Q=3 1.00   .35   .30   .30   .30
AZ          4 1.00   .75   .60   .40   .30
 -97.       5 1.00   .75   .60   .40   .30
              R=1    2     3     4     5

BOX 40      1 1.00   .30   .30   .30   .30
ELEV        2 1.00   .30   .30   .30   .30
 7.0      Q=3 1.00   .40   .30   .30   .30
AZ          4 1.00   .75   .60   .45   .40
-112.       5 1.00   .75   .60   .45   .40
              R=1    2     3     4     5
```

ZONE GROUP LOADS FOR NORFOLK, VA TRY 1951

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

NUMBER		NAME	MULTIPLIER
1	1	WEST CLASSROOM	1
2	2	EAST CLASSROOM	1
3	3	OFFICE	1
4	4	EQUIPMENT MAINTAINANCE	1
5	5	MECHANICAL EQUIPMENT	1
6	6	LOBBY	1

ZONE	TOTAL HEATING (BTU)	TOTAL COOLING (BTU)	PEAK HEATING (BTUH)	PEAK COOLING (BTUH)	MAX TEMP (F)	MIN TEMP (F)
1	3.602E+07	1.181E+07	4.017E+04	1.767E+04	78.00	68.02
2	3.608E+07	1.184E+07	4.018E+04	1.551E+04	78.00	68.02
3	6.690E+06	4.414E+06	9.865E+03	5.295E+03	78.00	68.02
4	7.947E+06	2.755E+06	9.454E+03	3.504E+03	78.00	68.02
5	1.772E+06	4.166E+06	4.062E+03	2.659E+03	78.00	68.02
6	8.975E+06	2.009E+06	9.852E+03	3.430E+03	78.00	68.02
GROUP:	9.748E+07	3.700E+07	1.136E+05	4.657E+04	78.00	68.02
PEAK DATES (MO/DY/HR)%			2/ 8/ 6	7/19/15	8/21/16	2/ 8/ 6

TOTAL ITERATIONS = 25482
DID NOT CONVERGE = 0

ZONE LOADS REPORT

SAMPLE BUILDING TEST

LOCATION: NORFOLK, VA TRY 1951

ZONE: 1 WEST CLASSROOM DELIVERY RETRAINING DETACHMENT BUILDING

ENVIRONMENT NORFOLK, VA TRY 1951 365 DAYS

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

MO	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	SYSTEM STATUS H-EX	H-ON	VENT	C-ON	C-EX
JAN	7.717E+06	3.517E+03	4.347E+05	0.	0.	1.033E+06	0.	6.735E+06	0.	0	680	0	3	0
FEB	7.930E+06	4.335E+04	3.915E+05	0.	0.	8.908E+05	0.	6.994E+06	0.	0	582	0	16	0
MAR	5.659E+06	7.479E+03	4.448E+05	0.	0.	9.698E+05	0.	5.408E+06	0.	0	633	0	7	0
APR	1.753E+06	2.029E+05	4.839E+05	0.	0.	9.109E+05	0.	2.017E+06	3.504E+04	0	368	0	57	0
MAY	2.663E+05	9.482E+05	5.908E+05	0.	0.	9.398E+05	0.	4.556E+05	5.582E+04	0	129	0	208	0
JUN	4.362E+02	2.281E+06	6.235E+05	0.	0.	9.090E+05	0.	3.465E+03	2.934E+05	0	1	0	456	0
JUL	0.	3.443E+06	6.413E+05	0.	0.	9.354E+05	0.	0.	4.250E+05	0	0	0	656	0
AUG	0.	3.058E+06	7.014E+05	0.	0.	9.601E+05	0.	0.	2.933E+05	0	0	0	640	0
SEP	2.974E+04	1.421E+06	5.640E+05	0.	0.	9.168E+05	0.	6.407E+04	9.838E+04	0	19	0	364	0
OCT	4.511E+05	3.666E+05	5.550E+05	0.	0.	9.933E+05	0.	6.339E+05	3.668E+04	0	177	0	99	0
NOV	5.510E+06	2.181E+04	4.269E+05	0.	0.	9.652E+05	0.	5.041E+06	0.	0	582	0	11	0
DEC	6.702E+06	1.534E+04	4.035E+05	0.	0.	1.025E+06	0.	5.825E+06	0.	0	629	0	8	0
TOT	3.602E+07	1.181E+07	6.261E+06	0.	0.	1.145E+07	0.	3.318E+07	1.238E+06	0	3800	0	2525	0

HEATING LOAD = 7.063E+04 BTU/SQFT COOLING LOAD = 2.316E+04 BTU/SQFT ZONE FLOOR AREA = 5.100E+02 SQFT

PEAK LOADS AND TEMPERATURES:
MAX HEATING LOAD = 4.017E+04 AT 2/ 8/ 6 WITH ZONE AIR TEMP OF 68.02
MAX COOLING LOAD = 1.767E+04 AT 8/21/16 WITH ZONE AIR TEMP OF 78.00
MAX ZONE AIR TEMP = 78.00 AT 8/21/16
MIN ZONE AIR TEMP = 68.02 AT 2/ 8/ 6

ZONE LOADS REPORT

SAMPLE BUILDING TEST

LOCATION: NORFOLK, VA TRY 1951

ZONE: 2 EAST CLASSROOM DELIVERY RETRAINING DETACHMENT BUILDING

ENVIRONMENT NORFOLK, VA TRY 1951 365 DAYS

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

MO	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	SYSTEM STATUS H-EX	H-ON	VENT	C-ON	C-EX
JAN	7.696E+06	4.071E+01	4.350E+05	0.	0.	1.033E+06	0.	6.742E+06	0.	0	681	0	1	0
FEB	8.007E+06	1.398E+04	3.922E+05	0.	0.	8.913E+05	0.	7.053E+06	0.	0	596	0	11	0
MAR	5.676E+06	9.003E+02	4.474E+05	0.	0.	9.702E+05	0.	5.381E+06	0.	0	628	0	3	0
APR	1.793E+06	2.008E+05	4.960E+05	0.	0.	9.148E+05	0.	1.992E+06	3.502E+04	0	363	0	63	0
MAY	3.181E+05	9.311E+05	6.078E+05	0.	0.	9.369E+05	0.	4.883E+05	5.581E+04	0	138	0	213	0
JUN	3.590E+03	2.308E+06	6.255E+05	0.	0.	9.044E+05	0.	1.158E+04	2.934E+05	0	4	0	440	0
JUL	0.	3.499E+06	6.411E+05	0.	0.	9.297E+05	0.	0.	4.250E+05	0	0	0	628	0
AUG	0.	3.088E+06	7.011E+05	0.	0.	9.549E+05	0.	0.	2.933E+05	0	0	0	622	0
SEP	2.516E+04	1.487E+06	5.654E+05	0.	0.	9.163E+05	0.	4.539E+04	9.838E+04	0	13	0	362	0
OCT	4.518E+05	2.939E+05	5.679E+05	0.	0.	9.903E+05	0.	6.245E+05	3.668E+04	0	171	0	97	0
NOV	5.407E+06	1.866E+04	4.272E+05	0.	0.	9.676E+05	0.	5.055E+06	0.	0	583	0	14	0
DEC	6.701E+06	3.090E+03	4.046E+05	0.	0.	1.025E+06	0.	5.828E+06	0.	0	635	0	5	0
TOT	3.608E+07	1.184E+07	6.311E+06	0.	0.	1.143E+07	0.	3.322E+07	1.238E+06	0	3812	0	2459	0

HEATING LOAD = 7.074E+04 BTU/SQFT COOLING LOAD = 2.322E+04 BTU/SQFT ZONE FLOOR AREA = 5.100E+02 SQFT

PEAK LOADS AND TEMPERATURES:
MAX HEATING LOAD = 4.018E+04 AT 2/ 8/ 6 WITH ZONE AIR TEMP OF 68.02
MAX COOLING LOAD = 1.551E+04 AT 6/28/15 WITH ZONE AIR TEMP OF 78.00
MAX ZONE AIR TEMP = 78.00 AT 6/28/15
MIN ZONE AIR TEMP = 68.02 AT 2/ 8/ 6

ZONE LOADS REPORT

SAMPLE BUILDING TEST

LOCATION: NORFOLK, VA TRY 1951

ZONE: 3 OFFICE DELIVERY RETRAINING DETACHMENT BUILDING

ENVIRONMENT NORFOLK, VA TRY 1951 365 DAYS

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

MO	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	SYSTEM STATUS H-EX	H-ON	VENT	C-ON	C-EX
JAN	1.475E+06	3.547E+04	6.066E+04	0.	0.	3.608E+05	0.	1.539E+06	0.	0	562	0	20	0
FEB	1.602E+06	7.197E+04	5.580E+04	0.	0.	3.122E+05	0.	1.610E+06	0.	0	492	0	44	0
MAR	1.044E+06	3.208E+04	6.421E+04	0.	0.	3.408E+05	0.	1.161E+06	0.	0	506	0	35	0
APR	3.121E+05	1.215E+05	6.959E+04	0.	0.	3.205E+05	0.	4.101E+05	8.756E+03	0	273	0	112	0
MAY	4.212E+04	2.922E+05	7.944E+04	0.	0.	3.300E+05	0.	8.234E+04	1.395E+04	0	86	0	228	0
JUN	7.029E+01	6.810E+05	8.309E+04	0.	0.	3.183E+05	0.	8.661E+02	7.335E+04	0	1	0	465	0
JUL	0.	9.689E+05	8.548E+04	0.	0.	3.275E+05	0.	0.	1.062E+05	0	0	0	655	0
AUG	0.	1.022E+06	9.357E+04	0.	0.	3.354E+05	0.	0.	7.332E+04	0	0	0	661	0
SEP	1.435E+03	7.203E+05	7.595E+04	0.	0.	3.220E+05	0.	3.414E+03	2.459E+04	0	3	0	460	0
OCT	3.945E+04	3.536E+05	7.959E+04	0.	0.	3.466E+05	0.	7.613E+04	9.170E+03	0	65	0	226	0
NOV	9.340E+05	4.592E+04	6.303E+04	0.	0.	3.373E+05	0.	1.060E+06	0.	0	423	0	47	0
DEC	1.240E+06	6.955E+04	5.752E+04	0.	0.	3.574E+05	0.	1.315E+06	0.	0	507	0	53	0
TOT	6.690E+06	4.414E+06	8.679E+05	0.	0.	4.009E+06	0.	7.257E+06	3.094E+05	0	2918	0	3006	0

HEATING LOAD = 6.371E+04 BTU/SQFT COOLING LOAD = 4.204E+04 BTU/SQFT ZONE FLOOR AREA = 1.050E+02 SQFT

PEAK LOADS AND TEMPERATURES:
MAX HEATING LOAD = 9.865E+03 AT 2/ 8/ 6 WITH ZONE AIR TEMP OF 68.02
MAX COOLING LOAD = 5.295E+03 AT 10/ 5/15 WITH ZONE AIR TEMP OF 78.00
MAX ZONE AIR TEMP = 78.00 AT 10/ 5/15
MIN ZONE AIR TEMP = 68.02 AT 2/ 8/ 6

ZONE LOADS REPORT

SAMPLE BUILDING TEST

LOCATION: NORFOLK, VA TRY 1951

ZONE: 4 EQUIPMENT MAINTAINANCE DELIVERY RETRAINING DETACHMENT BUILDING

ENVIRONMENT NORFOLK, VA TRY 1951 365 DAYS

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

MO	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	SYSTEM STATUS H-EX	H-ON	VENT	C-ON	C-EX
JAN	1.703E+06	0.	2.889E+04	0.	0.	5.194E+05	0.	1.675E+06	0.	0	658	0	0	0
FEB	1.811E+06	1.985E+03	2.588E+04	0.	0.	4.551E+05	0.	1.754E+06	0	0	579	0	8	0
MAR	1.274E+06	1.693E+02	2.951E+04	0.	0.	4.938E+05	0.	1.357E+06	0.	0	630	0	3	0
APR	3.817E+05	4.705E+04	3.151E+04	0.	0.	4.654E+05	0.	5.039E+05	8.757E+03	0	355	0	58	0
MAY	3.977E+04	1.704E+05	3.897E+04	0.	0.	4.749E+05	0.	8.751E+04	1.395E+04	0	90	0	185	0
JUN	0.	5.438E+05	4.162E+04	0.	0.	4.577E+05	0.	0.	7.335E+04	0	0	0	471	0
JUL	0.	8.213E+05	4.278E+04	0.	0.	4.721E+05	0.	0.	1.062E+05	0	0	0	681	0
AUG	0.	7.183E+05	4.679E+04	0.	0.	4.828E+05	0.	0.	7.332E+04	0	0	0	667	0
SEP	3.546E+03	3.656E+05	3.788E+04	0.	0.	4.696E+05	0.	8.970E+03	2.459E+04	0	9	0	409	0
OCT	7.423E+04	7.867E+04	3.715E+04	0.	0.	5.056E+05	0.	1.307E+05	9.170E+03	0	125	0	99	0
NOV	1.201E+06	6.824E+03	2.855E+04	0.	0.	4.953E+05	0.	1.248E+06	0.	0	545	0	18	0
DEC	1.459E+06	7.889E+02	2.683E+04	0.	0.	5.168E+05	0.	1.443E+06	0.	0	602	0	7	0
TOT	7.947E+06	2.755E+06	4.164E+05	0.	0.	5.809E+06	0.	8.209E+06	3.094E+05	0	3593	0	2606	0

HEATING LOAD = 8.905E+04 BTU/SQFT COOLING LOAD = 3.087E+04 BTU/SQFT ZONE FLOOR AREA = 8.925E+01 SQFT

PEAK LOADS AND TEMPERATURES:

MAX HEATING LOAD = 9.454E+03 AT 2/ 8/ 6 WITH ZONE AIR TEMP OF 68.02
MAX COOLING LOAD = 3.504E+03 AT 7/19/15 WITH ZONE AIR TEMP OF 78.00
MAX ZONE AIR TEMP = 78.00 AT 7/19/15
MIN ZONE AIR TEMP = 68.02 AT 2/ 8/ 6

ZONE LOADS REPORT

SAMPLE BUILDING TEST

LOCATION: NORFOLK, VA TRY 1951

ZONE: 5 MECHANICAL EQUIPMENT DELIVERY RETRAINING DETACHMENT BUILDING

ENVIRONMENT NORFOLK, VA TRY 1951 365 DAYS

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

MO	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	SYSTEM STATUS H-EX	H-ON	VENT	C-ON	C-EX
JAN	4.182E+05	1.543E+04	3.261E+04	0.	0.	9.033E+05	0.	6.736E+05	0.	0	407	0	35	0
FEB	5.175E+05	2.637E+04	2.881E+04	0.	0.	8.105E+05	0.	7.581E+05	0.	0	423	0	49	0
MAR	2.414E+05	2.484E+04	3.347E+04	0.	0.	9.033E+05	0.	4.871E+05	0.	0	371	0	50	0
APR	2.700E+03	1.197E+05	3.875E+04	0.	0.	8.723E+05	0.	1.860E+04	4.378E+03	0	18	0	190	0
MAY	0.	3.849E+05	4.461E+04	0.	0.	9.033E+05	0.	0.	6.976E+03	0	0	0	507	0
JUN	0.	7.195E+05	4.285E+04	0.	0.	8.723E+05	0.	0.	3.668E+04	0	0	0	701	0
JUL	0.	9.215E+05	4.286E+04	0.	0.	8.971E+05	0.	0.	5.312E+04	0	0	0	744	0
AUG	0.	8.931E+05	4.694E+04	0.	0.	9.095E+05	0.	0.	3.666E+04	0	0	0	744	0
SEP	0.	6.302E+05	3.877E+04	0.	0.	8.599E+05	0.	0.	1.230E+04	0	0	0	677	0
OCT	0.	3.192E+05	4.422E+04	0.	0.	9.033E+05	0.	0.	4.585E+03	0	0	0	540	0
NOV	2.384E+05	6.572E+04	3.230E+04	0.	0.	8.661E+05	0.	4.462E+05	0.	0	306	0	103	0
DEC	3.534E+05	4.532E+04	3.121E+04	0.	0.	8.909E+05	0.	5.645E+05	0.	0	360	0	92	0
TOT	1.772E+06	4.166E+06	4.574E+05	0.	0.	1.059E+07	0.	2.948E+06	1.547E+05	0	1885	0	4432	0

HEATING LOAD = 2.452E+04 BTU/SQFT COOLING LOAD = 5.766E+04 BTU/SQFT ZONE FLOOR AREA = 7.225E+01 SQFT

PEAK LOADS AND TEMPERATURES:
MAX HEATING LOAD = 4.062E+03 AT 2/ 8/ 6 WITH ZONE AIR TEMP OF 68.02
MAX COOLING LOAD = 2.659E+03 AT 7/19/15 WITH ZONE AIR TEMP OF 78.00
MAX ZONE AIR TEMP = 78.00 AT 7/19/15
MIN ZONE AIR TEMP = 68.02 AT 2/ 8/ 6

ZONE LOADS REPORT

SAMPLE BUILDING TEST

LOCATION: NORFOLK, VA TRY 1951

ZONE: 6 LOBBY DELIVERY RETRAINING DETACHMENT BUILDING

ENVIRONMENT NORFOLK, VA TRY 1951 365 DAYS

SIMULATION PERIOD 1 JAN 1951 THRU 31 DEC 1951

MO	HEATING LOAD (BTU)	COOLING LOAD (BTU)	LATENT LOAD (BTU)	RETURN AIR HEAT GAIN (BTU)	BASEBOARD LOAD (BTU)	ELECTRIC LOAD (BTU)	GAS LOAD (BTU)	INFILT HEAT LOSS (BTU)	INFILT HEAT GAIN (BTU)	SYSTEM STATUS H-EX	H-ON	VENT	C-ON	C-EX
JAN	1.928E+06	0.	5.657E+04	0.	0.	5.685E+05	0.	1.690E+06	0.	0	688	0	0	0
FEB	2.031E+06	0.	4.963E+04	0.	0.	5.081E+05	0.	1.764E+06	0.	0	596	0	0	0
MAR	1.507E+06	0.	5.710E+04	0.	0.	5.685E+05	0.	1.374E+06	0.	0	655	0	0	0
APR	4.726E+05	3.369E+03	5.875E+04	0.	0.	5.483E+05	0.	5.292E+05	2.488E+03	0	393	0	5	0
MAY	3.026E+04	3.543E+04	7.368E+04	0.	0.	5.685E+05	0.	5.972E+04	1.111E+04	0	68	0	56	0
JUN	0.	3.840E+05	8.248E+04	0.	0.	5.483E+05	0.	0.	7.330E+04	0	0	0	370	0
JUL	0.	6.846E+05	8.558E+04	0.	0.	5.623E+05	0.	0.	1.062E+05	0	0	0	653	0
AUG	0.	6.224E+05	9.364E+04	0.	0.	5.747E+05	0.	0.	7.332E+04	0	0	0	635	0
SEP	0.	2.511E+05	7.578E+04	0.	0.	5.359E+05	0.	0.	2.460E+04	0	0	0	328	0
OCT	5.151E+04	2.773E+04	7.048E+04	0.	0.	5.685E+05	0.	9.799E+04	8.453E+03	0	92	0	41	0
NOV	1.312E+06	0.	5.435E+04	0.	0.	5.421E+05	0.	1.248E+06	0.	0	557	0	0	0
DEC	1.642E+06	0.	5.204E+04	0.	0.	5.561E+05	0.	1.449E+06	0.	0	616	0	0	0
TOT	8.975E+06	2.009E+06	8.101E+05	0.	0.	6.650E+06	0.	8.212E+06	2.995E+05	0	3665	0	2088	0

HEATING LOAD = 2.957E+04 BTU/SQFT COOLING LOAD = 6.618E+03 BTU/SQFT ZONE FLOOR AREA = 3.035E+02 SQFT

PEAK LOADS AND TEMPERATURES:
MAX HEATING LOAD = 9.852E+03 AT 2/ 8/ 6 WITH ZONE AIR TEMP OF 68.02
MAX COOLING LOAD = 3.430E+03 AT 7/19/15 WITH ZONE AIR TEMP OF 78.00
MAX ZONE AIR TEMP = 78.00 AT 7/19/15
MIN ZONE AIR TEMP = 68.02 AT 2/ 8/ 6

```
                     ******************************************************
                     **                                                  **
                     **          R E V I E W   S U M M A R Y   R E P O R T         **
                     **                                                  **
                     ******************************************************
 1 BUILDING                                                   SIMULATION PERIOD =  1 JAN 1951 - 31 DEC 1951
 0 SYSTEMS                                                    LOCATION =    NORFOLK, VA   TRY    1951
 0 PLANTS                                                     HEATING DEGREE DAYS = 3294.0
                                                              COOLING DEGREE DAYS = 1398.0
PROJECT = SAMPLE BUILDING TEST


    FOR ZONE     1 FLOOR AREA        510.00 FT**2      CEILING HEIGHT      11.0 FT
          APPROXIMATED VOLUME         5610. FT**3

    FOR ZONE     2 FLOOR AREA        510.00 FT**2      CEILING HEIGHT      11.0 FT
          APPROXIMATED VOLUME         5610. FT**3

    FOR ZONE     3 FLOOR AREA        105.00 FT**2      CEILING HEIGHT      11.0 FT
          APPROXIMATED VOLUME         1155. FT**3

    FOR ZONE     4 FLOOR AREA         89.25 FT**2      CEILING HEIGHT      11.0 FT
          APPROXIMATED VOLUME          982. FT**3

    FOR ZONE     5 FLOOR AREA         72.25 FT**2      CEILING HEIGHT      11.0 FT
          APPROXIMATED VOLUME          795. FT**3

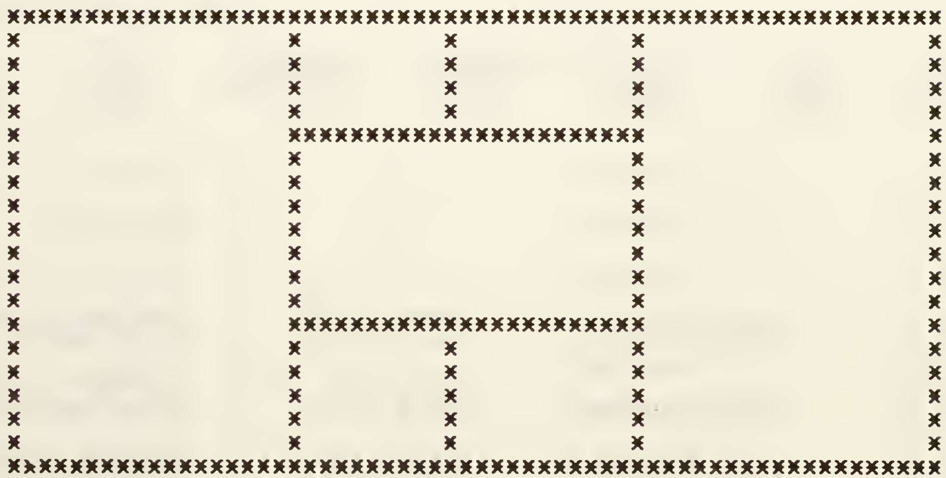
    FOR ZONE     6 FLOOR AREA        303.50 FT**2      CEILING HEIGHT      11.0 FT
          APPROXIMATED VOLUME         3338. FT**3
```

*** PLAN VIEW OF BUILDING SURFACES ***

```
MIN X =      0.00  FT
MAX X =     53.00  FT
MIN Y =      0.00  FT
MAX Y =     30.00  FT
```

* = BUILDING SURFACE, + = SHADOWING SURFACE

```
     Y+             N
     1              1
-X--+--+X       W--+--E
     1              1
    -Y              S
```



```
                              ***********************
                              *BUILDING ENVELOPE DATA*
                              ***********************
          NOTE-SURFACES IN ZONES DESIGNATED AS ATTIC OR CRAWLSPACE ARE NOT INCLUDED

                                                                                     *NORTH= 0.
                                 AREA           U        AZIMUTH*     TILT     PER CENT   EAST= 90.0
                               (FT**2)   (B/H*F**2*R) (DEGREES)  (DEGREES)   GLAZING

ROOF                           1590.00        .094      *****        0.0        0.0
 ROOF17                        1590.00        .094      *****        0.0

EXTERIOR WALL                   330.00        .286      270.0       90.0       36.4
 EXTWALL28                      210.00        .133      270.0       90.0
 DOUBLE PANE WINDOW             120.00        .553      270.0       90.0

EXTERIOR WALL                   583.00        .154        0.0       90.0        5.1
 EXTWALL28                      553.00        .133        0.0       90.0
 DOUBLE PANE WINDOW              30.00        .553        0.0       90.0

EXTERIOR WALL                   583.00        .167      180.0       90.0        8.1
 EXTWALL28                      535.50        .133      180.0       90.0
 DOUBLE PANE WINDOW              47.50        .553      180.0       90.0

EXTERIOR WALL                   330.00        .286       90.0       90.0       36.4
 EXTWALL28                      210.00        .133       90.0       90.0
 DOUBLE PANE WINDOW             120.00        .553       90.0       90.0

SLAB ON GRADE FLOOR            1590.00        .091      *****      180.0        0.0
 FLOOR SLAB 4 IN               1590.00        .091      *****      180.0

                               -------       -----                             -----
                               5006.00        .134 (AREA WEIGHTED AVERAGE)      17.4 PERCENT OF TOTAL WALL AREA
                                                                                20.0 PERCENT OF TOTAL FLOOR AREA

FLOOR AREA OF BUILDING                 =     1590.00  FT**2
APPROX EXTERIOR SURFACE AREA           =     5006.00  FT**2
APPROXIMATE VOLUME                     =    17488.64  FT**3
APPROX EXTERIOR SURFACE AREA/VOLUME =           .286
```

****
SCHEDULED LOADS
****

ZONE NUMBER	FROM	THRU	SCHEDULE	DESIGN PEAK LOAD		DESIGN PEAK LOAD PER FT**2	# HOURS PER WEEK	AVERAGE LOAD WHEN LOAD SCHEDULED	
PEOPLE:									
1	1JAN	31DEC	OFFICE OCCUPANCY	15.0	PEOPLE	2.941E-02	60.0	1.088E+01	PEOPLE
2	1JAN	31DEC	OFFICE OCCUPANCY	15.0	PEOPLE	2.941E-02	60.0	1.088E+01	PEOPLE
3	1JAN	31DEC	OFFICE OCCUPANCY	2.00	PEOPLE	1.905E-02	60.0	1.450E+00	PEOPLE
4	1JAN	31DEC	OFFICE OCCUPANCY	1.00	PEOPLE	1.120E-02	60.0	7.250E-01	PEOPLE
5	1JAN	31DEC	OFFICE OCCUPANCY	1.00	PEOPLE	1.384E-02	60.0	7.250E-01	PEOPLE
6	1JAN	31DEC	OFFICE OCCUPANCY	2.00	PEOPLE	6.590E-03	60.0	1.450E+00	PEOPLE
LIGHTS:									
1	1JAN	31DEC	OFFICE LIGHTING	1.84	1000BTU	3.614E-03	168.	6.461E-01	1000BTU
2	1JAN	31DEC	OFFICE LIGHTING	1.84	1000BTU	3.614E-03	168.	6.461E-01	1000BTU
3	1JAN	31DEC	OFFICE LIGHTING	.614	1000BTU	5.848E-03	168.	2.153E-01	1000BTU
4	1JAN	31DEC	OFFICE LIGHTING	.614	1000BTU	6.880E-03	168.	2.153E-01	1000BTU
5	1JAN	31DEC	OFFICE LIGHTING	.614	1000BTU	8.498E-03	168.	2.153E-01	1000BTU
6	1JAN	31DEC	OFFICE LIGHTING	.614	1000BTU	2.023E-03	168.	2.153E-01	1000BTU
ELECT EQUIP:									
1	1JAN	31DEC	CONSTANT	1.00	1000BTU	1.961E-03	168.	1.000E+00	1000BTU
2	1JAN	31DEC	CONSTANT	1.00	1000BTU	1.961E-03	168.	1.000E+00	1000BTU
3	1JAN	31DEC	CONSTANT	.360	1000BTU	3.429E-03	168.	3.600E-01	1000BTU
4	1JAN	31DEC	CONSTANT	.550	1000BTU	6.162E-03	168.	5.500E-01	1000BTU
5	1JAN	31DEC	CONSTANT	1.00	1000BTU	1.384E-02	168.	1.000E+00	1000BTU
6	1JAN	31DEC	CONSTANT	.550	1000BTU	1.812E-03	168.	5.500E-01	1000BTU

NO GAS EQUIP:

NO OTHER EQUIP LOADS

```
****************************
*INFILTRATION AND VENTILATION*
****************************
```

ZONE NUMBER	FROM	THRU			OCCUPIED MAX	OCCUPIED MIN	UNOCCUPIED MAX	UNOCCUPIED MIN	DESIGN PEAK LOAD
INFILTRATION:									
1	1JAN	31DEC	CONSTANT	AIR CH/HR	6.6	1.3	6.8	1.3	2.1
				FT**3/MIN	6.1E+02	1.3E+02	6.4E+02	1.3E+02	2.0E+02
				MO/DA/HR	2/ 7/15	8/10/ 7	2/ 7/24	8/17/23	
2	1JAN	31DEC	CONSTANT	AIR CH/HR	6.6	1.3	6.8	1.3	2.1
				FT**3/MIN	6.1E+02	1.3E+02	6.4E+02	1.3E+02	2.0E+02
				MO/DA/HR	2/ 7/15	8/10/ 7	2/ 7/24	8/17/23	
3	1JAN	31DEC	CONSTANT	AIR CH/HR	8.1	1.6	8.3	1.6	2.6
				FT**3/MIN	1.6E+02	3.1E+01	1.6E+02	3.1E+01	5.0E+01
				MO/DA/HR	2/ 7/15	8/10/ 7	2/ 7/24	8/17/23	
4	1JAN	31DEC	CONSTANT	AIR CH/HR	9.4	1.9	9.7	1.9	3.1
				FT**3/MIN	1.5E+02	3.1E+01	1.6E+02	3.1E+01	5.0E+01
				MO/DA/HR	2/ 7/15	8/10/ 7	2/ 7/24	8/17/23	
5	1JAN	31DEC	CONSTANT	AIR CH/HR	6.0	1.2	6.0	1.2	1.9
				FT**3/MIN	8.0E+01	1.6E+01	8.0E+01	1.6E+01	2.5E+01
				MO/DA/HR	2/ 7/15	8/10/ 7	2/ 7/24	8/17/23	
6	1JAN	31DEC	CONSTANT	AIR CH/HR	2.8	.6	2.9	.6	.9
				FT**3/MIN	1.5E+02	3.1E+01	1.6E+02	3.1E+01	5.0E+01
				MO/DA/HR	2/ 7/15	8/10/ 7	2/ 7/24	8/17/23	

NO VENTILATION:

****
ENERGY BUDGET
****

BUILDING NAME (CATEGORY CODE) = DELIVERY RETRAINING DETACHMENT BUILDING
LOCATION = NORFOLK, VA TRY 1951
PROJECT TITLE = SAMPLE BUILDING TEST

HEATING DEGREE DAYS = 3294.0
COOLING DEGREE DAYS = 1398.0

ZONE LOAD

NUMBER	TOTAL HEAT 1000BTU	TOTAL COOL 1000BTU	TOTAL ELECT 1000BTU	TOTAL GAS 1000BTU	TOTAL AREA FT**2	ENERGY BUDGET 1000BTU /FT**2
1	3.602E+04	1.181E+04	1.145E+04	0.	5.100E+02	1.162E+02
2	3.608E+04	1.184E+04	1.143E+04	0.	5.100E+02	1.164E+02
3	6.690E+03	4.414E+03	4.009E+03	0.	1.050E+02	1.439E+02
4	7.947E+03	2.755E+03	5.809E+03	0.	8.925E+01	1.850E+02
5	1.772E+03	4.166E+03	1.059E+04	0.	7.225E+01	2.288E+02
6	8.975E+03	2.009E+03	6.650E+03	0.	3.035E+02	5.810E+01
TOTAL	9.748E+04	3.700E+04	4.994E+04	0.	1.590E+03	

ENERGY BUDGET FOR ALL ZONES = 1.160E+02 1000BTU /FT**2

ZONE LOAD WITHOUT DAYLIGHTING
(NOT PART OF ORIGINAL BLAST OUTPUT)

NUMBER	TOTAL HEAT 1000BTU	TOTAL COOL 1000BTU	TOTAL ELECT 1000BTU	TOTAL GAS 1000BTU	TOTAL AREA FT**2	ENERGY BUDGET 1000BTU /FT**2
1	3.522E+04	1.306E+04	1.426E+04	0.	5.100E+02	1.226E+02
2	3.527E+04	1.310E+04	1.426E+04	0.	5.100E+02	1.228E+02
3	6.489E+03	4.953E+03	4.985E+03	0.	1.050E+02	1.565E+02
4	7.717E+03	3.171E+03	6.650E+03	0.	8.925E+01	1.965E+02
5	1.772E+03	4.166E+03	1.059E+04	0.	7.225E+01	2.288E+02
6	8.975E+03	2.009E+03	6.650E+03	0.	3.035E+02	5.810E+01
TOTAL	9.545E+04	4.046E+04	5.739E+04	0.	1.590E+03	

ENERGY BUDGET FOR ALL ZONES = 1.216E+02 1000BTU /FT**2

PSYCHROMETRIC ERROR SUMMARY

CUMULATIVE FOR ENTIRE RUN

ROUTINE	NUMBER OF ERRORS
PSYDPT	0
PSYRHT	0
PSYTWD	0
PSYVTW	0
PSYWDP	0
PSYWTH	0
PSYWTP	0
PSYWTR	0
SATUPT	0
SATUTH	0
SATUTP	0

```
COPY,ZONE5,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=05,DEBUG=DEBUGN.
ENDIF,ZONE6.
.**ZONE 6**
IFE,FILE(ZONE6,LO),ZONE7.
REWIND,TAPE5.
COPY,ZONE6,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=06,DEBUG=DEBUGN.
ENDIF,ZONE7.
.**ZONE 7**
IFE,FILE(ZONE7,LO),ZONE8.
REWIND,TAPE5.
COPY,ZONE7,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=07,DEBUG=DEBUGN.
ENDIF,ZONE8.
.**ZONE 8**
IFE,FILE(ZONE8,LO),ZONE9.
REWIND,TAPE5.
COPY,ZONE8,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=08,DEBUG=DEBUGN.
ENDIF,ZONE9.
.**ZONE 9**
IFE,FILE(ZONE9,LO),ZONE10.
REWIND,TAPE5.
COPY,ZONE9,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=09,DEBUG=DEBUGN.
ENDIF,ZONE10.
.**ZONE 10**
IFE,FILE(ZONE10,LO),ZONE11.
REWIND,TAPE5.
COPY,ZONE10,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=10,DEBUG=DEBUGN.
ENDIF,ZONE11.
.**ZONE 11**
IFE,FILE(ZONE11,LO),ZONE12.
REWIND,TAPE5.
COPY,ZONE11,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=11,DEBUG=DEBUGN.
ENDIF,ZONE12.
.**ZONE 12**
IFE,FILE(ZONE12,LO),ZONE13.
REWIND,TAPE5.
COPY,ZONE12,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=12,DEBUG=DEBUGN.
ENDIF,ZONE13.
.**ZONE 13**
IFE,FILE(ZONE13,LO),ZONE14.
REWIND,TAPE5.
COPY,ZONE13,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=13,DEBUG=DEBUGN.
ENDIF,ZONE14.
.**ZONE 14**
IFE,FILE(ZONE14,LO),ZONE15.
REWIND,TAPE5.
COPY,ZONE14,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=14,DEBUG=DEBUGN.
ENDIF,ZONE15.
.**ZONE 15**
IFE,FILE(ZONE15,LO),ZONE16.
REWIND,TAPE5.
```

Appendix A - CEL-1 PRECALCULATION AND BLAST INTERFACING ROUTINES

A-1. CEL-1 AND BLAST INTERFACING ROUTINES

The hybrid version of BLAST/CEL-1 consists of a custom update of BLAST and a special subset of CEL-1. Separate BLAST and CEL-1 input files are required, but all output is contained in the BLAST output file. Details on the procedural aspects of executing BLAST/CEL-1 are contained in appendix B of this report. This appendix describes the nature of the interfacing routines and the logic behind their implementation.

In addition to the original capabilities of BLAST and CEL-1, the hybrid version of the two programs includes routines to provide BLAST with a scaling factor for determination of lighting energy for each zone every hour. This scaling factor, called the lighting power multiplier, is determined by interpolating among a set of precalculated values, on the basis of solar position, direct normal illuminance and diffuse sky illuminance. The illuminance values for each hourly interpolation are calculated using the solar radiation values which BLAST is reading from a weather tape. During the initial stages of BLAST/CEL-1 execution, zone lighting energy requirements are calculated for 410 combinations of solar position and intensities. Details on the precalculation and interpolation routines are discussed in the following subsections.

A-2 FORMAT OF BLAST/CEL-1 INTERFACE

The user signifies an intent to run BLAST/CEL-1 by calling for report 26 in the BLAST input file. In addition, for any zone using CEL-1 control of lighting the PERCENT REPLACEABLE statement must be included in each lighting block, with any positive value. This value is not used except to cue the program that a CEL-1 lighting power multiplier should be obtained for that zone. The original BLAST daylighting capability (i.e., PERCENT USABLE BEAM, PERCENT USABLE DIFFUSE) should not be used when report 26 is selected. However, non-daylighting zones can be simulated by omitting the PERCENT REPLACEABLE statement, or by assigning it a value of zero or less. Also, CEL-1 can perform other lighting calculations, consistent with its original capabilities, simply by assembling the appropriate CEL-1 input file to correspond to each BLAST zone input.

During the initial stages of BLAST execution, the request for report 26 triggers a temporary halt of BLAST, and subsequent execution of CEL-1. This is accomplished through the use of a system utility called INVOKE. The INVOKE procedure temporarily stores an image of everything related to the BLAST execution, turning over control to the CEL-1 execution procedure file. CEL-1 will then attempt to process a CEL-1 input file for each BLAST zone. If no input file is found for a particular zone, the program will go on to the next zone, through the total number of BLAST zones. If the CEL-1 input file for a particular zone contains the keyword BLS, a lighting power multiplier (LPM) table will be generated for that zone. If a zone has no fenestration, a LPM table cannot be generated. However, the keyword HOR will cause the calculation and printout of horizontal footcandles at the task locations. Other calculation options are explained in the CEL-1 User's Guide.

Once CEL-1 has attempted to process input files for each of the BLAST zones, control is returned to BLAST, with execution resuming from the point of the temporary halt. The only difference is that now a table of lighting power multipliers has been generated, and stored on disk for subsequent use during the hourly BLAST loads calculations. Every hour, BLAST computes the loads for each zone by looping through each zone. One of the critical heat-balance elements is lighting power. If report 26 has been specified, the CEL-1 lighting power interpolation subroutine will be activated for each zone having a LPM table, so long as either direct or diffuse solar radiation is greater than zero.

BLAST supplies information about solar position and intensity to the CEL-1 subroutine, which returns a lighting power multiplier for scaling the BLAST lighting power. In this manner, the effects of daylighting and lighting system performance can be included in the BLAST energy calculations.

Details on each of the individual parts of the BLAST/CEL-1 interface are contained in the following sections.

A-3 THE CUSTOM BLAST UPDATE PROCEDURE

In order to implement the hybrid BLAST/CEL-1 program, some changes had to be made to the original BLAST itself. These changes consist mainly of additional sections of FORTRAN code. Additional changes in the system procedure files required for execution were required. While procedure files can easily be modified using the system editor, BLAST itself must be recompiled and saved after any changes. A system utility called UPDATE was used to change the BLAST FORTRAN source code, recompile the updated BLAST, and save the updated version. Normally the user need not worry about the update procedure, since once the updated version of BLAST is saved, it can be used repeatedly. A new update is required only if an updated version is not available or if additional changes are required. Information on the update procedure is given here to provide the user an understanding of the technical basis for the update.

A complete listing of the update procedure file is given in table B-1. The comments in the file help explain the logic of the FORTRAN code.

A-4 CEL-1 AND BLAST INPUT FILES

The details of the CEL-1 and BLAST input file format are contained in the respective user's guides [1,2,3]. It would be impossible to include here all potential input file combinations, but several important points should be made regarding the correspondence between the BLAST and CEL-1 input files, and the file naming conventions.

In a typical BLAST simulation, a building is divided into a number of thermal zones. A thermal zone does not have to be a single room, but should represent an area over which the thermal conditions are relatively equivalent. This is particularly important if fan systems are simulated. Also, since air temperature is assumed to be uniform throughout a thermal zone, a loss of simulation sensitivity and accuracy can result from inappropriate zone selection.

When assembling the BLAST input file, the user should number the building zones sequentially starting from one. A separate CEL-1 input file must be assembled for each BLAST zone which will have CEL-1 lighting control. If CEL-1 control of lighting is not desired for some zones, the corresponding CEL-1 input files need not be created. The program will process all CEL-1 data decks called for in procedure RUNCEL (table A-4).

The BLAST input files must contain the following elements for successful execution of BLAST/CEL-1:

In the run control block:

REPORTS (26),

In zone block requesting CEL-1 lighting control:

LIGHTS =< lighting power >, < lighting schedule >, N PERCENT REPLACEABLE;

where $0<N\leq100$

In zone block without CEL-1 lighting control:

Set N = 0 in lights statement above,
(or omit PERCENT REPLACEABLE statement).

The value N above is used only as a switch to cause implementation of the CEL-1 interpolation routines during the hourly BLAST load calculations. If N is inadvertently specified as a greater than zero for a zone which did not have a CEL-1 input file calling for a lighting power multiplier table precalculation, program execution will halt with error when the CEL-1 interpolation subroutine attempts to read from disk a lighting power table for that zone.

The CEL-1 input files for each zone must contain the following keyword to cause generation of the lighting power multiplier tables.

In the CALCULATE block:

BLS

If the BLAST zone has no fenestration, or if CEL-1 control lighting is not desired, the CEL-1 input file can be omitted, or the CALCULATE block can request other CEL-1 capabilities.

The corresponding BLAST and CEL-1 input files must maintain consistency regarding lighting system parameters. The lighting power specifications in the BLAST zone description and the associated CEL-1 input file must be equal.

A-5 THE PRECALCULATION ROUTINES

The following description applies for each zone using CEL-1 control of lighting. The zone number from BLAST corresponds to a CEL-1 data deck designated in the procedure which runs CEL-1 (RUNCEL). The procedure RUNCEL must be altered to get the CEL-1 data decks to be used. Table A-4 shows the procedure altered to get data decks NOSBDD1 through NOSBDD4. The other possible data decks for zones 5 through 20 are commented out. Only zones 1 through 4 will be run by CEL-1.

For each zone, 410 combinations of solar conditions are simulated, intended to cover the range of potential conditions. The 410 combinations consist of 10 overcast calculations, which are independent of solar position and 40 sets of solar altitude-azimuth combinations, each including 10 direct normal and diffuse illumance combinations. That is, the sky is subdivided into 40 regions, and calculations are made for each region assuming the sun is at the center of that region, for 10 combinations of direct normal and diffuse illuminances. Lighting power is calculated for each set of conditions, and the lighting power multiplier computed as the ratio of actual lighting power to maximum lighting power. The 410 conditions are combinations of different values of solar altitude, solar azimuth, direct normal illuminance, and diffuse sky illuminance. Figure A-2 shows the definitions of the solar angles. Figure A-3 displays typical combinations of direct normal and diffuse illuminances observed over a year near Washington, DC. Ten combinations of direct normal and diffuse illuminance were chosen to cover this range. These values are shown in table A-1 for overcast conditions and table A-2 for nonovercast conditions. For each zone, one set of calculations is made using the values in table A-1, and 40 sets of calculations are made using the values in table A-2, each using a different solar position.

The pairs of solar altitude and azimuth used by the program for the precalculations are automatically chosen by the program on the basis of site latitude. In this manner, the range of solar positions simulated can closely match the actual range. Four ranges are provided, based on latitudes of 24, 32, 40 and 48 degrees. Tables A-3a through A-3d present the altitude and azimuth ranges for each latitude.

The precalculation of lighting power requirements as a function of solar position and illumination conditions automatically incorporates the effects of sky condition on lighting energy, in terms of variables which can be provided by BLAST during the BLAST hourly simulation. It provides detailed information about lighting performance under a variety of conditions while minimizing the number of CEL-1 calculations required. This is necessary because the detailed nature of the CEL-1 calculations prohibits a large number of computations, as would be required if it were implemented hourly for an entire year.

The result of the precalculation portion of the hybrid BLAST/CEL-1 program is a disk file containing a table of lighting power multipliers for each zone, indexed by solar position and illuminance levels. The file is an indirect access, one with the name of the LPM table given by the user at the start of procedure RUNCEL. The name must be enclosed in dollar signs. In table A-4 the name chosen is NOSBTAB.

TABLE A-1. Diffuse and Direct Normal Illuminances Used for the Overcast Precalculations

Direct Normal Illuminance	Diffuse sky illuminance
0	0.1 fc (1 lux)
0	1226.3 (13,145)
0	1627.6 (17,513)
0	2029.0 (21,832)
0	2550.2 (27,440)
0	3071.3 (33,047)
0	3765.3 (40,515)
0	4459.3 (47,982)
0	5011.1 (53,919)
0	5563. (59,858)

TABLE A-2. Diffuse and Direct Normal Illuminances Used for the Non-Overcast Precalculations

Direct Normal illuminance	Diffuse sky Illuminance
2043.8 fc (21,911 lux)	4273.5 fc (45,983 lux)
1412.1 (15,194)	2945.0 (31,688)
929.0 (9,996)	1941.7 (20,892)
6317.4 (67,975)	4059.8 (43,683)
5072.5 (54,580)	3251.6 (34,987)
3493.1 (37,586)	2238.9 (24,090)
2304.0 (24,791)	1477.1 (15,894)
7144.2 (76,872)	1226.3 (13,195)
4914.5 (52,880)	845.4 (9,097)
3251.6 (34,987)	555.6 (5,978)

TABLE A-3a

Solar Position Boxes for Latitude 24°

	AZ	ALT	ALT	RANGE	AZ	RANGE
BOX 1:	105	75	60	90	0	120
BOX 2:	135	75	60	90	120	150
BOX 3:	165	75	60	90	150	180
BOX 4:	105	52	45	60	0	120
BOX 5:	135	52	45	60	120	150
BOX 6:	165	52	45	60	150	180
BOX 7:	80	37	30	45	0	90
BOX 8:	97	37	30	45	90	105
BOX 9:	112	37	30	45	105	120
BOX 10:	127	37	30	45	120	135
BOX 11:	142	37	30	45	135	150
BOX 12:	165	37	30	45	150	180
BOX 13:	80	22	15	30	0	90
BOX 14:	97	22	15	30	90	105
BOX 15:	112	22	15	30	105	120
BOX 16:	130	22	15	30	120	180
BOX 17:	73	7	0	15	0	80
BOX 18:	85	7	0	15	80	90
BOX 19:	97	7	0	15	90	105
BOX 20:	112	7	0	15	105	180

TABLE A-3b

Solar Position Boxes for Latitude 32°

	AZ	ALT	ALT	RANGE	AZ	RANGE
BOX 1:	105	75	60	90	0	120
BOX 2:	135	75	60	90	120	150
BOX 3:	165	75	60	90	150	180
BOX 4:	105	52	45	60	0	120
BOX 5:	135	52	45	60	120	150
BOX 6:	165	52	45	60	150	180
BOX 7:	90	37	30	45	0	105
BOX 8:	110	37	30	45	105	120
BOX 9:	127	37	30	45	120	135
BOX 10:	145	37	30	45	135	150
BOX 11:	158	37	30	45	150	165
BOX 12:	173	37	30	45	165	180
BOX 13:	80	22	15	30	0	90
BOX 14:	95	22	15	30	90	105
BOX 15:	112	22	15	30	105	120
BOX 16:	135	22	15	30	120	180
BOX 17:	75	7	0	15	0	80
BOX 18:	85	7	0	15	80	90
BOX 19:	97	7	0	15	90	105
BOX 20:	115	7	0	15	105	180

TABLE A-3c

Solar Position Boxes for Latitude 40°

	AZ	ALT	ALT	RANGE	AZ	RANGE
BOX 1:	133	75	60	90	0	150
BOX 2:	165	75	60	90	150	180
BOX 3:	110	52	45	60	0	120
BOX 4:	135	52	45	60	120	150
BOX 5:	165	52	45	60	150	180
BOX 6:	95	37	30	45	0	105
BOX 7:	112	37	30	45	105	120
BOX 8:	127	37	30	45	120	135
BOX 9:	142	37	30	45	135	150
BOX 10:	157	37	30	45	150	165
BOX 11:	172	37	30	45	165	180
BOX 12:	80	22	15	30	0	90
BOX 13:	97	22	15	30	90	105
BOX 14:	112	22	15	30	105	120
BOX 15:	127	22	15	30	120	135
BOX 16:	142	22	15	30	135	180
BOX 17:	75	7	0	15	0	80
BOX 18:	85	7	0	15	80	90
BOX 19:	97	7	0	15	90	105
BOX 20:	112	7	0	15	105	180

TABLE A-3d

Solar Position Boxes for Latitude 48°

	AZ	ALT	ALT	RANGE	AZ	RANGE
BOX 1:	110	52	45	90	0	120
BOX 2:	130	52	45	90	120	150
BOX 3:	150	52	45	90	140	160
BOX 4:	170	52	45	90	160	180
BOX 5:	110	37	30	45	0	120
BOX 6:	130	37	30	45	120	140
BOX 7:	150	37	30	45	140	160
BOX 8:	170	37	30	45	160	180
BOX 9:	90	22	15	30	0	100
BOX 10:	110	22	15	30	100	120
BOX 11:	125	22	15	30	120	130
BOX 12:	135	22	15	30	130	140
BOX 13:	145	22	15	30	140	150
BOX 14:	155	22	15	30	150	160
BOX 15:	170	22	15	30	160	180
BOX 16:	70	7	0	15	0	80
BOX 17:	90	7	0	15	80	100
BOX 18:	105	7	0	15	100	110
BOX 19:	115	7	0	15	110	120
BOX 20:	130	7	0	15	120	180

Before any precalculations are attempted, the program looks for the LPM table file requested by RUNCEL. If one is found, no precalculations are done, and the program assumes that the LPM table file is correct for that BLAST simulation. Thus, if a new LPM table file is required, the LPM table name RUNCEL must be changed. It is wise to save any LPM tables since they can be reused for any zone of similar daylight design. In this manner, system variations or other changes not influencing the lighting system (i.e., wall type, site location) can be simulated without generating a new LPM table. To be most accurate, large changes in site latitude might require a new set of precalculations, but this is not essential since the interpolation will still be valid, since it is based on solar position and daylight levels.

A-6 HOURLY LIGHTING POWER DETERMINATION

CEL-1 control of lighting during the hourly BLAST loads calculations is accomplished through the use of CEL-1 based subroutines added to BLAST during the custom update procedure. The basic functions of the additional code are to:

a) convert BLAST-supplied direct normal and diffuse irradiances to equivalent illuminances,
b) recompute solar altitude and azimuth,
c) determine lighting power for each zone by interpolation among the precalculated values.

The irradiances are converted to illuminances using luminous efficacy relations. The luminous efficacy of solar radiation represents its light content in units of lumens (weighted by the spectral response of the eye). Luminous efficacy converts watts per square meter to lumens per square meter. Values for the luminous efficacy of various solar radiation components are not constants, but are influenced by atmospheric conditions, such as cloudiness, water vapor or airborne particulates, and solar position, which influences both the atmospheric path length for direct beam radiation and the spectral distribution of the diffuse radiation.

Based on measurements made at the National Bureau of Standards [12], luminous efficacy equations were developed for both direct normal and diffuse irradiance (solar radiation) as functions of cloud ratio. Cloud ratio is defined as [12]:

$$\frac{Id}{Ig} = \frac{\text{diffuse horizontal irradiance}}{\text{global horizontal irradiance}}$$

Global irradiance includes radiation from both the sun and the sky, while diffuse includes only radiation from the sky. Cloud ratio (CR) is a general indicator of sky condition. If CR equals one, there is no direct beam radiation. This can occur if

a) sun is below the horizon, or
b) sun is behind a cloud

Consistently overcast or predominantly cloudy skies will have cloud ratios near one. Occasionally, a predominantly clear sky will temporarily have a high cloud ratio, due to the presence of a cloud patch in front of the solar disk. Usually, however, clear skies will have cloud ratios near 0.1. Since the relative contribution of the direct beam to horizontal global decreases with solar altitude, using cloud ratio as a parameter in determining luminous efficacy implicitly incorporates the effect of solar altitude along with the effect of the relative contribution of diffuse irradiance.

The equations used for calculating luminous efficacy are:

$$N_d = 136 - 31.9\ (CR)$$

$$N_D = 89 + 40.1\ (CR)$$

where

N_d = diffuse luminous efficacy
N_D = direct beam luminous efficacy

Diffuse illuminance (E_d) and direct normal illuminance (E_{DN}) are computed from

$$E_{DN} = I_{DN}\ \ N_D$$

$$E_d = I_d\ \ N_d$$

The solar altitude and azimuth are computed routinely from the solar direction cosines in BLAST common storage.

The CEL-1 hourly lighting power interpolation takes the current hour's solar altitude and azimuth, and determines which precalculated region of the sky corresponds to the solar position. This choice is made from a selection of 40 sky boxes chosen to cover all possible solar positions. Once the sky box is picked, a two-dimensional interpolation is performed, using direct beam and diffuse sky illuminances as the interpolation parameters. The particular combination of diffuse and direct illuminances is usually bounded by four precalculated points. If, due to extraordinary circumstances or erroneous weather data, the diffuse or direct illuminances exceed the precalculated ranges, extrapolation is used to compute the lighting power for that set of conditions.

A-7 BLAST/ŒL-1 OUTPUT

When executing BLAST/ŒL-1, all of the simulation output is contained with the BLAST output. The only differences between standard BLAST output and that from BLAST/ŒL-1 are in the lighting and electrical energy results themselves, and the additional output generated by ŒL-1 during the precalculation stage.

If a new lighting power multiplier table is generated, as would occur if no LPM table file existed, the ŒL-1 input data file will be echoed, and the pre-calculation results printed. This section of printout will occur in the BLAST output file immediately following the echo of the BLAST input file. If BLAST/ŒL-1 is run using an existing LPM table file, no additional BLAST output occurs.

When a new lighting power multiplier table is generated, it will appear as an indirect access file. The name of this file is defined in the procedure RUNŒL.

Table A-4. Procedure File to Execute CEL-1 from BLAST

```
.PROC,RUNCEL,DEBUGN,CELTABS=$NOSBTAB$.
.* RUNCEL IS CALLED FROM BLAST BY THE INVOKE COMMAND.
.* RUNCEL RUNS ANY OF 20 CEL-1 LPM TABLE GENERATION
.* RUNS FOR WHICH IT FINDS DATA DECKS. CHANGE $CELTABS$
.* IN FIRST LINE ONLY TO THE NEW TABLE FILE TO BE USED,
.*  $NEWTABS$ .
.* GET EXISTING LPM TABLE. IF FOUND, EXISTING TABLE USED.
RETURN,TAPE91.
GET,TAPE91=CELTABS/NA.
IFE,.NOT.FILE(TAPE91,LO),END.
.* GET THE CEL-1 DATA DECKS FOR ZONES 1-20 IF AVAILABLE.
.* ALTER NEXT 20 LINES TO GET CORRECT DATA DECKS.
GET,ZONE1=NOSBDD1/PW=PW,NA.
GET,ZONE2=NOSBDD2/PW=PW,NA.
GET,ZONE3=NOSBDD3/PW=PW,NA.
GET,ZONE4=NOSBDD4/PW=PW,NA.
.*GET,ZONE5=CELDD5/NA.
.*GET,ZONE6=CELDD6/NA.
.*GET,ZONE7=CELDD7/NA.
.*GET,ZONE8=CELDD8/NA.
.*GET,ZONE9=CELDD9/NA.
.*GET,ZONE11=CELDD11/NA.
.*GET,ZONE12=CELDD12/NA.
.*GET,ZONE13=CELDD13/NA.
.*GET,ZONE14=CELDD14/NA.
.*GET,ZONE15=CELDD15/NA.
.*GET,ZONE16=CELDD16/NA.
.*GET,ZONE17=CELDD17/NA.
.*GET,ZONE18=CELDD18/NA.
.*GET,ZONE19=CELDD19/NA.
.*GET,ZONE20=CELDD20/NA.
.* FOR EACH ZONE DO: IF DATA DECK FOR THE ZONE IS LOCAL
.* RUN CEL-1 FOR THAT ZONE.
.**ZONE 1**
IFE,FILE(ZONE1,LO),ZONE2.
REWIND,TAPE5.
COPY,ZONE1,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=01,DEBUG=DEBUGN.
ENDIF,ZONE2.
.**ZONE 2**
IFE,FILE(ZONE2,LO),ZONE3.
REWIND,TAPE5.
COPY,ZONE2,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=02,DEBUG=DEBUGN.
ENDIF,ZONE3.
.**ZONE 3**
IFE,FILE(ZONE3,LO),ZONE4.
REWIND,TAPE5.
COPY,ZONE3,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=03,DEBUG=DEBUGN.
ENDIF,ZONE4.
.**ZONE 4**
IFE,FILE(ZONE4,LO),ZONE5.
REWIND,TAPE5.
COPY,ZONE4,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=04,DEBUG=DEBUGN.
ENDIF,ZONE5.
.**ZONE 5**
IFE,FILE(ZONE5,LO),ZONE6.
REWIND,TAPE5.
```

```
COPY,ZONE15,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=15,DEBUG=DEBUGN.
ENDIF,ZONE16.
.**ZONE 16**
IFE,FILE(ZONE16,LO),ZONE17.
REWIND,TAPE5.
COPY,ZONE16,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=16,DEBUG=DEBUGN.
ENDIF,ZONE17.
.**ZONE 17**
IFE,FILE(ZONE17,LO),ZONE18.
REWIND,TAPE5.
COPY,ZONE17,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=17,DEBUG=DEBUGN.
ENDIF,ZONE18.
.**ZONE 18**
IFE,FILE(ZONE18,LO),ZONE19.
REWIND,TAPE5.
COPY,ZONE18,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=18,DEBUG=DEBUGN.
ENDIF,ZONE19.
.**ZONE 19**
IFE,FILE(ZONE19,LO),ZONE20.
REWIND,TAPE5.
COPY,ZONE19,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=19,DEBUG=DEBUGN.
ENDIF,ZONE20.
.**ZONE 20**
IFE,FILE(ZONE20,LO),END.
REWIND,TAPE5.
COPY,ZONE20,TAPE5,V.
BEGIN,CELPROC,CELPROC,ZONE=20,DEBUG=DEBUGN.
ENDIF,END.
REPLACE,TAPE91=CELTABS.
REVERT.
.* IF ERROR WRITE DAYFILE, STOP EXECUTION
EXIT.
DAYFILE,DFCR.
ENQUIRE,OP=A,O=DFCR.
REPLACE,DFCR.
RETURN,*.
EXIT.
```

Figure A-1 Update file procedure listing

```
*IDENT CELUPS2
*/
*/ THE FOLLOWING ARE CHANGES TO THE BLAST 3.0.107 PROGRAM
*/ TO ENABLE IT TO INTERFACE TO THE CEL-1 LIGHTING PROGRAM
*/
*/     ADD THE CEL INTERFACE FILE TO THE BLAST PROGRAM STATEMENT
*DELETE BLAST.9
      -   TWOONE=0,TWOTWO=0,TWO3=0,TWO4=0,
      -   AHLDFL=460,SINPFL,OLDLIB=350,TAPE21=TWOONE,TAPE22=TWOTWO,
*DELETE ECIPUP.6
      -   TAPE23=TWO3,RPTFLE=460,TAPE24=TWO4,ECIPFL=0,
      -   TAPE25=ECIPFL,
*DELETE BLAST.14
      -   TWOONE=0,TWOTWO=0,TWO3=0,TWO4=0,
      -   AHLDFL=65,SINPFL=65,OLDLIB=65,TAPE21=TWOONE,TAPE22=TWOTWO,
*DELETE ECIPUP.7
      -   TAPE23=TWO3,RPTFLE=65,TAPE24=TWO4,ECIPFL=0,
      -   TAPE25=ECIPFL,
*DELETE BLAST.20
     - TAPE18=RPTFLE,DEBUG=OUTPUT,TAPE91=0)
*/
*/     ADD THE CALL TO THE CEL INTERFACE SUBROUTINE
*INSERT INITBL.27
      INTEGER DEBUGON,DEBGOFF,TEXT(12)
      EXTERNAL INVOKE
      DATA TEXT(1)/10LBEGIN,RUNC/,TEXT(2)/10LEL,RUNCEL,/
      DATA DEBUGON/9LDEBUGN=1./,DEBGOFF/9LDEBUGN=0./,TEXT(4)/0/
*INSERT INITBL.50
C THE CEL-1 LIGHTING PROGRAM IS ACTIVATED AND RUN AT THIS TIME
C IF BLAST REPORT #26 IS CHOSEN.

      IF (.NOT.RFLAGS(26)) GO TO 999
C
C DEBUG LISTING IS IS PRINTED IF REPORT 27 REQUESTED
C
      TEXT(3) = DEBGOFF
      IF(RFLAGS(27)) TEXT(3) = DEBUGON
C
C USE THE INVOKE FORTRAN LIBRARY ROUTINE TO INTERRUPT THE EXECUTION
C OF BLAST. SAVE THE PRESENT PROGRAM STATUS AND THEN EXECUTE CEL-1.
C UPON COMPLETION OF CEL-1 THE BLAST PROGRAM IS RESTORED AND RESTARTED.
C
      CALL INVOKE(TEXT,4,1,IERR)
*INSERT QINSRC.23
*CALL REPORT
*INSERT QINSRC.71
C
C IF REPORT 26 IS REQUESTED CALL SUBROUTINE LPMTAB TO INTERPOLATE FROM
C THE CEL-1 GENERATED LIGHTING POWER MULTIPLIER TABLE. REDUCE LIGHTING
C BY AMOUNT OF FACTOR. SKIP BLAST DAYLIGHT ROUTINE.
C
      IF(.NOT.RFLAGS(26)) GOTO 121
      CALL LPMTAB(NZ,ALPM)
      Q = Q * ALPM
      GOTO 122
 121  CONTINUE
*BEFORE LSQFIT.1
*DECK LPMTAB
C*********************************************************************
C  THIS SUBROUTINE SELECTS FROM THE TABLE OF LPM'S USING THE ZONE
```

```
C NUMBER, SOLAR POSITION AND EXTERNAL IRRADIATION VALUES PROVIDED BY
C BLAST. LPMTAB FINDS THE CLOSEST ALT/AZ BOX THEN INTERPOLATES USING
C THE PRECALCULATED ILLUMINANCE VALUES TO FIND THE LPM. THE LPM TABLE
C MUST BE CALCULATED IN ADVANCE BY THE USE OF THE CEL1RUN KEYWORD IN
C THE BLAST DATA DECK.
C
C
      SUBROUTINE LPMTAB(ZONE,LPM)
C
*CALL REPORT
*CALL BFLHDR
*CALL CIRCLE
*CALL ZONCON
*CALL ENVDAT
C
C DECLARATIONS, EQUIVALENCES FOR BLAST CEL INTERFACE VARIABLES
C
      REAL IDIR,IDIRN,IDIF,ALT,AZ,LPM,EDIF,EDIR,EDIRN,CR,ATEXCO
     &     ,DIFEF,DIREF,ITOT,IXT
     &      ,SCDIF,W1,W2,W3,W4,RPT,THETAPT
     &      ,AREA1,AREA2,AREA3,AREA4,WHAREA,RADIUS(5),THETA(5)
      INTEGER BOX,I,HI,LO
      REAL LUMCLPC(10,2),LUMOV(10),MIN
     &      ,MAX,SOLALT(20,4),SOLAZ(20,4),LOWALT(20,4),HIGHALT(20,4)
     &      ,LOWAZ(20,4),HIGHAZ(20,4)
      INTEGER DEBUG,ZONE,LATNO,LUTABS,NR,NTH,CONVTAB(5,5),BOXN
      REAL CELTABS(8223),LPMCPCO(20,41,10),ZONFLG(20),TABIN,SYSFLG
     &     ,LPM1,LPM2,LPM3,LPM4,LAT,CELLAT
      EQUIVALENCE (CELTABS(1),LPMCPCO(1,1,1)),(CELTABS(8201),ZONFLG(1))
     & ,(CELTABS(8221),TABIN),(CELTABS(8222),CELLAT)
     & ,(CELTABS(8223),SYSFLG)
      COMMON /CELTABS/ CELTABS
C
      DATA EXTILL/127500.0/,DEGTRAD/.017453293/,SCALE/1.6667/
      DATA RADIUS/0.0,36400.0,55100.0,80000.0,99800.0/
      DATA THETA/0.0,0.2793,0.7505,1.2915,1.5708/
      DATA LUMOV/1.0,13200.0,17520.0,21840.0,27450.0
     &      ,33060.0,40530.0,48000.0,53940.0,59880.0/
      DATA CONVTAB/1,4,6,8,10,
     &             1,3,2,1,4,
     &             1,7,6,5,4,
     &             1,10,9,8,4,
     &             1,10,9,8,4/
      DATA SOLALT/
     &  75.0, 75.0, 75.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0,
     &  37.0, 37.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,
     &  75.0, 75.0, 75.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0,
     &  37.0, 37.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,
     &  75.0, 75.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0, 37.0,
     &  37.0, 22.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,
     &  52.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0, 22.0, 22.0,
     &  22.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,  7.0/
      DATA SOLAZ/
     & 105.0,135.0,165.0,105.0,135.0,165.0, 80.0, 97.0,112.0,127.0,
     & 142.0,165.0, 80.0, 97.0,112.0,130.0, 73.0, 85.0, 97.0,112.0,
     & 105.0,135.0,165.0,105.0,135.0,165.0, 90.0,110.0,127.0,145.0,
     & 158.0,173.0, 80.0, 95.0,112.0,135.0, 75.0, 85.0, 97.0,115.0,
     & 133.0,165.0,110.0,135.0,165.0, 97.0,112.0,127.0,142.0,157.0,
     & 172.0, 80.0, 97.0,112.0,127.0,142.0, 75.0, 85.0, 97.0,112.0,
     & 110.0,130.0,150.0,170.0,110.0,130.0,150.0,170.0, 90.0,110.0,
```

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     & 125.0,135.0,145.0,155.0,170.0, 70.0, 90.0,105.0,115.0,130.0/
      DATA LOWAZ/
     &   0.0,120.0,150.0,  0.0,120.0,150.0,  0.0, 90.0,105.0,120.0,
     & 135.0,150.0,  0.0, 90.0,105.0,120.0,  0.0, 80.0, 90.0,105.0,
     &   0.0,120.0,150.0,  0.0,120.0,150.0,  0.0,105.0,120.0,135.0,
     & 150.0,165.0,  0.0, 90.0,105.0,120.0,  0.0, 80.0, 90.0,105.0,
     &   0.0,150.0,  0.0,120.0,150.0,  0.0,105.0,120.0,135.0,150.0,
     & 165.0,  0.0, 90.0,105.0,120.0,135.0,  0.0, 80.0, 90.0,105.0,
     &   0.0,120.0,140.0,160.0,  0.0,120.0,140.0,160.0,  0.0,100.0,
     & 120.0,130.0,140.0,150.0,160.0,  0.0, 80.0,100.0,110.0,120.0/
      DATA HIGHAZ/
     & 120.0,150.0,180.0,120.0,150.0,180.0, 90.0,105.0,120.0,135.0,
     & 150.0,180.0, 90.0,105.0,120.0,180.0, 80.0, 90.0,105.0,180.0,
     & 120.0,150.0,180.0,120.0,150.0,180.0,105.0,120.0,135.0,150.0,
     & 165.0,180.0, 90.0,105.0,120.0,180.0, 80.0, 90.0,105.0,180.0,
     & 150.0,180.0,120.0,150.0,180.0,105.0,120.0,135.0,150.0,165.0,
     & 180.0, 90.0,105.0,120.0,135.0,180.0, 80.0, 90.0,105.0,180.0,
     & 120.0,140.0,160.0,180.0,120.0,140.0,160.0,180.0,100.0,120.0,
     & 130.0,140.0,150.0,160.0,180.0, 80.0,100.0,110.0,120.0,180.0/
      DATA LOWALT/
     &  60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0,
     &  30.0, 30.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,
     &  60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0,
     &  30.0, 30.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,
     &  60.0, 60.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 30.0,
     &  30.0, 15.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,
     &  45.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0,
     &  15.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,  0.0/
      DATA HIGHALT/
     &  90.0, 90.0, 90.0, 60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 45.0,
     &  45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0,
     &  90.0, 90.0, 90.0, 60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 45.0,
     &  45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0,
     &  90.0, 90.0, 60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 45.0, 45.0,
     &  45.0, 30.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0,
     &  90.0, 90.0, 90.0, 90.0, 45.0, 45.0, 45.0, 45.0, 30.0, 30.0,
     &  30.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0, 15.0/
C
      IF(RFLAGS(27)) DEBUG = 1
C
C CHECK TO SEE THAT THE LPM TABLE HAS BEEN INPUT. BUFFER IN TABLE
C IF REQUIRED.
      IF(TABIN.EQ.1.0) GOTO 1900
        IF(UNIT(91).LT.1) GOTO 1910
        PRINT *,"ERROR IN BUFFER OUT OF CELTABS DETECTED FROM LPMTAB"
        STOP
 1910   REWIND 91
        BUFFER IN(91,1)(CELTABS(1),CELTABS(8223))
        IF(UNIT(91).LT.1) GOTO 1920
          PRINT *,"ERROR OF BUFFER IN OF CELTABS IN LPMTAB"
          STOP
 1920   TABIN = 1.0
        CALL TABLIST
C       IF(DEBUG.EQ.1) CALL TABLIST
C
C SET INTERNAL VARIABLES, CHECK FOR NO LIGHT
C
 1900 CONTINUE
      IDIRN = SRADBM(STDTIM)
      IDIF =  SRADDF(STDTIM)
```

```
      LPM = 1.0
      IF((IDIRN.LE.0.0).AND.(IDIF.LE.0.0)) GOTO 300
C
C CALCULATE SOLAR AZIMUTH AND SOLAR ALTITUDE
C
C                                   COMPUTE THE HOUR ANGLE
      H = (15.*(12.-(FLOAT(STDTIM)+EQTIME))+MERID)*DTR
      COSH = COS(H)
C                                   COMPUTE THE COSINE OF THE
C                                   ZENITH ANGLE
      SUNCOS3 = SSDECL*SINL+CSDECL*COSL*COSH
C                                   COMPUTE THE OTHER DIRECTION COSINES
      SUNCOS2 = SSDECL*COSL-CSDECL*SINL*COSH
      SUNCOS1 = CSDECL*SIN(H)
C                                   COMPUTE THE SOLAR AZIMUTH AND ALTITUDE
      ALT = ASIN(SUNCOS3) / DTR
      IF(ALT.LT.0.0) ALT = -ALT
      AZ = ASIN(SUNCOS1/SQRT(1.0-SUNCOS3**2)) / DTR
      IF(SUNCOS2.LT.0.0) AZ = 180.0 - AZ
C                                    CHANGE AZ. COORD. FROM 0 THRU 360
C                                    0 THRU 180, -180 THRU 0
      IF(AZ.GT.180.0) AZ = AZ - 360.0
C
C SELECT THE LATITUDE TABLE CLOSEST TO THE SITE LATITUDE.
C  USE THE ALTITUDE AND AZIMUTH POINTS FROM TABLE FOR CALCULATIONS
C
      LAT = CELLAT
      LATNO = 1
      IF(LAT .LT. 28.0) GOTO 31
      LATNO = 2
      IF(LAT .LT. 36.0) GOTO 31
      LATNO = 3
      IF(LAT .LT. 44.0) GOTO 31
      LATNO = 4
   31 CONTINUE
C
C CONVERT IRRADIANCES TO ILLUMINANCES
C CALCULATE CLOUD RATIO
C
      IDIR = IDIRN*SIN(ALT*DEGTRAD)
      ITOT = IDIR + IDIF
      CR = IDIF / ITOT
C
C CALCULATE EFFICACIES
C
      DIFEF = 136.0 - 31.9*CR
      DIREF  =  86.9 + 40.1*CR
C
C CALCULATE ILLUMINANCES
C
      EDIF = DIFEF * IDIF
      EDIR = DIREF * IDIR
      EDIRN = EDIR / SIN(ALT*DEGTRAD)
C
CALULATE ATMOSPHERIC EXTINCTION COEFFICIENT
C
      ATEXCO = 4.0
      IF(EDIRN.LE.0.0) GOTO 20
      ATEXCO = -SIN(ALT*DEGTRAD) * ALOG(EDIRN / EXTILL)
   20 CONTINUE
```

```
C
C USE EXTINCTION COEFFICIENT TO SELECT EITHER OVERCAST OR PARTLY CLOUDY AND
C CLEAR TABLE OF LPM'S. IF EXTINCTION COEFFICIENT IS GREATER THAN
C 1.6 USE OVERCAST LPM TABLE, ELSE USE CLEAR/ PARTLY CLOUDY
C TABLE
      IF(DEBUG.EQ.1) WRITE(6,6660)
     &              ZONE,STDTIM,SRADDF(STDTIM),SRADBM(STDTIM),CSDECL
     &             ,SSDECL,SINL,COSL,EQTIME,MERID,ALT,AZ,EDIF,EDIR
     &             ,EDIRN,ATEXCO
 6660 FORMAT(T2,"ZONE",T10,"STDTIM",T18,"SRADDF",T26,"SRADBM",T34
     &       ,"CSDECL",T42,"SSDECL",T50,"SINL",T58,"COSL",T66,"EQTIME"
     &       ,T74,"MERID",T82,"ALT",T90,"AZ",T98,"EDIF",T106,"EDIR"
     &       ,T114,"EDIRN",T122,"ATEXCO"/
     &       ,T3,I3,5X,I3,14F8.2)
      IF(ATEXCO .GE. 1.6) GOTO 180
C
C CLEAR AND PARTLY CLOUDY
C
C FIND WHICH SOLAR POSITION POINT ALREADY CALCULATED IS CLOSEST TO THE
C POINT TO BE USED. THE ALT'S AND AZ'S SURROUNDING THE PRECALCULATED POINTS
C ARE DEVIDED INTO "BOXES". IF THE POINT DESIRED FALLS IN A BOX, THE
C PRECALCULATED POINT IN THE CENTER OF THAT BOX IS USED FOR THE
C LPM TABLE LOOK UP.
C
      I = 0
      BOX = 0
 30   I = I + 1
      IF(AZ.GE.LOWAZ(I,LATNO).AND.AZ.LE.HIGHAZ(I,LATNO).AND.
     &  ALT.GE.LOWALT(I,LATNO).AND.ALT.LE.HIGHALT(I,LATNO)) BOX = I
      IF((-AZ).GE.LOWAZ(I,LATNO).AND.(-AZ).LE.HIGHAZ(I,LATNO).AND.
     &  ALT.GE.LOWALT(I,LATNO).AND.ALT.LE.HIGHALT(I,LATNO)) BOX = I + 20
      IF(BOX.EQ.0) GOTO 30
C
C INTERPOLATE FROM THE LPM'S AT THE CORNERS OF THE SELECTED ALT/AZ BOX
C BY DIRECT AND DIFFUSE ILLUMINATION POINTS AREADY CALCULATED. THE
C POINTS ARE AT THE INTERSECTIONS OF A POLAR COORDINATE GRID.
C DIFFUSE ILLUMINATION OF THE POINT IS SCALED TO ALLOW INTERPOLATION
C ON THE PRESCALED GRID POINTS.
C
      SCDIF = EDIF * SCALE
C
C COMPUTE R FOR THE POINT
C
      RPT = SQRT(ELIRN**2 + SCDIF**2)
C
C COMPUTE THE ANGLE FOR THE POINT AND CONVERT IT TO RADIANS
C
      THETAPT = 3.1416/2.0 - ATAN2(SCDIF,EDIRN)
C
C CHECK TO SEE IF THE POINT IS OUTSIDE THE INTERPOLATION RANGE AND ASSIGN AN
C APPROPRIATE LPM IF IT IS.
C
      LPM = LPMCPCO(ZONE,BOX,4)
      IF(RPT.GT.RADIUS(5)) GOTO 300
C
      DO 9 I = 1,4
        NR = I
        IF(RPT.LE.RADIUS(I+1)) GOTO 10
 9    CONTINUE
 10   DO 11 I = 1,4
```

```
         NTH = I
         IF(THETAPT.LE.THETA(I+1)) GOTO 12
 11    CONTINUE
 12    CONTINUE
C
C COMPUTE THE AREA FOR EACH OF THE FOUR AREAS. COMPUTE THE WHOLE AREA.
C
       AREA1 = RPT * (THETAPT - THETA(NTH)) * (RPT - RADIUS(NR))
       AREA2 = RPT * (THETA(NTH+1) - THETAPT) * (RPT - RADIUS(NR))
       AREA3 = RPT * (THETAPT - THETA(NTH)) * (RADIUS(NR+1) - RPT)
       AREA4 = RPT * (THETA(NTH+1) - THETAPT) * (RADIUS(NR+1) - RPT)
       WHAREA = AREA1 + AREA2 + AREA3 + AREA4
       W4 = AREA1 / WHAREA
       W3 = AREA2 / WHAREA
       W2 = AREA3 / WHAREA
       W1 = AREA4 / WHAREA
C
C GET LPM VALUE FOR POINTS FROM LPM TABLE. USES CONVTAB TO CONVERT
C RADIUS AND THETA TO POINT NUMBER INDEX TO LPM TABLE. IF RADIUS
C OR THETA INDEX IS EQUAL TO ONE USE OVERCAST TABLE STORED IN BOX 41
C
       BOXN = BOX
       LPM4 = LPMCPCO(ZONE,BOXN,CONVTAB(NR+1,NTH+1))
       BOXN = BOX
       IF(NTH.EQ.1) BOXN = 41
       LPM3 = LPMCPCO(ZONE,BOXN,CONVTAB(NR+1,NTH))
       BOXN = BOX
       IF(NR.EQ.1) BOXN = 41
       LPM2 = LPMCPCO(ZONE,BOXN,CONVTAB(NR,NTH+1))
       BOXN = BOX
       IF(NTH.EQ.1.OR.NR.EQ.1) BOXN = 41
       LPM1 = LPMCPCO(ZONE,BOXN,CONVTAB(NR,NTH))
C
C INTERPOLATE LPM FOR CLEAR AND PARTLY CLOUDY SKY
C
       LPM = W4*LPM4 + W3*LPM3 + W2*LPM2 + W1*LPM1
       IF(DEBUG.EQ.1) WRITE(6,6661) BOX,NR,NTH,AREA1,AREA2,AREA3,AREA4
      &                            ,LPM1,LPM2,LPM3,LPM4,LPM
 6661      FORMAT(T5,"BOX",T15,"NR",T25,"NTH",T31,"AREA1",T41,"AREA2"
      &          ,T51,"AREA3",T61,"AREA4",T75,"LPM1",T85,"LPM2",T95
      &          ,"LPM3",T105,"LPM4",T115,"LPM"/
      &          ,T4,I3,T14,I3,T24,I3,T29,4F10.0,5F10.2)
       GOTO 300
C
C OVERCAST
C
C FIND THE DIFFUSE ILLUMINANCES FROM THE TABLE WHICH ARE CLOSEST TO
C THE POINT DESIRED. USE THESE FOR A LINEAR INTERPOLATION. IF THE POINT IS
C OUTSIDE OF THE GIVEN POINTS EXTRAPOLATE USING THE TWO CLOSEST POINTS.
C
 180   CONTINUE
       DO 3000 I = 1,9
         LO = I
         HI = I+1
         IF(EDIF.LT.LUMOV(HI)) GOTO 3100
 3000  CONTINUE
 3100  CONTINUE
       LPM =  LPMCPCO(ZONE,41,LO)
      &    + (LPMCPCO(ZONE,41,HI)-LPMCPCO(ZONE,41,LO))
      &    * (EDIF-LUMOV(LO))/(LUMOV(HI)-LUMOV(LO))
```

```
      IF(DEBUG.EQ.1) WRITE(6,6881) DAYOFY,LO,HI,LPM
 6881 FORMAT(1X,"OVERCAST:  DAYOFY = ",I4,"LO = ",I3
     &       ,"HI = ",I3,"LPM = ",F5.3)
C
 300  CONTINUE
      RETURN
      END
*BEFORE LSQFIT.1
*DECK TABLIST
C TABLIST PROVIDES A REPORT OF THE LIGHTING POWER MULTIPLIER (LPM) TABLE
C CONTENTS AND THE SOLAR POSITION AND ILLUMINANCE VALUES USED TO GENERATE
C THE LPM'S.
C
      SUBROUTINE TABLIST
      INTEGER I,J,K,ZONE,LATNO,Z,CONVTAB(5,5),NR,NTH,LUM,DIRN,DIF,R
      REAL CELTABS(8223),LPMCPCO(20,41,10),ZONFLG(20),TABIN,SYSFLG
     &    ,LAT,SOLALT(20,4),SOLAZ(20,4),LOWALT(20,4),LOWAZ(20,4)
     &     ,CELLAT,HIGHALT(20,4),HIGHAZ(20,4),LUMOV(10),LUMCLPC(10,2)
     &     ,RADIUS(5),THETA(5),SUNAZ,SUNEL,MAXEL,MINEL,MAXAZ,MINAZ
     &     ,ILLUM(5,5,2)
      EQUIVALENCE (CELTABS(1),LPMCPCO(1,1,1)),(CELTABS(8201),ZONFLG(1))
     & ,(CELTABS(8221),TABIN),(CELTABS(8222),CELLAT)
     & ,(CELTABS(8223),SYSFLG)
      NAMELIST /LATDATA/ SOLALT,SOLAZ,LOWALT,HIGHALT,LOWAZ,HIGHAZ
      DATA LUMCLPC/22000.0,15200.0,10000.0,68000.0,54600.0
     &           ,37600.0,24800.0,76900.0,52900.0,35000.0
     &           ,46000.0,31700.0,20900.0,43700.0,35000.0
     &           ,24100.0,15900.0,13200.0,9100.0,5980.0/
      DATA LUMOV/1.0,13200.0,17520.0,21840.0,27450.0
     &     ,33060.0,40530.0,48000.0,53940.0,59880.0/
      DATA RADIUS/0.0,36400.0,55100.0,80000.0,99800.0/
      DATA THETA/0.0,0.2793,0.7505,1.2915,1.5708/
      DATA CONVTAB/1,4,6,8,10,
     &            1,3,2,1,4,
     &            1,7,6,5,4,
     &            1,10,9,8,4,
     &            1,10,9,8,4/
      DATA SOLALT/
     &  75.0, 75.0, 75.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0,
     &  37.0, 37.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,
     &  75.0, 75.0, 75.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0,
     &  37.0, 37.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,
     &  75.0, 75.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0, 37.0,
     &  37.0, 22.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,
     &  52.0, 52.0, 52.0, 52.0, 37.0, 37.0, 37.0, 37.0, 22.0, 22.0,
     &  22.0, 22.0, 22.0, 22.0, 22.0,  7.0,  7.0,  7.0,  7.0,  7.0/
      DATA SOLAZ/
     & 105.0,135.0,165.0,105.0,135.0,165.0, 80.0, 97.0,112.0,127.0,
     & 142.0,165.0, 80.0, 97.0,112.0,130.0, 73.0, 85.0, 97.0,112.0,
     & 105.0,135.0,165.0,105.0,135.0,165.0, 90.0,110.0,127.0,145.0,
     & 158.0,173.0, 80.0, 95.0,112.0,135.0, 75.0, 85.0, 97.0,115.0,
     & 133.0,165.0,110.0,135.0;165.0, 97.0,112.0,127.0,142.0,157.0,
     & 172.0, 80.0, 97.0,112.0,127.0,142.0, 75.0, 85.0, 97.0,112.0,
     & 110.0,130.0,150.0,170.0,110.0,130.0,150.0,170.0, 90.0,110.0,
     & 125.0,135.0,145.0,155.0,170.0, 70.0, 90.0,105.0,115.0,130.0/
      DATA LOWAZ/
     &   0.0,120.0,150.0,  0.0,120.0,150.0,  0.0, 90.0,105.0,120.0,
     & 135.0,150.0,  0.0, 90.0,105.0,120.0,  0.0, 80.0, 90.0,105.0,
     &   0.0,120.0,150.0,  0.0,120.0,150.0,  0.0,105.0,120.0,135.0,
     & 150.0,165.0,  0.0, 90.0,105.0,120.0,  0.0, 80.0, 90.0,105.0,
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     &   0.0,150.0,  0.0,120.0,150.0,  0.0,105.0,120.0,135.0,150.0,
     & 165.0,  0.0, 90.0,105.0,120.0,135.0,  0.0, 80.0, 90.0,105.0,
     &   0.0,120.0,140.0,160.0,  0.0,120.0,140.0,160.0,  0.0,100.0,
     & 120.0,130.0,140.0,150.0,160.0,  0.0, 80.0,100.0,110.0,120.0/
      DATA HIGHAZ/
     & 120.0,150.0,180.0,120.0,150.0,180.0, 90.0,105.0,120.0,135.0,
     & 150.0,180.0, 90.0,105.0,120.0,180.0, 80.0, 90.0,105.0,180.0,
     & 120.0,150.0,180.0,120.0,150.0,180.0,105.0,120.0,135.0,150.0,
     & 165.0,180.0, 90.0,105.0,120.0,180.0, 80.0, 90.0,105.0,180.0,
     & 150.0,180.0,120.0,150.0,180.0,105.0,120.0,135.0,150.0,165.0,
     & 180.0, 90.0,105.0,120.0,135.0,180.0, 80.0, 90.0,105.0,180.0,
     & 120.0,140.0,160.0,180.0,120.0,140.0,160.0,180.0,100.0,120.0,
     & 130.0,140.0,150.0,160.0,180.0, 80.0,100.0,110.0,120.0,180.0/
      DATA LOWALT/
     &  60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0,
     &  30.0, 30.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,
     &  60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0,
     &  30.0, 30.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,
     &  60.0, 60.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 30.0,
     &  30.0, 15.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,
     &  45.0, 45.0, 45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0,
     &  15.0, 15.0, 15.0, 15.0, 15.0,  0.0,  0.0,  0.0,  0.0,  0.0/
      DATA HIGHALT/
     &  90.0, 90.0, 90.0, 60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 45.0,
     &  45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0,
     &  90.0, 90.0, 90.0, 60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 45.0,
     &  45.0, 45.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0,
     &  90.0, 90.0, 60.0, 60.0, 60.0, 45.0, 45.0, 45.0, 45.0, 45.0,
     &  45.0, 30.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0,
     &  90.0, 90.0, 90.0, 90.0, 45.0, 45.0, 45.0, 45.0, 30.0, 30.0,
     &  30.0, 30.0, 30.0, 30.0, 30.0, 15.0, 15.0, 15.0, 15.0, 15.0/
C
C INPUT TABLE DATA INTO CELTABS ARRAY
C
      IF(UNIT(91).LT.1) GOTO 9898
        PRINT *,"ERROR IN BUFFER OUT BEFORE TABLIST CALL"
        STOP
 9898 REWIND 91
      BUFFER IN(91,1)(CELTABS(1),CELTABS(8223))
      IF(UNIT(91).LT.1) GOTO 1000
        PRINT *,"ERROR IN BUFFER IN FOR PROGRAM TABLIST"
        STOP
 1000 CONTINUE
C
C LIST SOLAR ELEVATION AND AZIMUTH BOXES AND CENTER POINTS
C
C SELECT THE LATITUDE TABLE CLOSEST TO THE SITE LATITUDE.
C  USE THE ALTITUDE AND AZIMUTH POINTS FROM TABLE FOR CALCULATIONS
C
      LAT = CELLAT
      LATNO = 1
      IF(LAT .LT. 28.0) GOTO 30
      LATNO = 2
      IF(LAT .LT. 36.0) GOTO 30
      LATNO = 3
      IF(LAT .LT. 44.0) GOTO 30
      LATNO = 4
   30 CONTINUE
C
C
```

```
      WRITE(6,6000) LAT
 6000 FORMAT("1",T45,"LPM TABLE INPUT DATA FOR CALCULATED POINTS"//
     & ,T43,"SOLAR ALTITUDES AND AZIMUTHS FOR LATITUDE "
     & ," =  ",F5.1,/,T18,"POINT NUMBER"
     & ,T32,"ALTITUDE",T42,"AZIMUTH",T54,"MAX ALTITUDE"
     & ,T68,"MIN ALTITUDE",T82,"MAX AZIMUTH",T95,"MIN AZIMUTH")
      DO 1100 I=1,20
          SUNAZ = SOLAZ(I,LATNO)
          SUNEL = SOLALT(I,LATNO)
          MAXEL = HIGHALT(I,LATNO)
          MINEL = LOWALT(I,LATNO)
          MAXAZ = HIGHAZ(I,LATNO)
          MINAZ = LOWAZ(I,LATNO)
        WRITE(6,6001) I,SUNEL,SUNAZ,MAXEL,MINEL,MAXAZ,MINAZ
 6001   FORMAT(1X,T22,I2,T34,F4.1,T43,F6.1,T58,F4.1
     &         ,T72,F4.1,T86,F6.1,T99,F6.1)
 1100 CONTINUE
      WRITE(6,6002)
 6002 FORMAT(T25,"POINTS 21 - 40 HAVE THE SAME ALTITUDES BUT "
     &          ,"NEGATIVE AZIMUTHS TO POINTS 1 - 20 "/)
      WRITE(6,6003)
 6003 FORMAT(1X,T48,"ILLUMINATION POINTS CALCULATED (UNITS LUX)"
     &      /T41,"OVERCAST SKY",T71,"CLEAR AND PARTLY CLOUDY SKY"
     &      /T31,"POINT NO."
     &     ,T44,"DIFFUSE",T65,"DIRECT NORMAL",T85,"DIFFUSE"/)
      DO 1300 I = 1,10
        WRITE(6,6004) I,LUMOV(I),LUMCLPC(I,1),LUMCLPC(I,2)
 6004   FORMAT(1X,T35,I2,T45,F8.2,T68,F8.2,T86,F8.2)
 1300 CONTINUE
      DO 1350 ZONE = 1,20
        IF(ZONFLG(ZONE).EQ.0.0) GOTO 1350
        WRITE(6,6005) ZONE,(LUMOV(L),L=1,10),(LPMCPCO(ZONE,41,M),M=1,10)
 6005   FORMAT("1",T20,30("*"),T50," LIGHTING POWER MULTIPLIER "
     &        ,"TABLES FOR ZONE ",I2,30("*")//
     &        ,T62,"OVERCAST SKY"/
     &        ,T10,"POINT NO.",T25,"1",T35,"2",T45,"3",T55,"4"
     &        ,T65,"5",T75,"6",T85,"7",T95,"8",T105,"9",T115,"10"/
     &       ,T10,"DIFF ILL.",T20,10(2X,F6.0,2X)/
     &        ,T10,"LPM",T20,10(3X,F4.2,3X)/)
      WRITE(6,6007)
 6007 FORMAT(T48,"CLEAR AND PARTLY CLOUDY SKY"/
     &       T40,"ILLUMINATION AT TABLE POINTS(DIRECT NORMAL,DIFFUSE)"/
     &       T15,"THETA(Q)  (Q=1 IS ALL DIFFUSE)")
      DIRN = 1
      DIF = 2
      DO 1020 NTH = 1,5
        DO 1020 NR = 1,5
            ILLUM(NR,NTH,DIRN) = 0.0
            ILLUM(NR,NTH,DIF)  = LUMOV(CONVTAB(NR,NTH))
          IF(NTH.EQ.1.OR.NR.EQ.1) GOTO 1020
            ILLUM(NR,NTH,DIRN) = LUMCLPC(CONVTAB(NR,NTH),DIRN)
            ILLUM(NR,NTH,DIF)  = LUMCLPC(CONVTAB(NR,NTH),DIF)
 1020 CONTINUE
      DO 1021 NTH = 1,5
        WRITE(6,6021) NTH,((ILLUM(NR,NTH,LUM),LUM=DIRN,DIF),NR=1,5)
 6021   FORMAT(T20,I1,5(5X,"(",F6.0,",",F6.0,")"))
 1021 CONTINUE
      WRITE(6,6022)
 6022 FORMAT(T23,"RADIUS",T33,"1",T53,"2",T73,"3",T93,"4",T113,"5"/)
      DO 1500 I = 1,37,3
```

```
      J = I+1
      K = I+2
        SUNAZ1 = SOLAZ(I,LATNO)
        SUNEL1 = SOLALT(I,LATNO)
        SUNAZ2 = SOLAZ(J,LATNO)
        SUNEL2 = SOLALT(J,LATNO)
        SUNAZ3 = SOLAZ(K,LATNO)
        SUNEL3 = SOLALT(K,LATNO)
      IF(I.LE.20) GOTO 1410
        SUNAZ1 = -SOLAZ(I-20,LATNO)
        SUNEL1 = SOLALT(I-20,LATNO)
1410  IF(J.LE.20) GOTO 1420
        SUNAZ2 = -SOLAZ(J-20,LATNO)
        SUNEL2 = SOLALT(J-20,LATNO)
1420  IF(K.LE.20) GOTO 1430
        SUNAZ3 = -SOLAZ(K-20,LATNO)
        SUNEL3 = SOLALT(K-20,LATNO)
1430  CONTINUE
      Z = ZONE
      IF(I.EQ.19) WRITE(6,6108)
6108  FORMAT("1")
      WRITE(6,6008)
     &  I,LPMCPCO(Z,41,1),(LPMCPCO(Z,41,R),R=4,10,2)
     & ,J,LPMCPCO(Z,41,1),(LPMCPCO(Z,41,R),R=4,10,2)
     & ,K,LPMCPCO(Z,41,1),(LPMCPCO(Z,41,R),R=4,10,2)
6008  FORMAT(4X,3("BOX ",I2,4X,"1",5F5.2,4X))
      WRITE(6,6009)
     &  LPMCPCO(Z,41,1),LPMCPCO(Z,I,3),LPMCPCO(Z,I,2)
     & ,LPMCPCO(Z,I,1),LPMCPCO(Z,I,4)
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,J,3),LPMCPCO(Z,J,2)
     & ,LPMCPCO(Z,J,1),LPMCPCO(Z,J,4)
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,K,3),LPMCPCO(Z,K,2)
     & ,LPMCPCO(Z,K,1),LPMCPCO(Z,K,4)
6009  FORMAT(4X,3("ELEV",6X,"2",5F5.2,4X))
      WRITE(6,6010)
     &   SUNEL1,LPMCPCO(Z,41,1),LPMCPCO(Z,I,7),LPMCPCO(Z,I,6)
     &  ,LPMCPCO(Z,I,5),LPMCPCO(Z,I,4)
     &  ,SUNEL2,LPMCPCO(Z,41,1),LPMCPCO(Z,J,7),LPMCPCO(Z,J,6)
     &  ,LPMCPCO(Z,J,5),LPMCPCO(Z,J,4)
     &  ,SUNEL3,LPMCPCO(Z,41,1),LPMCPCO(Z,K,7),LPMCPCO(Z,K,6)
     &  ,LPMCPCO(Z,K,5),LPMCPCO(Z,K,4)
6010  FORMAT(4X,3(F4.1,4X,"Q=3",5F5.2,4X))
      WRITE(6,6011)
     &  LPMCPCO(Z,41,1),LPMCPCO(Z,I,10),LPMCPCO(Z,I,9)
     & ,LPMCPCO(Z,I,8),LPMCPCO(Z,I,4)
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,J,10),LPMCPCO(Z,J,9)
     & ,LPMCPCO(Z,J,8),LPMCPCO(Z,J,4)
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,K,10),LPMCPCO(Z,K,9)
     & ,LPMCPCO(Z,K,8),LPMCPCO(Z,K,4)
6011  FORMAT(4X,3("AZ",8X,"4",5F5.2,4X))
      WRITE(6,6012)
     &  SUNAZ1
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,I,10),LPMCPCO(Z,I,9)
     & ,LPMCPCO(Z,I,8),LPMCPCO(Z,I,4)
     & ,SUNAZ2
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,J,10),LPMCPCO(Z,J,9)
     & ,LPMCPCO(Z,J,8),LPMCPCO(Z,J,4)
     & ,SUNAZ3
     & ,LPMCPCO(Z,41,1),LPMCPCO(Z,K,10),LPMCPCO(Z,K,9)
     & ,LPMCPCO(Z,K,8),LPMCPCO(Z,K,4)
```

11

```
6012   FORMAT(4X,3(F5.0,5X,"5",5F5.2,4X)/
    &    4X,3(11X,"R=1    2    3    4    5  ",4X)/)
1500 CONTINUE
       I = 40
     SUNAZ = -SOLAZ(I-20)
     SUNEL =  SOLALT(I-20)
     WRITE(6,6013)
    &     I,LPMCPCO(Z,41,1),(LPMCPCO(Z,41,R),R=4,10,2)
    &    ,LPMCPCO(Z,41,1),LPMCPCO(Z,I,3),LPMCPCO(Z,I,2)
    &    ,LPMCPCO(Z,I,1),LPMCPCO(Z,I,4)
    &    ,SUNEL,LPMCPCO(Z,41,1),LPMCPCO(Z,I,7),LPMCPCO(Z,I,6)
    &    ,LPMCPCO(Z,I,5),LPMCPCO(Z,I,4)
    &    ,LPMCPCO(Z,41,1),LPMCPCO(Z,I,10),LPMCPCO(Z,I,9)
    &    ,LPMCPCO(Z,I,8),LPMCPCO(Z,I,7)
    &    ,SUNAZ
    &    ,LPMCPCO(Z,41,1),LPMCPCO(Z,I,10),LPMCPCO(Z,I,9)
    &    ,LPMCPCO(Z,I,8),LPMCPCO(Z,I,7)
6013   FORMAT(4X,"BOX ",I2,4X,"1",5F5.2,4X/
    &          4X,"ELEV",6X,"2",5F5.2,4X/
    &          4X,F4.1,4X,"Q=3",5F5.2,4X/
    &          4X,"AZ",8X,"4",5F5.2,4X/
    &          4X,F5.0,5X,"5",5F5.2,4X/
    &          4X,11X,"R=1    2    3    4    5  ",4X/)
1350 CONTINUE
     RETURN
     END
```

=solar altitude

=solar azimuth

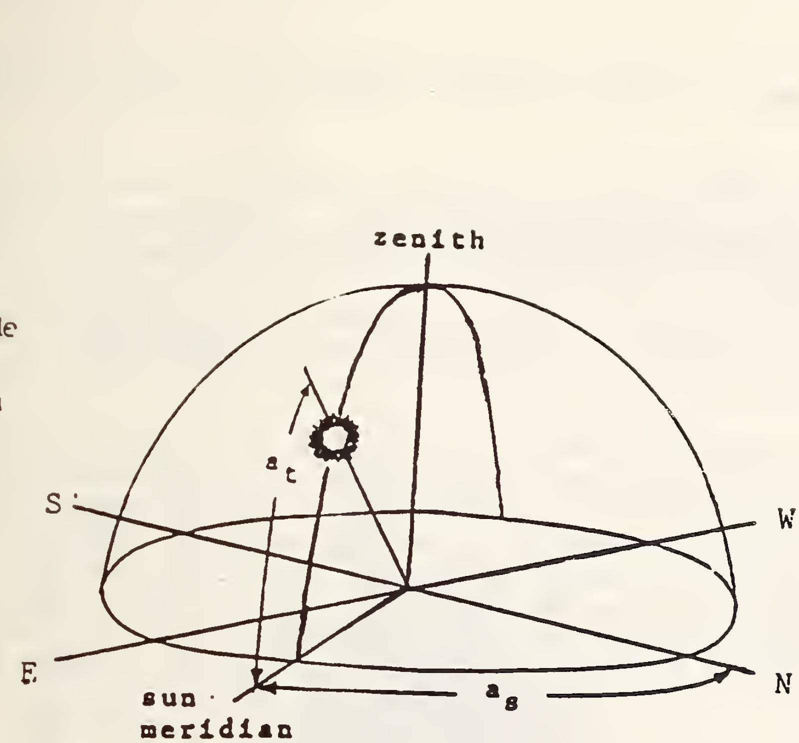

Figure A-1 Definitions of solar angles

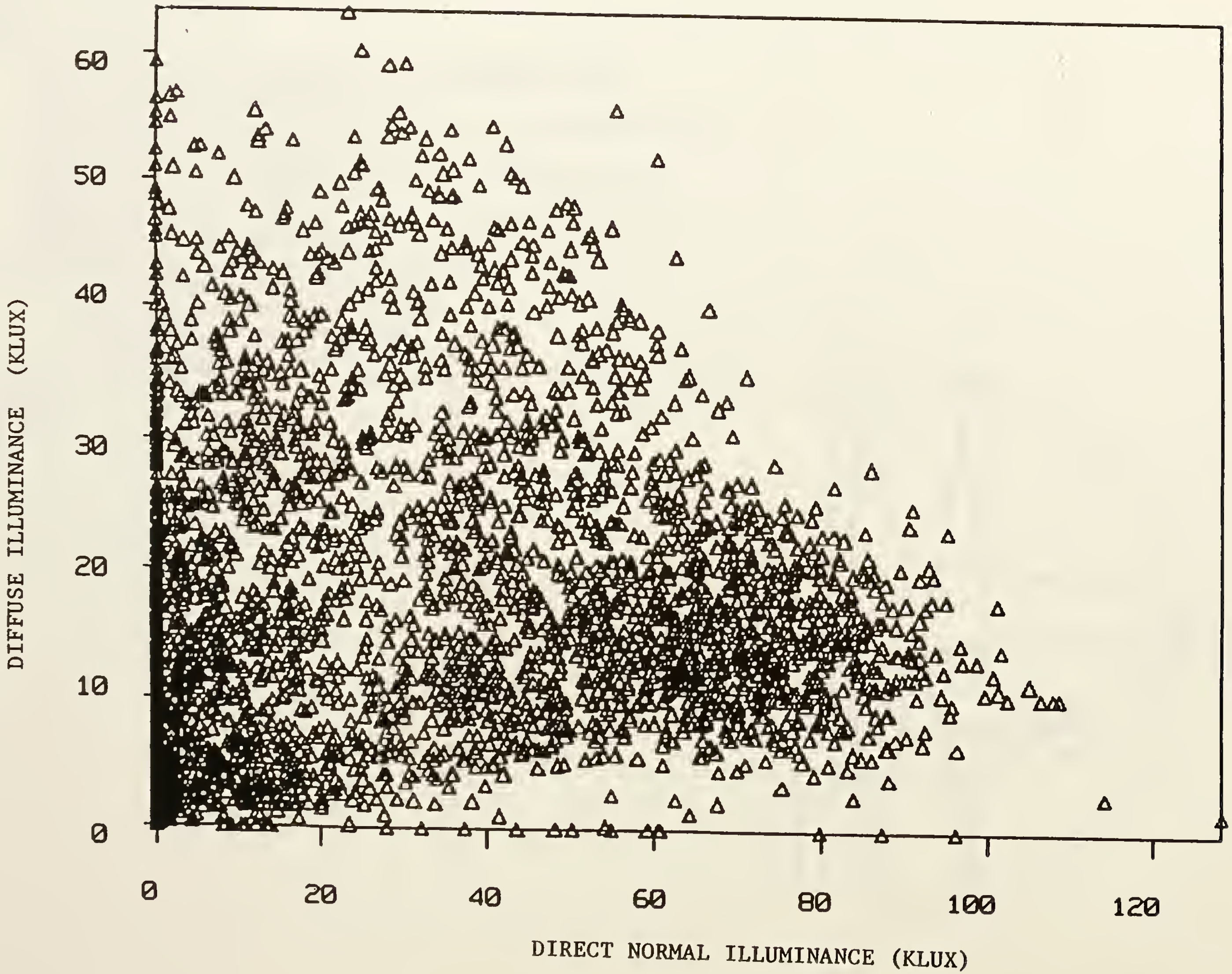

Figure A-2 Typical combinations of diffuse and direct illuminances observed over a year near Washington, D.C.

APPENDIX B - ACCESSING THE BOEING COMPUTER SYSTEM AND RUNNING BLAST/CEL-1

The user must first establish an account with the BOEING COMPUTER SERVICE, through the closest office. The user will be supplied with an account number and means of accessing the system using a user-supplied password. Once the user has successfully gained access to the system, the BLAST and CEL-1 input files can be generated, in accordance with the related information in this report and the respective user's guides (see references). At that point BLAST/CEL-1 can be executed using a procedure file to run the program.

The procedure file to run BLAST/CEL-1 can have different forms depending upon the options selected by the user. The procedure file to update BLAST with the CEL-1 changes and then execute BLAST/CEL-1 is listed in table A-1, including self-explanatory comments. BLAST3X is the name of the updated BLAST/CEL-1 program, in executable form. Once this has been generated, subsequent execution of BLAST/CEL-1 requires only a small procedure file, as shown in table B-1. If BLAST3X is available, the procedure file to run BLAST/CEL-1 is identical to that for standard BLAST, except for the addition of a single line

```
ATTACH, ABLAST = BLAST3X
```

before the call to BLAST.

Table B-1. Procedure File to Execute BLAST/CEL-1

```
BLS6UPX,CM250000,P01,T700,STEKS1.
USER,*.
CHARGE,YCNBSA,1003.
*.**********************************
*.                                 *
*. SEND TO:                        *
*. NATIONAL BUREAU OF STANDARDS    *
*. STEPHEN J. TREADO              *
*. BLDG. 226  ROOM A313            *
*. GAITHERSBURG,MD. 20899          *
*.                                 *
*.**********************************
$NOTIFY. BLS6UPX HAS STARTED
*. BLAST 3.0 LEVEL 107 UPDATE FOR CEL-1 INTERFACING
*.      UPDATE 6 (TEMPORARY)
*.      LAST MODIFIED:MARCH 7, 1985
*.
*. THIS JOB WILL GATHER OLD BLAST FILES FROM TAPE,
*. UPDATE THE BLAST PROGRAM FILES AND RUN THE NEW
*. VERSION OF BLAST.
*.
*. WAIT FOR MORNING BEFORE STARTING (OPTIONAL)
$WHILE, TIME .GT. 0400 .AND. TIME .LT. 2400 ,WAITANHOUR.
$ROLLOUT,3600.
$ENDW,WAITANHOUR.
*.
*.*. GET NEEDED FILES FROM SCATER TAPE
*.
$LABEL,SCATAPE,D=GE,SI=$BLAST3.107$,UN=BA6402,VSN=BLAST5,FI=GATHER,QN=1.
$COPY,SCATAPE,GATHER.
$CALL,GATHER,BLSOPL5.
$CALL,GATHER,BLSLGO5.
$RETURN,*,INPUT,OUTPUT.
*.
*. DEFINE OUTPUT FILE NAME.
*.
$PURGE,NOSBOUT/NA.
$DEFINE,OUTPUT=NOSBOUT.
*.
*. GENERATE BLAST LISTING AND LOADER DIRECTIVE LISTING
*. THIS IS A FULL UPDATE LISTING IT IS QUITE LONG.
*.$UPDATE,F,C=0,L=F7,P=BLSOPL5,Y.*ID DUMMYNAME
*.$COPY,BLSDIR5,OUTPUT.
*.$RETURN,NEWPL,COMPILE.
*.*.
*.*. NOW BEGIN THE UPDATE PROCESS
*.*.
$GET,SEGDIR=CELDIR2.
$GET,UPDIR=CELUPS2.
$ATTACH,OLDPL=BLSOPL5.
*.
*. FIRST UPDATE THE PROGRAM LIBRARY
*. (OPTIONAL FOR TEMPORARY UPDATES)
*.
*.$PURGE,BLSOPL6.
*.$DEFINE,NEWPL=BLSOPL6.
* USE THE FOLLOWING LINE TO GET THE UPDATE SOURCE ACTIVE LINE LIST
* $UPDATE,F,I=UPDIR,N=NEWPL,C=0,L=67.
* THIS ALTERNATE COMMAND PRODUCES NO LISTING AT ALL
*.$UPDATE,F,I=UPDIR,N=NEWPL,C=0,L=1.
```

```
*.
*. NOW CREATE THE COMPILER READY CHANGES
*.
* USE THE FOLLOWING LINE FOR A NORMAL UPDATE LISTING
*.$UPDATE,I=UPDIR,R=*.
*.
* USE THE NEXT LINE FOR A MINIMAL UPDATE DECK NAME LIST ONLY
$UPDATE,I=UPDIR,L=A1,R=*.
$RETURN,OLDPL,UPDIR,NEWPL.
*.
*. COMPILE THE CHANGES
*.
$REWIND,COMPILE.
*.
*. IF A LISTING OF THE ALTERED FILES IS DESIRED USE NEXT TWO LINES.
*.$COPY,COMPILE,OUTPUT.
*.$REWIND,COMPILE.
$RFL,157000B.
*.
* FULL FORTRAN COMPILER LISTING OF CHANGES:
* $FTN,I=COMPILE,B=LGO,PL=99999,REW,P,ER,L=OUTPUT,R=3.
* NO FTN LISTING IS PRODUCED UNLESS AN ERROR OCCURS:
$FTN,I=COMPILE,B=LGO,PL=99999,REW,P,ER,L=0.
$PURGE,BLSLG06/NA.
$DEFINE,NEWLGO=BLSLG06.
$ATTACH,OLDLGO=BLSLG05/NA.
$COPYL,OLDLGO,LGO,NEWLGO,,RA.
$RETURN,OLDLGO,LGO,COMPILE.
*.
*. LOAD SEGMENTED
*.
$PURGE,BLAST3X/NA.
$DEFINE,XECUTE=BLAST3X.
$LIBRARY,NEWLGO.
* ACTIVATE LINE BELOW FOR A FULL MAP:
$LDSET(PRESET=ZERO,MAP=OFF,LIB=NEWLGO).
$SEGLOAD(I=SEGDIR,B=XECUTE).
$LOAD(NEWLGO).
$NOGO.
$RETURN,XECUTE,NEWLGO,SEGDIR.
*.
*. SUCCESS |||
*. THIS WILL RUN THE BLAST PROGRAM
*.
$ATTACH,ABLAST=BLAST3X.
$GET,BLASTPF/UN=EKSAPP.
$GET,BIDNOS1/PW=PW.
$BEGIN,EXEC,BLASTPF,I=BIDNOS1,O=OUTPUT,WFILE=NORFOLK.
*.
EXIT,U.
$CATLIST,LO=F,TY=D,NA.
$ENQUIRE.
* ONLY FOR THE CONFIDENT...
*.$PURGE,BLSLG05,BLSOPL5.
$DAYFILE.
*:
*. ACTIVATE NEXT THREE LINES TO PRINT OUTPUT.
*.$REWIND,OUTPUT.
*.$GET,MAILBOX/NA.
*.$ROUTE,OUTPUT,DC=PR,UN=LOCAL,STOUT=VTSO,UJN=BLAST6J,MB=MAILBOX.
```

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10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report describes the capabilities of the BLAST and CEL-1 computer programs, and the procedures for using a hybrid version which incorporates both programs into a single design and analysis tool. Details on assembling the required information for development of the input files and the actual execution of the hybrid program are covered. The program allows detailed simulation of actual lighting systems using CEL-1 including daylighting effects, while providing BLAST with lighting energy modifiers on an hourly basis.

The procedure is demonstrated using a sample building.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

daylighting; energy simulation; lighting; solar radiation

13. AVAILABILITY

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