Description and Validation of a Computer Modeled Building Heating and Cooling System

by

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Acknowledgments

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My wife, Jan, and family, Melissa and Mathew, provided the emotional support necessary for this effort. Beyond support, they had to do without a dad and husband for the time spent in study and writing. For their sacrifice and help, I am truly grateful.

Chapter 1

Introduction

Project Background

In 1973, the Organization of Petroleum Exporting Countries (OPEC) initiated a program of restricted oil supplies to the United States. Reduced supplies to a country that had grown dependent on the use of imported oil resulted in an immediate increase in the price of oil-related goods and direct energy prices. Further action by OPEC in subsequent years continued to force the price of crude oil up to more than $30 per barrel. This time has been referred to as the Energy Crisis.

This had several far reaching national implications. The most obvious to the average consumer were lines for gasoline and increased costs for heating fuel oil. The price of propane also rose to more than 80 cents per gallon during this time.

Increased costs for crude spurred exploration for crude oil within the United States. Within Kansas, oil exploration contributed significantly to local economies. Low volume wells producing only one barrel per day were profitable to drill and operate.

On a larger scale, national policies were beginning to take shape that recognized America's dependence on imported oil and the vulnerability it implied. Home grown energy in the form of grain-to-methanol plants and energy conservation approaches were given tax incentives. Foreign policy was directed at maintaining close relations with major oil suppliers. After all, dependence on foreign oil placed the security of this nation's defenses and way of life at risk.

Another outgrowth of the Energy Crisis was the increase in research in how to reduce the energy use of commercial buildings. The U. S. Corps of Engineers' Research Lab has been charged with reducing energy use in newly-constructed buildings by nearly 45 percent. As part of this effort, they are conducting a demonstration project at Ft. Riley, Kansas, titled "Design, Build, and Operate Energy Efficient Buildings." The project is intended to show significant energy reductions in newly designed and built Army facilities as compared to early 1970 vintage buildings.

One of the tasks assigned to the demonstration project is to define methods for accounting for energy consumption differences between new and old facilities. More specifically, the project must not only produce more efficient buildings but must also provide the knowledge of why the new buildings use less energy.

Four buildings located at Ft. Riley, Kansas, will be used as part of the study. Two of the buildings, numbers 8025 and 8037, are early 1970 vintage buildings and will represent the pre-Energy Crisis buildings. These are located on Custer Hill within two hundred yards of each other. The buildings are typical battalion headquarters classroom type buildings. Buildings 8025 and 8037 are single story structures with a floor area of approximately 12,000 square feet. Details of construction will be provided later.

Two new buildings also will be included the CERL study. One of the new buildings will utilize a constant volume multizone heating and cooling system, while the other will use a variable volume system. The size and intended function of the new facilities are similar to the old building.

Unlike the old buildings, which receive heating and cooling energy from a central plant, the new buildings will share a split-system chiller and hot water boiler.

Project Goals

The goal of this research is twofold. The first is to develop a BLAST model that predicts the energy use at the building boundaries taking into account the building envelope, mechanical systems, occupant interaction, and the actual operating modes of the building. The energy use as predicted by this model will be compared to the monitored energy use.

The second goal is to modify this model to the "as designed" condition. The second model will utilize the same occupancy scheduling, but will include design features that have been rendered inoperable or undesirable by the occupants. The second model is necessary in order for CERL to evaluate the design of old versus new buildings.

With a validated model of the building, "what if" situations can be applied to the model. For example, a variable volume system can be applied to the model to see what effect it has on the energy use.

Future researchers will develop validated models of the new buildings for comparison. Again, new systems, modifications to building envelope parameters, control strategies, and occupant interaction can be modified to quantify why the new building designs use less energy.

Project Scope

This research will be limited to the development and validation of a model for Building 8037. Included will be the preparation of a model representing the "as designed" building. Comparisons of the "as operated" and the "as designed" models will be done to indicate the significance of operational changes implemented in this building.

Building 8037 was chosen primarily because of access to the building. While Buildings 8025 and 8037 are nearly identical and in very close proximity to each other, the presence of a military intelligence unit in Building 8025 made access more difficult.

Weather data from a weather station located on Building 8025 will be utilized for environmental conditions on Building 8037. Energy use data collected on Building 8037 will be used for validation of the model. The data acquisition systems and instrumentation for the collection of both weather data and building energy use data has been documented (1). Details of data conversion from collected data to BLAST input are provided in Chapter 4 and Appenxix E.

A major effort was the development of a model that accurately represented the operational modes of the building. Physical descriptions of the building were available but only represent the design conditions. Some of the controls were not installed, and others were non-functional. Modeling of nonfunctional controls presented special problems.

To evaluate many of the actual operating situations encountered within the building, several site visits were made. Conversations with occupants provided many clues to the use of the building as well as the problems with overheating and overcooling. These situations were incorporated within the model to account for occupants interaction and to correctly schedule areas of the building.

Validation of the model consists of comparison of monitored energy use with energy use as predicted by BLAST. Absolute energy use as well as trends in use are examined to show the model -- as developed -- represents the building. Discrepancies in predicted energy use and monitored energy use can in most cases be accounted for. Unusual weather or building energy use data will be pointed out where significant discrepancies occur.

The final effort within the project is to modify the operational model to reflect the "as designed" model. In many cases, the changes involve equipment scheduling and the use of controls. The energy use predicted from the "as designed" model is compared to the "as built" model with explanations of results.

Chapter 2

Building Description and Model

Building Description

Building 8037 is a single story heavy masonry building with a slab on grade floor. It is located on Custer Hill at Fort Riley, Kansas. Custer Hill is a relatively flat area on the Flint Hills. A map showing the location and orientation of the building is included in Appendix A.

There are several barrack type buildings as well as other single and multiple story buildings in the area but none are so close or so tall that they shade Building 8037.

The building is occupied by an engineering battalion headquarters and a mobile army surgical hospital (MASH) company.

Building floor area is approximately 11,900 square feet. Building use can be divided into three main categories: administration, classrooms, and service. Included in the service category is the central corridor, the rest rooms, and the mechanical room. There are approximately 3,600 square feet of classrooms, 2,400 square feet of service, and 5,900 square feet of administration.

BLAST Description

Modeling of a building structure in BLAST requires the facility be divided into zones representing thermal environments. The division of the building into zones is dictated partially by the arrangement of the mechanical systems. Simplification of BLAST input is recommended (2)(3) by combining rooms or areas into a single zone. The primary consideration of building division is the thermal performance of the building rather than the physical layout and details of the building.

Building 8037 has been divided into 12 zones for this study. The arrangement of the zones is shown on Figure 2.1. In addition, the attic area has been modeled as a separate zone, 12.

Review of Figure 2.1 shows some model simplification was included, two small offices on the east and on the west end of the building were grouped together. The two large classrooms on each end of the building have been grouped into a single zone as well.

Building Envelope

The building's exterior walls and roof have construction as shown in Figure 2.2. All materials used in the modeling of these sections are from the BLAST standard library with the exception of the Jumbo Brick.

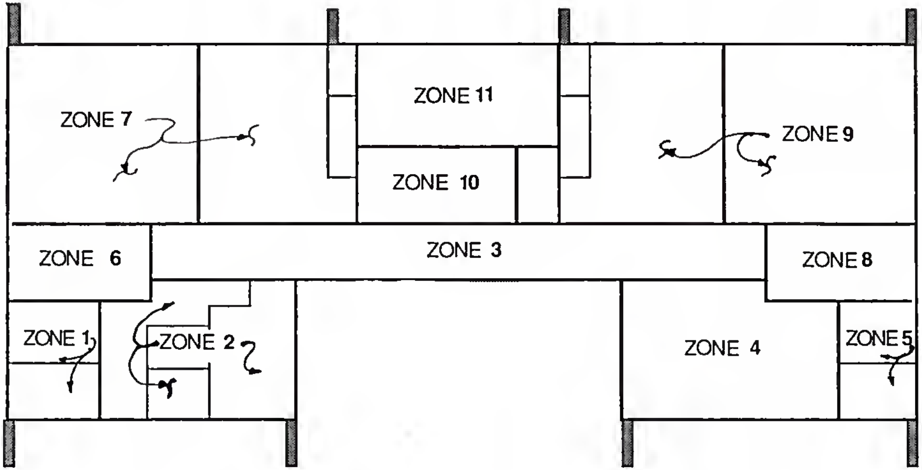


Figure 2.1 Zone Definition for Building 8037 BLAST Model

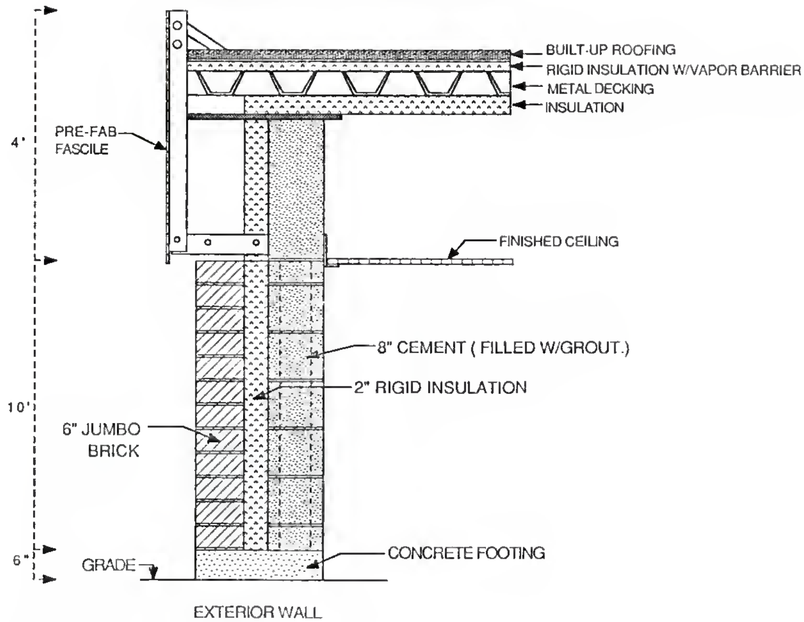


Figure 2.2 Wall and Roof Construction Details

This material was added as a temporary material to the library. The need for this was that the thickness of the brick differed significantly from conventional face brick and the thermal capacitance differences may influence the time lag and hence the loading of the zones.

Table 2.1 shows the R-values used for the major exterior materials used in this analysis. BLAST analysis utilizes more than just a straight forward $Q=U*A*(T_2-T_1)$ approach in the computation of loads and temperatures. Material properties such as specific heat, density, thermal absorptance, and solar absorptance are required to develop the transfer functions for the analysis.

The thickness of the rigid insulation included in the walls had to be scaled from the drawings. It was not possible to visually inspect this insulation to determine installed levels. A similar problem exists in determining the thickness of the rigid insulation used in the roof.

The underside of the roof has a layer of conventional fiberglass insulation with a kraft paper vapor barrier. Condensation on the underside of the roof deck has caused some of the insulation to sag and some of the insulation fasteners have failed. The net result is that the insulation system is not continuous under the deck. To account for this in the model, only two inches were specified in the "as operated" model while three inches were specified in the "as designed" model. Table 2.1 reflects the two-inch configuration.

Film coefficients are calculated by BLAST and are not shown below.

Table 2.1
Thermal Properties
of Exterior Walls and Roof

Specification=EX99 (Wall from grade to 10')

Material	*	R-Value HR*FT^2*F/BTU
Jumbo Brick	*	.65
Air Space	*	.91
2" Dense Insul.	*	6.68
8" Block	*	5.05
		Sum= 13.39

Composite U value = .0752 BTU/HR*FT^2*F

Specification=EX98 (Wall above 10')

Material	*	R-Value HR*FT^2*F/BTU
Steel Siding	*	.00
Air Space	*	.91
2" Dense Insul.	*	6.68
8" Block	*	5.05
		Sum= 12.64

Composite U value = .0791 BTU/HR*FT^2*F

Specification=RF99 (Roof)

Material	*	R-Value $HR*FT^2*F/BTU$
1/2" Stone	*	.05
3/8" Built up Roof	*	.28
1" Dense Insul.	*	3.34
Steel Deck	*	.00
2" Insul.	*	6.68
	Sum=	10.35

Composite U value = .0966 $BTU/HR*FT^2*F$

Windows are located on the north, east, and west side of the building. All windows are single pane with lightweight drapes. An insulation panel is installed directly below each window so the window mullions run the full wall height. The windows are aluminum frame awning type windows with locks. The seals installed on the windows provide a good seal when closed.

Doors in the building are of two types. Doors on the rear of the building are hollow metal doors with no seals. The front doors are all glass doors with minimal weather-stripping. An insulated panel is located above the glass doors.

Two small vestibule type entrances into Zones 2 and 4 exist in the building but were not included in the model. These entrances are frequently locked. The area was modeled as a single glass door.

All glass doors actually were modeled as windows in both analyses to allow the admittance of solar radiation. Use of a glass door specification in BLAST allows only thermal transfer but no solar transmittance or interior re-radiation to the outside (4).

Zone Descriptions

Zones 1 and 5

These zones consist of two small offices. A single thermostat controls the cooling in these areas. A cement block partition wall separates the two offices.

Zones 2 and 4

These zones are primarily administrative areas. Zone 2 has been divided into four areas. Two areas are small offices for battalion staff. A large conference room has been made in the zone. The remaining area is a reception area. Little thought was given to heating and cooling these areas when the partitions were erected. The conference room has two of the four cooling system diffusers and about 80 percent of the baseboard heating. One of the small offices receives no cooling and the remaining 20 percent of the heating. The other small office receives no heating or cooling. The reception area has the other two cooling diffusers and no heat. Each diffuser represents 25 percent of the cooling capacity for this zone. The location of the zone cooling thermostat compounds the problem. It is located in a corridor remote from the load. The wall additions have been modeled by the inclusion of additional mass.

Zone 4 has not been partitioned.

Zone 3

Zone 3 is a central corridor and main entrance to the facility. There is considerable glass area and frequent door openings.

Zones 6 and 8

These zones have not been modified. There are no windows and no external doors. Occupancy differs greatly between these zones and will be discussed later in this chapter.

Zones 7 and 9

The projection area in both zones has been included as additional internal mass, as has the stage and storage area. Some ceiling tiles are missing or were never installed in the projection areas. The projection area in Zone 9 is used as an office.

Two double metal doors provide access to the outside.

Zone 10

Zone 10 is the rest rooms. Both rest rooms are included in this zone, as is a small closet used for cleaning supplies. Considerable internal mass was added to this zone to account for the additional walls used to provide plumbing chases. This area receives no cooling directly. Cooling was provided in the model by drawing the exhaust volume of the rest rooms from Zone 3. The mixing occurs on a continuous basis.

Zone 11

Zone 11 is the mechanical room. No modifications were made in the basic wall arrangement. A double metal door provides access to the outside. The occupants do not have access to this area.

Zone 12

Zone 12 is the ceiling plenum. While there are no open returns, the plenum plays an important role in the thermal performance of the building. The mechanical room and plenum are not separated by walls. Air exchange takes place between these two zones. Since the boundary between the occupied space and the plenum consists of lay-in acoustical tile, considerable heat can be lost or gained from this space. The mixing with the mechanical room will affect this transfer. The mixing was modeled by forcing air exchange at the rate of one volume of the mechanical room to cross-mix with the ceiling plenum each hour. The intent was to force the temperatures of the mechanical room and the plenum close together.

Zone Loads

In addition to heating and cooling loads driven by weather conditions, it is necessary to provide BLAST with a description of the loads that exist within the zone. Zone loads include people, electrical appliances, lighting, infiltration, and ventilation. Each of these loads must be described not only in magnitude, but a schedule must also be provided. The schedule consists of the percentage of a maximum load and the hours it is scheduled. For example, a room is to be at half lighting intensity at night and weekends but full intensity during the day would be scheduled as follows.

```
Schedule Name
MONDAY THRU FRIDAY (0 TO 7,-.5,7 TO 18,-1.,18 TO 24,-.5)
SATURDAY THRU SUNDAY (0 TO 24,-.5)
FROM 01JAN THRU 31DEC
```

This schedule could be used to describe lighting, occupancy, infiltration, or a variety of other loads. Specific schedules have been used to control all facets of building usage. Review of the input in Appendices B, C, and D will allow a complete understanding of the scheduled loads.

Electrical Loads

Electrical loads include lighting and any appliances in operation.

Lighting loads were obtained from on-site inspection of the number and type of fixtures and are shown in Table 2.2 for both "as operated" and "as designed". Lighting is scheduled to be on with the same schedule as occupancy. Several schedules were used.

Zones 1 and 5 are scheduled only a few hours daily. These offices were not occupied regularly throughout the day. Zones 2, 4, 6, and 9 were scheduled as normal office spaces. Since Zone 9 is only half occupied, only the occupied area lighting was included in the "as operated" model. Zone 3 and 10 were scheduled continuously because these lights were always on. Zone 7 was used as a classroom two hours daily and is scheduled as such. Lighting in Zone 11 is used infrequently and was not included. Zone 8 is used for meetings and was so scheduled. Average times and duration of occupancy of these zones were obtained from conversations with the building occupants and on-site observations.

In evaluating the "as designed" conditions, the same schedules were used but all fixtures were assumed to operate in an area. Including different schedules would have had a significant effect on building energy use and would not provide a good basis for comparison.

Table 2.2

Lighting Loads KBTU/HR

Zone #	As Operated	As Designed
1	3.48	3.48
2	5.68	10.34
3	3.48	3.48
4	7.43	10.34
5	3.48	3.38
6	2.90	3.48
7	8.41	17.27
8	3.48	3.48
9	15.38	17.27
10	2.63	2.63

Other electrical loads included in various areas include computers, typewriters, soft drink coolers, exhaust fan motors, pneumatic air compressors, pneumatic air dryers, and pumps. Many of these small electrical appliances originally were considered insignificant, but analysis showed even though they are small loads, the hours of operation added significantly to the total electrical load.

The method used to determine loads needed for inclusion was to perform a simulation analysis. The electrical loads were then summed and compared with the "as monitored" data. In general, this was done by day of the week for the period under analysis. Original work in this area indicated there was a considerable electrical load missing from the model. A more careful survey of the building indicated several loads had been ignored. Amperage and voltage readings were obtained as well as scheduled operations and load profiles.

For example, the air compressor for the pneumatic control system cycles based on the storage tank pressure. A schedule of on and off times was recorded, and the average time of use was estimated. The measured power for the unit was then multiplied by the fraction of on time to develop the energy consumption. This was then used as an input to BLAST.

Data developed for miscellaneous loads was added to the analysis and the total and daily usage matched the monitored data for the winter months. These loads are shown in Table 2.3.

The load comparison was done using winter conditions so that large fan usage would be eliminated from the electrical loads. The analysis was repeated for summer conditions with the fans operating and reasonable agreement was acheived. A more complete discussion of the results will be presented Chapter 5.

Table 2.3

Miscellaneous Electrical Loads

Zone	Load Type	Load KBTU/HR
2	2 Typewriters	.6
3	Soft Drink	1.5
4	4 Typewriters	1.2
6	2 Typewriters	.6
9	2 Typewriters	.6
	1 Computer	.3
11	CW/HW Pump	6.39
	Dryer	.8
	Air Compressor	.33
12	Exhaust Fan 11	1.72
	Exhaust Fan 12	1.72
	Exhaust Fan 2	1.37

It should be noted that all miscellaneous electrical loads can add heat to the space as well as register electrical usage. BLAST includes a specification that allows some percentage of the heat to be lost. The exhaust fans have in-duct motors so the heat generated is exhausted rather than admitted to the space. The specification for these loads is "100 PERCENT LOST", indicating the energy is not to be added to the internal loads of the zone.

Large air handler electrical usage was measured with a three-phase power factor meter because it was anticipated a standard current and voltage measurement would result in erroneous information. The actual power factor was surprising low. Actual loads are shown in Table 2.4.

Table 2.4

Air Handler Load Characteristics

	AHU 1	*	AHU 2	*	AHU 3
Average Amps	4.47	*	10.4	*	4.43
Average Volts	119.8	*	120.0	*	119.9
KVA	1.61	*	3.74	*	1.59
Power Factor %	51.	*	78.5	*	43.7
KW	.82	*	2.94	*	.69
BHP	1.1	*	3.94	*	.93

The electrical input to the air handlers is computed by BLAST based on fan and drive efficiency, air volume, and pressure rise across the fan. The measured electrical values were forced into BLAST by manually calculating the necessary pressure drop for an assumed fan and drive efficiency.

Occupancy Loads

Occupancy loads on the zones were obtained by observing the number of people in each area. The activity level was assumed to be constant at 640 BTU/HR. This corresponds to a moderately active office environment. No latent balances are performed by BLAST, so the heat is assumed to be sensible. Default values of 70 percent radiant were used on occupant loading.

Infiltration and Ventilation

Infiltration into a building always has been a very difficult value to calculate. Several methods have been suggested by the American Society of Heating, Refrigerating, and Air Conditioning Engineers (5),(6),(7), each providing significantly different answers. Most have been suggested for use in residential structures. The method chosen for this analysis was the method proposed in the 1985 ASHRAE Handbook of Fundamentals (7). The results of this analysis are shown in Table 2.5 by zone.

These values were used as input to the analysis. To account for frequent door openings, Zone 3, the corridor, and main entrance to the facility, was assigned an infiltration rate of four times its calculated value (7). This increased ventilation was scheduled only during normal office hours.

The infiltration values as calculated provide an air change rate for the facility of less than .5 air changes per hour. This is considered low for infiltration.

Zone 4 temperatures resulting from analyses were above any recorded on the monitoring equipment. After review of the heating model, it was decided that other factors must be considered.

Exhaust fans are operated continuously in the rest rooms and in the projection rooms. Because the mechanical systems are off during the winter, the measured exhaust volume must be made up by infiltration. The infiltration values were increased to equal the exhaust fan volumes. Infiltration rates into specific zones were determined by proportioning the exhaust volume according to the calculated infiltration rate in each zone.

Table 2.5

Infiltration By Zone

Zone #	*	Infiltration CFM
1 & 5	*	7.4
2 & 4	*	13.8
3	*	31.0
6 & 8	*	2.3
7 & 9	*	35.5
10	*	Interior
11	*	15.3

To assist in validating this concept, pressure differences were measured between various areas of the building and the outside using a micro-manometer. The micro-manometer has the ability to measure pressure differences of 0.001 inches water column. Very small and unstable pressure differences did exist, but nothing repeatable could be measured.

The experiment was repeated with the fan systems running in an attempt to pressurize the building. Again, only small and unstable pressure differences could be detected. Differences in the range of 0.015 inches water column maximum with wide swings were measurable but not repeatable.

Exhaust fan volumes were also measured during this experiment. With the air handler fans off, the exhaust fan had an exhaust rate of 630 CFM. With the fans on, exhaust rates increased to 720 CFM. This is an indication the exhaust fans would tend to induce infiltration. Reduced exhaust volumes are an indication that flow is restricted into the building on a global scale, hence the building is operating at a somewhat negative pressure.

The results of a BLAST analysis with infiltration equal to exhaust volumes brought the zone temperatures close to the monitored temperatures. Temperatures are monitored in Zones 4 and 7 only. Monitored temperatures and BLAST predicted temperatures are shown in Figures 2.3 through 2.6 for the months of February and March. Zone 4, a heavily occupied zone, predicted higher than monitored temperatures. Zone 7, a seldom used classroom, tracked fairly well.

Other zones, in particular Zones 1 and 5, still predicted higher than expected temperatures. Even though

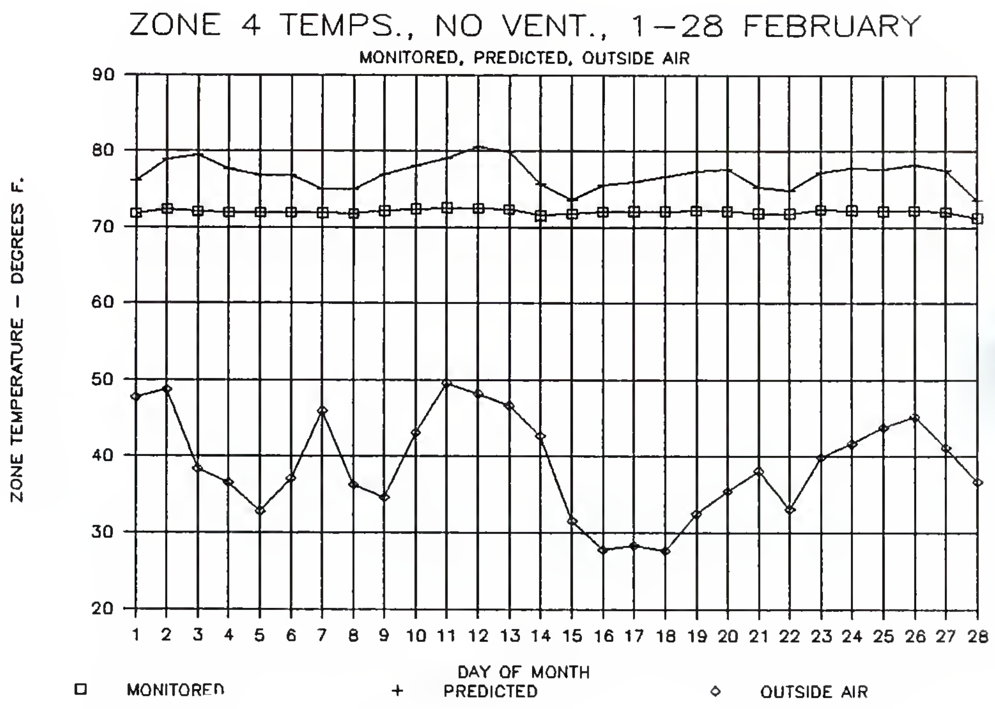

ZONE 4 TEMPS., NO VENT., 1–28 FEBRUARY
MONITORED, PREDICTED, OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
90
80
70
60
50
40
30
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH
□ MONITORED
+ PREDICTED
◇ OUTSIDE AIR

Figure 2.3

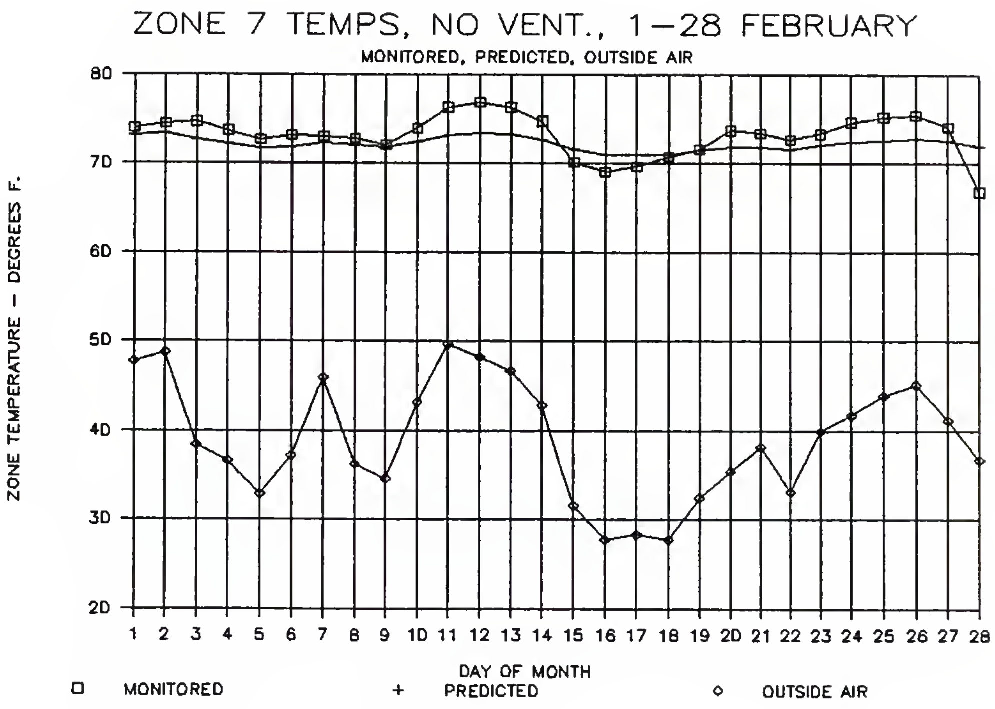
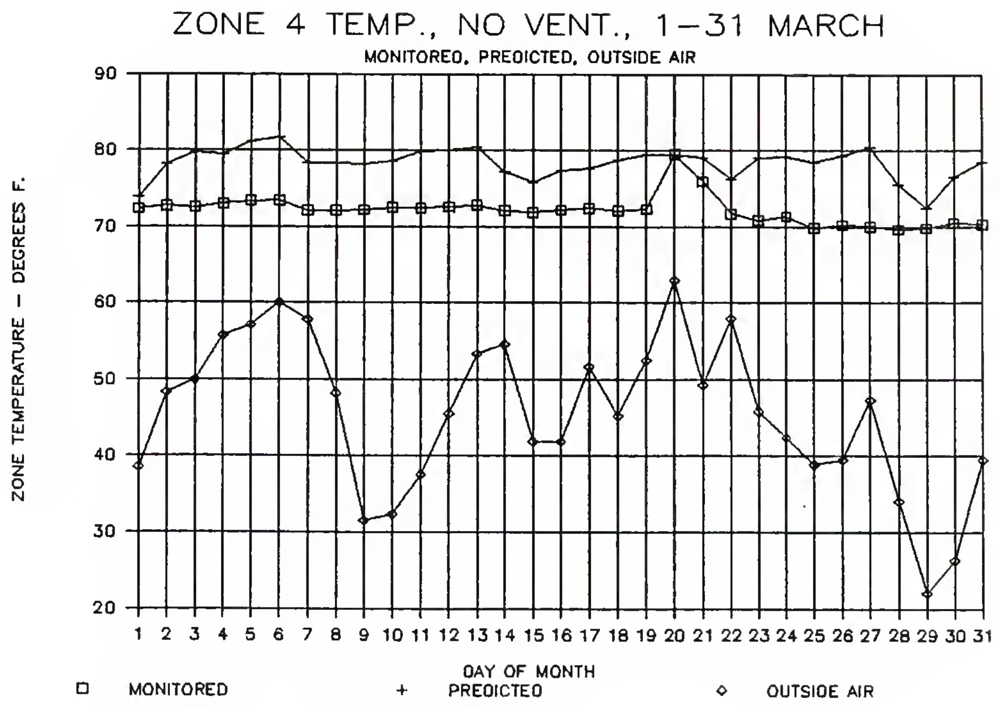
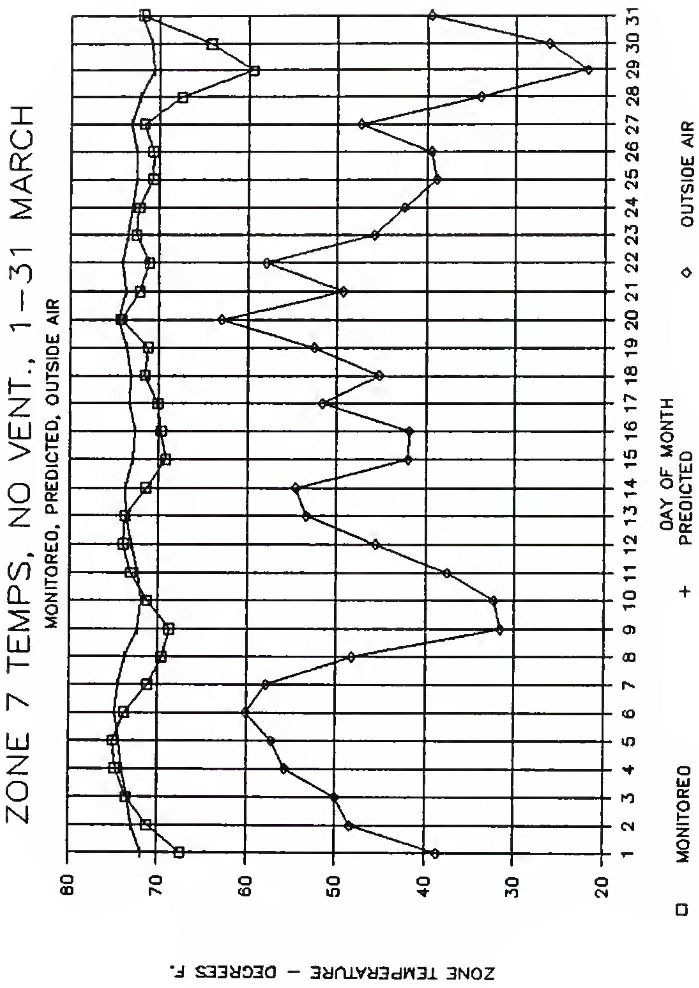

ZONE 7 TEMPS, NO VENT., 1—28 FEBRUARY
MONITORED, PREDICTED, OUTSIDE AIR
ZONE TEMPERATURE — DEGREES F.
80
70
60
50
40
30
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH
MONITORED
PREDICTED
OUTSIDE AIR

Figure 2.4



ZONE 4 TEMP., NO VENT., 1—31 MARCH
MONITORED, PREDICTED, OUTSIDE AIR
ZONE TEMPERATURE — DEGREES F.
90
80
70
60
50
40
30
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH
MONITORED
PREDICTED
OUTSIDE AIR

Figure 2.5



ZONE 7 TEMPS, NO VENT., 1 — 31 MARCH
MONITORED, PREDICTED, OUTSIDE AIR
ZONE TEMPERATURE — DEGREES F.
80
70
60
50
40
30
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH
MONITORED
+ PREDICTED
OUTSIDE AIR

Figure 2.6

there were no monitoring equipment in these zones, the BLAST predictions on temperature had highs near 90 F on occasion.

From conversations with the occupants, overheating was common. The response was to open windows. An analysis was made allowing the zones with operable windows to ventilate the space whenever inside temperatures rose above 73 F. This includes Zones 1 through 5. Maximum ventilation rates of six air changes per hour were established. Six air changes per hour represents a typical ventilation rate with the windows in Zone 1 open under average winter temperatures and wind speeds. The results of these analyses are shown in Figures 2.7 and 2.8. The temperature of Zone 4 was now in close agreement with the monitored data. Zone seven was not ventilated, and the results were identical to Figures 2.4 and 2.6.

A plausible explanation is that Zone 4, the occupied zone, did ventilate to control temperatures. Because Zone 7 was seldom occupied, and ventilation was possible only by leaving a door open, it did not ventilate on a regular basis.

The winter model was left with ventilation possible whenever interior temperature exceeded 73 F. The heating system energy usage is not dependent upon room temperature (see Chapter 3). The purpose of this exercise was to show

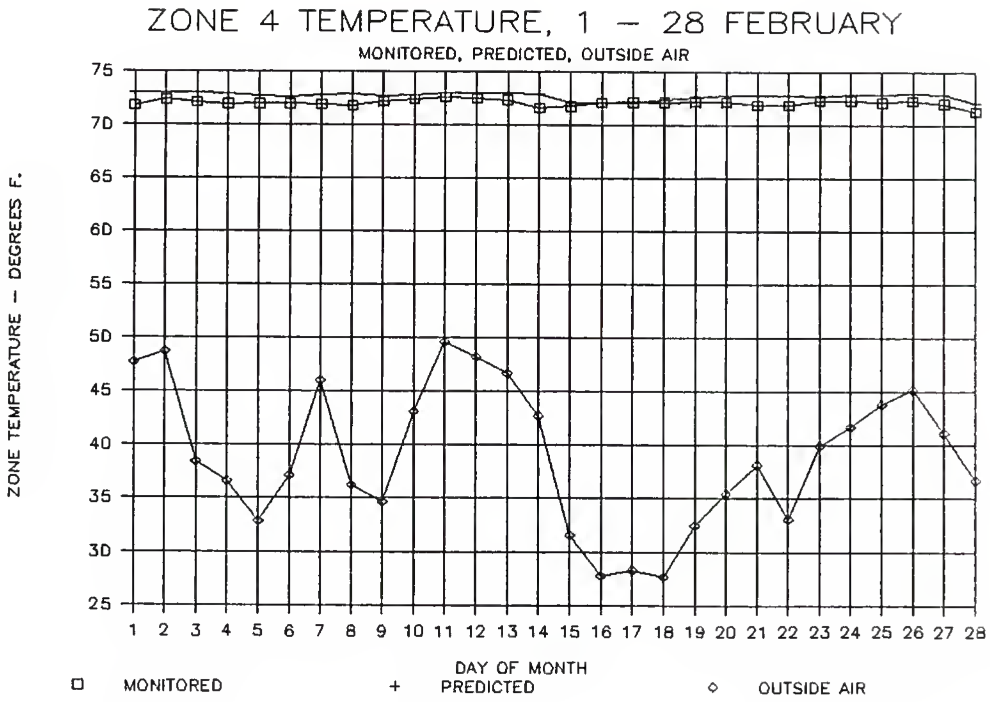
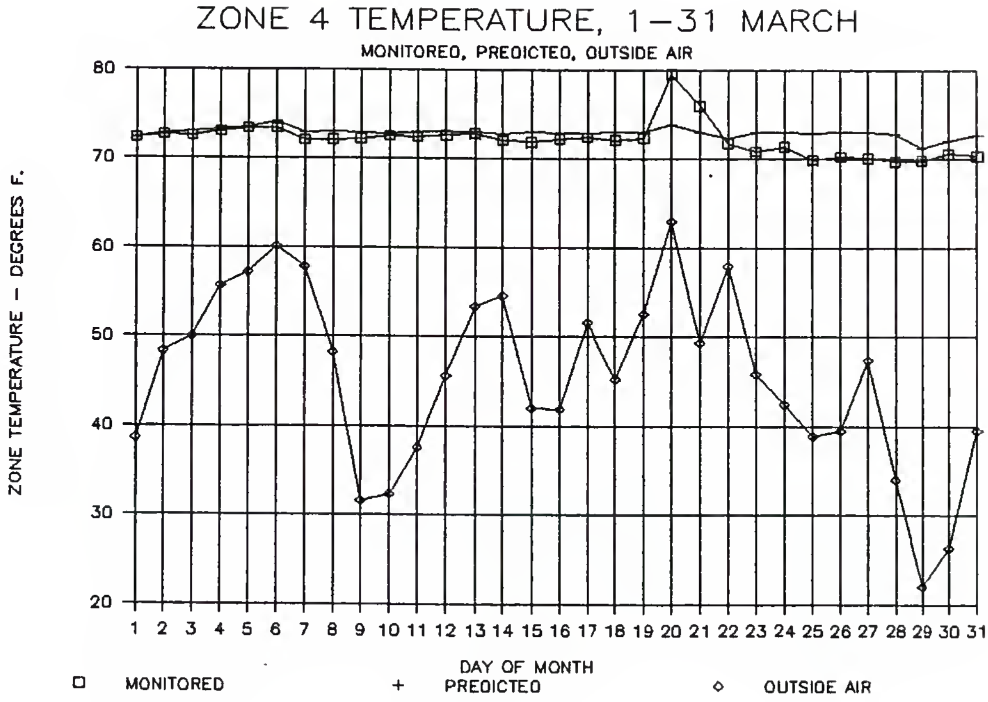

ZONE 4 TEMPERATURE, 1 – 28 FEBRUARY
MONITORED, PREDICTED, OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
75
70
65
60
55
50
45
40
35
30
25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH
□ MONITORED
+ PREDICTED
◇ OUTSIDE AIR

Figure 2.7



ZONE 4 TEMPERATURE, 1–31 MARCH
MONITORED, PREDICTED, OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
80
70
60
50
40
30
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH
MONITORED
PREDICTED
OUTSIDE AIR

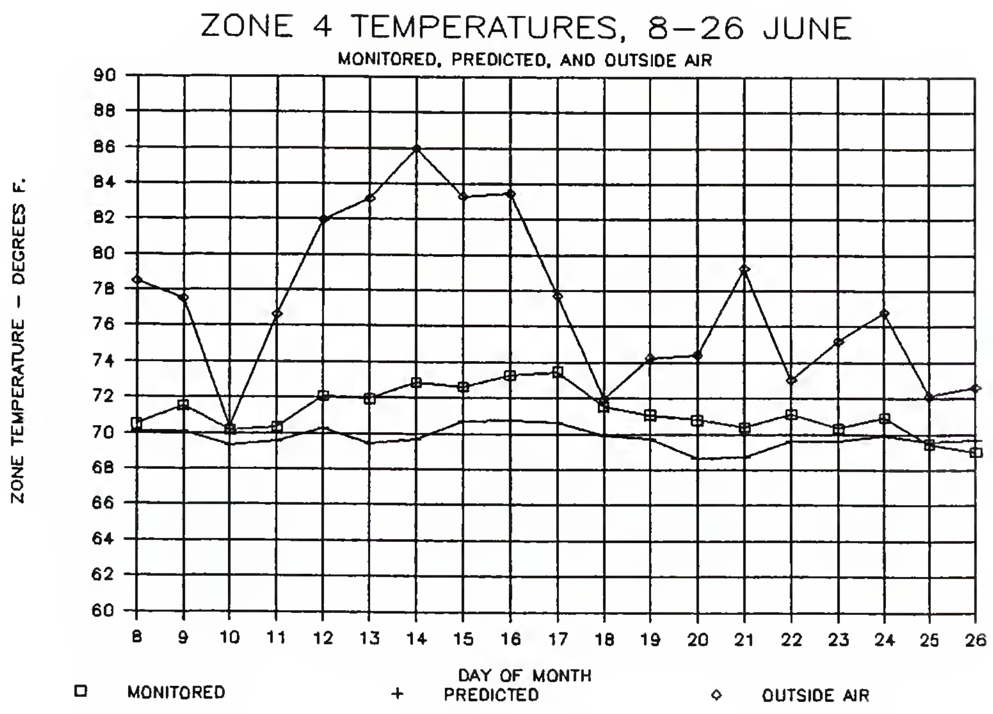
Figure 2.8

room temperatures could be controlled by ventilation.

Infiltration during the summer months was modeled as calculated. Discussion of the modeling of exhaust fan and supply fan operation is included in Chapter 3 for the "as operated" summer conditions and for the "as designed" model.

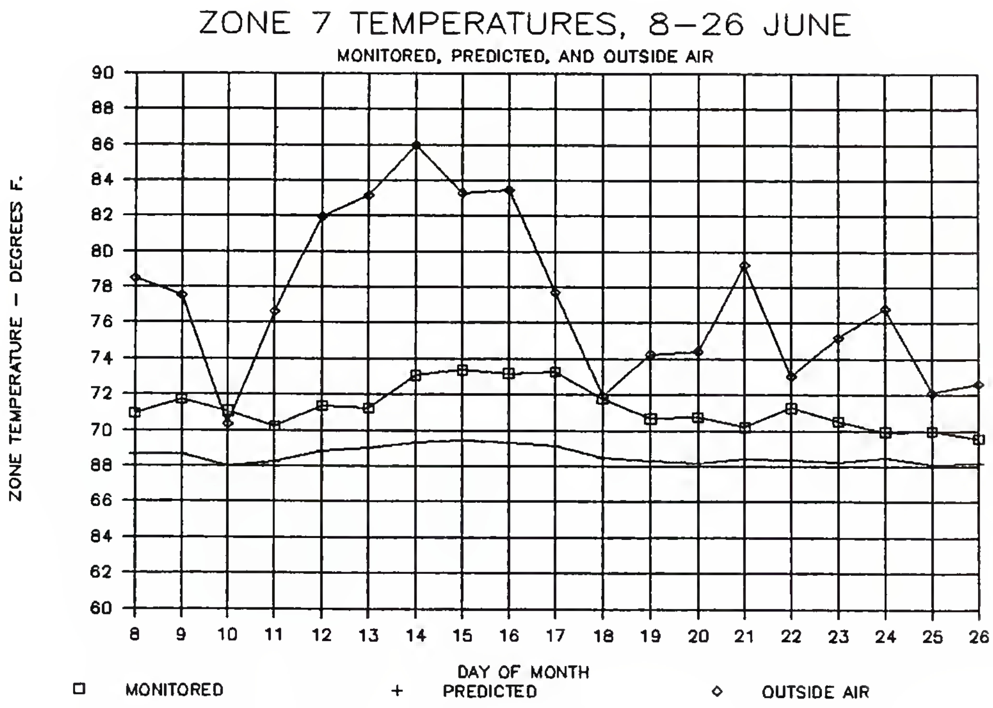
BLAST has the ability to vary infiltration with wind velocity and with inside-to-outside temperature differences. A comparison was made of the differences between the BLAST algorithm for varying infiltration and one suggested by the ASHRAE Fundamentals (7). As a base, infiltration was calculated by the method suggested by ASHRAE at zero temperature difference and a wind speed of 7.5 MPH. At these conditions, the BLAST algorithm would reduce the infiltration to 72 percent of the calculated value. If the infiltration was calculated using average conditions for February and March of 8.57 MPH and 42.4 degrees, BLAST over predicts infiltration with respect to ASHRAE by 10 percent. Considering the uncertainty involved in infiltration calculations, this was considered insignificant.

Summer operational temperatures were compared for Zones 4 and 7. These are presented in Figures 2.9 through 2.12. Monitored temperatures generally are higher than the predicted temperatures, by as much as 4 F. It was



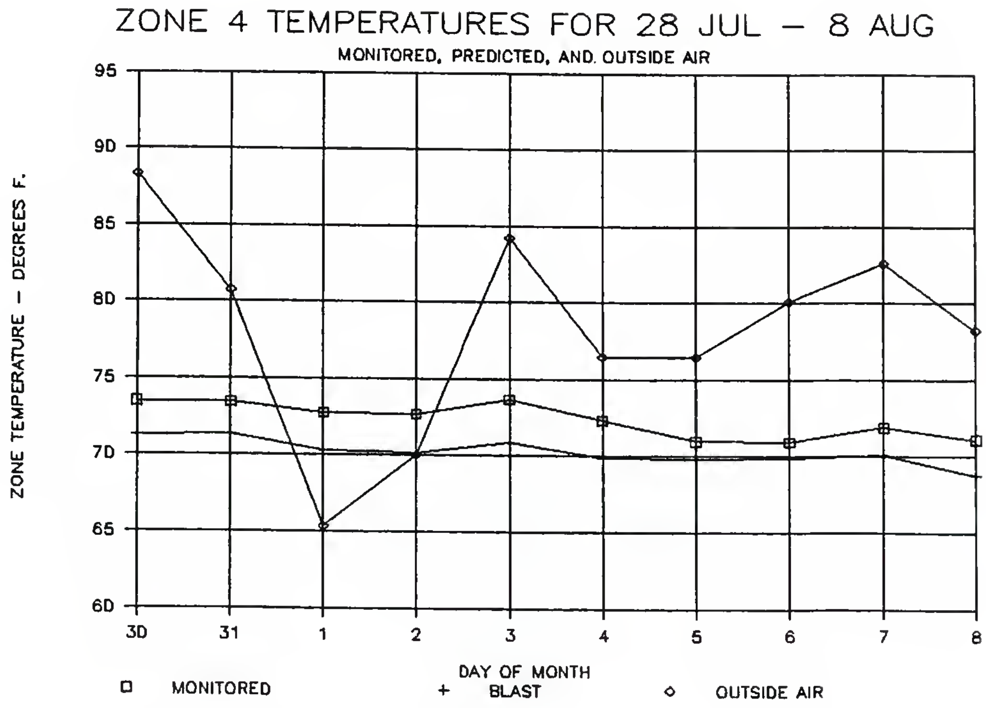
ZONE 4 TEMPERATURES, 8–26 JUNE
MONITORED, PREDICTED, AND OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
90
88
86
84
82
80
78
76
74
72
70
68
66
64
62
60
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
DAY OF MONTH
MONITORED
PREDICTED
OUTSIDE AIR

Figure 2.9



ZONE 7 TEMPERATURES, 8–26 JUNE
MONITORED, PREDICTED, AND OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
DAY OF MONTH
MONITORED
PREDICTED
OUTSIDE AIR

Figure 2.10



ZONE 4 TEMPERATURES FOR 28 JUL – 8 AUG
MONITORED, PREDICTED, AND OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
95
9D
85
8D
75
7D
65
6D
3D
31
1
2
3
4
5
6
7
8
DAY OF MONTH
MONITORED
BLAST
OUTSIDE AIR

Figure 2.11

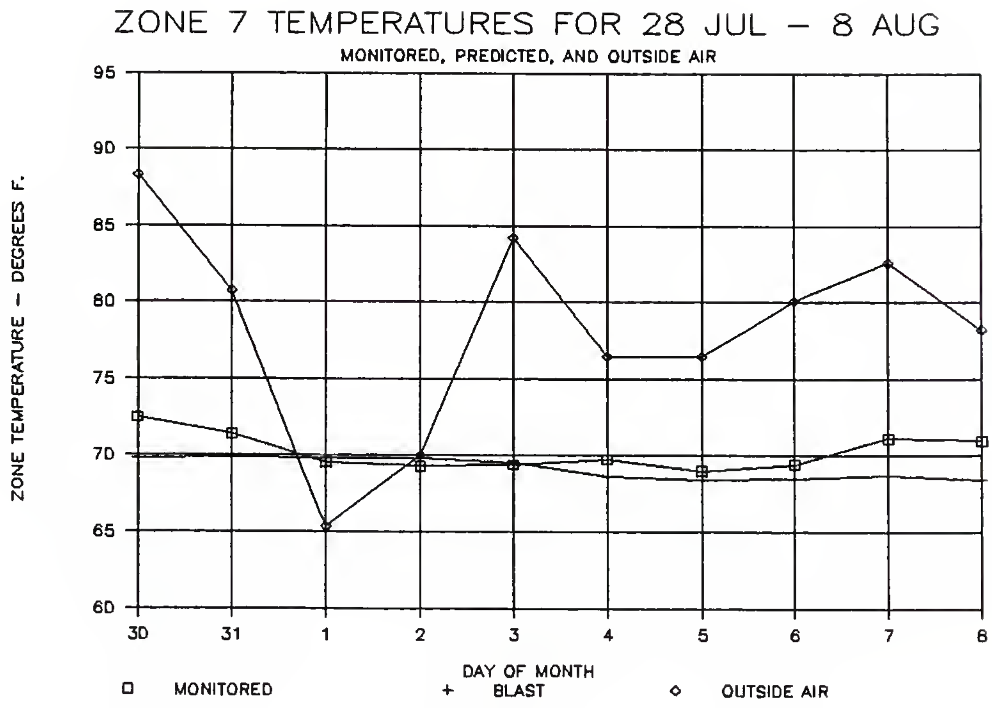

ZONE 7 TEMPERATURES FOR 28 JUL – 8 AUG
MONITORED, PREDICTED, AND OUTSIDE AIR
ZONE TEMPERATURE – DEGREES F.
95
90
85
80
75
70
65
60
30
31
1
2
3
4
5
6
7
8
DAY OF MONTH
MONITORED
+ BLAST
OUTSIDE AIR

Figure 2.12

possible to achieve a closer match of temperature by adjusting the control range and set points in BLAST. When this was done, energy predictions were off by nearly 20 percent. Considering only two of the 12 zones were monitored for temperature, and significant differences in thermostat set point exist within the facility, it was decided a reasonable match on cooling energy was more realistic than great concern on a temperature match for the monitored zones.

Chapter 3

Heating and Cooling System Description and Model

Building Heating System

Heat is supplied to the building as high pressure steam, approximately 100 psig. The steam goes through a pressure reducing station, where it is reduced to approximately 15 psig. The high-to-low pressure reducing station is shown in Figure 3.1.

The steam is then directed to a steam-to-hot water converter (shell and tube heat exchanger) where the latent heat of the steam is transferred to the water. The admittance of steam to the heat exchanger is controlled by a reset control system that sets the leaving water temperature in accordance with a reset schedule controlled by outside air temperature. Above about 60 F, the steam valve closes and the circulating pump stops.

Conventional plumbing specialties are included on the steam side of the system. These include traps on all downcomers, before the pressure reducing station and at the outlet of the heat exchanger. Trap discharges are directed to a condensate receiver which is vented outside. Both the high and low pressure steam systems are protected by relief valves with discharges vented to the outside. An expansion tank and air eliminator are included on the

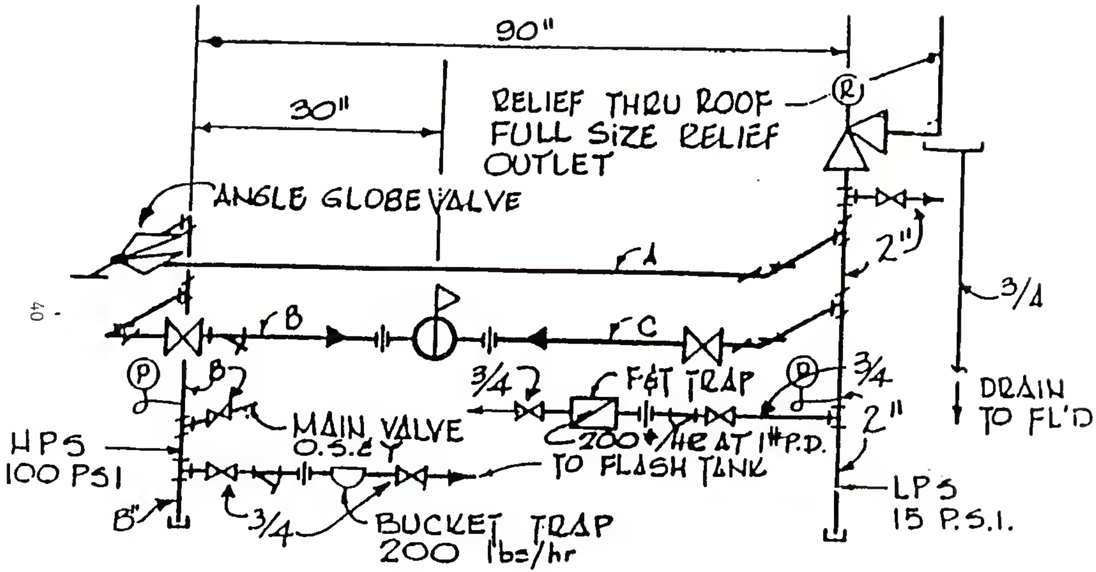


Figure 3.1 High Pressure Steam Pressure Reducing Station

suction side of the pump. Pressure gages are provided on both sides of the pump, and thermometers are included on both sides of the heat exchanger. Figure 3.2 shows the steam-to-hot water system.

If outside conditions dictate, the circulating water pump is energized and heated water is circulated to the building.

Heating Terminal Units

There are four basic categories of heat release devices in the building. There are baseboard convective heaters, cabinet heaters, and two styles of unit heater, designated as Unit Heater 1 and Unit Heater 2.

Distribution within the space is shown in Table 3.1.

The baseboard heaters were fitted with hand-operated dampers for heat control, but these were largely found to be inoperative or missing. The cabinet heaters had no controls. Unit Heater 1 was equipped with hand-operated fan controls as well as a thermostat. Unit Heater 2 is equipped with a thermostat operated fan.

Conversations with several occupants indicate there is still considerable confusion among the occupants as to what the proper method was to control space temperature. Some were certain the pneumatic thermostats had no control while others still made adjustments. A common theme was

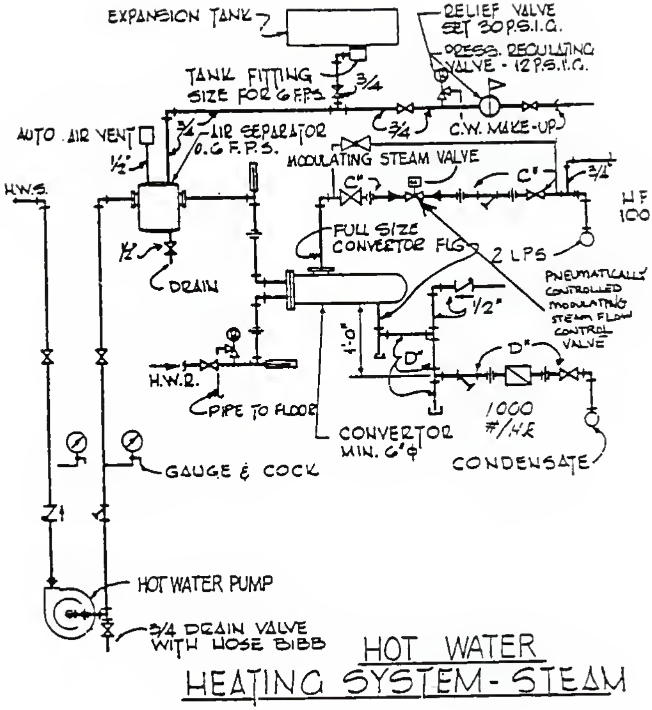


Figure 3.2 Steam to Hot Water Converter and Buliding Heating

frequent periods of discomfort.

Table 3.1

Heater Terminal Units

Zone Served	Heater Style
1	Baseboard
2	Baseboard
3	Baseboard
4	Baseboard
5	Baseboard
6	Unit Htr 1
7	Unit Htr 1 & Baseboard
8	Unit Htr 1
9	Unit Htr 1 & Baseboard
10	Cabinet
11	Unit Htr 2

Original drawings indicate the baseboard heaters located in Zones 1 and 5 were to have been fitted with pneumatic operated control valves. However, piping diagrams indicated on the same drawing would not have allowed them to function. The piping to all heaters is a simple loop with all heaters in series. In order for control valves to have operated well, a conventional supply and return system with the heaters in parallel would have been employed.

Hot Water Reset Schedule

Controls on the steam-to-hot water converter are pneumatic, as are all controls within the building. The outdoor air sensor is located in the outside air duct just inside the building envelope. This is on the south side of the building, so there may be some solar effect. The sensor is a Johnson pneumatic temperature sensor with a temperature range of 0 F. to 100 F. An initial check of the sensor calibration (done at night to negate solar influence) showed that while it was actually about 73 F outside, the sensor output pressure was 9.7 psig, indicating a temperature of 56 F. Because the sensor used for resetting the water temperature was not accurate, the reset schedule as indicated on the design drawings would probably not be found within the building.

To determine the control range accuracy expected with the controls, an examination of the control settings and an analysis of the throttling range is necessary. Figure 3.3 shows the pneumatic controls for the hot water reset.

The gain setting on the controller was 10. Gain is the change in output pressure to the steam control valve divided by the change in input pressure from the primary control sensor. In this case, the primary control sensor is the temperature sensor located in the hot water supply piping.

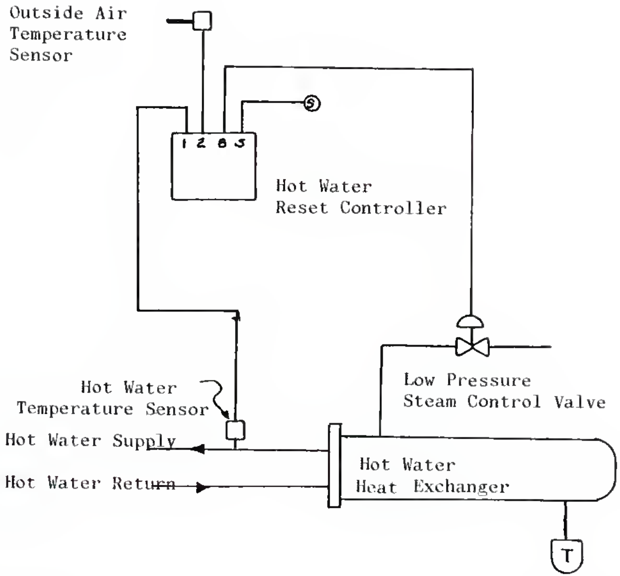


Figure 3.3 Pneumatic Controls for Regulation of Building Heating Water Temperature

$$\text{Gain} = \frac{\text{delta } P_{out}}{\text{delta } P_{in}}$$

The steam control valve has a spring range of 10 psig, so a one psig change in primary sensor pressure would have the effect of moving the steam valve from full open to full closed. With a primary sensor span of 200 degrees, a one psig change in sensor pressure would equate to a 17 degree change in hot water temperature, the throttling range of the controller. Whenever the hot water temperature is within $\pm$ 8.5 degrees, it is in control.

The same outside temperature sensor is used for shutting the steam valve and for stopping the pump as the temperature exceeds 60 F.

Supply water temperatures versus outside air temperatures have been plotted in Figure 3.4. A least squares fit of the data produces a reset schedule central to the data.

The data centering around 180 F supply water temperature above the general cluster is the result of the compressor malfunction that began around 6 AM on March 20 and ended about 3 AM on the March 21.

The data cluster below the norm centering around 65 to 70 F outside air temperature shows the approximate

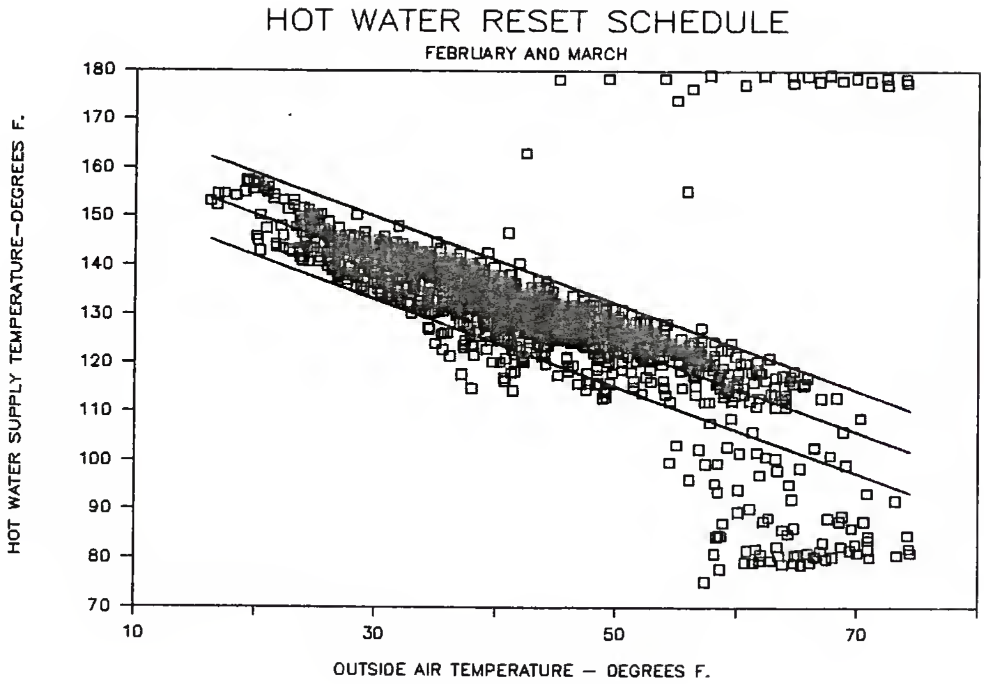

HOT WATER RESET SCHEDULE
FEBRUARY AND MARCH
HOT WATER SUPPLY TEMPERATURE-DEGREES F.
180
170
160
150
140
130
120
110
100
90
80
70
10
30
50
70
OUTSIDE AIR TEMPERATURE — DEGREES F.

Figure 3.4

temperature that the steam valve closes. It is interesting to note the pump does not shut off even though the steam valve closes down. It should be noted the shut off temperature is above the design value as would be expected because the outside temperature sensor reads low.

Three lines are plotted on Figure 3.4. The central line is the least squares fit of the data. The upper and lower line represent the temperature limits based on the reset schedule plus and minus the controller throttling range. As is evident, the controller maintains the supply water temperature very close to the control range.

The reset schedule used for later calculations, as well as the design reset schedule, are shown in Table 3.2.

Table 3.2

Hot Water Reset Schedules

Actual Reset Schedule			Design Reset Schedule		
OAT-F	*	SWT-F	OAT-F	*	SWT-F
0	*	168	0	*	200
70	*	106	70	*	80

The design reset schedule was obtained from the design drawings.

Heating Model

Heating is provided by a combination of baseboard heaters, unit heaters, and cabinet heaters as discussed above. Cooling to all but the mechanical room is provided by multizone units. Due to a limitation of BLAST, it is possible to have only one system type serving a zone. Because it is desirable to model the cooling systems in the same model as the heating system, a decision was made to use a multizone system for the heating model in all zones served by unit heaters except the mechanical room.

Zones heated by baseboard heaters were modeled as outside temperature controlled baseboard heaters.

The mechanical room heater was modeled as a unit heater because it is not served by a multizone unit.

Heating Capacities Correction

The heat release rate of the baseboard heaters is directly related to the average water temperature and to the temperature difference between the average water temperature and the zone temperature. The heating loop temperature drop was examined as a function of outside air temperature for several ranges. The results are presented below in Table 3.3.

Table 3.3

Outside Air Temperature vs.
Hot Water Temperature Drop

OAT - F	*	Temp. Diff - F
15-20	*	9.6
20-30	*	9.5
30-40	*	8.2
40-50	*	6.1
50-60	*	4.7
60-70	*	3.0

Using the reset schedule and the temperatures difference from Table 3.3, the average water temperatures in the baseboard convectors can be determined. The capacities of the units can then be adjusted to the actual temperature conditions.

Baseboard units are normally rated at the temperature equivalent of 1 psig steam, or about 215 F (8). Because the actual temperatures supplied are considerably less, the capacities must be adjusted. This was done in two steps.

The first was to adjust the design capacities provided at supply water temperatures of 190 F with a 10 degree temperature drop to the standard rating of 215 F. The capacities were then adjusted downward to comply with the actual supply water temperatures and the associated temperature drop. Correction factors for baseboard capacities for units at other than 215 F average water temperature (8) are given in Table 3.4.

Table 3.4
Factors Used to Convert 1 PSI
Steam Ratings to Hot Water
Ratings at
Temperature Indicated

Average Water Temperature	Correction Factor
100	.15
110	.20
120	.26
130	.33
140	.40
150	.45
155	.49
160	.53
165	.57
170	.61
175	.65
180	.69
185	.73
190	.78
195	.82
200	.86
205	.91
210	.95
215	1.00
220	1.05

Capacities for the "as operated" and the "as designed" conditions were adjusted and added to the BLAST analysis.

It is critical to adjust the baseboard capacities as accurately as possible because the heat release rate is set only by the outside temperature in BLAST. There are no thermostats for control, and overheating does not limit output as it would in the real building.

Zones 6, 7, 8, and 9 are modeled as multizone heaters. In order to simulate the operation of a unit heater with the multizone model, several modifications had to be made. The outside air was set to zero since there are no outside air provisions in the unit heaters. The air handler pressure rise was zero and the fan and motor efficiency were set to one to eliminate fan heating of the air and electrical usage. A small fan motor operating off a thermostat control with no ductwork will not add extensively to the electrical energy use. A temperature control profile, HEAT, for the multizone heaters was established to match the monitored temperatures in Zone 7.

The mechanical room heating system is a thermostat controlled unit heater with a set point of about 72 F. This was modeled as a system in BLAST using control profile HEAT2.

Because of the modeling changes needed to accurately model the unit heaters as multizone heaters, a separate model was developed for the winter operation of the building in the "as operated" condition. This was not desirable but was the best compromise available.

Modeling in this fashion did allow for only minor modifications of the model for the "as designed" condition.

Heating Season Air Handler Operation

The air handlers are not operated during the heating season. The "as operated" analysis have these units off from October 16 through May 15. Design drawings and control logic diagrams indicate the units serving Zones 6, 7, 8, and 9 (AHU's 1 & 3) were intended to operate year-round. These areas do not have windows, so system operation was intended to provide ventilation. A temperature controlled economizer cycle was installed so a mixed air temperature of 55 F would be maintained with a minimum fresh air setting of 860 CFM. It appears these areas, designated as "class room," were envisioned to require cooling during mild to cold weather as a result of large occupancy loading. System operation year around with a temperature controlled economizer are modeled in the "as designed" analysis. The benefit of the temperature controlled economizer, however, will not be demonstrated due to the relatively low occupancy load in the classrooms.

The temperature controlled economizer cycle in BLAST modulates the fresh air to maintain a fixed mixed air set point. The maximum fresh air admitted was set at the design air handler flow rate, and the minimum air was set at the minimum specification of 860 CFM. Whenever the outside temperature rises above the desired mixed air set point, the fresh air goes to minimum volume. This cycle differs only slightly from the desired cycle in that the "as designed" control scheme had the economized changeover point at 60 F, five degrees above the desired mixed air temperature. The consequence of this is that between 55 and 60 F, minimum fresh air -- rather than maximum fresh air -- would be introduced to the building.

It should be noted the outside temperature-controlled economizer controls are not calibrated properly. When the air handlers are started manually during the winter, the outside air dampers remain in the closed position. The controls shown in Figure 3.5 consist of a two position controller designed to provide main air pressure to the modulating controls whenever outside temperatures are below 60 F. With main air pressure, the modulating controller should position the damper to maintain the mixed air temperature at 55 F, or maintain minimum outside air, whichever demands the greatest outside air. The set point of the modulating control is in error. In addition, one of the minimum position switches for setting minimum outside air is broken. The other switch is set low so the dampers stay closed.

Air Handler 2 is designed to operate whenever the outside temperature is above 60 F. This schedule would preclude the operation of the unit during heating conditions.

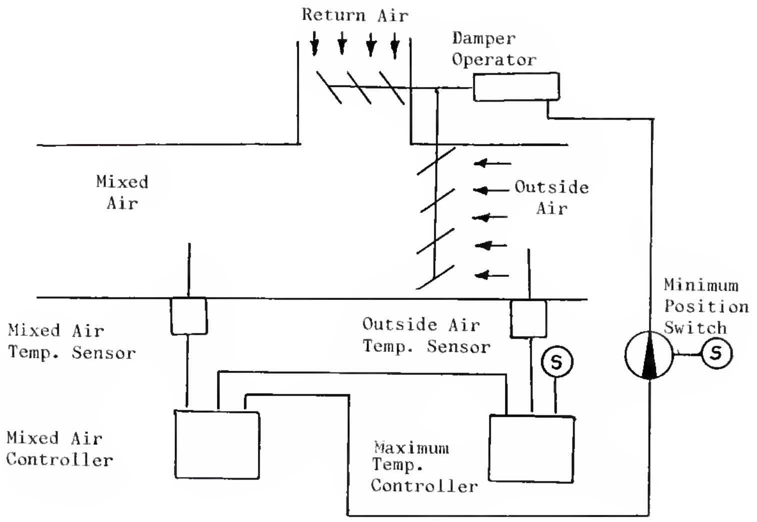


Figure 3.5 Pneumatie Controls for Mixed Air Temperature

With zones 6, 7, 8, and 9 modeled as multizone units, the only changes in the model from the "as operated" to the "as designed" configuration was the addition of the economizer, factors related to the fan energy use, and the addition of fan heat.

Winter Exhaust Fan Operation

Exhaust fans located in Zones 7 and 9 are operated year-round. Actual flow rates were 630 CFM with the air handlers off, and 720 CFM with the systems on. As discussed in the building section, infiltration rates were adjusted to account for exhaust fan operation in the winter conditions. For the "as designed" condition, because the air handlers are supplying outside air at rate near or greater than the exhaust rates, the infiltration was set to calculated rates.

Building Cooling System

Cooling is provided to the building by the three multizone air handling units. Building areas being served by each unit are illustrated in Figures 3.6 and 3.7.

Primary cooling energy is provided to the building by chilled water from a central plant. A secondary pumping loop is operated within the building to provide chilled water to each of the air handlers. The flow to each AHU

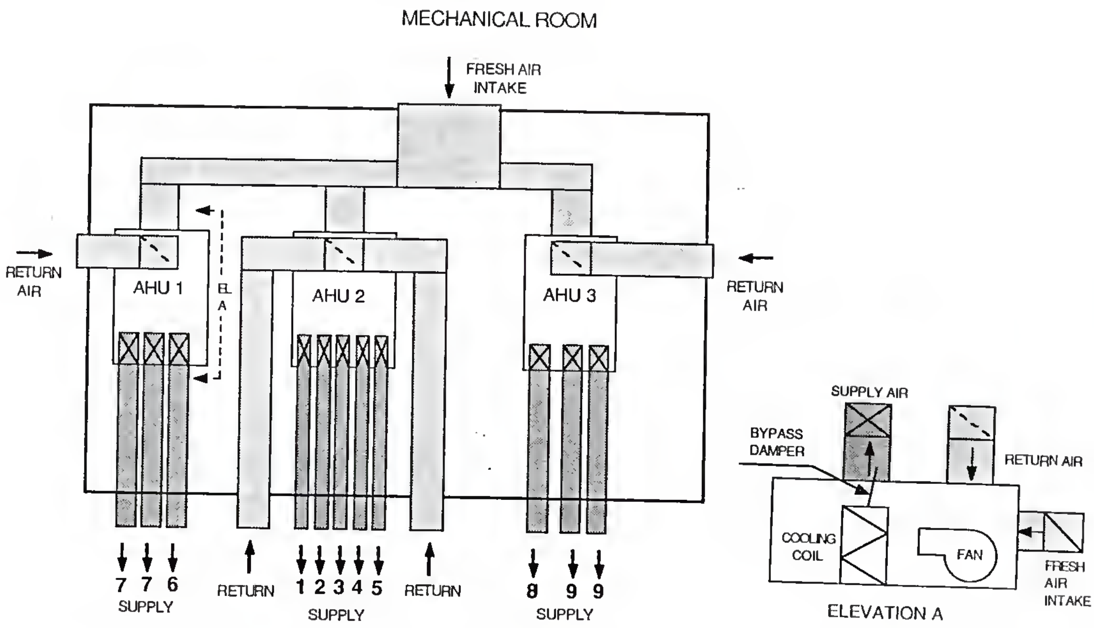


Figure 3.6 Air Handler, Supply, Return, and Outside Air Duct Arrangement

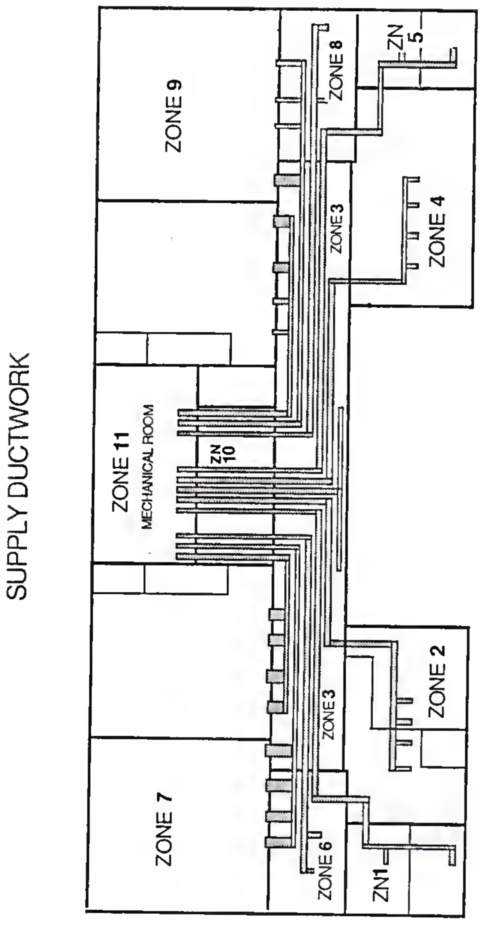


Figure 3.7 Supply Duct Arrangement

is set by natural flow balancing. There are no chilled water control valves, and no attempt is made to control the coil leaving air temperature. Piping configurations are shown in Figure 3.8.

Whenever outside temperatures drop below 60 F, the bypass valve is intended to divert flow from the air handlers. The bypass valve is intended to be a two-position valve, but some leakage has been speculated. Temperature control in the zones is accomplished through the use of pneumatic thermostats. The thermostats position a damper in the outlet of the multizone unit to regulate the volume of chilled air sent to the zone. Some air is bypassed around the cooling coil and blended with the chilled air so the total volume of air delivered to the zone is held constant. This configuration is shown in Figure 3.6.

It is worth noting an inspection of all the thermostats on Building 8037 showed the occupants had tampered with them to the point that internal adjustments as well as set points were unrealistic. Some were set at 55 F while others were at 85 F. The sensitivity slider (throttling range adjustment) in some of the thermostats was at one end of scale and the linkages were not aligned properly. In a Johnson thermostat, such as these installed in this building, misalignment renders the

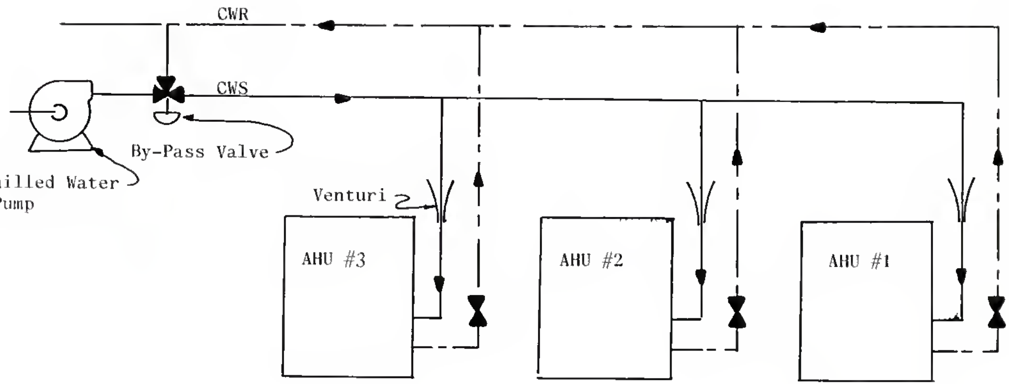


Figure 3.8 Chilled Water Piping Arrangement

thermostat inaccurate and impossible to calibrate.

Measurement of cooling energy is made with temperature sensors on supply and return water lines to each AHU as well as on the main lines. Flow sensors also are installed on these lines so that an energy balance can be checked on the data acquisition system. This is useful as a check on monitored energy use and to determine bypass valve leakage.

Supply chilled water temperature is held fairly constant throughout the cooling season. There is a slight tendency for the chilled water temperature to rise as the outside temperature rises. This is probably due to a combined effect of rising ground temperatures and the chiller plant control throttling range. This was ignored in the model because chilled water reset will not significantly affect energy use in a model which does not include the chiller model.

Cooling Capacities Correction

Coil capacities were specified with an entering water temperature of 44 F. Design coil conditions are in Table 3.5 for a 44 F entering water temperature.

With higher entering water temperatures, the coil capacities must be reduced. Catalog data is not readily available for coils operating at 55 F chilled water temperature. With most coil configurations, a nearly counter flow arrangement would be a good assumption.

Table 3.5

Cooling Coil Design Parameters

Parameter		AHU-1 & 2		AHU-3
Entering DB	*	84.3	*	79.9
Entering WB	*	68.6	*	66.1
Leaving DB	*	55.5	*	58.5
Leaving WB	*	54.0	*	57.5
Capacity Btu/H	*	117307.	*	135070.
GPM	*	22.	*	25.
CFM	*	2610.	*	4850.

Insufficient data on actual entering and leaving air state points, however, makes a log mean temperature difference approach for reducing coil capacity impractical. The method used was to reduce coil capacity in a linear relationship to the difference between entering air temperature and entering chilled water temperature.

$$\text{Capacity @ 55 F} = \frac{T_{air} - T_{cw=55}}{T_{air} - T_{cw=44}} \times \text{Original Capacity}$$

The air temperature was assumed to be 70 F.

As a check on the method, catalog data (9) was used to compare coil capacities when changing the entering water temperature from 45 F to 50 F. The design entering and leaving conditions were used as criteria for coil selection. The reduction in capacity was about 20 percent using catalog data and when using the above formula with modifications for a 45 F to 50 F change in chilled water temperature. The coils in the simulations are never fully loaded, and an error of several percent on coil capacity should have a negligible effect on overall energy use.

Zone Air Flows and Cooling Capacities

In order to calculate the proportion of air handler cooling capacity received by each zone, it is necessary to determine the air flow into each zone. Air flow measurements were made using an Alnor Valometer, Model 6461, to determine zone air flow. Actual air flows are presented in Table 3.6 along with design air flows.

Table 3.6

Zone Air Flows

Zone #	Actual Flow (CFM)	Design Flow (CFM)
1	930	1010
2	1140	1080
3	615	740
4	1125	1360
5	710	660
6	310	550
7	1710	2060
8	550	550
9	1830	2060

The cooling capacity of each air handler was proportioned to each zone based on the percentage of total air handler flow delivered to the zone. This same scheme was used for both the "as operated" and the "as designed" conditions.

Outside Air Quantities

As discussed earlier, the outside air controls did not operate as designed. Nevertheless, it was necessary to determine the actual outside air volumes being admitted. To obtain these values, a duct traverse was made with a directional hot wire anemometer. Details of this work are provided in Appendix F. The resulting fresh air flows are summarized in Table 3.7. Design minimum values also are shown. Even though the outside air dampers were closed on Air Handlers 1 and 3, there was still measurable air flow. This is the result of leakage through the dampers.

Cooling Season Air Handler Operation

The three air handlers operate continuously during the cooling season. Minimum volumes of outside air are admitted according to Table 3.7.

One problem encountered was the air handlers will not restart automatically after a power outage. Sometimes the only indication of a problem was the space temperature increased to uncomfortable levels.

Table 3.7

Outside Air Volumes

AHU #	Actual Vol. (CFM)	Design Vol. (CFM)
1	64	860
2	1704	200
3	55	860

Summer Exhaust Fan Operation

Provisions for air exhausted through the exhaust fans must be made manually in the analysis, because only limited air balances can be accomplished by BLAST. During the "as operated" summer conditions, only a small amount of outside air is admitted by AHU 1 and 3, while considerable outside air is admitted by AHU 2. In this situation, the exhaust fans were assumed to draw air from the ceiling plenum. Additional infiltration was provided to the ceiling plenum to account for the loss. In the "as designed case," the minimum air flows were close to the exhaust flows, so no additional flows were introduced.

Chapter 4

Weather Data and Weather Data Processing

In validating a building energy use model against monitored energy use data, it is essential the building model be placed in the same weather environment experienced by building. The CERL personnel, realizing the need for accurate weather information, installed a weather-monitoring station on Building 8025 at Ft. Riley. A second station was erected on Marshal Air Field on Ft. Riley.

As discussed earlier, Building 8025 is located on Custer Hill, adjacent to Building 8037. Marshal Air Field is located south of Custer Hill on the Kansas River plain. Several of the new buildings to be monitored will be or are erected on Marshal Field.

One reason two weather stations were erected within 10 miles of each other was the concern that significant differences in weather would exist between the two sites. Marshal Field is located on the Kansas River bottoms with high bluffs to the north and south. Because of the bluffs, it might be protected from some of the winds and might have higher humidities and warmer temperatures than Custer Hill. When preparing a validated model of the buildings located on Marshal Air Field, weather information from that site would be needed. Model validation for buildings on Custer Hill requires weather data from Custer Hill. A second reason it became obvious during this project was a second source of weather data would allow holes in data to be realistically filled.

No data collection program is without a period of shakedown and periodic failures. The weather station at Custer Hill was no exception. One of the problems encountered in this work was finding times of long enough duration where both weather data and building energy use data were available. In order to perform the needed comparisons, both building and weather data systems had to be working. Periods of suspicious data were not considered unless a method was devised to reconstruct the missing information and to check the reconstruction.

Winter Weather

The weather station located on Custer Hill was very reliable during the winter of 1986 and 1987. Reliable building data was also available during this time. The months of February and March were chosen for model validation because the weather represented extremes in heating requirements. A model predicting energy use accurately during cold weather would not necessarily perform well during minimum heating requirements. Use of this time frame allowed a variety of heating requirements to be evaluated in a single, continuous analysis.

February and March

The weather data during this time was not without a few trouble spots. There were approximately six hours of data missing in the 1,416 hours of data collected during this period. When a single hour of data was missing, the values were obtained from a linear interpolation of the data points on either side of the missing data. While there may be some abnormality during the missing hour, it was decided that a single hour of questionable weather data would not affect the overall analysis.

A more significant problem resulted from the failure of the dew point sensor on or about March 12. All dew point information after this date for Custer Hill was faulty.

This missing data was provided by using the dew point information from Marshal Air Field for the same period of time. While the dew point between the two stations agreed to within two degrees, there was little concern for the error this may introduce. One significant thing to point out is the operation of BLAST in a heating condition is not dependent upon humidity. During the winter, the cooling coil is off in both the "as operated" and the "as designed" condition. No moisture balance is done internal to BLAST. The net result is totally erroneous dew point data could have been used, and the results of the analysis would have been the same.

Summer Weather

It was not possible to obtain a long time period for analysis of a range of cooling requirements due to either building or weather data collection problems. Two periods were chosen during the summer of 1987 for analysis. The first period was from June 8 through June 26. The second period was from July 30 through August 8.

Weather data for a considerably longer period of time was available for Marshal Air Field, as was building data. The Marshal Air Field data was complete with the exception of the faulty anemometer. The bearings had gone bad.

An analysis using the Marshal Field data was made with wind speed information omitted. The purpose was to evaluate whether the Marshal Air Field data could be substituted for the Custer Hill data. If the comparisons were close, a long run could be made, approximately five weeks, with the Marshal Air Field data.

The comparison analysis would be for a short period of time because only limited good weather data was available for Custer Hill.

The analysis using Custer Hill Weather produced significantly different energy use information than the Marshal Field data.

A second check was made by augmenting the Marshal Air Field data with Custer Hill wind data. With the addition of wind data, the results were comparable to the results from the Custer Hill analysis.

This was surprising at first. The only effect that was expected was a modification of the infiltration values. The infiltration specifications were removed from the model, and results similar to those above were obtained again.

The other effect that had previously been ignored was the outside film coefficient of exterior walls. In BLAST, the film coefficient is controlled by wind speed. During the cooling season, the surface temperature of these walls will often be greater than the air temperature due to the absorption of solar radiation. Wind, at less than the wall temperatures will have the effect of cooling the walls. Zero wind speed will negate that effect.

Because the wind had a significant effect on the cooling energy use of the facility, it was not possible to use the Marshal Air Field weather data. This limited the available time for summer analysis to a few days in late

July and early August. Nineteen days in mid-June also were analyzed.

Weather Data Conversion

Data collection and verification have been documented(1). The data collected, however, requires some processing prior to inclusion in a BLAST analysis. Two steps in processing are required.

The first step involves the conversion of the raw weather data into a Test Reference Year (TRY) format. All data necessary for this effort was collected. Conversion of units was necessary in the case of barometric pressure and solar radiation. In addition to simple unit conversion, TRY format requires the dew point data be converted to wet bulb. A routine was developed to perform this conversion and is included in Appendix E. The output from this routine provides weather data in the proper units and format for the second step of conversion.

BLAST provides a means of converting weather data in a variety of standard formats to the format required by BLAST. The Weather Information File Encoder (WIFE) routine provides this conversion. In addition to format changes, data checks are performed and missing data is supplied from either interpolation or from standard year data. Missing temperature information is interpolated by

WIFE, wind speed and direction are set to zero if missing, and solar data is obtained from clear-sky calculations.

One requirement of the first step conversion was to identify missing data and provide the required bad data flags in the input to WIFE. In general, these are fields filled with 9's. Missing data was limited to very few hours in any of the analysis periods.

A second function of WIFE is to convert solar radiation on a horizontal surface into beam, diffuse, and reflected components. This posed some problems. While methods used to make this conversion are well documented (10), they all require an accurate account be made of time. For example, any solar radiation received after sundown must be diffuse. Radiation received just prior to sundown should be of low intensity and will be primarily diffuse. If timing is off by as much as a few minutes, erroneous assumptions will be made by the conversion algorithm. The result will be very high components of beam radiation either at the beginning or at the end of the day.

Exact timing of the weather data acquisition system was not of high priority (11). The result was high values of beam radiation calculated by WIFE during the hours of sunrise and sunset.

Solar radiation during these time of the day should not have a significant effect on the loading of the building. The data was modified to remove the abnormally high values of beam radiation during these hours. The attempt was to modify the TRY formatted data so the beam components computed by WIFE were no higher than the beam component in the hour immediately before or after, depending if it was morning or evening.

Plots of solar insulation, dry bulb temperatures, dew point temperatures, and wind speed are provided in Figures 4.1 through 4.16 for the periods being simulated.

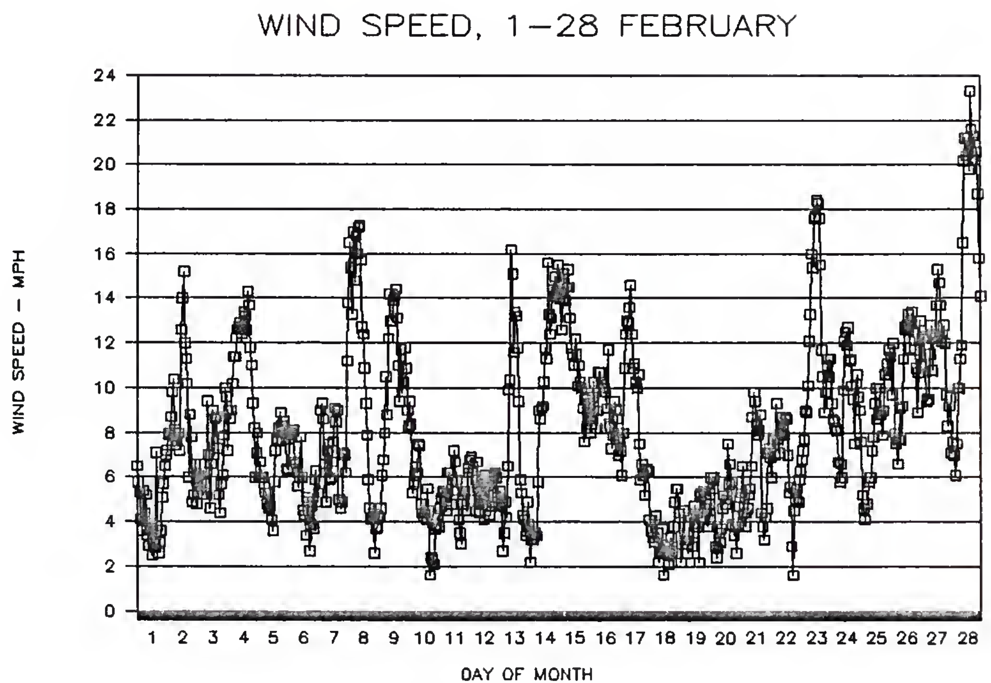

WIND SPEED, 1—28 FEBRUARY
WIND SPEED — MPH
24
22
20
18
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH

Figure 4.1

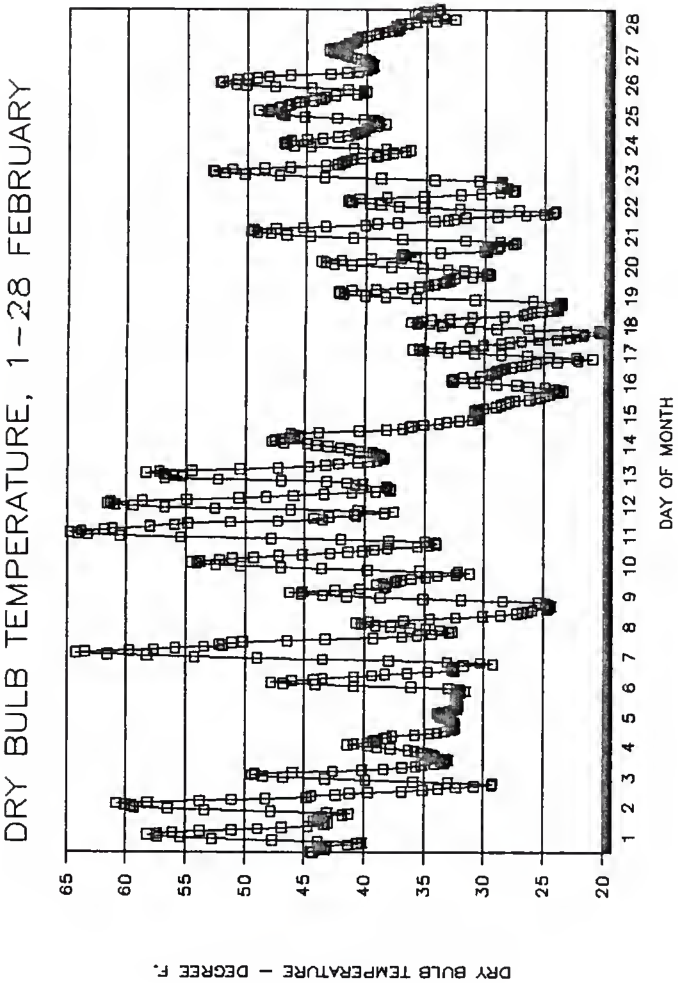

DRY BULB TEMPERATURE, 1-28 FEBRUARY
DRY BULB TEMPERATURE - DEGREE F.
65
60
55
50
45
40
35
30
25
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH

Figure 4.2

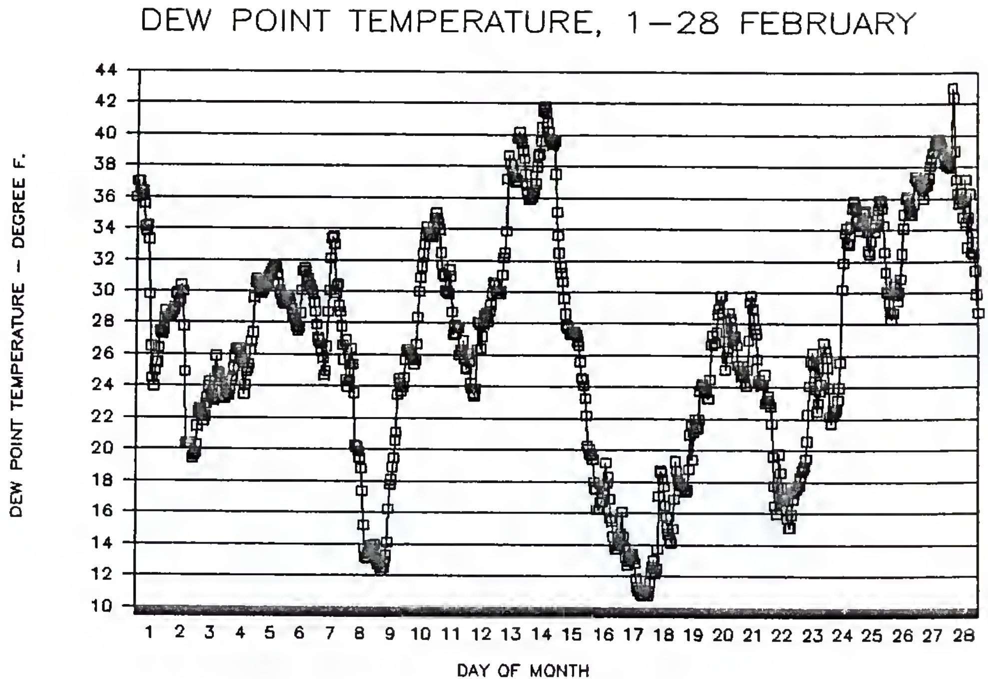

DEW POINT TEMPERATURE, 1–28 FEBRUARY
DEW POINT TEMPERATURE – DEGREE F.
44
42
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH

Figure 4.3

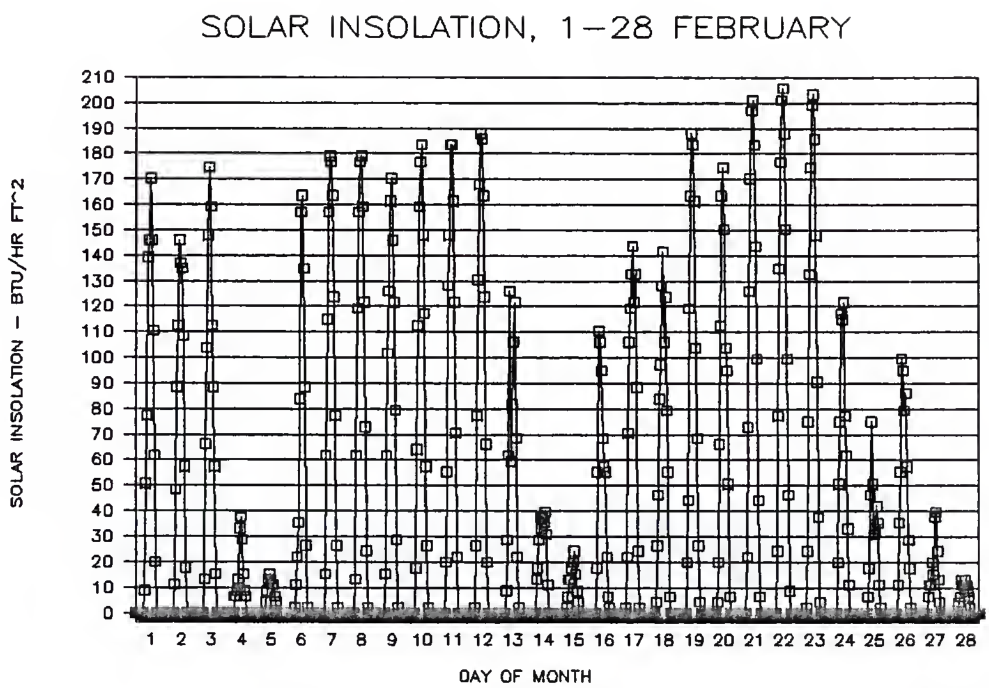

SOLAR INSOLATION, 1–28 FEBRUARY
SOLAR INSOLATION – BTU/HR FT^2
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH

Figure 4.4

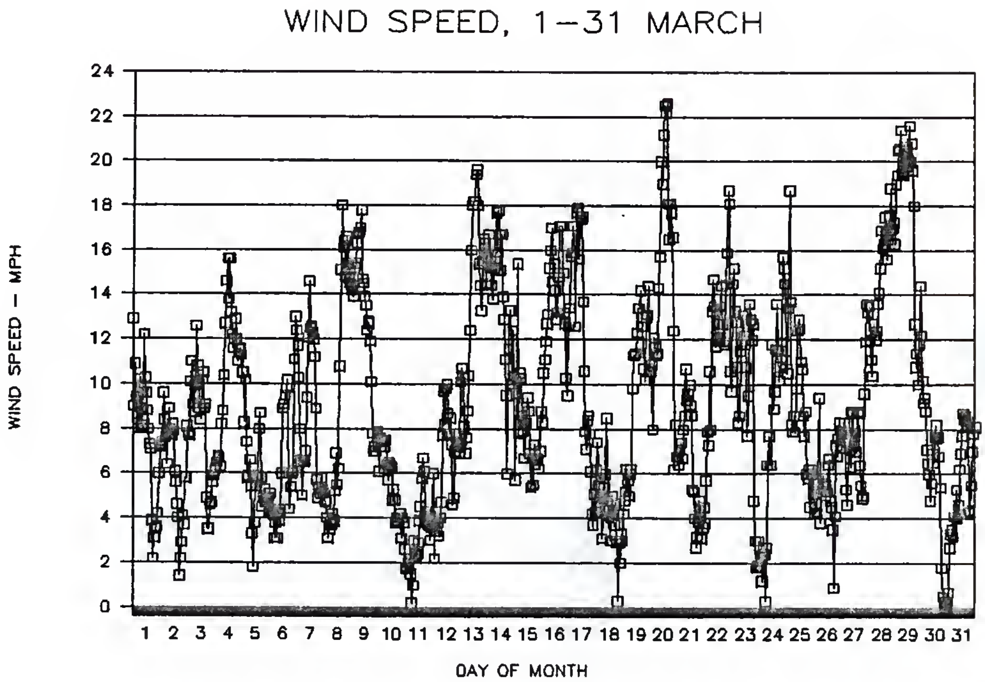

WIND SPEED, 1—31 MARCH
WIND SPEED — MPH
24
22
20
18
16
14
12
10
8
6
4
2
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH

Figure 4.5

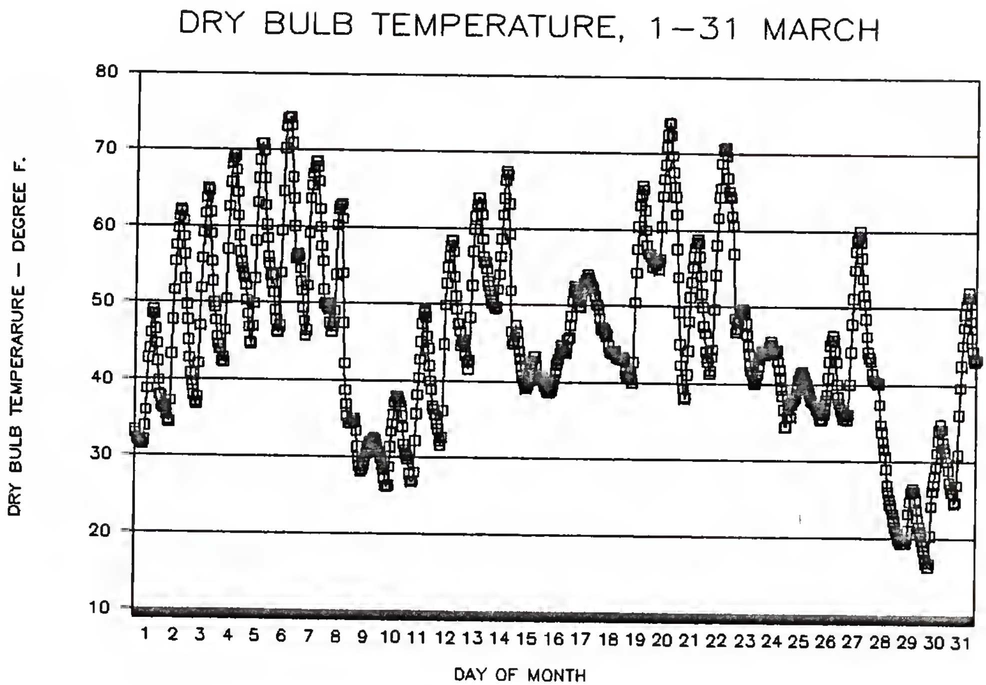

DRY BULB TEMPERATURE, 1—31 MARCH
DRY BULB TEMPERARURE — DEGREE F.
80
70
60
50
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH

Figure 4.6

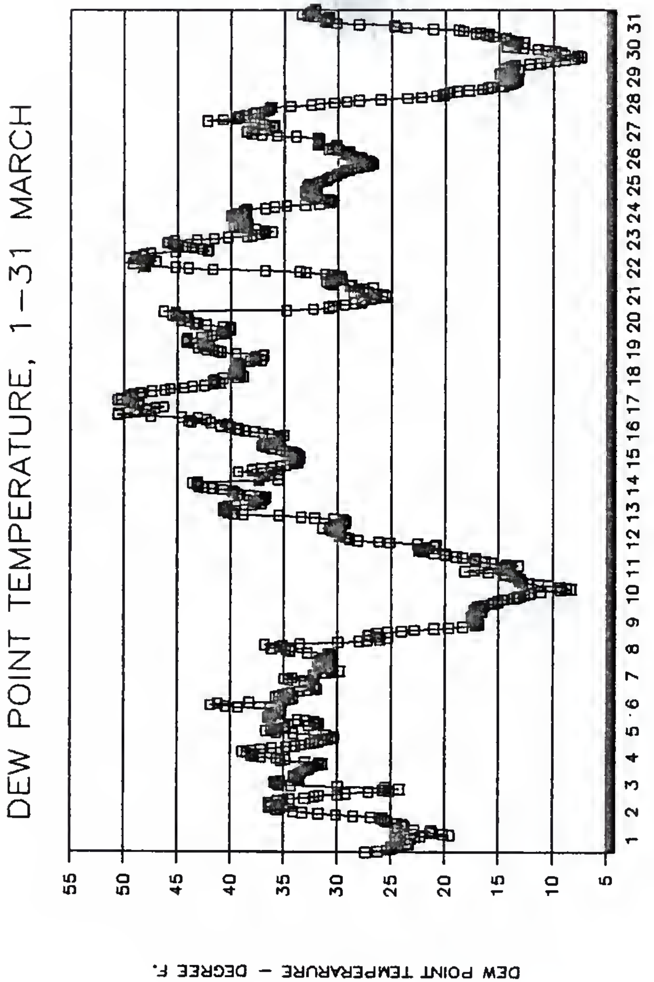

DEW POINT TEMPERATURE, 1 — 31 MARCH
DEW POINT TEMPERARURE — DEGREE F.
DAY OF MONTH
55
50
45
40
35
30
25
20
15
10
5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Figure 4.7

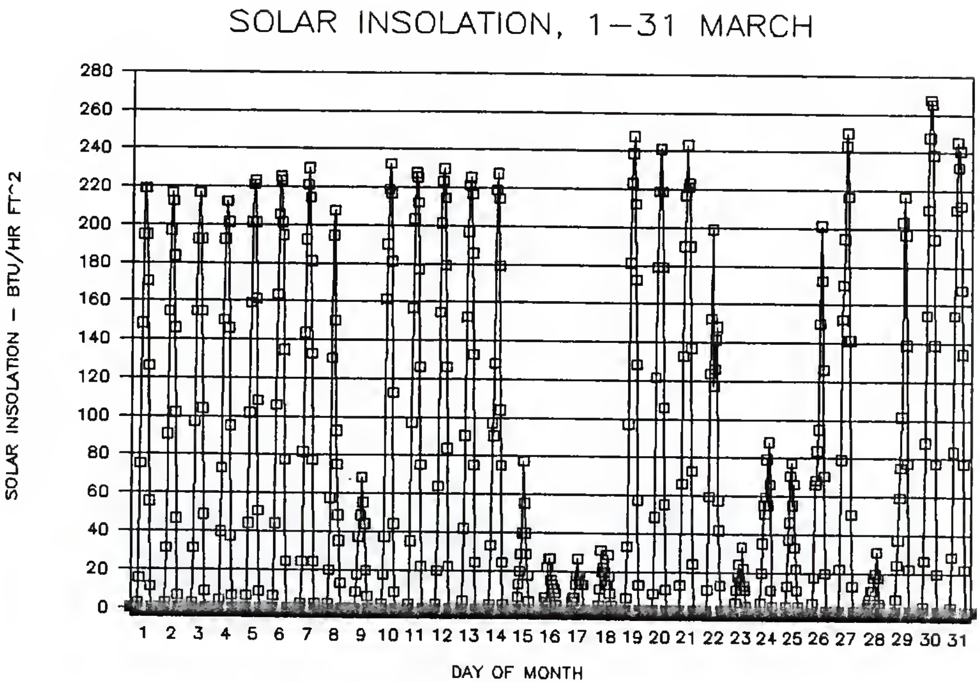

SOLAR INSOLATION, 1—31 MARCH
SOLAR INSOLATION – BTU/HR FT^2
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH

Figure 4.8

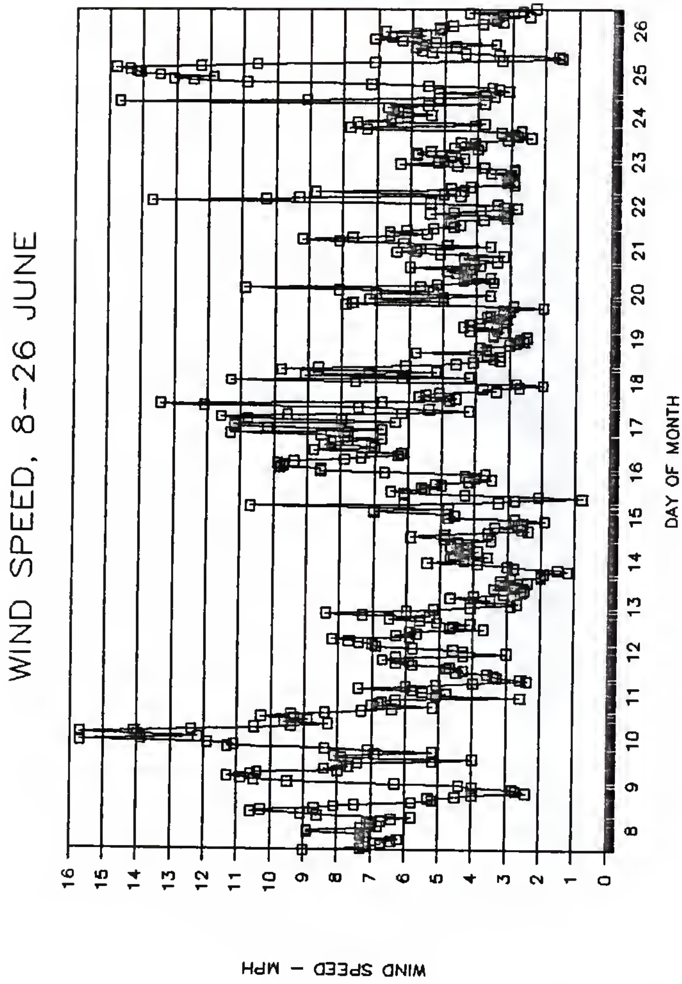

WIND SPEED, 8—26 JUNE
WIND SPEED — MPH
DAY OF MONTH
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26

Figure 4.9

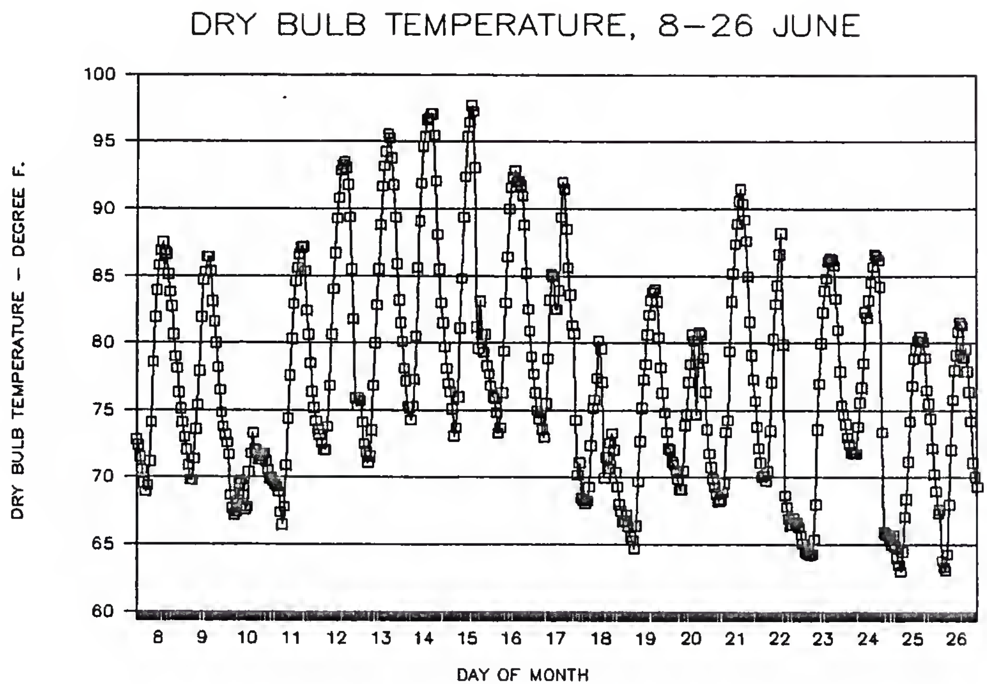

DRY BULB TEMPERATURE, 8-26 JUNE
DRY BULB TEMPERATURE - DEGREE F.
100
95
90
85
80
75
70
65
60
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
DAY OF MONTH

Figure 4.10

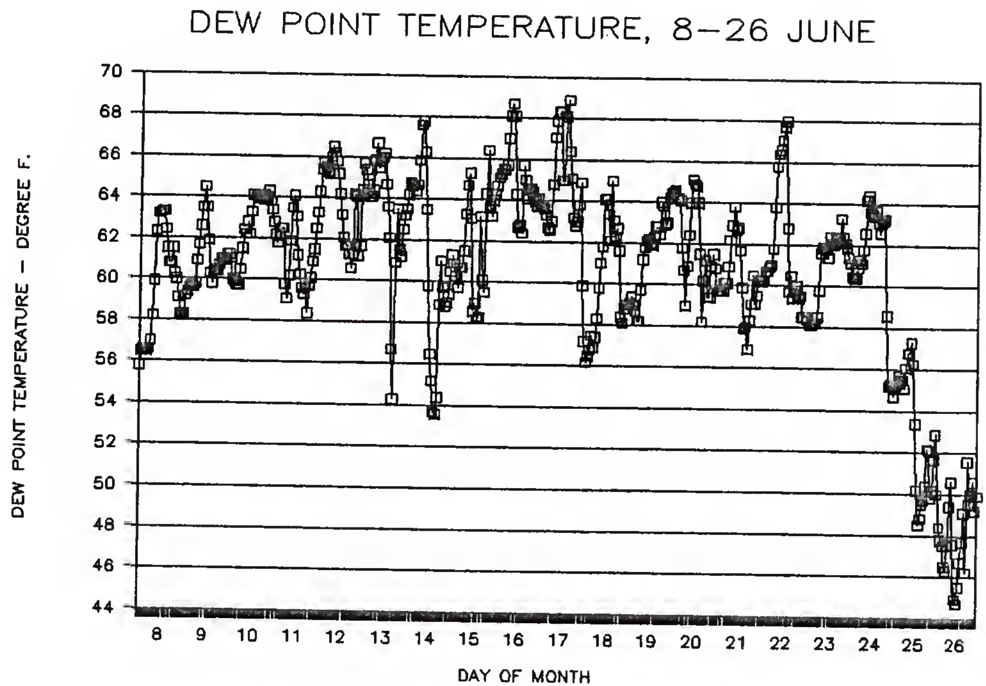

DEW POINT TEMPERATURE, 8–26 JUNE
DEW POINT TEMPERATURE – DEGREE F.
70
68
66
64
62
60
58
56
54
52
50
48
46
44
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
DAY OF MONTH

Figure 4.11

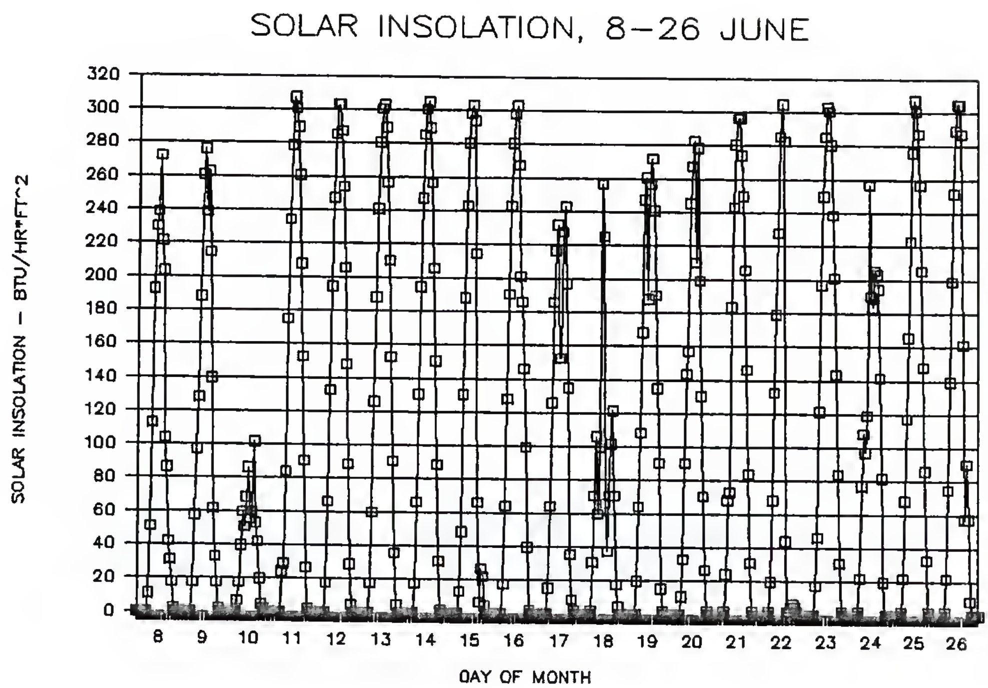

SOLAR INSOLATION, 8-26 JUNE
SOLAR INSOLATION - BTU/HR*FT^2
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
DAY OF MONTH

Figure 4.12

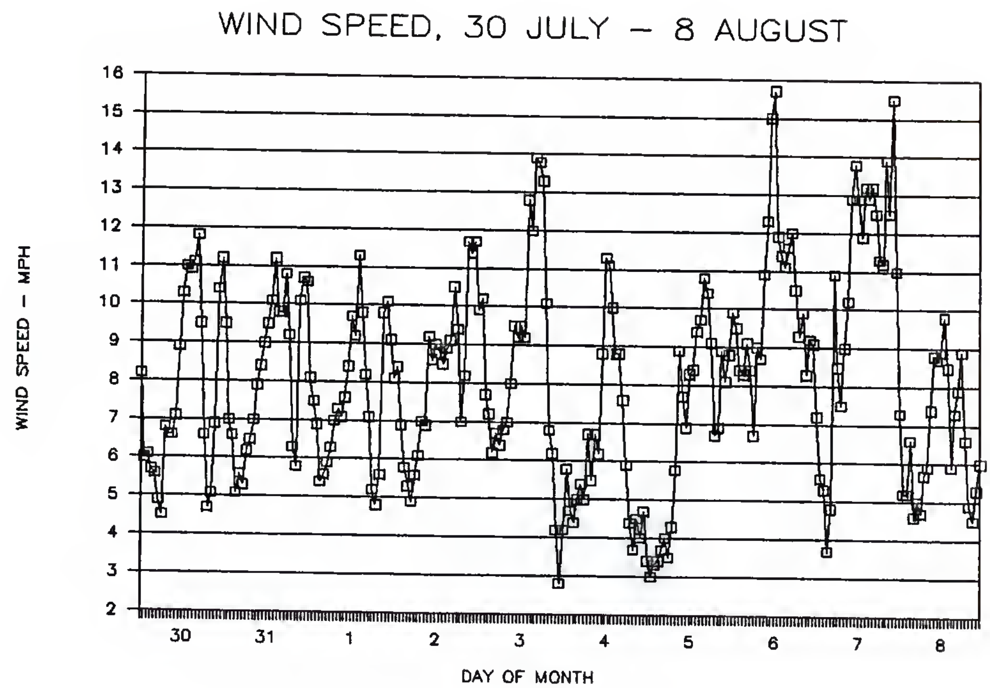
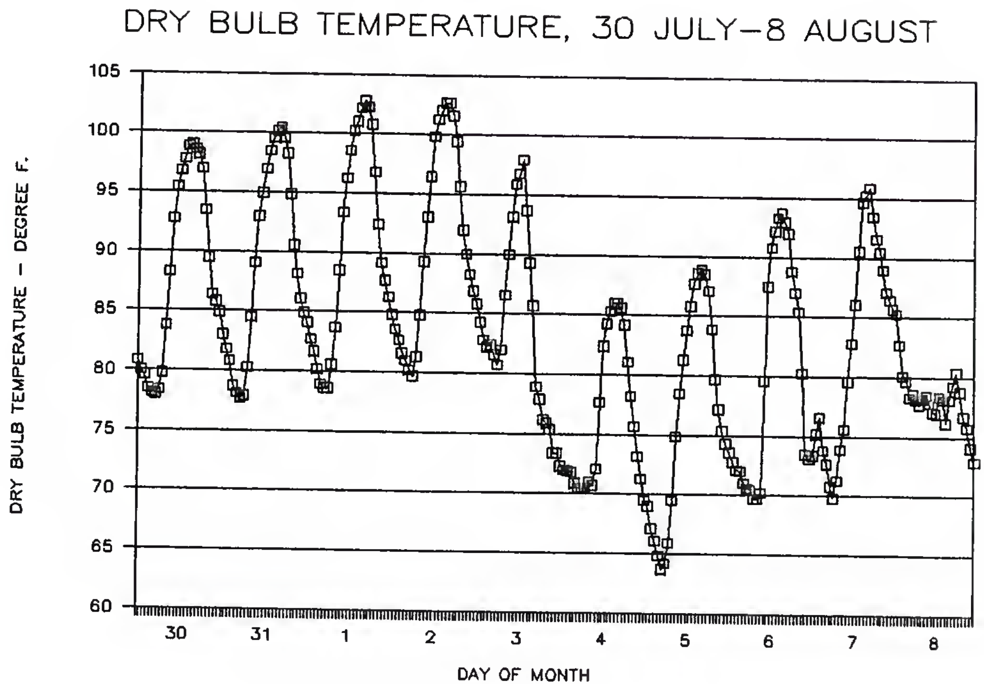

WIND SPEED, 30 JULY – 8 AUGUST
WIND SPEED – MPH
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
30
31
1
2
3
4
5
6
7
8
DAY OF MONTH

Figure 4.13



DRY BULB TEMPERATURE, 30 JULY–8 AUGUST
DRY BULB TEMPERATURE – DEGREE F.
105
100
95
90
85
80
75
70
65
60
30
31
1
2
3
4
5
6
7
8
DAY OF MONTH

Figure 4.14

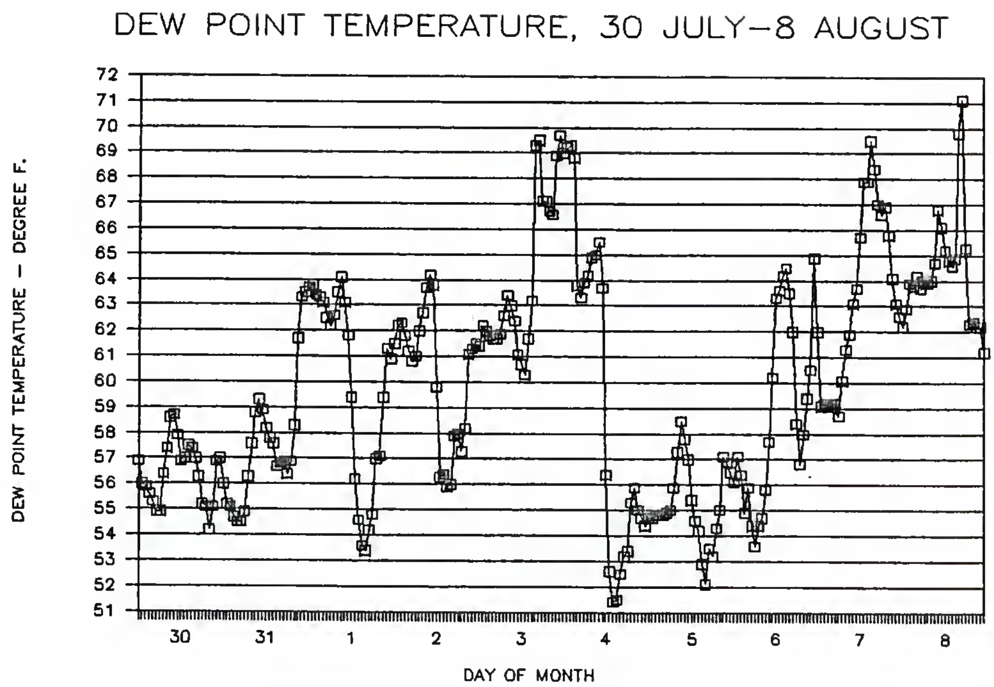
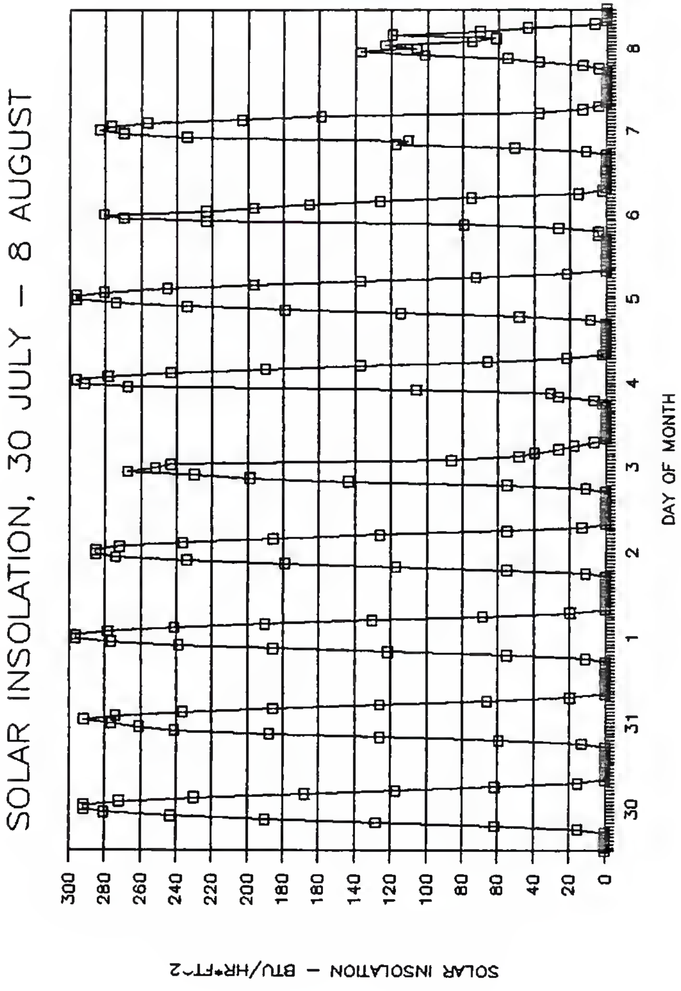

DEW POINT TEMPERATURE, 30 JULY–8 AUGUST
72
71
70
69
68
67
66
65
64
63
62
61
60
59
58
57
56
55
54
53
52
51
30
31
1
2
3
4
5
6
7
8
DAY OF MONTH
DEW POINT TEMPERATURE – DEGREE F.

Figure 4.15



SOLAR INSOLATION, 30 JULY – 8 AUGUST
SOLAR INSOLATION – BTU/HR*FT^2
DAY OF MONTH
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
30
31
1
2
3
4
5
6
7
8

Figure 4.16

Chapter 5

Monitored and Predicted Energy Use

One of the goals of this work is to provide a model of Building 8037 and its occupants that will accurately predict the energy use as compared with monitored energy use.

Heating and cooling energy usage was measured, as well as electrical usage. This information was recorded on an hourly basis. Hourly energy use is not readily available from BLAST. Details for obtaining hourly temperature and load information from BLAST simulations are included in Appendix G. Hourly values of monitored and predicted energy use were converted to daily values for evaluation.

Error of Monitored Energy Use

Prior to comparing the results of BLAST to the monitored data, it is first necessary to evaluate the accuracy of the monitored energy data. Previous work (1) has provided an estimate of the possible error involved in the sensors and data acquisition system. The equations of error for heating and cooling energy are shown below.

The possible error introduced based according to this equation was calculated and summed on an hourly basis and is presented as a range of actual energy usage. This method assumes the flow and temperature sensors are calibrated.

$$e_{\dot{Q}} = \pm[(0.02)^2 + (0.5(\frac{C_1 * C_2^2}{\dot{V}^2}))^2 + (\frac{C_3}{T})^2]^{1/2}$$

Where: $e_{\dot{Q}}$ = maximum error, dimensionless

$\dot{V}$ = volumetric flow rate, GPM

T = difference in supply and return water temperature, F

C_1 = 0.256 inches H_2O

C_2 = constant GPM/(inches $H_2O)^{1/2}$

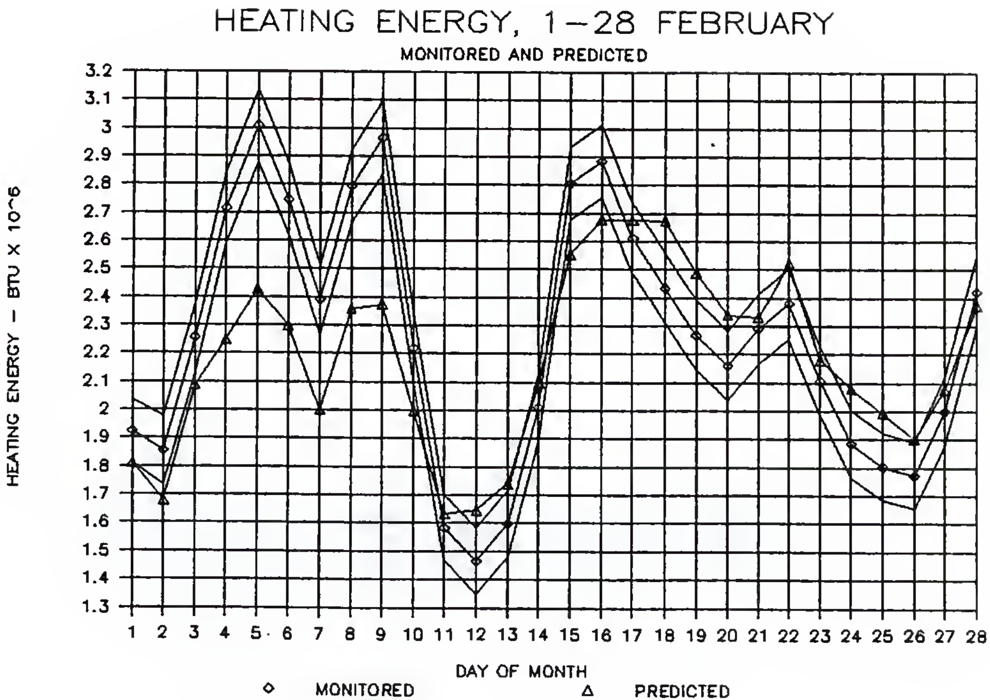
= 5.8 for flow measurements in the main piping for heating or cooling

= 4.5 for flow measurement in branch supply lines, cooling only

C_3 = 0.39 F

Heating Simulation

An analysis was performed for the months of February and March, 1987. The results of this analysis are shown in Figures 5.1 and 5.2. Three lines on each figure represent the monitored energy use plus and minus the possible error. The predicted energy use is below the monitored data through about February 10. The most significant differences occur from the 4th to the 8th. As a point of comparison, monitored heating energy data on June 5 is similar in



HEATING ENERGY, 1—28 FEBRUARY
MONITORED AND PREDICTED
HEATING ENERGY — BTU X 10^6
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH
◇ MONITORED
Δ PREDICTED

Figure 5.1

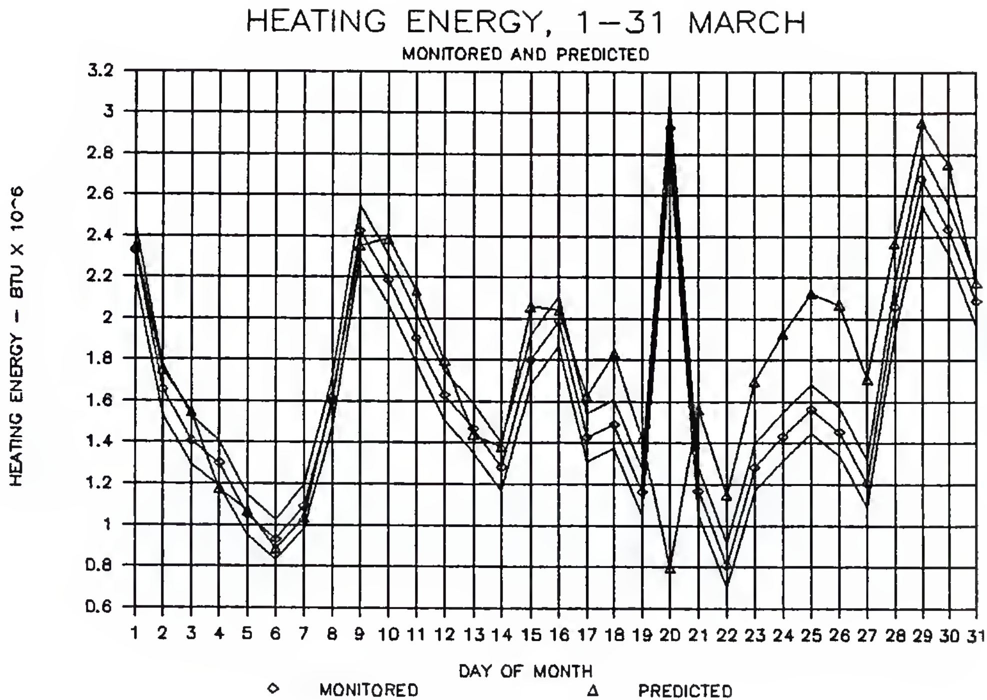

HEATING ENERGY, 1—31 MARCH
MONITORED AND PREDICTED
HEATING ENERGY — BTU X 10^6
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH
◇ MONITORED
Δ PREDICTED

Figure 5.2

magnitude to the 15th. From Figure 4.2, temperatures on the 5th were near 33 F and constant while temperatures on the 15th ranged from 31 F to 22 F. There was almost no solar insolation on either day (Figure 4.4). Winds were stronger on the 15th. Because of lower temperatures, similar solar conditions, and stronger winds on the 15th, higher heating loads would have been expected. BLAST predicted higher loads. Other than occupant interaction, no explanation for the differences during this time can be offered.

For the remainder of the month, the energy use tracked well, and the there were no significant variations.

March energy use as predicted by BLAST compared well with the exception of the 20th. On that day, the air compressor failed (11) and the hot water temperature went to a maximum setting. Heating systems often are designed to fail in full heating to protect buildings from freezing. This is indicated on Figure 3.4 as unusually high water temperatures and on Figures 2.9 and 2.10 as a spike in room temperature.

The predicted energy use stays within the possible error of the monitored energy use.

The failure of the compressor indicates the need for hot water reset in zones without heating thermostats.

For the two month period, the total heating as predicted by BLAST as well as the measured data also is shown in Table 5.1. The possible maximum error on monitored data is also shown.

Table 5.1

February and March Heating Energy
Monitored and Predicted
BTU X 10^6

BLAST Prediction	Monitored	Monitored Error
116.5	114.6	$\pm$ 7.1

For the period of February and March, 1987, the total predicted energy usage for space heating was 1.7 percent greater than the monitored heating energy.

Cooling Simulation

Cooling energy was monitored on the lines supplying chilled water to each air handler and on the main chilled water supply and return lines. The purpose was to provide a check on the cooling energy use. Results are presented for both the sum of the individual air handler units and for the main lines.

The error resulting from instrumentation is calculated by the same equation as presented above with the appropriate value of "C." The monitored energy usage obtained from the individual air handler and main line method closely agree for the periods analyzed.

Two short cooling simulations were run. One was from June 8 through June 26, 1987, while the other was from July 30 through August 8, 1987. The results of these are provided for the sum of the individual air handling units and for the main chilled water lines in Figures 5.3 through 5.6. For both simulation periods, the predicted and the monitored data tracked well and generally stayed within the envelope of possible error.

Between the 15th and the 17th of June, the predicted energy use exceeded the monitored data by as much as 11 percent. Review of weather data provides no clue to the cause. Monitored zone temperatures, shown in Figures 2.11 and 2.12, peaked during this same period. Occupant interaction with the thermostats may have been the cause.

During the period of August 4 through the 8th, the predicted energy use is less than the monitored data. Cool dry bulb temperatures on the 5th and rising temperatures through the 7th are reflected as rises in cooling energy use but do not provide insight into why the prediction is low. Zone temperatures did not change significantly. Again, no definitive reason can be given for the divergence other than occupant interaction or possibly an increase in occupant loading.

The total cooling energy for the two periods analyzed is provided in Tables 5.2 and 5.3

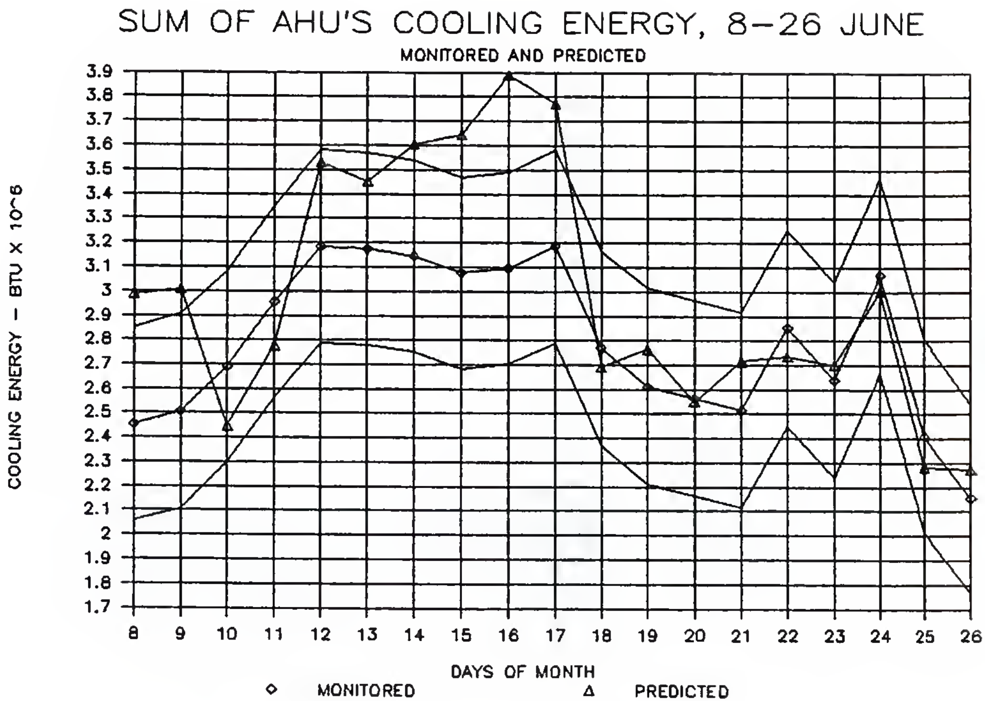

SUM OF AHU'S COOLING ENERGY, 8–26 JUNE
MONITORED AND PREDICTED
COOLING ENERGY – BTU X 10^6
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
2.1
2
1.9
1.8
1.7
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
DAYS OF MONTH
◇ MONITORED
Δ PREDICTED

Figure 5.3

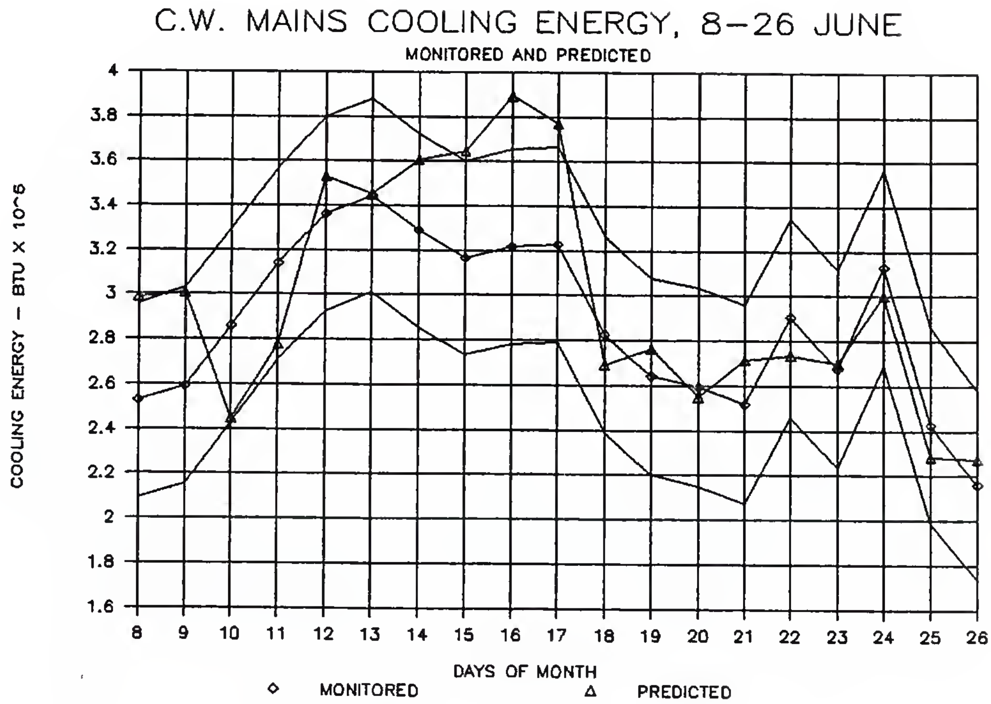
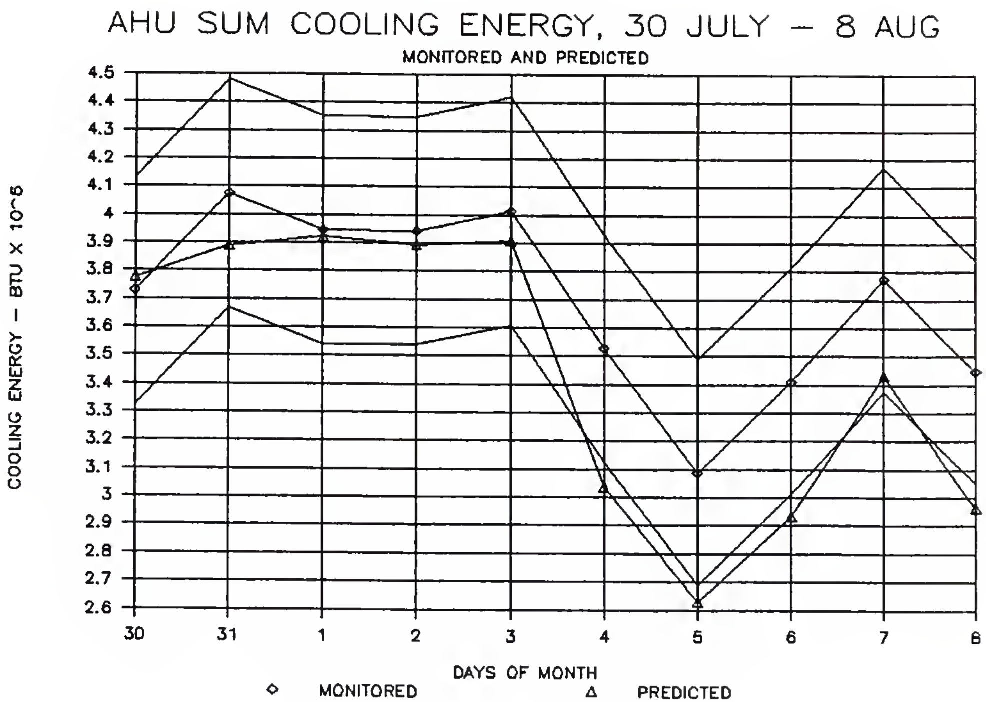
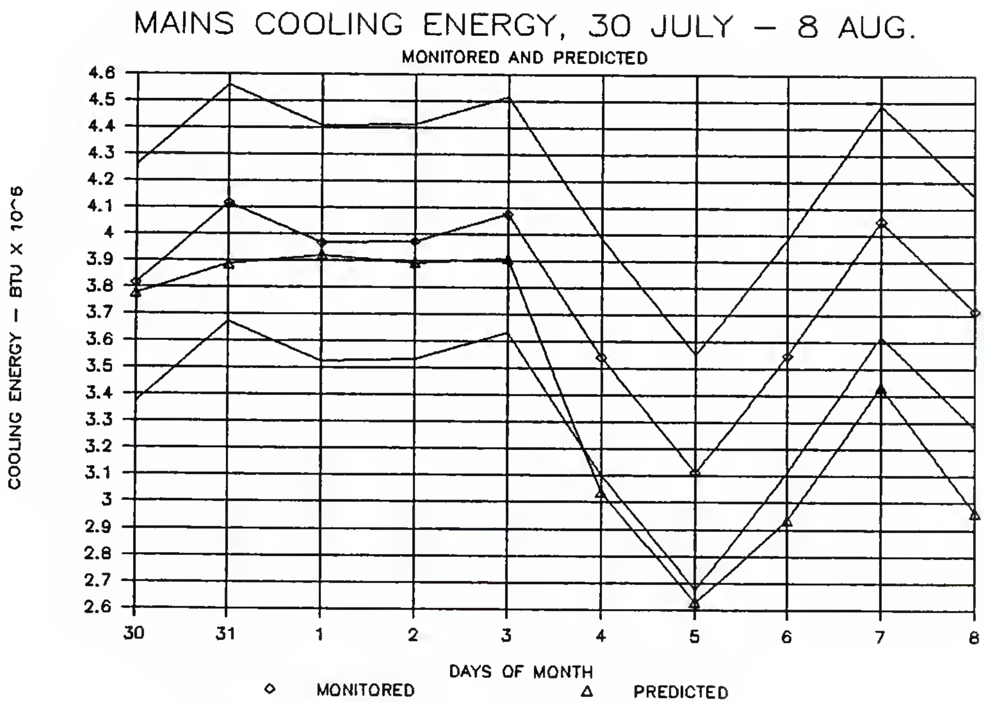

C.W. MAINS COOLING ENERGY, 8–26 JUNE
MONITORED AND PREDICTED
COOLING ENERGY – BTU X 10^6
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
DAYS OF MONTH
◇ MONITORED
Δ PREDICTED

Figure 5.4



AHU SUM COOLING ENERGY, 30 JULY – 8 AUG
MONITORED AND PREDICTED
COOLING ENERGY – BTU X 10^6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
30
31
1
2
3
4
5
6
7
8
DAYS OF MONTH
◇ MONITORED
Δ PREDICTED

Figure 5.5



MAINS COOLING ENERGY, 30 JULY – 8 AUG.
MONITORED AND PREDICTED
COOLING ENERGY – BTU X 10^6
4.6
4.5
4.4
4.3
4.2
4.1
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
30
31
1
2
3
4
5
6
7
8
DAYS OF MONTH
◇ MONITORED
Δ PREDICTED

Figure 5.6

Table 5.2

8-26 June Cooling Energy
Monitored and Predicted
BTU X 10^6

BLAST Prediction	Monitored Mains	Monitored AHU Sum	Monitored Error, Mains
56.8	54.7	53.1	$\pm$15.2

Table 5.3

30 July - 8 August Cooling Energy
Monitored and Predicted
BTU X 10^6

BLAST Prediction	Monitored Mains	Monitored AHU Sum	Monitored Error, Mains
34.4	37.9	37.0	$\pm$11.6

For the period of June 8 through the 26th, the BLAST prediction is 3.8 percent greater than the monitored data. For July 30 through August 8, the BLAST prediction is 9.2 percent less than the monitored data. In both cases, the predicted energy is within the accuracy of the energy monitoring instrumentation.

Electric Energy Consumption

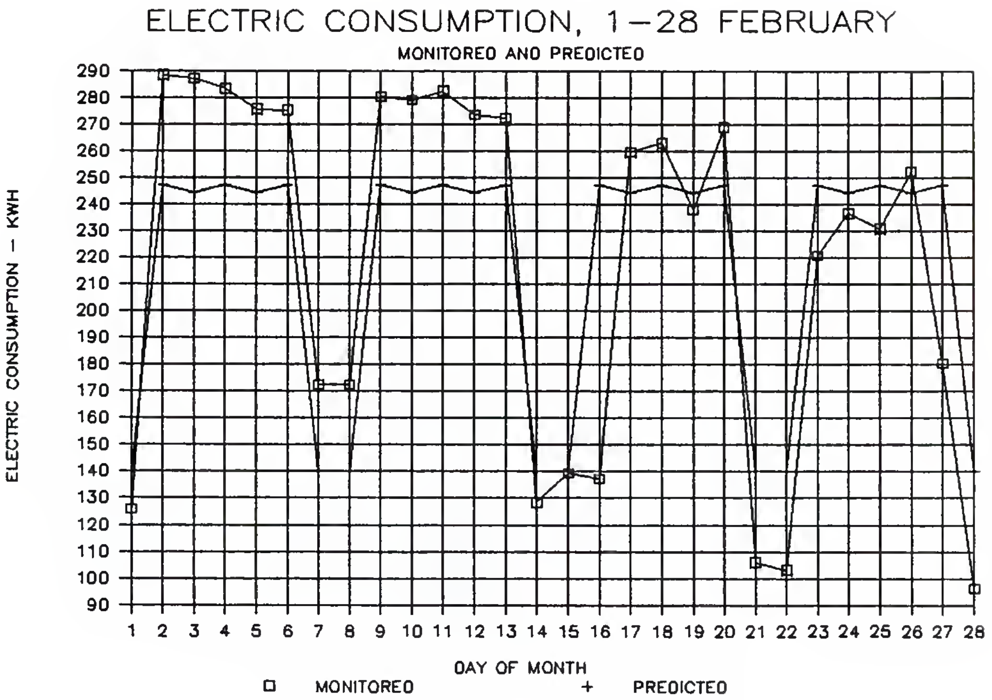
It was not the intent of this study to predict the use of electrical energy. The electrical consumption, however, adds heat to the facility in both the winter and summer seasons. For this reason, it was necessary to verify the electrical energy use as monitored was in agreement with the predicted electric energy. The methodology used to develop the electrical usage was described in Chapter 2. The electric use profiles are shown in Figures 5.7 through 5.10.

There is excellent agreement for the winter months, but the profile is high for the summer months. Total electrical usage, both monitored and predicted, for each period is shown in Table 5.4. There are no estimates on the accuracy of the electrical energy monitoring equipment.

Electrical Consumption
Monitored and Predicted
KWH X 10^3

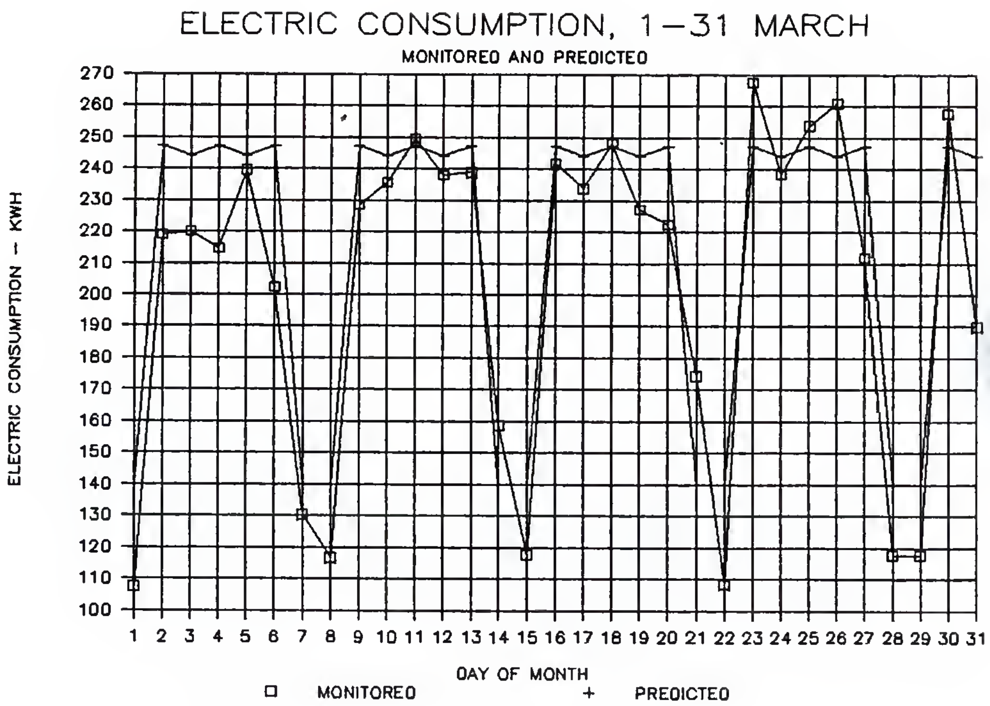
	Monitored	*	Predicted
Feb. & March	12.4	*	12.7
8-26 June	5.9	*	6.3
30 July-8 Aug.	2.9	*	3.2

The percentage differences for the three periods respectively are 2.4, 6.3, and 11.2 percent.



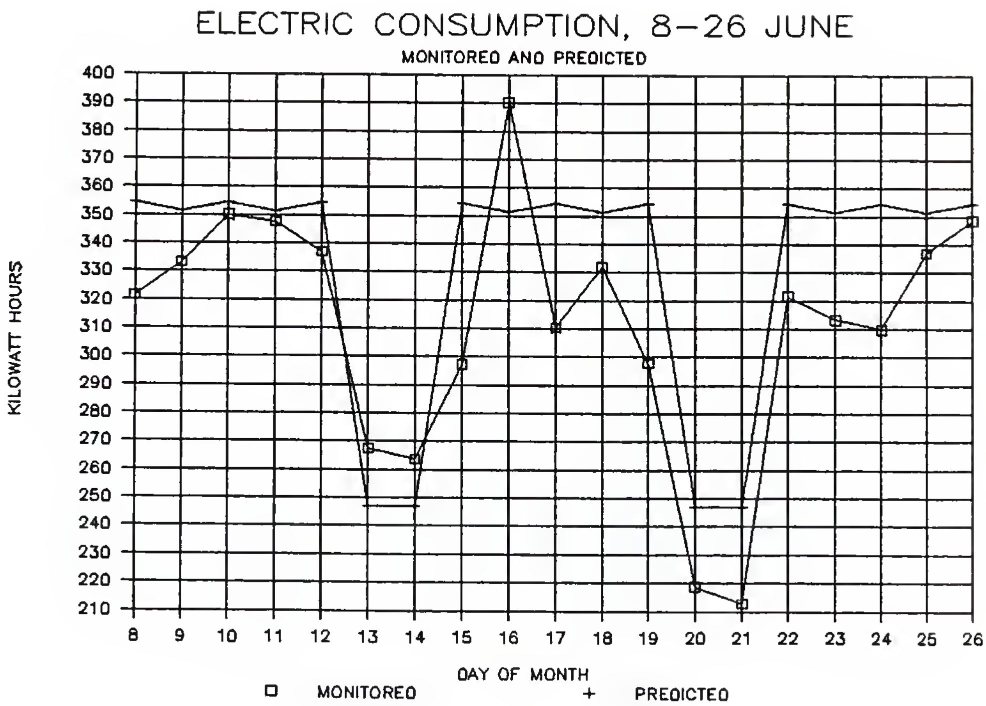
ELECTRIC CONSUMPTION, 1—28 FEBRUARY
MONITORED AND PREDICTED
ELECTRIC CONSUMPTION - KWH
290
280
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
DAY OF MONTH
MONITORED
+ PREDICTED

Figure 5.7



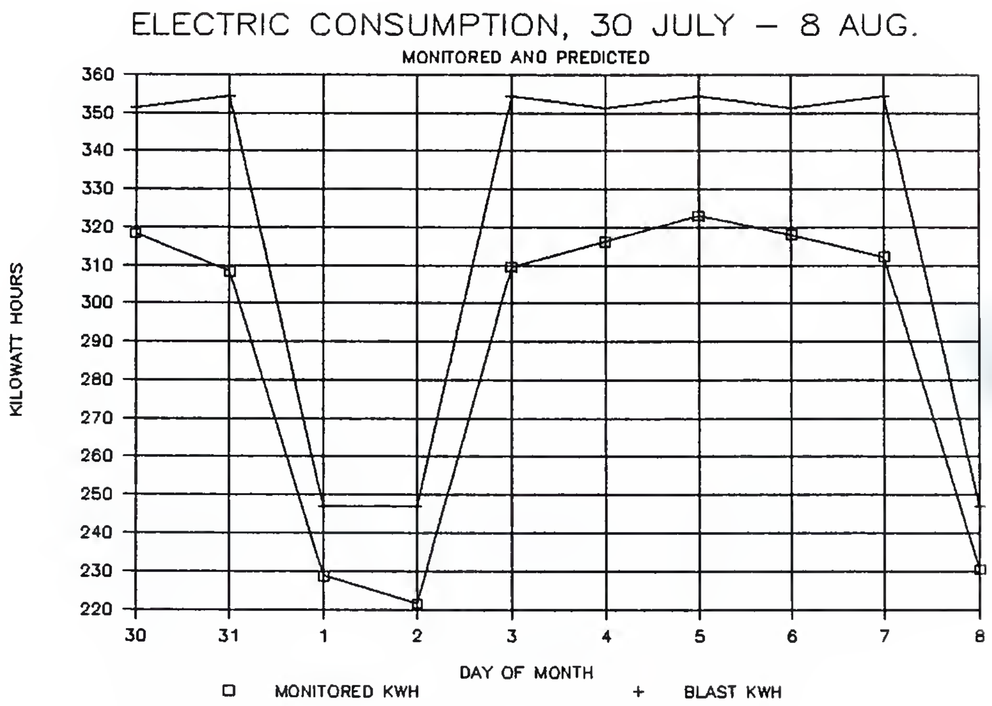
ELECTRIC CONSUMPTION, 1—31 MARCH
MONITORED AND PREDICTED
ELECTRIC CONSUMPTION - KWH
270
260
250
240
230
220
210
200
190
180
170
160
150
140
130
120
110
100
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH
MONITORED
+ PREDICTED

Figure 5.8



ELECTRIC CONSUMPTION, 8-26 JUNE
MONITORED AND PREDICTED
KILOWATT HOURS
400
390
380
370
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
210
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
DAY OF MONTH
MONITORED
PREDICTED

Figure 5.9



ELECTRIC CONSUMPTION, 30 JULY – 8 AUG.
MONITORED ANO PREDICTED
KILOWATT HOURS
360
350
340
330
320
310
300
290
280
270
260
250
240
230
220
30
31
1
2
3
4
5
6
7
8
DAY OF MONTH
MONITORED KWH
+ BLAST KWH

Figure 5.10

As Designed Simulation

Winter "As Designed" Model

The buildings are not operated as designed. The most significant differences exist in the winter use of the air handlers and the amount of outside air introduced.

The air handlers are shut off during the winter so no outside air is brought into the facility. The design called for operation of Air Handlers 1 and 3. Outside air was to be introduced to maintain a mixed air temperature of 55 F. The minimum volume of fresh air was to be 860 CFM.

Introduction of this volume of fresh air would have the effect of increasing the heating requirement in the zones served by these air handlers. Zones served by Air Handler 2 would not be affected by this change because this air handler was scheduled off whenever outside temperatures fell below 60 F.

The heating energy supplied to the zones served by Air Handler 2 would be increased by elevated hot water supply temperatures, as dictated by the design hot water reset schedule. These zones are served by baseboard convectors with no room thermostats. The heat release rate into the rooms is controlled only by the supply water temperature and the room temperature. Heating energy use for the "as designed" model are presented in Figures 5.11 and 5.12. Nearly twice the total heating energy is required as a result of the changes to the "as designed" conditions.

It should be noted that significant room overheating will result in zones served by Air Handler 2 as a result of the higher hot water reset schedule. It appears the design reset schedule is overly conservative and the adjustments made in the field to the "as operated" condition were necessary for occupant comfort.

Room temperature is not a problem in the zones served by Air Handlers 1 and 3. These areas are equipped with thermostat-controlled unit heaters. In addition, the constant supply of 55 F mixed air will moderate the space if large classes use the class rooms.

Summer "As Designed" Model

Summer differences in the "as operated" and "as designed" models are limited to the changes in the minimum fresh air supplied. Air Handlers 1 and 3 have the minimum fresh air in the closed position with measured leakages of 64 CFM and 59 CFM respectively. Air Handler 2 has approximately 1,703 CFM of outside air. In the design condition, Air Handlers 1 and 3 have 860 CFM each while Air Handler 2 has 200 CFM. This shifts the cooling

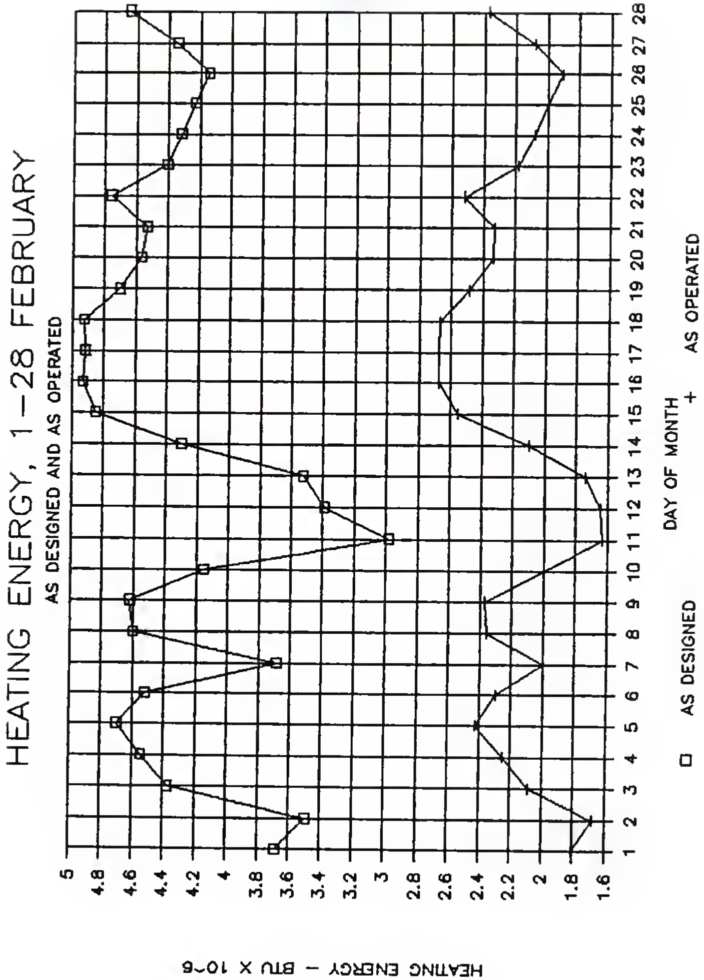
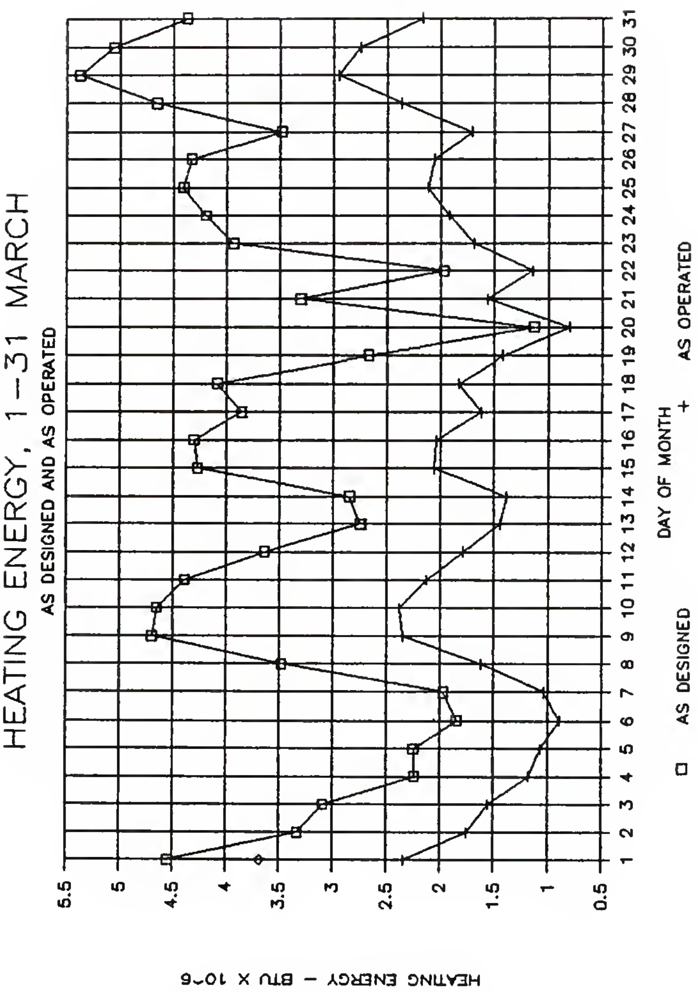

HEATING ENERGY, 1 – 28 FEBRUARY
AS DESIGNED AND AS OPERATED
HEATING ENERGY – BTU X 10^6
DAY OF MONTH
□ AS DESIGNED
+ AS OPERATED
5
4.8
4.6
4.4
4.2
4
3.8
3.6
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28

Figure 5.11



HEATING ENERGY, 1 — 31 MARCH
AS DESIGNED AND AS OPERATED
HEATING ENERGY — BTU X 10^6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DAY OF MONTH
□ AS DESIGNED
+ AS OPERATED

Figure 5.12

requirements from Air Handler 2 to Air Handlers 1 and 3. Because the only significant changes in the model are the result of outside air, and because the total flows are similar, the total cooling energy is nearly equal. Results from these simulations are presented in Figures 5.13 through 5.14.

Other changes in the cooling model involve the adjustment of the chilled water temperature to 44 F rather than the 55 F actually received. This will affect the amount of dehumidification the·by the coils but will have a much greater impact on the chiller efficiency. Chiller performance is not included in this analysis.

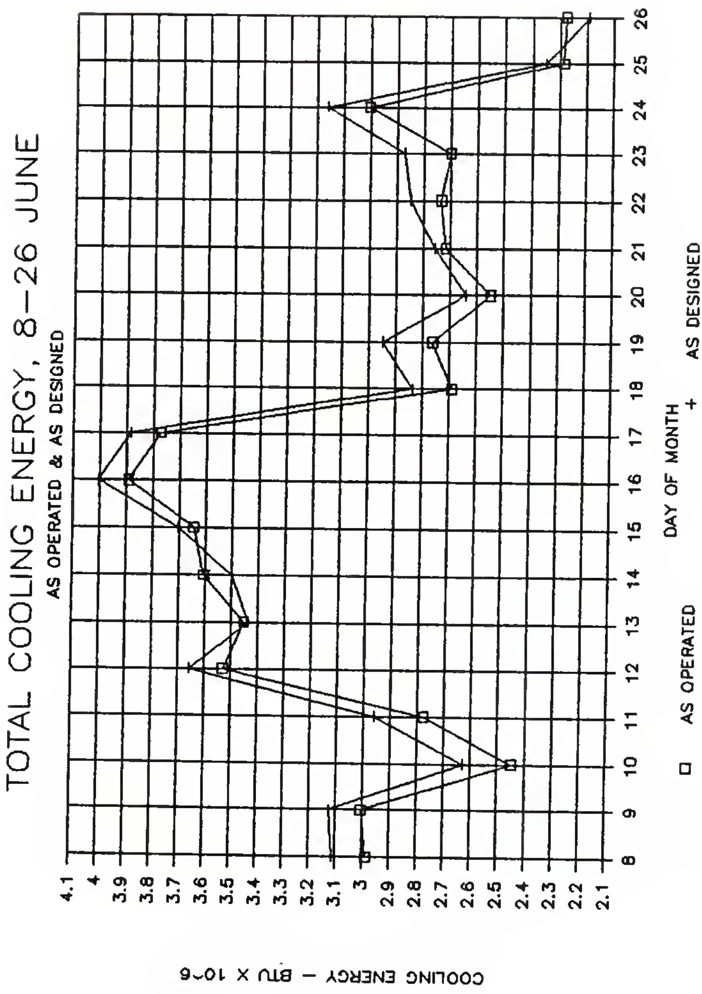
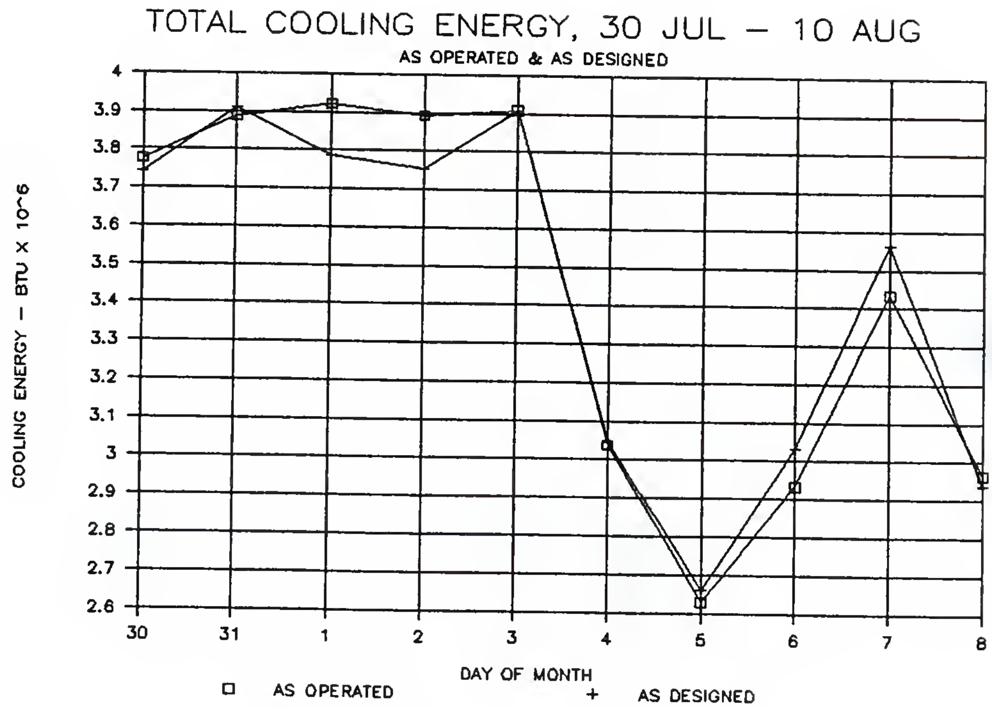

TOTAL COOLING ENERGY, 8–26 JUNE
AS OPERATED & AS DESIGNED
COOLING ENERGY – BTU X 10^6
DAY OF MONTH
AS OPERATED
AS DESIGNED

Figure 5.13



TOTAL COOLING ENERGY, 30 JUL — 10 AUG
AS OPERATED & AS DESIGNED
COOLING ENERGY — BTU X 10^6
4
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
30
31
1
2
3
4
5
6
7
8
DAY OF MONTH
AS OPERATED
+ AS DESIGNED

Figure 5.14

Chapter 6

Conclusions and Recommendations

Conclusions

The results of the above analysis show the heating and cooling energy of Building 8037 can be predicted to the accuracy of the monitoring equipment.

In order to develop a model, however, it is critical for the researcher to be familiar with the building, the mechanical systems employed, how they are operated, and the occupants' interaction with the building.

Even with intimate knowledge, many assumptions must be made as to the physical results of operational procedures. The total number of variables that control building energy use make these assumptions necessary. One significant assumption made in this effort was exhaust fan operation and its effect on infiltration and air flow in the building. Building pressure tests were inconclusive. The approaches taken to account for this exhaust fan driven infiltration and inter-zone air movement were deemed reasonable, though no experimental verification was performed.

Infiltration is another unknown. Numerous procedures are available for estimating infiltration. Calculation procedures for infiltration have been modified and refined, but little is directly applicable to structures other than residents. Again, the best estimates of infiltration were used considering the operational modes of the mechanical equipment.

Occupant interaction will affect energy use significantly. While attempts were made to account for most possibilities, it would be impossible to account for all. Thermostats are accessible to the occupants for adjustment, and when external adjustments fail to provide relief, internal settings are disturbed. When that fails, windows and doors are propped open to moderate temperatures. Exact occupancy rates were not known but were estimated by observations and discussions with the occupants. Metabolic rates differ from summer to winter, but were not adjusted in the model.

Recommendations

Numerous attempts have been made to use programs such as BLAST to predict energy use in buildings. With a laboratory setting, where most of the variables are in control, very good results have been obtained (12). This study showed excellent correlation between monitored and predicted energy use. Accurate weather data, data relating infiltration to wind speed, constant thermostat set point, and measured U values for construction materials all allowed accurate input to the simulation program.

In another study (13), the conclusions reached were computer studies were not necessarily suited to predicting actual energy consumption in buildings. The reason stated was that there were simply too many variables beyond the control of the engineer. In this study, only standard weather data was available. Building operation and envelope specifications were developed from design drawings. Limited knowledge of occupancy load and interaction were provided to the engineer.

Another study (14) found the single most significant factor in computer studies was the engineer doing the modeling. Again, only limited information on the actual operation of the building was available. The assumptions made by the engineer concerning occupant interaction and building operation controlled the results.

The conclusions that can be drawn from these studies are not surprising. Energy use in a building is strongly affected by occupant interaction and operation of the building. Without knowledge and control of all the variables affecting energy use in a building, assumptions will be made. With a little luck, and an experienced engineer, a reasonable model can be developed. However, confidence in the model can only be obtained by eliminating these assumptions and replacing them with actual conditions.

Simulation studies such as this are often used to validate a simulation program. While one can show energy use predictions parallel actual energy use, to extend the results to a validation of the program is questionable. The intricate paths through a program such as BLAST change with each model. No single model, or series of models can expect to test every possible situation. The engineer must constantly check intermediate results to determine if the program provides reasonable answers. With good correlation between actual and predicted energy use, the researcher shows the program works well for this set of conditions.

This study, however, has concentrated on eliminating as many of the variables as possible in order to obtain an accurate model and model inputs. Previous chapters detailed the development of the model and internal loads affecting energy use.

In spite of the care taken, there are still serious problems with maintaining control of this experiment. The most significant is the lack of adequate temperature control in the space. While it is the intent of this study to develop a model of the building for comparison to the current building design, it would add significantly to the study if minor changes were made in the controls of the existing building so occupant interactions were minimized. These modifcation must not significantly change the energy use or energy use profile of the building. In particular, it would be desirable to provide a controlled temperature environment where windows would remain closed and thermostat set points are known.

These modifications would include the addition of working, non-adjustable cooling thermostats. When possible, these should be located in return duct work. In zones without return ducts, these should be wall-mounted, adjacent to existing thermostats. The branch lines of existing thermostats should be disconnected and plugged so the thermostats still bleed air when adjusted but do not control anything. The existing thermostats should be left in place to satisfy the need of some occupants for a feeling of control. Daily, weekly, or monthly calibration should be performed, depending upon the degree of control obtained.

Monitoring of return air temperatures would assist in verifying accurate room temperature control.

The hot water reset controller should be replaced with a controller with a remote control point adjustment. Here, the reset schedule is maintained unless a zone is under- or over-heated. Adjustment of the reset temperature is accomplished through the use of a single heating thermostat in a zone that often overheats. Several thermostats could be added with a discriminator to determine the worst zone.

Outside air volumes should be set to design conditions in the summer. This would tend to load the proper air handling unit for a better check of needed system capacity and control. This change would allow for more confident assumptions concerning exhaust fan driven air flows.

All controls should be made operational, including minimum air setting, outside temperature sensors, hot water pump cut-off controls, and chilled water bypass valves.

The compressed air dryer should be repaired or replaced so the control air was free of moisture and the controls can stay in calibration. At present, a considerable amount of water in the lines is evident by removing a thermostat and watching water flow from the supply line. The air compressor storage tank needs to be drained weekly as well. It may be necessary to clean the entire pneumatic system, depending upon the level of contamination. If the contamination is only water, blowing the system with dry air will remove the moisture.

If oil is present, use of commercial cleaner is recommended.

In order to reduce the possible error of the cooling energy use monitoring equipment, the chilled water flow should be reduced to obtain a larger temperature drop across the coils. With flows of 90 GPM and a 3 degree rise in chilled water temperature, the error introduced is $\pm$ 13 percent. If the flows were reduced to half with a corresponding doubling of the temperature rise across the coils, the error would be reduced to $\pm$ 6.8 percent. This could be accomplished by trimming the chilled water pump impeller or by adding resistance to the piping circuit. Total energy use of the facility would not be affected significantly but the chilled water energy measurement error would be improved greatly.

Better methods of estimating infiltration need to be implemented. Constant concentration tracer gas methods (12) have provided good infiltration values at a variety of wind speeds. This should be done in all conditioning modes of the facility.

Implementation of the these suggestions will assist in the final determination as to the validity of the models generated as part of this effort.

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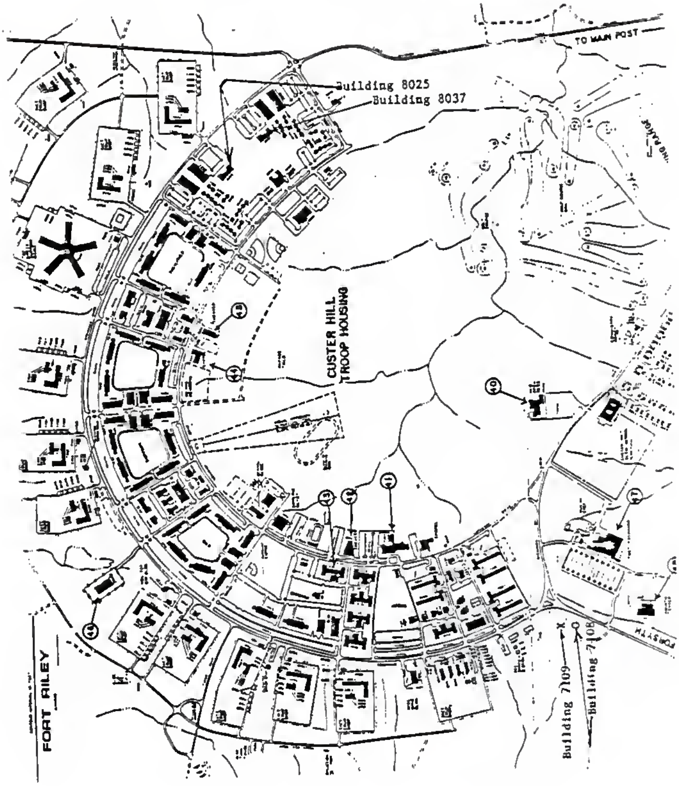
Appendix A
Map of Ft. Riley's Custer Hill



Appendix B

BLAST Input for Winter "As Operated" Model

```
BEGIN INPUT;
   RUN CONTROL:
     NEW ZONES,
     REPORTS(59),
     NEW AIR SYSTEMS,
     UNITS(IN=ENGLISH, OUT=ENGLISH);
     TEMPORARY LOCATION:
       FTRILY
         = (LAT=39.03,LONG=96.40,TZ=6);
     END;
     TEMPORARY MATERIALS:
       JUMBO BRICK
         = (L=0.50,K=0.77,D=125.00,CP=0.22,ABS=0.93,
         TABS=0.90,ROUGH);
       HWCB-6
         = (L=0.50,K=0.53,D=61.00,CP=0.20,ABS=0.65,
         TABS=0.90,MEDIUM ROUGH);
       HWCB-12
         = (L=1.00,K=0.53,D=61.00,CP=0.20,ABS=0.65,
         TABS=0.90,MEDIUM ROUGH);
     END;
     TEMPORARY WALLS:
       WALL-6
         = (HWCB-6);
       WALL-12
         = (HWCB-12);
       EX98
         = (A3 ,
            B1 ,
            B6 ,
            CB17);
       EX99
         = (JUMBO BRICK ,
            B1 ,
            B6 ,
            CB17);
     END;
     TEMPORARY ROOFS:
       CEILING
         = (E5);
       RF99
         = (E2 ,
            E3 ,
            B5 ,
```

```
        A3 ,
        B3);
END;
TEMPORARY FLOORS:
  CEILINGS
    = (E5);
END;
 TEMPORARY SCHEDULE (INFILOCC):
    MONDAY THRU FRIDAY =
               (7 TO 17 - 1.0,17 TO 7 - .25),
    SATURDAY THRU SUNDAY = (00 TO 24 - .25),
    HOLIDAY = SUNDAY,
    SPECIAL1=SUNDAY,
    SPECIAL2=SUNDAY,
    SPECIAL3=SUNDAY,
    SPECIAL4=SUNDAY;
  END SCHEDULE;
 TEMPORARY SCHEDULE (CLASS):
    MONDAY THRU FRIDAY =
               (9 TO 11 - 1.0, 11 TO 9 - 0.0),
    SATURDAY THRU SUNDAY = (00 TO 24 - .00),
    HOLIDAY = SUNDAY,
    SPECIAL1=SUNDAY,
    SPECIAL2=SUNDAY,
    SPECIAL3=SUNDAY,
    SPECIAL4=SUNDAY;
  END SCHEDULE;
 TEMPORARY SCHEDULE (OCCAS):
    MONDAY THRU FRIDAY =
     (7 TO 9-1.0,9 TO 11-0.,11 TO 12-1.,12 TO 15-0.0,
                15 TO 17-1.,17 TO 7-0.),
    SATURDAY THRU SUNDAY = (00 TO 24 - .00),
    HOLIDAY = SUNDAY,
    SPECIAL1=SUNDAY,
    SPECIAL2=SUNDAY,
    SPECIAL3=SUNDAY,
    SPECIAL4=SUNDAY;
  END SCHEDULE;
 TEMPORARY SCHEDULE (MEETING):
    MONDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
    TUESDAY = (0 TO 24 - 0.0),
    WEDNESDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
    THURSDAY = (0 TO 24 - 0.0),
    FRIDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
    SATURDAY THRU SUNDAY = (00 TO 24 - 0.0),
    HOLIDAY = SUNDAY,
    SPECIAL1=SUNDAY,
    SPECIAL2=SUNDAY,
```

```
      SPECIAL3=SUNDAY,
      SPECIAL4=SUNDAY;
      END SCHEDULE;
  TEMPORARY CONTROLS (COOL):
    PROFILES:
      COOL=( 0.0 AT 66.,-1.0 AT 74.);
    SCHEDULES:
      MONDAY THRU FRIDAY=(0 TO 24-COOL),
      SATURDAY=(0 TO 24-COOL),
      SUNDAY=(0 TO 24-COOL),
      HOLIDAY=(0 TO 24-COOL),
      SPECIAL1=(0 TO 24-COOL),
      SPECIAL2=(0 TO 24-COOL),
      SPECIAL3=(0 TO 24-COOL),
      SPECIAL4=(0 TO 24-COOL);
      END CONTROLS;
  TEMPORARY CONTROLS (HEAT):
      PROFILES:
       HEAT=(1.0 AT 69., 0.0 AT 77.);
     SCHEDULES:
        MONDAY THRU SUNDAY=(0 TO 24-HEAT),
        HOLIDAY=(0 TO 24-HEAT),
        SPECIAL1=(0 TO 24-HEAT),
        SPECIAL2=(0 TO 24-HEAT),
        SPECIAL3=(0 TO 24-HEAT),
        SPECIAL4=(0 TO 24-HEAT);
        END CONTROLS;
  TEMPORARY CONTROLS (HEAT2):
      PROFILES:
       HEAT=(1.0 AT 70., 0.0 AT 72.);
     SCHEDULES:
        MONDAY THRU SUNDAY=(0 TO 24-HEAT),
        HOLIDAY=(0 TO 24-HEAT),
        SPECIAL1=(0 TO 24-HEAT),
        SPECIAL2=(0 TO 24-HEAT),
        SPECIAL3=(0 TO 24-HEAT),
        SPECIAL4=(0 TO 24-HEAT);
        END CONTROLS;
  PROJECT="FORT RILEY, BLDG 8037
          BATTALION HEADQUARTERS
          GENE MEYER";
  LOCATION=FTRILY ;
  WEATHER TAPE FROM 01FEB THRU 31MAR;
  GROUND TEMPERATURES=
      (54, 55, 58, 62, 67, 74, 72, 68, 64, 62, 58, 55);
BEGIN BUILDING DESCRIPTION;
  BUILDING="BATTALION HEADQUARTERS ";
    NORTH AXIS=-153.;
```

```
SOLAR DISTRIBUTION=-1;
ZONE 1 "AHU-2 Z1 ":
  ORIGIN:(0.00, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (16.50 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (0.00, 0.00),
    STARTING AT(0.00, 24.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (24.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (1.33, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (5.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (16.33, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (12.67, 2.00);
  PARTITIONS :
    STARTING AT(0.00, 12.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    WALL-6 (16.50 BY 9.00)
      WITH DOORS OF TYPE
      SWD (3.00 BY 7.17)
        AT (9.33, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(16.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    WALL-6 (24.00 BY 9.00)
    ADJACENT TO ZONE (2),
    STARTING AT(16.50, 24.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
```

```
    PT19 (16.50 BY 9.00)
    ADJACENT TO ZONE (6);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (24.00 BY 16.50);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (16.50 BY 24.00)
    ADJACENT TO ZONE (12);
  CONTROLS=HEAT ,
             0.000 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 01JAN THRU 15MAY;
  CONTROLS=COOL ,
             0.000 HEATING, 16.363 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16MAY THRU 15OCT;
  CONTROLS=HEAT ,
             0.000 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  PEOPLE=2,OCCAS,
    AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=3.48,OCCAS,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(10.6 AT 0., 2.8 AT 65.),CONSTANT,
     0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
   INFILTRATION=46.6,CONSTANT,
                WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                FROM 01JAN THRU 15MAY;
   INFILTRATION=7.4,CONSTANT,
            WITH COEFFICIENTS(.606,.02,.000598,0.0),
                FROM 16MAY THRU 15OCT;
   INFILTRATION=46.6,CONSTANT,
                WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                FROM 16OCT THRU 31DEC;
   VENTILATION=356., CONSTANT, 73 MIN TEMP,
               0. DEL TEMP, FROM 01JAN THRU 15MAY;
   VENTILATION=356., CONSTANT, 73 MIN TEMP,
               0. DEL TEMP, FROM 15OCT THRU 31DEC;
END ZONE;
```

```
ZONE 2 "AHU-2 Z2 ":
  ORIGIN:(16.50, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (40.50 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (2.50, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (6.17, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (15.17, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (18.84, 2.00)
      WITH WINGS (9.00 BY 3.50)
        AT (40.50, 0.00),
    STARTING AT(40.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (20.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW (2.67 BY 7.00)
        REVEAL(0.50)
        AT (6.67, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (10.33, 2.00),
    STARTING AT(40.50, 20.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (8.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW (3.00 BY 7.17)
        REVEAL(0.00)
        AT (1.00, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(13.50, 28.00, 0.00)
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```
  FACING(270.00)
  TILTED(90.00)
  PT19 (4.00 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(13.50, 24.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (13.50 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(0.00, 24.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  WALL-6 (24.00 BY 9.00)
  ADJACENT TO ZONE (1),
  STARTING AT(40.50, 28.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (3);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (24.00 BY 13.50),
  STARTING AT(13.50, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (28.00 BY 27.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (13.50 BY 24.00)
  ADJACENT TO ZONE (12),
  STARTING AT(13.50, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (27.00 BY 28.00)
  ADJACENT TO ZONE (12);
INTERNAL MASS: PT23
  ( 554.00 BY 2.00);
CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
         0.000 HEATING, 19.481 COOLING,
    0.00 PERCENT RADIANT,
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      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
               0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=3,OFFICE OCCUPANCY ,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=5.68,OFFICE OCCUPANCY ,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
  BASEBOARD HEATING=(18.1 AT 0., 4.8 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=88.2,CONSTANT,
                  WITH COEFFICIENTS(1.,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=13.8,CONSTANT,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 15MAY THRU 15OCT;
     INFILTRATION=88.2,CONSTANT,
                  WITH COEFFICIENTS(1.,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
     ELECTRIC EQUIPMENT=.6, OFFICE OCCUPANCY,
                    0.0 PERCENT RADIANT,
              0.0 PERCENT LATENT, 0.0 PERCENT LOST,
              FROM 01JAN THRU 31 DEC;
      END ZONE;
  ZONE 3 "AHU-2 Z3 ":
    ORIGIN:(30.00, 28.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
      STARTING AT(27.00, 0.00, 0.00)
      FACING(180.00)
      TILTED(90.00)
      EX99 (64.00 BY 9.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (7.33, 2.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (11.00, 2.00)
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    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (38.42, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (42.00, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (49.34, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (53.00, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (18.25, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (21.92, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (14.22 BY 9.00)
      REVEAL(0.00)
      AT (25.60, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(91.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (4),
  STARTING AT(118.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (11.00 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(118.00, 11.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
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      ADJACENT TO ZONE (9),
      STARTING AT(77.00, 11.00, 0.00)
      FACING(0.00)
      TILTED(90.00)
      WALL-12 (36.00 BY 9.00)
      ADJACENT TO ZONE (10),
      STARTING AT(41.00, 11.00, 0.00)
      FACING(0.00)
      TILTED(90.00)
      WALL-12 (41.00 BY 9.00)
      ADJACENT TO ZONE (7),
      STARTING AT(0.00, 11.00, 0.00)
      FACING(270.00)
      TILTED(90.00)
      PT19 (11.00 BY 9.00)
      ADJACENT TO ZONE (6);
    SLAB ON GRADE FLOORS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(180.00)
      FL18 (11.00 BY 118.00);
    INTERZONE CEILINGS :
      STARTING AT(0.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (118.00 BY 11.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
               0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
             0.000 HEATING, 10.910 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
               0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=3,CONSTANT,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,CONSTANT,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(25.3 AT 0.,6.7 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
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    VENTILATION=1168., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 01JAN THRU 15MAY;
    VENTILATION=1168., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 15OCT THRU 31DEC;
    INFILTRATION=195.4,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 01JAN THRU 15MAY;
    INFILTRATION=124.,INFILOCC,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                 FROM 16MAY THRU 15OCT;
    INFILTRATION=195.4,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 16OCT THRU 31DEC;
    ELECTRIC EQUIPMENT=1.5,CONSTANT,
                        0.0 PERCENT RADIANT,
             0.0 PERCENT LATENT, 0.0 PERCENT LOST,
             FROM 01JAN THRU 31 DEC;
END ZONE;
ZONE 4 "AHU-2 Z4 ":
  ORIGIN:(121.00, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (40.50 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (0.00, 0.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (19.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (22.67, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (29.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (32.67, 2.00),
    STARTING AT(0.00, 28.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (8.00 BY 9.00),
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    STARTING AT(0.00, 20.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (20.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (7.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (10.67, 2.00);
  INTERZONE PARTITIONS :
    STARTING AT(40.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    WALL-6 (24.00 BY 9.00)
    ADJACENT TO ZONE (5),
    STARTING AT(40.50, 24.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    PT19 (13.50 BY 9.00)
    ADJACENT TO ZONE (8),
    STARTING AT(27.00, 24.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (4.00 BY 9.00)
    ADJACENT TO ZONE (8),
    STARTING AT(27.00, 28.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    PT19 (27.00 BY 9.00)
    ADJACENT TO ZONE (3);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (28.00 BY 27.00),
    STARTING AT(27.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (24.00 BY 13.50);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (27.00 BY 28.00)
    ADJACENT TO ZONE (12),
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      STARTING AT(27.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (13.50 BY 24.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
            0.000 HEATING, 16.364 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=7,OFFICE OCCUPANCY ,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=7.43,OFFICE OCCUPANCY ,
        0.00 PERCENT RETURN AIR,
          20.00 PERCENT RADIANT,
       20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
   BASEBOARD HEATING=(18.1 AT 0.,4.8 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=88.2,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=13.8,CONSTANT,
            WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
     INFILTRATION=88.2,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
     ELECTRIC EQUIPMENT=1.5,OFFICE OCCUPANCY,
                         0.0 PERCENT RADIANT,
              0.0 PERCENT LATENT, 0.0 PERCENT LOST,
              FROM 01JAN THRU 31 DEC;
  END ZONE;
  ZONE 5 "AHU-2 Z5 ":
    ORIGIN:(161.50, 0.00, 0.00);
    NORTH AXIS=0.00;
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EXTERIOR WALLS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (16.50 BY 9.00)
    WITH WINGS (9.00 BY 3.50)
      AT (16.50, 0.00),
  STARTING AT(16.50, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  EX99 (24.00 BY 9.00)
    WITH WINDOWS OF TYPE
    SPWD (2.67 BY 7.00)
      REVEAL(0.50)
      AT (5.00, 2.00)
    WITH WINDOWS OF TYPE
    SPWD (2.67 BY 7.00)
      REVEAL(0.50)
      AT (8.67, 2.00)
    WITH WINDOWS OF TYPE
    SPWD (2.67 BY 7.00)
      REVEAL(0.50)
      AT (16.33, 2.00)
    WITH WINDOWS OF TYPE
    SPWD (2.67 BY 7.00)
      REVEAL(0.50)
      AT (20.00, 2.00);
PARTITIONS :
  STARTING AT(0.00, 12.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-6 (16.50 BY 9.00)
    WITH DOORS OF TYPE
    SWD (3.00 BY 7.17)
      AT (9.33, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(16.50, 24.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (16.50 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(0.00, 24.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  WALL-6 (24.00 BY 9.00)
  ADJACENT TO ZONE (4);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
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      FACING(90.00)
      TILTED(180.00)
      FL18 (24.00 BY 16.50);
    INTERZONE CEILINGS :
      STARTING AT(0.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (16.50 BY 24.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
                 0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
              0.000 HEATING, 12.468 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
                 0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=2,OCCAS,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,OCCAS,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
  BASEBOARD HEATING=(10.6 AT 0.,2.8 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=46.6,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=7.4,CONSTANT,
           WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
     INFILTRATION=46.6,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
  END ZONE;
  ZONE 6 "AHU-3 Z3 ":
    ORIGIN:(0.00, 24.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
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  STARTING AT(0.00, 15.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  EX99 (15.00 BY 9.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (16.50 BY 9.00)
  ADJACENT TO ZONE (1),
  STARTING AT(16.50, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (13.50 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(30.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (4.00 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(30.00, 4.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (11.00 BY 9.00)
  ADJACENT TO ZONE (3),
  STARTING AT(30.00, 15.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  WALL-12 (30.00 BY 9.00)
  ADJACENT TO ZONE (7);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (15.00 BY 30.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (30.00 BY 15.00)
  ADJACENT TO ZONE (12);
CONTROLS=HEAT ,
           3.330 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
            0.000 HEATING, 10.152 COOLING,
    0.00 PERCENT RADIANT,
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    FROM 16MAY THRU 15OCT;
   CONTROLS=HEAT ,
             3.330 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
     FROM 16OCT THRU 31DEC;
   PEOPLE=2,OFFICE OCCUPANCY ,
     AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
     FROM 01JAN THRU 31DEC;
   LIGHTS=2.90,OFFICE OCCUPANCY ,
   0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
   20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
     FROM 01JAN THRU 31DEC;
  INFILTRATION=14.5,CONSTANT,
              WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                FROM 01JAN THRU 15MAY;
  INFILTRATION=2.3,CONSTANT,
        WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                FROM 16MAY THRU 15OCT;
  INFILTRATION=14.5,CONSTANT,
              WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                FROM 16OCT THRU 31DEC;
    ELECTRIC EQUIPMENT=.6, OFFICE OCCUPANCY,
                  0.0 PERCENT RADIANT,
            0.0 PERCENT LATENT, 0.0 PERCENT LOST,
            FROM 01JAN THRU 31 DEC;
END ZONE;
ZONE 7 "AHU-3 Z1&2 ":
  ORIGIN:(0.00, 39.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 38.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (38.00 BY 9.00),
    STARTING AT(71.00, 38.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX99 (71.00 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (71.00, 0.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (12.00, 0.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (56.00, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
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    FACING(180.00)
    TILTED(90.00)
    WALL-12 (30.00 BY 9.00)
    ADJACENT TO ZONE (6),
    STARTING AT(30.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    WALL-12 (41.00 BY 9.00)
    ADJACENT TO ZONE (3),
    STARTING AT(71.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (16.00 BY 9.00)
    ADJACENT TO ZONE (10),
    STARTING AT(71.00, 16.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (22.00 BY 9.00)
    ADJACENT TO ZONE (11);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (38.00 BY 71.00);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (71.00 BY 38.00)
    ADJACENT TO ZONE (12);
  INTERNAL MASS: PT19
    ( 361.00 BY 2.00);
  CONTROLS=HEAT ,
             27.60 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 01JAN THRU 15MAY;
  CONTROLS=COOL ,
             0.000 HEATING, 57.526 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16MAY THRU 15OCT;
  CONTROLS=HEAT ,
             27.60 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  LIGHTS=8.41,CLASS ,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
 20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
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  PEOPLE=30,CLASS,
     AT ACTIVITY LEVEL 0.64, 70 PERCENT RADIANT,
     FROM 01 JAN THRU 31 DEC;
  INFILTRATION=223.8,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 01JAN THRU 15MAY;
  INFILTRATION=35.5,CONSTANT,
       WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                 FROM 16MAY THRU 15OCT;
  INFILTRATION=223.8,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 16OCT THRU 31DEC;
  MIXING=720., CONSTANT,FROM ZONE 12,0.0 DEL TEMP,
        FROM 16MAY THRU 15OCT;
END ZONE;
ZONE 8 "AHU-1 Z3 ":
  ORIGIN:(148.00, 24.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(30.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (15.00 BY 9.00);
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    PT19 (13.50 BY 9.00)
    ADJACENT TO ZONE (4),
    STARTING AT(13.50, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    PT19 (16.50 BY 9.00)
    ADJACENT TO ZONE (5),
    STARTING AT(30.00, 15.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    WALL-12 (30.00 BY 9.00)
    ADJACENT TO ZONE (9),
    STARTING AT(0.00, 15.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (11.00 BY 9.00)
    ADJACENT TO ZONE (3),
    STARTING AT(0.00, 4.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (4.00 BY 9.00)
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    ADJACENT TO ZONE (4);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (15.00 BY 30.00);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (30.00 BY 15.00)     .
    ADJACENT TO ZONE (12);
  CONTROLS=HEAT ,
            3.330 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 01JAN THRU 15MAY;
  CONTROLS=COOL ,
             0.000 HEATING, 15.566 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16MAY THRU 15OCT;
  CONTROLS=HEAT ,
            3.330 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  PEOPLE=6,MEETING ,
    AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=3.48,MEETING,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
   INFILTRATION=14.5,CONSTANT,
             WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
             FROM 01JAN THRU 15MAY;
   INFILTRATION=2.3,CONSTANT,
        WITH COEFFICIENTS(.606,.0202,.000598,0.0),
             FROM 16MAY THRU 15OCT;
   INFILTRATION=14.5,CONSTANT,
             WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
             FROM 16OCT THRU 31DEC;
END ZONE;
ZONE 9 "AHU-1 Z1&2 ":
  ORIGIN:(107.00, 39.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(71.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
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  EX99 (38.00 BY 9.00),
  STARTING AT(71.00, 38.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 9.00)
    WITH WINGS (9.00 BY 3.50)
      AT (0.00, 0.00)
    WITH DOORS OF TYPE
    ALD (6.33 BY 7.16)
      AT (9.00, 0.00)
    WITH DOORS OF TYPE
    ALD (6.33 BY 7.16)
      AT (53.00, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
  ADJACENT TO ZONE (3),
  STARTING AT(41.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (30.00 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(0.00, 38.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  PT19 (22.00 BY 9.00)
  ADJACENT TO ZONE (11),
  STARTING AT(0.00, 16.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  PT19 (16.00 BY 9.00)
  ADJACENT TO ZONE (10);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (38.00 BY 71.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (71.00 BY 38.00)
  ADJACENT TO ZONE (12);
INTERNAL MASS: PT19
  ( 361.00 BY 2.00);
CONTROLS=HEAT ,
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              27.60 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
     FROM 01JAN THRU 15MAY;
   CONTROLS=COOL ,
              0.000 HEATING, 52.111 COOLING,
       0.00 PERCENT RADIANT,
     FROM 16MAY THRU 15OCT;
   CONTROLS=HEAT ,
              27.6 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
     FROM 16OCT THRU 31DEC;
   PEOPLE=6,OFFICE OCCUPANCY ,
     AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
     FROM 01JAN THRU 31DEC;
   LIGHTS=15.38,OFFICE OCCUPANCY ,
   0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
     FROM 01JAN THRU 31DEC;
    INFILTRATION=223.8,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 01JAN THRU 15MAY;
    INFILTRATION=35.5,CONSTANT,
         WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                 FROM 16MAY THRU 15OCT;
    INFILTRATION=223.8,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 16OCT THRU 31DEC;
    ELECTRIC EQUIPMENT=.9, OFFICE OCCUPANCY,
                   0.0 PERCENT RADIANT,
             0.0 PERCENT LATENT, 0.0 PERCENT LOST,
             FROM 01JAN THRU 31 DEC;
   MIXING=720., CONSTANT,FROM ZONE 12,0.0 DEL TEMP,
          FROM 16MAY THRU 15OCT;
 END ZONE;
 ZONE 10 "RESTROOMS ":
   ORIGIN:(71.00, 39.00, 0.00);
   NORTH AXIS=0.00;
   INTERZONE PARTITIONS :
     STARTING AT(0.00, 0.00, 0.00)
     FACING(180.00)
     TILTED(90.00)
     WALL-12 (36.00 BY 9.00)
     ADJACENT TO ZONE (3),
     STARTING AT(36.00, 0.00, 0.00)
     FACING(90.00)
     TILTED(90.00)
     PT19 (16.00 BY 9.00)
     ADJACENT TO ZONE (9),
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        STARTING AT(36.00, 16.00, 0.00)
        FACING(0.00)
        TILTED(90.00)
        PT19 (36.00 BY 9.00)
        ADJACENT TO ZONE (11),
        STARTING AT(0.00, 16.00, 0.00)
        FACING(270.00)
        TILTED(90.00)
        PT19 (16.00 BY 9.00)
        ADJACENT TO ZONE (7);
      SLAB ON GRADE FLOORS :
        STARTING AT(0.00, 0.00, 0.00)
        FACING(90.00)
        TILTED(180.00)
        FL18 (16.00 BY 36.00);
      INTERZONE CEILINGS :
        STARTING AT(0.00, 0.00, 9.00)
        FACING(180.00)
        TILTED(0.00)
        CEILING (36.00 BY 16.00)
        ADJACENT TO ZONE (12);
      INTERNAL MASS: PT19
        ( 390.00 BY 2.00);
      CONTROLS=HEAT ,
               0.000 HEATING, 0.0 COOLING,
          0.00 PERCENT RADIANT,
        FROM 01JAN THRU 15MAY;
      CONTROLS=COOL ,
               0.000 HEATING, 0.001 COOLING,
          0.00 PERCENT RADIANT,
        FROM 16MAY THRU 15OCT;
      CONTROLS=HEAT ,
               0.000 HEATING, 0.0 COOLING,
          0.00 PERCENT RADIANT,
        FROM 16OCT THRU 31DEC;
      PEOPLE=1,OFFICE OCCUPANCY ,
        AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
        FROM 01JAN THRU 31DEC;
      MIXING=900.00,CONSTANT ,
        FROM ZONE 3, 0.00 DEL TEMP,
        FROM 01JAN THRU 31DEC;
      LIGHTS=2.63,CONSTANT,
      0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
     20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
        FROM 01JAN THRU 31DEC;
 BASEBOARD HEATING=(2.74 AT 0., 0.7 AT 65.),CONSTANT,
         0. PERCENT RADIANT, FROM 01FEB THRU 31MAR;
   END ZONE;
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ZONE 11 "MECHANICAL ROOM ":
  ORIGIN:(71.00, 55.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(36.00, 22.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX99 (36.00 BY 10.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (10.00, 0.00),
    STARTING AT(36.00, 22.00, 10.00)
    FACING(0.00)
    TILTED(90.00)
    EX98 (36.00 BY 2.50);
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    PT19 (36.00 BY 9.00)
    ADJACENT TO ZONE (10),
    STARTING AT(36.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (22.00 BY 9.00)
    ADJACENT TO ZONE (9),
    STARTING AT(0.00, 22.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (22.00 BY 9.00)
    ADJACENT TO ZONE (7);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (22.00 BY 36.00);
  ROOFS :
    STARTING AT(0.00, 0.00, 12.50)
    FACING(180.00)
    TILTED(0.00)
    RF99 (36.00 BY 22.00);
  INFILTRATION=96.4,CONSTANT,
           WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
               FROM 01JAN THRU 15MAY;
  INFILTRATION=15.3,CONSTANT,
   WITH COEFFICIENTS(.606,.0202,.000598,0.0),
               FROM 16MAY THRU 15OCT;
  INFILTRATION=96.4,CONSTANT,
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              WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                   FROM 15OCT THRU 31DEC;
       ELECTRIC EQUIPMENT=7.5,CONSTANT,
                     0.0 PERCENT RADIANT,
              0.0 PERCENT LATENT, 0.0 PERCENT LOST,
                FROM 01JAN THRU 31 DEC;
       CROSS MIXING=9900,CONSTANT,
                 FROM ZONE 12,0.0 DEL TEMP,
                FROM 01 JAN THRU 31DEC;
       CONTROLS=HEAT2,10.6 HEATING,0.0 COOLING,
          0.0 PERCENT RADIANT, FROM 01JAN THRU 31DEC;
    END ZONE;
    ZONE 12 "CEILING PLENUM ":
      ORIGIN:(0.00, 0.00, 10.00);
      NORTH AXIS=0.00;
      EXTERIOR WALLS :
        STARTING AT(0.00, 0.00, 0.00)
        FACING(180.00)
        TILTED(90.00)
        EX98 (57.00 BY 2.50),
        STARTING AT(57.00, 0.00, 0.00)
        FACING(90.00)
        TILTED(90.00)
        EX98 (28.00 BY 2.50),
        STARTING AT(57.00, 28.00, 0.00)
        FACING(180.00)
        TILTED(90.00)
        EX98 (64.00 BY 2.50),
        STARTING AT(121.00, 28.00, 0.00)
        FACING(270.00)
        TILTED(90.00)
        EX98 (28.00 BY 2.50),
        STARTING AT(121.00, 0.00, 0.00)
        FACING(180.00)
        TILTED(90.00)
        EX98 (57.00 BY 2.50),
        STARTING AT(178.00, 0.00, 0.00)
        FACING(90.00)
        TILTED(90.00)
        EX98 (77.00 BY 2.50),
        STARTING AT(178.00, 77.00, 0.00)
        FACING(0.00)
        TILTED(90.00)
        EX98 (71.00 BY 2.50),
        STARTING AT(71.00, 77.00, 0.00)
        FACING(0.00)
        TILTED(90.00)
        EX98 (71.00 BY 2.50),
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  STARTING AT(0.00, 77.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  EX98 (77.00 BY 2.50),
  STARTING AT(0.00, 0.00, -1.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (57.00 BY 1.00),
  STARTING AT(57.00, 0.00, -1.00)
  FACING(90.00)
  TILTED(90.00)
  EX99 (28.00 BY 1.00),
  STARTING AT(57.00, 28.00, -1.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (64.00 BY 1.00),
  STARTING AT(121.00, 28.00, -1.00)
  FACING(270.00)
  TILTED(90.00)
  EX99 (28.00 BY 1.00),
  STARTING AT(121.00, 0.00, -1.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (57.00 BY 1.00),
  STARTING AT(178.00, 0.00, -1.00)
  FACING(90.00)
  TILTED(90.00)
  EX99 (77.00 BY 1.00),
  STARTING AT(178.00, 77.00, -1.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 1.00),
  STARTING AT(71.00, 77.00, -1.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 1.00),
  STARTING AT(0.00, 77.00, -1.00)
  FACING(270.00)
  TILTED(90.00)
  EX99 (77.00 BY 1.00);
INTERZONE FLOORS :
  STARTING AT(0.00, 0.00, -1.00)
  FACING(90.00)
  TILTED(180.00)
  CEILINGS (24.00 BY 16.50)
  ADJACENT TO ZONE (1),
  STARTING AT(16.50, 0.00, -1.00)
  FACING(90.00)
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TILTED(180.00)
CEILINGS (24.00 BY 13.50)
ADJACENT TO ZONE (2),
STARTING AT(30.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (28.00 BY 27.00)
ADJACENT TO ZONE (2),
STARTING AT(30.00, 28.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (11.00 BY 118.00)
ADJACENT TO ZONE (3),
STARTING AT(121.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (28.00 BY 27.00)
ADJACENT TO ZONE (4),
STARTING AT(148.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 13.50)
ADJACENT TO ZONE (4),
STARTING AT(161.50, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 16.50)
ADJACENT TO ZONE (5),
STARTING AT(0.00, 24.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (15.00 BY 30.00)
ADJACENT TO ZONE (6),
STARTING AT(0.00, 39.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (38.00 BY 71.00)
ADJACENT TO ZONE (7),
STARTING AT(148.00, 24.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (15.00 BY 30.00)
ADJACENT TO ZONE (8),
STARTING AT(107.00, 39.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (38.00 BY 71.00)
ADJACENT TO ZONE (9),
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        STARTING AT(71.00, 39.00, -1.00)
        FACING(90.00)
        TILTED(180.00)
        CEILINGS (16.00 BY 36.00)
        ADJACENT TO ZONE (10);
      ROOFS :
        STARTING AT(0.00, 0.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (57.00 BY 28.00),
        STARTING AT(121.00, 0.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (57.00 BY 28.00),
        STARTING AT(0.00, 28.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (178.00 BY 27.00),
        STARTING AT(107.00, 55.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (71.00 BY 22.00),
        STARTING AT(107.00, 55.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (71.00 BY 22.00);
       ELECTRIC EQUIPMENT=4.8,CONSTANT,
                          0.0 PERCENT RADIANT,
                0.0 PERCENT LATENT, 100.0 PERCENT LOST,
                FROM 01JAN THRU 31 DEC;
    END ZONE;
END BUILDING DESCRIPTION;
BEGIN FAN SYSTEM DESCRIPTION;
  MULTIZONE SYSTEM 1
  "AIR HANDLER NUMBER 1 " SERVING ZONES 8,9;
  FOR ZONE 8:
  SUPPLY AIR VOLUME=550.;
  END ZONE;
  FOR ZONE 9:
  EXHAUST AIR VOLUME=0.0;
  SUPPLY AIR VOLUME=1830.;
  END ZONE;
    OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=0.0;
      SUPPLY FAN EFFICIENCY=1.;
      EXHAUST FAN PRESSURE=0.0;
      EXHAUST FAN EFFICIENCY=1.0;
      RETURN FAN PRESSURE=0.0;
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    RETURN FAN EFFICIENCY=1.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=63.;
    COLD DECK THROTTLING RANGE=10.;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=35.0;
    HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
    HOT DECK CONTROL SCHEDULE=
          (135 AT 20., 90 AT 65.);
    HOT DECK THROTTLING RANGE=10.;
    MIXED AIR CONTROL=FIXED AMOUNT;
   OUTSIDE AIR VOLUME=0.;
    PREHEAT COIL LOCATION=NONE;
    HUMIDIFIER TYPE=NONE;
    COOLING SAT DIFFERENCE=20.;
    HEATING SAT DIFFERENCE=40.;
    AIR VOLUME COEFFICIENT=1.0;
  END OTHER SYSTEM PARAMETERS;
  COOLING COIL DESIGN PARAMETERS:
     COIL TYPE = CHILLED WATER;
     AIR VOLUME FLOW RATE=2380.;
     BAROMETRIC PRESSURE=407.;
     AIR FACE VELOCITY=490.;
     ENTERING AIR DRY BULB TEMPERATURE=84.3;
     ENTERING AIR WET BULB TEMPERATURE=68.6;
     LEAVING AIR DRY BULB TEMPERATURE=55.5;
     LEAVING AIR WET BULB TEMPERATURE=54.0;
     ENTERING WATER TEMPERATURE=44.0;
     LEAVING WATER TEMPERATURE=55.;
     WATER VOLUME FLOW RATE=3.;
     WATER VELOCITY=275.;
  END COOLING COIL DESIGN PARAMETERS;
  EQUIPMENT SCHEDULES:
  SYSTEM OPERATION=ON,
                    FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,
                    FROM 01 JAN THRU 31DEC;
    HEATING COIL OPERATION=ON,
                    FROM 01JAN THRU 15MAY;
    HEATING COIL OPERATION=OFF,
                    FROM 16MAY THRU 15OCT;
    HEATING COIL OPERATION=ON,
                    FROM 16OCT THRU 31DEC;
    COOLING COIL OPERATION=OFF,
                    FROM 01JAN THRU 15MAY;
    COOLING COIL OPERATION=ON,
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                    FROM 16MAY THRU 15OCT;
    COOLING COIL OPERATION=OFF,
                    FROM 16OCT THRU 31DEC;
    HUMIDIFIER OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=CONSTANT,
                    FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=OFF,
                    FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                    FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
END SYSTEM;
MULTIZONE SYSTEM 2
"AIR HANDLER NUMBER 2 "
               SERVING ZONES 1,2,3,4,5,10,12;
FOR ZONE 1:
SUPPLY AIR VOLUME=930.;
END ZONE;
FOR ZONE 2:
SUPPLY AIR VOLUME=1140.;
END ZONE;
FOR ZONE 3:
SUPPLY AIR VOLUME=615.;
END ZONE;
FOR ZONE 4:
SUPPLY AIR VOLUME=1125.;
END ZONE;
FOR ZONE 5:
SUPPLY AIR VOLUME=710.;
END ZONE;
FOR ZONE 10:
SUPPLY AIR VOLUME=1.0;
END ZONE;
FOR ZONE 12:
SUPPLY AIR VOLUME=1.0;
END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=3.32;
    SUPPLY FAN EFFICIENCY=.6;
    EXHAUST FAN PRESSURE=0.0;
    EXHAUST FAN EFFICIENCY=1.0;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=1.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=63.;
```

```
   COLD DECK THROTTLING RANGE=10.;
   HEATING COIL ENERGY SUPPLY=HOT WATER;
   HEATING COIL CAPACITY=0.00;
   HOT DECK CONTROL=FIXED SET POINT;
   HOT DECK TEMPERATURE=55.5;
   HOT DECK THROTTLING RANGE=10.;
   MIXED AIR CONTROL=FIXED AMOUNT;
   PREHEAT COIL LOCATION=NONE;
   HUMIDIFIER TYPE=NONE;
   COOLING SAT DIFFERENCE=20.;
   HEATING SAT DIFFERENCE=40.;
   AIR VOLUME COEFFICIENT=1.0;
   OUTSIDE AIR VOLUME=1704.;
END OTHER SYSTEM PARAMETERS;
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE = CHILLED WATER;
    AIR VOLUME FLOW RATE=4520.;
    BAROMETRIC PRESSURE=407.;
    AIR FACE VELOCITY=490.;
    ENTERING AIR DRY BULB TEMPERATURE=79.9;
    ENTERING AIR WET BULB TEMPERATURE=66.1;
    LEAVING AIR DRY BULB TEMPERATURE=58.5;
    LEAVING AIR WET BULB TEMPERATURE=57.5;
    ENTERING WATER TEMPERATURE=44.0;
    LEAVING WATER TEMPERATURE=55.;
    WATER VOLUME FLOW RATE=3.4;
    WATER VELOCITY=275.;
END COOLING COIL DESIGN PARAMETERS;
EQUIPMENT SCHEDULES:
  SYSTEM OPERATION=OFF,
                 FROM 01JAN THRU 15MAY;
  SYSTEM OPERATION=ON,
                 FROM 16MAY THRU 15OCT;
  SYSTEM OPERATION=OFF,
                 FROM 16OCT THRU 31DEC;
  EXHAUST FAN OPERATION=OFF,
                 FROM 01JAN THRU 31DEC;
  PREHEAT COIL OPERATION=OFF,
                 FROM 01 JAN THRU 31DEC;
  HEATING COIL OPERATION=OFF,
                 FROM 01JAN THRU 31DEC;
  COOLING COIL OPERATION=OFF,
                 FROM 01JAN THRU 15MAY;
  COOLING COIL OPERATION=ON,
                 FROM 16MAY THRU 15OCT;
  COOLING COIL OPERATION=OFF,
                 FROM 16OCT THRU 31DEC;
  HUMIDIFIER OPERATION=OFF,
```

```
                       FROM 01JAN THRU 31DEC;
     HEAT RECOVERY OPERATION=OFF,
                       FROM 01JAN THRU 31DEC;
     MINIMUM VENTILATION SCHEDULE=CONSTANT,
                       FROM 01JAN THRU 31DEC;
     MAXIMUM VENTILATION SCHEDULE=OFF,
                       FROM 01JAN THRU 31DEC;
     SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                       FROM 01JAN THRU 31DEC;
   END EQUIPMENT SCHEDULES;
END SYSTEM;
MULTIZONE SYSTEM 3
"AIR HANDLER NUMBER 3 " SERVING ZONES 6,7;
FOR ZONE 6:
SUPPLY AIR VOLUME=310.;
END ZONE;
FOR ZONE 7:
SUPPLY AIR VOLUME=1710.;
EXHAUST AIR VOLUME=0.0;
END ZONE;
   OTHER SYSTEM PARAMETERS:
     SUPPLY FAN PRESSURE=0.0;
     SUPPLY FAN EFFICIENCY=1.;
     EXHAUST FAN PRESSURE=0.0;
     EXHAUST FAN EFFICIENCY=1.0;
     RETURN FAN PRESSURE=0.0;
     RETURN FAN EFFICIENCY=1.0;
     COLD DECK CONTROL=FIXED SET POINT;
     COLD DECK TEMPERATURE=63.;
     COLD DECK THROTTLING RANGE=10.;
     HEATING COIL ENERGY SUPPLY=HOT WATER;
     HEATING COIL CAPACITY=35.0;
     HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
     HOT DECK CONTROL SCHEDULE=
                       (135 AT 20., 90 AT 65.);
     HOT DECK THROTTLING RANGE=10.;
     MIXED AIR CONTROL=FIXED AMOUNT;
    OUTSIDE AIR VOLUME=0.0;
     PREHEAT COIL LOCATION=NONE;
     HUMIDIFIER TYPE=NONE;
     COOLING SAT DIFFERENCE=20.;
     HEATING SAT DIFFERENCE=40.;
     AIR VOLUME COEFFICIENT=1.0;
   END OTHER SYSTEM PARAMETERS;
   COOLING COIL DESIGN PARAMETERS:
      COIL TYPE = CHILLED WATER;
      AIR VOLUME FLOW RATE=2020.;
      BAROMETRIC PRESSURE=407.;
```

```
    AIR FACE VELOCITY=490.;
    ENTERING AIR DRY BULB TEMPERATURE=84.3;
    ENTERING AIR WET BULB TEMPERATURE=68.6;
    LEAVING AIR DRY BULB TEMPERATURE=55.5;
    LEAVING AIR WET BULB TEMPERATURE=54.0;
    ENTERING WATER TEMPERATURE=44.0;
    LEAVING WATER TEMPERATURE=55.;
    WATER VOLUME FLOW RATE=3.;
    WATER VELOCITY=275.;
END COOLING COIL DESIGN PARAMETERS;
EQUIPMENT SCHEDULES:
  SYSTEM OPERATION=ON,
                FROM 01JAN THRU 31DEC;
  EXHAUST FAN OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  PREHEAT COIL OPERATION=OFF,
                FROM 01 JAN THRU 31DEC;
  HEATING COIL OPERATION=ON,
                FROM 01JAN THRU 15MAY;
  HEATING COIL OPERATION=OFF,
                FROM 16MAY THRU 15OCT;
  HEATING COIL OPERATION=ON,
                FROM 16OCT THRU 31DEC;
  COOLING COIL OPERATION=OFF,
                FROM 01JAN THRU 15MAY;
  COOLING COIL OPERATION=ON,
                FROM 16MAY THRU 15OCT;
  COOLING COIL OPERATION=OFF,
                FROM 16OCT THRU 31DEC;
  HUMIDIFIER OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  HEAT RECOVERY OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  MINIMUM VENTILATION SCHEDULE=CONSTANT,
                FROM 01JAN THRU 31DEC;
  MAXIMUM VENTILATION SCHEDULE=OFF,
                FROM 01JAN THRU 31DEC;
  SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                FROM 01JAN THRU 31DEC;
END EQUIPMENT SCHEDULES;
 END SYSTEM;
UNIT HEATER SYSTEM 4 "ZONE 11"
                SERVING ZONES 11;
  FOR ZONE 11:
  SUPPLY AIR VOLUME=550.;
  REHEAT CAPACITY=0.0;
  END ZONE;
 OTHER SYSTEM PARAMETERS:
```

```
        SUPPLY FAN PRESSURE=0.0;
        HEATING COIL ENERGY SUPPLY=HOT WATER;
        SUPPLY FAN EFFICIENCY=1.0;
        HEATING COIL CAPACITY=10.55;
        SYSTEM ELECTRICAL DEMAND=0.0;
        HEATING SAT DIFFERENCE=50.;
        AIR VOLUME COEFFICIENT=1.0;
       END OTHER SYSTEM PARAMETERS;
      EQUIPMENT SCHEDULES:
        SYSTEM OPERATION=OFF, FROM 01JAN THRU 31DEC;
       END EQUIPMENT SCHEDULES;
        END SYSTEM;
  END FAN SYSTEM DESCRIPTION;
END INPUT;
```

Appendix C

BLAST Input for Summer "As Operated" Model

```
BEGIN INPUT;
   RUN CONTROL:
     NEW ZONES,
     REPORTS(21,25),
     NEW AIR SYSTEMS,
     UNITS(IN=ENGLISH, OUT=ENGLISH);
     TEMPORARY LOCATION:
       FTRILY
         = (LAT=39.03,LONG=96.40,TZ=6);
     END;
     TEMPORARY MATERIALS:
       JUMBO BRICK
         = (L=0.50,K=0.77,D=125.00,CP=0.22,ABS=0.93,
         TABS=0.90,ROUGH);
       HWCB-6
         = (L=0.50,K=0.53,D=61.00,CP=0.20,ABS=0.65,
         TABS=0.90,MEDIUM ROUGH);
       HWCB-12
         = (L=1.00,K=0.53,D=61.00,CP=0.20,ABS=0.65,
         TABS=0.90,MEDIUM ROUGH);
     END;
     TEMPORARY WALLS:
       WALL-6
         = (HWCB-6);
       WALL-12
         = (HWCB-12);
       EX98
         = (A3 ,
            B1 ,
            B6 ,
            CB17);
       EX99
         = (JUMBO BRICK ,
            B1 ,
            B6 ,
            CB17);
     END;
     TEMPORARY ROOFS:
       CEILING
         = (E5);
       RF99
         = (E2 ,
            E3 ,
            B5 ,
```

```
            A3 ,
            B3);
      END;
      TEMPORARY FLOORS:
        CEILINGS
          = (E5);
      END;
       TEMPORARY SCHEDULE (INFILOCC):
          MONDAY THRU FRIDAY = (7 TO 17 - 1.0,
                          17 TO 7 - .25),
          SATURDAY THRU SUNDAY = (00 TO 24 - .25),
          HOLIDAY = SUNDAY,
          SPECIAL1=SUNDAY,
          SPECIAL2=SUNDAY,
          SPECIAL3=SUNDAY,
          SPECIAL4=SUNDAY;
        END SCHEDULE;
       TEMPORARY SCHEDULE (CLASS):
          MONDAY THRU FRIDAY = (9 TO 11 - 1.0,
                               11 TO 9 - 0.0),
          SATURDAY THRU SUNDAY = (00 TO 24 - .00),
          HOLIDAY = SUNDAY,
          SPECIAL1=SUNDAY,
          SPECIAL2=SUNDAY,
          SPECIAL3=SUNDAY,
          SPECIAL4=SUNDAY;
        END SCHEDULE;
       TEMPORARY SCHEDULE (OCCAS):
MONDAY THRU FRIDAY = (7 TO 9-1.0,9 TO 11-0.,
                          11 TO 12-1.,12 TO 15-0.0,
                       15 TO 17-1.,17 TO 7-0.),
          SATURDAY THRU SUNDAY = (00 TO 24 - .00),
          HOLIDAY = SUNDAY,
          SPECIAL1=SUNDAY,
          SPECIAL2=SUNDAY,
          SPECIAL3=SUNDAY,
          SPECIAL4=SUNDAY;
        END SCHEDULE;
       TEMPORARY SCHEDULE (MEETING):
          MONDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
          TUESDAY = (0 TO 24 - 0.0),
          WEDNESDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
          THURSDAY = (0 TO 24 - 0.0),
          FRIDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
          SATURDAY THRU SUNDAY = (00 TO 24 - 0.0),
          HOLIDAY = SUNDAY,
          SPECIAL1=SUNDAY,
          SPECIAL2=SUNDAY,
```

```
      SPECIAL3=SUNDAY,
      SPECIAL4=SUNDAY;
      END SCHEDULE;
  TEMPORARY CONTROLS (COOL):
    PROFILES:
      COOL=( 0.0 AT 66.,-1.0 AT 74.);
    SCHEDULES:
      MONDAY THRU FRIDAY=(0 TO 24-COOL),
      SATURDAY=(0 TO 24-COOL),
      SUNDAY=(0 TO 24-COOL),
      HOLIDAY=(0 TO 24-COOL),
      SPECIAL1=(0 TO 24-COOL),
      SPECIAL2=(0 TO 24-COOL),
      SPECIAL3=(0 TO 24-COOL),
      SPECIAL4=(0 TO 24-COOL);
      END CONTROLS;
  TEMPORARY CONTROLS (HEAT):
      PROFILES:
       HEAT=(1.0 AT 69., 0.0 AT 72.);
     SCHEDULES:
        MONDAY THRU SUNDAY=(0 TO 24-HEAT),
        HOLIDAY=(0 TO 24-HEAT),
        SPECIAL1=(0 TO 24-HEAT),
        SPECIAL2=(0 TO 24-HEAT),
        SPECIAL3=(0 TO 24-HEAT),
        SPECIAL4=(0 TO 24-HEAT);
        END CONTROLS;
  TEMPORARY CONTROLS (HEAT2):
      PROFILES:
       HEAT=(1.0 AT 70., 0.0 AT 72.);
     SCHEDULES:
        MONDAY THRU SUNDAY=(0 TO 24-HEAT),
        HOLIDAY=(0 TO 24-HEAT),
        SPECIAL1=(0 TO 24-HEAT),
        SPECIAL2=(0 TO 24-HEAT),
        SPECIAL3=(0 TO 24-HEAT),
        SPECIAL4=(0 TO 24-HEAT);
        END CONTROLS;
  PROJECT="FORT RILEY, BLDG 8037
         BATTALION HEADQUARTERS
         GENE MEYER";
  LOCATION=FTRILY ;
  WEATHER TAPE FROM 30JUL THRU 08AUG;
  GROUND TEMPERATURES=(54, 55, 58, 62, 67, 74, 72,
                           68, 64, 62, 58, 55);
BEGIN BUILDING DESCRIPTION;
  BUILDING="BATTALION HEADQUARTERS ";
    NORTH AXIS=-153.;
```

```
SOLAR DISTRIBUTION=-1;
ZONE 1 "AHU-2 Z1 ":
  ORIGIN:(0.00, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (16.50 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (0.00, 0.00),
    STARTING AT(0.00, 24.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (24.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (1.33, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (5.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (16.33, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (12.67, 2.00);
  PARTITIONS :
    STARTING AT(0.00, 12.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    WALL-6 (16.50 BY 9.00)
      WITH DOORS OF TYPE
      SWD (3.00 BY 7.17)
        AT (9.33, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(16.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    WALL-6 (24.00 BY 9.00)
    ADJACENT TO ZONE (2),
    STARTING AT(16.50, 24.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
```

```
      PT19 (16.50 BY 9.00)
      ADJACENT TO ZONE (6);
    SLAB ON GRADE FLOORS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(180.00)
      FL18 (24.00 BY 16.50);
    INTERZONE CEILINGS :
      STARTING AT(0.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (16.50 BY 24.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
              0.000 HEATING, 16.363 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=2,OCCAS,
   AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,OCCAS,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(10.6 AT 0., 2.8 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     INFILTRATION=46.6,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=7.4,CONSTANT,
             WITH COEFFICIENTS(.606,.02,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
     INFILTRATION=46.6,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
 END ZONE;
```

```
ZONE 2 "AHU-2 Z2 ":
  ORIGIN:(16.50, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (40.50 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (2.50, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (6.17, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (15.17, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (18.84, 2.00)
      WITH WINGS (9.00 BY 3.50)
        AT (40.50, 0.00),
    STARTING AT(40.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (20.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW (2.67 BY 7.00)
        REVEAL(0.50)
        AT (6.67, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (10.33, 2.00),
    STARTING AT(40.50, 20.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (8.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW (3.00 BY 7.17)
        REVEAL(0.00)
        AT (1.00, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(13.50, 28.00, 0.00)
```

```
  FACING(270.00)
  TILTED(90.00)
  PT19 (4.00 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(13.50, 24.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (13.50 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(0.00, 24.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  WALL-6 (24.00 BY 9.00)
  ADJACENT TO ZONE (1),
  STARTING AT(40.50, 28.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (3);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (24.00 BY 13.50),
  STARTING AT(13.50, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (28.00 BY 27.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (13.50 BY 24.00)
  ADJACENT TO ZONE (12),
  STARTING AT(13.50, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (27.00 BY 28.00)
  ADJACENT TO ZONE (12);
INTERNAL MASS: PT23
  ( 554.00 BY 2.00);
CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
         0.000 HEATING, 19.481 COOLING,
    0.00 PERCENT RADIANT,
```

```
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=3,OFFICE OCCUPANCY ,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=5.68,OFFICE OCCUPANCY ,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(18.1 AT 0., 4.8 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=88.2,CONSTANT,
                  WITH COEFFICIENTS(1.,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=13.8,CONSTANT,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 15MAY THRU 15OCT;
     INFILTRATION=88.2,CONSTANT,
                  WITH COEFFICIENTS(1.,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
     ELECTRIC EQUIPMENT=.6, OFFICE OCCUPANCY,
                          0.0 PERCENT RADIANT,
              0.0 PERCENT LATENT, 0.0 PERCENT LOST,
              FROM 01JAN THRU 31 DEC;
      END ZONE;
  ZONE 3 "AHU-2 Z3 ":
    ORIGIN:(30.00, 28.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
      STARTING AT(27.00, 0.00, 0.00)
      FACING(180.00)
      TILTED(90.00)
      EX99 (64.00 BY 9.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (7.33, 2.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (11.00, 2.00)
```

```
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (38.42, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (42.00, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (49.34, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (53.00, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (18.25, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (21.92, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (14.22 BY 9.00)
      REVEAL(0.00)
      AT (25.60, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(91.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (4),
  STARTING AT(118.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (11.00 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(118.00, 11.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
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    ADJACENT TO ZONE (9),
    STARTING AT(77.00, 11.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    WALL-12 (36.00 BY 9.00)
    ADJACENT TO ZONE (10),
    STARTING AT(41.00, 11.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    WALL-12 (41.00 BY 9.00)
    ADJACENT TO ZONE (7),
    STARTING AT(0.00, 11.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (11.00 BY 9.00)
    ADJACENT TO ZONE (6);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (11.00 BY 118.00);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (118.00 BY 11.00)
    ADJACENT TO ZONE (12);
  CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 01JAN THRU 15MAY;
  CONTROLS=COOL ,
         0.000 HEATING, 10.910 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16MAY THRU 15OCT;
  CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  PEOPLE=3,CONSTANT,
  AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=3.48,CONSTANT,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(25.3 AT 0.,6.7 AT 65.),CONSTANT,
     0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
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    VENTILATION=1168., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
    VENTILATION=1168., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
    INFILTRATION=195.4,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
    INFILTRATION=124.,INFILOCC,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
    INFILTRATION=195.4,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
    ELECTRIC EQUIPMENT=1.5,CONSTANT,
                    0.0 PERCENT RADIANT,
             0.0 PERCENT LATENT, 0.0 PERCENT LOST,
             FROM 01JAN THRU 31 DEC;
END ZONE;
ZONE 4 "AHU-2 Z4 ":
  ORIGIN:(121.00, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (40.50 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (0.00, 0.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (19.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (22.67, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (29.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (32.67, 2.00),
    STARTING AT(0.00, 28.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (8.00 BY 9.00),
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    STARTING AT(0.00, 20.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (20.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (7.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (10.67, 2.00);
  INTERZONE PARTITIONS :
    STARTING AT(40.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    WALL-6 (24.00 BY 9.00)
    ADJACENT TO ZONE (5),
    STARTING AT(40.50, 24.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    PT19 (13.50 BY 9.00)
    ADJACENT TO ZONE (8),
    STARTING AT(27.00, 24.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (4.00 BY 9.00)
    ADJACENT TO ZONE (8),
    STARTING AT(27.00, 28.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    PT19 (27.00 BY 9.00)
    ADJACENT TO ZONE (3);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (28.00 BY 27.00),
    STARTING AT(27.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (24.00 BY 13.50);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (27.00 BY 28.00)
    ADJACENT TO ZONE (12),
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        STARTING AT(27.00, 0.00, 9.00)
        FACING(180.00)
        TILTED(0.00)
        CEILING (13.50 BY 24.00)
        ADJACENT TO ZONE (12);
      CONTROLS=HEAT ,
                 0.000 HEATING, 0.0 COOLING,
          0.00 PERCENT RADIANT,
        FROM 01JAN THRU 15MAY;
      CONTROLS=COOL ,
               0.000 HEATING, 16.364 COOLING,
          0.00 PERCENT RADIANT,
        FROM 16MAY THRU 15OCT;
      CONTROLS=HEAT ,
                 0.000 HEATING, 0.0 COOLING,
          0.00 PERCENT RADIANT,
        FROM 16OCT THRU 31DEC;
      PEOPLE=7,OFFICE OCCUPANCY ,
        AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
        FROM 01JAN THRU 31DEC;
      LIGHTS=7.43,OFFICE OCCUPANCY ,
      0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
      20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
        FROM 01JAN THRU 31DEC;
   BASEBOARD HEATING=(18.1 AT 0.,4.8 AT 65.),CONSTANT,
         0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
       VENTILATION=972., CONSTANT, 73 MIN TEMP,
                   0. DEL TEMP, FROM 01JAN THRU 15MAY;
       VENTILATION=972., CONSTANT, 73 MIN TEMP,
                   0. DEL TEMP, FROM 15OCT THRU 31DEC;
       INFILTRATION=88.2,CONSTANT,
                    WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                    FROM 01JAN THRU 15MAY;
       INFILTRATION=13.8,CONSTANT,
             WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                    FROM 16MAY THRU 15OCT;
       INFILTRATION=88.2,CONSTANT,
                    WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                    FROM 16OCT THRU 31DEC;
       ELECTRIC EQUIPMENT=1.5,OFFICE OCCUPANCY,
                      0.0 PERCENT RADIANT,
                0.0 PERCENT LATENT, 0.0 PERCENT LOST,
                FROM 01JAN THRU 31 DEC;
    END ZONE;
    ZONE 5 "AHU-2 Z5 ":
      ORIGIN:(161.50, 0.00, 0.00);
      NORTH AXIS=0.00;
      EXTERIOR WALLS :
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   STARTING AT(0.00, 0.00, 0.00)
   FACING(180.00)
   TILTED(90.00)
   EX99 (16.50 BY 9.00)
     WITH WINGS (9.00 BY 3.50)
       AT (16.50, 0.00),
   STARTING AT(16.50, 0.00, 0.00)
   FACING(90.00)
   TILTED(90.00)
   EX99 (24.00 BY 9.00)
     WITH WINDOWS OF TYPE
     SPWD (2.67 BY 7.00)
       REVEAL(0.50)
       AT (5.00, 2.00)
     WITH WINDOWS OF TYPE
     SPWD (2.67 BY 7.00)
       REVEAL(0.50)
       AT (8.67, 2.00)
     WITH WINDOWS OF TYPE
     SPWD (2.67 BY 7.00)
       REVEAL(0.50)
       AT (16.33, 2.00)
     WITH WINDOWS OF TYPE
     SPWD (2.67 BY 7.00)
       REVEAL(0.50)
       AT (20.00, 2.00);
 PARTITIONS :
   STARTING AT(0.00, 12.00, 0.00)
   FACING(180.00)
   TILTED(90.00)
   WALL-6 (16.50 BY 9.00)
     WITH DOORS OF TYPE
     SWD (3.00 BY 7.17)
       AT (9.33, 0.00);
 INTERZONE PARTITIONS :
   STARTING AT(16.50, 24.00, 0.00)
   FACING(0.00)
   TILTED(90.00)
   PT19 (16.50 BY 9.00)
   ADJACENT TO ZONE (8),
   STARTING AT(0.00, 24.00, 0.00)
   FACING(270.00)
   TILTED(90.00)
   WALL-6 (24.00 BY 9.00)
   ADJACENT TO ZONE (4);
 SLAB ON GRADE FLOORS :
   STARTING AT(0.00, 0.00, 0.00)
   FACING(90.00)
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      TILTED(180.00)
      FL18 (24.00 BY 16.50);
    INTERZONE CEILINGS :
      STARTING AT(0.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (16.50 BY 24.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
                0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
             0.000 HEATING, 12.468 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
                0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=2,OCCAS,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,OCCAS,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(10.6 AT 0.,2.8 AT 65.),CONSTANT,
       0.,PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=46.6,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=7.4,CONSTANT,
           WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
     INFILTRATION=46.6,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
 END ZONE;
 ZONE 6 "AHU-3 Z3 ":
   ORIGIN:(0.00, 24.00, 0.00);
   NORTH AXIS=0.00;
   EXTERIOR WALLS :
     STARTING AT(0.00, 15.00, 0.00)
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FACING(270.00)
TILTED(90.00)
EX99 (15.00 BY 9.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (16.50 BY 9.00)
  ADJACENT TO ZONE (1),
  STARTING AT(16.50, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (13.50 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(30.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (4.00 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(30.00, 4.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (11.00 BY 9.00)
  ADJACENT TO ZONE (3),
  STARTING AT(30.00, 15.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  WALL-12 (30.00 BY 9.00)
  ADJACENT TO ZONE (7);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (15.00 BY 30.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (30.00 BY 15.00)
  ADJACENT TO ZONE (12);
CONTROLS=HEAT ,
           3.330 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
            0.000 HEATING, 10.152 COOLING,
    0.00 PERCENT RADIANT,
  FROM 16MAY THRU 15OCT;
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  CONTROLS=HEAT ,
            3.330 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  PEOPLE=2,OFFICE OCCUPANCY ,
    AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=2.90,OFFICE OCCUPANCY ,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
 INFILTRATION=14.5,CONSTANT,
                WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                FROM 01JAN THRU 15MAY;
 INFILTRATION=2.3,CONSTANT,
         WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                FROM 16MAY THRU 15OCT;
 INFILTRATION=14.5,CONSTANT,
                WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                FROM 16OCT THRU 31DEC;
   ELECTRIC EQUIPMENT=.6, OFFICE OCCUPANCY,
                       0.0 PERCENT RADIANT,
           0.0 PERCENT LATENT, 0.0 PERCENT LOST,
           FROM 01JAN THRU 31 DEC;
END ZONE;
ZONE 7 "AHU-3 Z1&2 ":
  ORIGIN:(0.00, 39.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 38.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (38.00 BY 9.00),
    STARTING AT(71.00, 38.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX99 (71.00 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (71.00, 0.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (12.00, 0.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (56.00, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
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  TILTED(90.00)
  WALL-12 (30.00 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(30.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
  ADJACENT TO ZONE (3),
  STARTING AT(71.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (16.00 BY 9.00)
  ADJACENT TO ZONE (10),
  STARTING AT(71.00, 16.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (22.00 BY 9.00)
  ADJACENT TO ZONE (11);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (38.00 BY 71.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (71.00 BY 38.00)
  ADJACENT TO ZONE (12);
INTERNAL MASS: PT19
  ( 361.00 BY 2.00);
CONTROLS=HEAT ,
           27.60 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
           0.000 HEATING, 57.526 COOLING,
    0.00 PERCENT RADIANT,
  FROM 16MAY THRU 15OCT;
CONTROLS=HEAT ,
           27.60 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 16OCT THRU 31DEC;
LIGHTS=8.41,CLASS ,
0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
  FROM 01JAN THRU 31DEC;
PEOPLE=30,CLASS,
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      AT ACTIVITY LEVEL 0.64, 70 PERCENT RADIANT,
      FROM 01 JAN THRU 31 DEC;
    VENTILATION=2428., CONSTANT, 73 MIN TEMP,
              0. DEL TEMP, FROM 01JAN THRU 15MAY;
    VENTILATION=2428., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 15OCT THRU 31DEC;
   INFILTRATION=223.8,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 01JAN THRU 15MAY;
   INFILTRATION=35.5,CONSTANT,
         WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                 FROM 16MAY THRU 15OCT;
   INFILTRATION=223.8,CONSTANT,
                 WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 16OCT THRU 31DEC;
   MIXING=720., CONSTANT,FROM ZONE 12,0.0 DEL TEMP,
          FROM 16MAY THRU 15OCT;
 END ZONE;
 ZONE 8 "AHU-1 Z3 ":
   ORIGIN:(148.00, 24.00, 0.00);
   NORTH AXIS=0.00;
   EXTERIOR WALLS :
     STARTING AT(30.00, 0.00, 0.00)
     FACING(90.00)
     TILTED(90.00)
     EX99 (15.00 BY 9.00);
   INTERZONE PARTITIONS :
     STARTING AT(0.00, 0.00, 0.00)
     FACING(180.00)
     TILTED(90.00)
     PT19 (13.50 BY 9.00)
     ADJACENT TO ZONE (4),
     STARTING AT(13.50, 0.00, 0.00)
     FACING(180.00)
     TILTED(90.00)
     PT19 (16.50 BY 9.00)
     ADJACENT TO ZONE (5),
     STARTING AT(30.00, 15.00, 0.00)
     FACING(0.00)
     TILTED(90.00)
     WALL-12 (30.00 BY 9.00)
     ADJACENT TO ZONE (9),
     STARTING AT(0.00, 15.00, 0.00)
     FACING(270.00)
     TILTED(90.00)
     PT19 (11.00 BY 9.00)
     ADJACENT TO ZONE (3),
     STARTING AT(0.00, 4.00, 0.00)
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      FACING(270.00)
      TILTED(90.00)
      PT19 (4.00 BY 9.00)
      ADJACENT TO ZONE (4);
    SLAB ON GRADE FLOORS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(180.00)
      FL18 (15.00 BY 30.00);
    INTERZONE CEILINGS :
      STARTING AT(0.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (30.00 BY 15.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
              3.330 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
               0.000 HEATING, 15.566 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
              3.330 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=6,MEETING ,
    AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,MEETING,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
     INFILTRATION=14.5,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=2.3,CONSTANT,
            WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
     INFILTRATION=14.5,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
END ZONE;
ZONE 9 "AHU-1 Z1&2 ":
   ORIGIN:(107.00, 39.00, 0.00);
   NORTH AXIS=0.00;
   EXTERIOR WALLS :
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  STARTING AT(71.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  EX99 (38.00 BY 9.00),
  STARTING AT(71.00, 38.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 9.00)
    WITH WINGS (9.00 BY 3.50)
      AT (0.00, 0.00)
    WITH DOORS OF TYPE
    ALD (6.33 BY 7.16)
      AT (9.00, 0.00)
    WITH DOORS OF TYPE
    ALD (6.33 BY 7.16)
      AT (53.00, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
  ADJACENT TO ZONE (3),
  STARTING AT(41.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (30.00 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(0.00, 38.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  PT19 (22.00 BY 9.00)
  ADJACENT TO ZONE (11),
  STARTING AT(0.00, 16.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  PT19 (16.00 BY 9.00)
  ADJACENT TO ZONE (10);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (38.00 BY 71.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (71.00 BY 38.00)
  ADJACENT TO ZONE (12);
```

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    INTERNAL MASS: PT19
      ( 361.00 BY 2.00);
    CONTROLS=HEAT ,
               27.60 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
               0.000 HEATING, 52.111 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
               27.6 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=6,OFFICE OCCUPANCY ,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=15.38,OFFICE OCCUPANCY ,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
     VENTILATION=2428., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=2428., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=223.8,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 01JAN THRU 15MAY;
     INFILTRATION=35.5,CONSTANT,
           WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 16MAY THRU 15OCT;
     INFILTRATION=223.8,CONSTANT,
                  WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                  FROM 16OCT THRU 31DEC;
     ELECTRIC EQUIPMENT=.9, OFFICE OCCUPANCY,
                    0.0 PERCENT RADIANT,
               0.0 PERCENT LATENT, 0.0 PERCENT LOST,
               FROM 01JAN THRU 31 DEC;
    MIXING=720., CONSTANT,FROM ZONE 12,0.0 DEL TEMP,
           FROM 16MAY THRU 15OCT;
  END ZONE;
  ZONE 10 "RESTROOMS ":
    ORIGIN:(71.00, 39.00, 0.00);
    NORTH AXIS=0.00;
    INTERZONE PARTITIONS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(180.00)
      TILTED(90.00) '
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   WALL-12 (36.00 BY 9.00)
   ADJACENT TO ZONE (3),
   STARTING AT(36.00, 0.00, 0.00)
   FACING(90.00)
   TILTED(90.00)
   PT19 (16.00 BY 9.00)
   ADJACENT TO ZONE (9),
   STARTING AT(36.00, 16.00, 0.00)
   FACING(0.00)
   TILTED(90.00)
   PT19 (36.00 BY 9.00)
   ADJACENT TO ZONE (11),
   STARTING AT(0.00, 16.00, 0.00)
   FACING(270.00)
   TILTED(90.00)
   PT19 (16.00 BY 9.00)
   ADJACENT TO ZONE (7);
 SLAB ON GRADE FLOORS :
   STARTING AT(0.00, 0.00, 0.00)
   FACING(90.00)
   TILTED(180.00)
   FL18 (16.00 BY 36.00);
 INTERZONE CEILINGS :
   STARTING AT(0.00, 0.00, 9.00)
   FACING(180.00)
   TILTED(0.00)
   CEILING (36.00 BY 16.00)
   ADJACENT TO ZONE (12);
 INTERNAL MASS: PT19
   ( 390.00 BY 2.00);
 CONTROLS=HEAT ,
            0.000 HEATING, 0.0 COOLING,
     0.00 PERCENT RADIANT,
   FROM 01JAN THRU 15MAY;
 CONTROLS=COOL ,
            0.000 HEATING, 0.001 COOLING,
     0.00 PERCENT RADIANT,
   FROM 16MAY THRU 15OCT;
 CONTROLS=HEAT ,
            0.000 HEATING, 0.0 COOLING,
     0.00 PERCENT RADIANT,
   FROM 16OCT THRU 31DEC;
 PEOPLE=1,OFFICE OCCUPANCY ,
   AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
   FROM 01JAN THRU 31DEC;
 MIXING=900.00,CONSTANT ,
   FROM ZONE 3, 0.00 DEL TEMP,
   FROM 01JAN THRU 31DEC;
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    LIGHTS=2.63,CONSTANT,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(2.74 AT 0., 0.7 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01FEB THRU 31MAR;
  END ZONE;
  ZONE 11 "MECHANICAL ROOM ":
    ORIGIN:(71.00, 55.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
      STARTING AT(36.00, 22.00, 0.00)
      FACING(0.00)
      TILTED(90.00)
      EX99 (36.00 BY 10.00)
        WITH DOORS OF TYPE
        ALD (6.33 BY 7.16)
          AT (10.00, 0.00),
      STARTING AT(36.00, 22.00, 10.00)
      FACING(0.00)
      TILTED(90.00)
      EX98 (36.00 BY 2.50);
    INTERZONE PARTITIONS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(180.00)
      TILTED(90.00)
      PT19 (36.00 BY 9.00)
      ADJACENT TO ZONE (10),
      STARTING AT(36.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(90.00)
      PT19 (22.00 BY 9.00)
      ADJACENT TO ZONE (9),
      STARTING AT(0.00, 22.00, 0.00)
      FACING(270.00)
      TILTED(90.00)
      PT19 (22.00 BY 9.00)
      ADJACENT TO ZONE (7);
    SLAB ON GRADE FLOORS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(180.00)
      FL18 (22.00 BY 36.00);
    ROOFS :
      STARTING AT(0.00, 0.00, 12.50)
      FACING(180.00)
      TILTED(0.00)
      RF99 (36.00 BY 22.00);
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    INFILTRATION=96.4,CONSTANT,
             WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 01JAN THRU 15MAY;
    INFILTRATION=15.3,CONSTANT,
      WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                 FROM 16MAY THRU 15OCT;
    INFILTRATION=96.4,CONSTANT,
             WITH COEFFICIENTS(1.0,0.0,0.0,0.0),
                 FROM 15OCT THRU 31DEC;
    ELECTRIC EQUIPMENT=7.5,CONSTANT,
                   0.0 PERCENT RADIANT,
             0.0 PERCENT LATENT, 0.0 PERCENT LOST,
             FROM 01JAN THRU 31 DEC;
    CROSS MIXING=9900,CONSTANT,
                   FROM ZONE 12,0.0 DEL TEMP,
             FROM 01 JAN THRU 31DEC;
    CONTROLS=HEAT2,10.6 HEATING,0.0 COOLING,
      0.0 PERCENT RADIANT, FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 12 "CEILING PLENUM ":
  ORIGIN:(0.00, 0.00, 10.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX98 (57.00 BY 2.50),
    STARTING AT(57.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX98 (28.00 BY 2.50),
    STARTING AT(57.00, 28.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX98 (64.00 BY 2.50),
    STARTING AT(121.00, 28.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX98 (28.00 BY 2.50),
    STARTING AT(121.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX98 (57.00 BY 2.50),
    STARTING AT(178.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX98 (77.00 BY 2.50),
    STARTING AT(178.00, 77.00, 0.00)
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    FACING(0.00)
    TILTED(90.00)
    EX98 (71.00 BY 2.50),
    STARTING AT(71.00, 77.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX98 (71.00 BY 2.50),
    STARTING AT(0.00, 77.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX98 (77.00 BY 2.50),
    STARTING AT(0.00, 0.00, -1.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (57.00 BY 1.00),
    STARTING AT(57.00, 0.00, -1.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (28.00 BY 1.00),
    STARTING AT(57.00, 28.00, -1.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (64.00 BY 1.00),
    STARTING AT(121.00, 28.00, -1.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (28.00 BY 1.00),
    STARTING AT(121.00, 0.00, -1.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (57.00 BY 1.00),
    STARTING AT(178.00, 0.00, -1.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (77.00 BY 1.00),
    STARTING AT(178.00, 77.00, -1.00)
    FACING(0.00)
    TILTED(90.00)
    EX99 (71.00 BY 1.00),
    STARTING AT(71.00, 77.00, -1.00)
    FACING(0.00)
    TILTED(90.00)
    EX99 (71.00 BY 1.00),
    STARTING AT(0.00, 77.00, -1.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (77.00 BY 1.00);
INTERZONE FLOORS :
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STARTING AT(0.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 16.50)
ADJACENT TO ZONE (1),
STARTING AT(16.50, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 13.50)
ADJACENT TO ZONE (2),
STARTING AT(30.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (28.00 BY 27.00)
ADJACENT TO ZONE (2),
STARTING AT(30.00, 28.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (11.00 BY 118.00)
ADJACENT TO ZONE (3),
STARTING AT(121.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (28.00 BY 27.00)
ADJACENT TO ZONE (4),
STARTING AT(148.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 13.50)
ADJACENT TO ZONE (4),
STARTING AT(161.50, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 16.50)
ADJACENT TO ZONE (5),
STARTING AT(0.00, 24.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (15.00 BY 30.00)
ADJACENT TO ZONE (6),
STARTING AT(0.00, 39.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (38.00 BY 71.00)
ADJACENT TO ZONE (7),
STARTING AT(148.00, 24.00, -1.00)
FACING(90.00)
TILTED(180.00)
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        CEILINGS (15.00 BY 30.00)
        ADJACENT TO ZONE (8),
        STARTING AT(107.00, 39.00, -1.00)
        FACING(90.00)
        TILTED(180.00)
        CEILINGS (38.00 BY 71.00)
        ADJACENT TO ZONE (9),
        STARTING AT(71.00, 39.00, -1.00)
        FACING(90.00)
        TILTED(180.00)
        CEILINGS (16.00 BY 36.00)
        ADJACENT TO ZONE (10);
      ROOFS :
        STARTING AT(0.00, 0.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (57.00 BY 28.00),
        STARTING AT(121.00, 0.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (57.00 BY 28.00),
        STARTING AT(0.00, 28.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (178.00 BY 27.00),
        STARTING AT(107.00, 55.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (71.00 BY 22.00),
        STARTING AT(107.00, 55.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (71.00 BY 22.00);
       ELECTRIC EQUIPMENT=4.8,CONSTANT,
                      0.0 PERCENT RADIANT,
                0.0 PERCENT LATENT, 100.0 PERCENT LOST,
                FROM 01JAN THRU 31 DEC;
    END ZONE;
END BUILDING DESCRIPTION;
BEGIN FAN SYSTEM DESCRIPTION;
  MULTIZONE SYSTEM 1
  "AIR HANDLER NUMBER 1 " SERVING ZONES 8,9;
  FOR ZONE 8:
  SUPPLY AIR VOLUME=550.;
  END ZONE;
  FOR ZONE 9:
  EXHAUST AIR VOLUME=0.0;
  SUPPLY AIR VOLUME=1830.;
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END ZONE;
  OTHER SYSTEM PARAMETERS:
  SUPPLY FAN PRESSURE=1.7663;
    SUPPLY FAN EFFICIENCY=.6;
    EXHAUST FAN PRESSURE=0.0;
    EXHAUST FAN EFFICIENCY=1.0;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=1.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=63.;
    COLD DECK THROTTLING RANGE=10.;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=35.0;
    HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
    HOT DECK CONTROL SCHEDULE=
                    (135 AT 20., 90 AT 65.);
    HOT DECK THROTTLING RANGE=10.;
    MIXED AIR CONTROL=FIXED AMOUNT;
   OUTSIDE AIR VOLUME=64.;
    PREHEAT COIL LOCATION=NONE;
    HUMIDIFIER TYPE=NONE;
    COOLING SAT DIFFERENCE=20.;
    HEATING SAT DIFFERENCE=40.;
    AIR VOLUME COEFFICIENT=1.0;
  END OTHER SYSTEM PARAMETERS;
  COOLING COIL DESIGN PARAMETERS:
     COIL TYPE = CHILLED WATER;
     AIR VOLUME FLOW RATE=2380.;
     BAROMETRIC PRESSURE=407.;
     AIR FACE VELOCITY=490.;
     ENTERING AIR DRY BULB TEMPERATURE=84.3;
     ENTERING AIR WET BULB TEMPERATURE=68.6;
     LEAVING AIR DRY BULB TEMPERATURE=55.5;
     LEAVING AIR WET BULB TEMPERATURE=54.0;
     ENTERING WATER TEMPERATURE=44.0;
     LEAVING WATER TEMPERATURE=55.;
     WATER VOLUME FLOW RATE=3.;
     WATER VELOCITY=275.;
  END COOLING COIL DESIGN PARAMETERS;
  EQUIPMENT SCHEDULES:
  SYSTEM OPERATION=ON,
                   FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=OFF,
                   FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,
                   FROM 01 JAN THRU 31DEC;
    HEATING COIL OPERATION=ON,
                   FROM 01JAN THRU 15MAY;
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    HEATING COIL OPERATION=OFF,
                    FROM 16MAY THRU 15OCT;
    HEATING COIL OPERATION=ON,
                    FROM 16OCT THRU 31DEC;
    COOLING COIL OPERATION=OFF,
                    FROM 01JAN THRU 15MAY;
    COOLING COIL OPERATION=ON,
                    FROM 16MAY THRU 15OCT;
    COOLING COIL OPERATION=OFF,
                    FROM 16OCT THRU 31DEC;
    HUMIDIFIER OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=CONSTANT,
                    FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=OFF,
                    FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                    FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
END SYSTEM;
MULTIZONE SYSTEM 2
"AIR HANDLER NUMBER 2 "
               SERVING ZONES 1,2,3,4,5,10,12;
FOR ZONE 1:
SUPPLY AIR VOLUME=930.;
END ZONE;
FOR ZONE 2:
SUPPLY AIR VOLUME=1140.;
END ZONE;
FOR ZONE 3:
SUPPLY AIR VOLUME=615.;
END ZONE;
FOR ZONE 4:
SUPPLY AIR VOLUME=1125.;
END ZONE;
FOR ZONE 5:
SUPPLY AIR VOLUME=710.;
END ZONE;
FOR ZONE 10:
SUPPLY AIR VOLUME=1.0;
END ZONE;
FOR ZONE 12:
SUPPLY AIR VOLUME=1.0;
END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=3.32;
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    SUPPLY FAN EFFICIENCY=.6;
    EXHAUST FAN PRESSURE=0.0;
    EXHAUST FAN EFFICIENCY=1.0;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=1.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=63.;
    COLD DECK THROTTLING RANGE=10.;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=0.00;
    HOT DECK CONTROL=FIXED SET POINT;
    HOT DECK TEMPERATURE=55.5;
    HOT DECK THROTTLING RANGE=10.;
    MIXED AIR CONTROL=FIXED AMOUNT;
    PREHEAT COIL LOCATION=NONE;
    HUMIDIFIER TYPE=NONE;
    COOLING SAT DIFFERENCE=20.;
    HEATING SAT DIFFERENCE=40.;
    AIR VOLUME COEFFICIENT=1.0;
    OUTSIDE AIR VOLUME=1704.;
END OTHER SYSTEM PARAMETERS;
COOLING COIL DESIGN PARAMETERS:
    COIL TYPE = CHILLED WATER;
    AIR VOLUME FLOW RATE=4520.;
    BAROMETRIC PRESSURE=407.;
    AIR FACE VELOCITY=490.;
    ENTERING AIR DRY BULB TEMPERATURE=79.9;
    ENTERING AIR WET BULB TEMPERATURE=66.1;
    LEAVING AIR DRY BULB TEMPERATURE=58.5;
    LEAVING AIR WET BULB TEMPERATURE=57.5;
    ENTERING WATER TEMPERATURE=44.0;
    LEAVING WATER TEMPERATURE=55.;
    WATER VOLUME FLOW RATE=3.4;
    WATER VELOCITY=275.;
END COOLING COIL DESIGN PARAMETERS;
EQUIPMENT SCHEDULES:
  SYSTEM OPERATION=OFF,
                    FROM 01JAN THRU 15MAY;
  SYSTEM OPERATION=ON,
                    FROM 16MAY THRU 15OCT;
  SYSTEM OPERATION=OFF,
                    FROM 16OCT THRU 31DEC;
  EXHAUST FAN OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
  PREHEAT COIL OPERATION=OFF,
                    FROM 01 JAN THRU 31DEC;
  HEATING COIL OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
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      COOLING COIL OPERATION=OFF,
                        FROM 01JAN THRU 15MAY;
      COOLING COIL OPERATION=ON,
                        FROM 16MAY THRU 15OCT;
      COOLING COIL OPERATION=OFF,
                        FROM 16OCT THRU 31DEC;
      HUMIDIFIER OPERATION=OFF,
                        FROM 01JAN THRU 31DEC;
      HEAT RECOVERY OPERATION=OFF,
                        FROM 01JAN THRU 31DEC;
      MINIMUM VENTILATION SCHEDULE=CONSTANT,
                        FROM 01JAN THRU 31DEC;
      MAXIMUM VENTILATION SCHEDULE=OFF,
                        FROM 01JAN THRU 31DEC;
      SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                        FROM 01JAN THRU 31DEC;
   END EQUIPMENT SCHEDULES;
END SYSTEM;
MULTIZONE SYSTEM 3
"AIR HANDLER NUMBER 3 " SERVING ZONES 6,7;
FOR ZONE 6:
SUPPLY AIR VOLUME=310.;
END ZONE;
FOR ZONE 7:
SUPPLY AIR VOLUME=1710.;
EXHAUST AIR VOLUME=0.0;
END ZONE;
   OTHER SYSTEM PARAMETERS:
      SUPPLY FAN PRESSURE=1.745;
      SUPPLY FAN EFFICIENCY=.6;
      EXHAUST FAN PRESSURE=0.0;
      EXHAUST FAN EFFICIENCY=1.0;
      RETURN FAN PRESSURE=0.0;
      RETURN FAN EFFICIENCY=1.0;
      COLD DECK CONTROL=FIXED SET POINT;
      COLD DECK TEMPERATURE=63.;
      COLD DECK THROTTLING RANGE=10.;
      HEATING COIL ENERGY SUPPLY=HOT WATER;
      HEATING COIL CAPACITY=35.0;
      HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
      HOT DECK CONTROL SCHEDULE=
                       (135 AT 20., 90 AT 65.);
      HOT DECK THROTTLING RANGE=10.;
      MIXED AIR CONTROL=FIXED AMOUNT;
     OUTSIDE AIR VOLUME=59.;
      PREHEAT COIL LOCATION=NONE;
      HUMIDIFIER TYPE=NONE;
      COOLING SAT DIFFERENCE=20.;
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    HEATING SAT DIFFERENCE=40.;
    AIR VOLUME COEFFICIENT=1.0;
  END OTHER SYSTEM PARAMETERS;
  COOLING COIL DESIGN PARAMETERS:
     COIL TYPE = CHILLED WATER;
     AIR VOLUME FLOW RATE=2020.;
     BAROMETRIC PRESSURE=407.;
     AIR FACE VELOCITY=490.;
     ENTERING AIR DRY BULB TEMPERATURE=84.3;
     ENTERING AIR WET BULB TEMPERATURE=68.6;
     LEAVING AIR DRY BULB TEMPERATURE=55.5;
     LEAVING AIR WET BULB TEMPERATURE=54.0;
     ENTERING WATER TEMPERATURE=44.0;
     LEAVING WATER TEMPERATURE=55.;
     WATER VOLUME FLOW RATE=3.;
     WATER VELOCITY=275.;
  END COOLING COIL DESIGN PARAMETERS;
  EQUIPMENT SCHEDULES:
    SYSTEM OPERATION=ON,
                     FROM 01JAN THRU 31DEC;
    EXHAUST FAN OPERATION=OFF,
                     FROM 01JAN THRU 31DEC;
    PREHEAT COIL OPERATION=OFF,
                     FROM 01 JAN THRU 31DEC;
    HEATING COIL OPERATION=ON,
                     FROM 01JAN THRU 15MAY;
    HEATING COIL OPERATION=OFF,
                     FROM 16MAY THRU 15OCT;
    HEATING COIL OPERATION=ON,
                     FROM 16OCT THRU 31DEC;
    COOLING COIL OPERATION=OFF,
                     FROM 01JAN THRU 15MAY;
    COOLING COIL OPERATION=ON,
                     FROM 16MAY THRU 15OCT;
    COOLING COIL OPERATION=OFF,
                     FROM 16OCT THRU 31DEC;
    HUMIDIFIER OPERATION=OFF,
                     FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,
                     FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=CONSTANT,
                     FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=OFF,
                     FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                     FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
  END SYSTEM;
```

```
      UNIT HEATER SYSTEM 4 "ZONE 11" SERVING ZONES 11;
        FOR ZONE 11:
        SUPPLY AIR VOLUME=550.;
        REHEAT CAPACITY=0.0;
        END ZONE;
       OTHER SYSTEM PARAMETERS:
        SUPPLY FAN PRESSURE=0.0;
        HEATING COIL ENERGY SUPPLY=HOT WATER;
        SUPPLY FAN EFFICIENCY=1.0;
        HEATING COIL CAPACITY=10.55;
        SYSTEM ELECTRICAL DEMAND=0.0;
        HEATING SAT DIFFERENCE=50.;
        AIR VOLUME COEFFICIENT=1.0;
       END OTHER SYSTEM PARAMETERS;
      EQUIPMENT SCHEDULES:
        SYSTEM OPERATION=OFF, FROM 01JAN THRU 31DEC;
       END EQUIPMENT SCHEDULES;
        END SYSTEM;
  END FAN SYSTEM DESCRIPTION;
END INPUT;
```

Appendix D

BLAST Input for "As Designed" Model

```
BEGIN INPUT;
   RUN CONTROL:
     NEW ZONES,
     REPORTS(59),
     NEW SYSTEMS,
     UNITS(IN=ENGLISH, OUT=ENGLISH);
     TEMPORARY LOCATION:
       FTRILY
         = (LAT=39.03,LONG=96.40,TZ=6);
     END;
     TEMPORARY MATERIALS:
       JUMBO BRICK
         = (L=0.50,K=0.77,D=125.00,CP=0.22,ABS=0.93,
         TABS=0.90,ROUGH);
       HWCB-6
         = (L=0.50,K=0.53,D=61.00,CP=0.20,ABS=0.65,
         TABS=0.90,MEDIUM ROUGH);
       HWCB-12
         = (L=1.00,K=0.53,D=61.00,CP=0.20,ABS=0.65,
         TABS=0.90,MEDIUM ROUGH);
     END;
     TEMPORARY WALLS:
       WALL-6
         = (HWCB-6);
       WALL-12
         = (HWCB-12);
       EX98
         = (A3 ,
            B1 ,
            B6 ,
            CB17);
       EX99
         = (JUMBO BRICK ,
            B1 ,
            B6 ,
            CB17);
     END;
     TEMPORARY ROOFS:
       CEILING
         = (E5);
       RF99
         = (E2 ,
            E3 ,
            B5 ,
```

```
            A3 ,
            B4);
     END;
     TEMPORARY FLOORS:
       CEILINGS
         = (E5);
     END;
      TEMPORARY SCHEDULE (INFILOCC):
         MONDAY THRU FRIDAY =
               (7 TO 17 - 1.0,17 TO 7 - .25),
         SATURDAY THRU SUNDAY = (00 TO 24 - .25),
         HOLIDAY = SUNDAY,
         SPECIAL1=SUNDAY,
         SPECIAL2=SUNDAY,
         SPECIAL3=SUNDAY,
         SPECIAL4=SUNDAY;
       END SCHEDULE;
      TEMPORARY SCHEDULE (MINAIR):
         SUNDAY THRU SATURDAY = (00 TO 24 - .333),
         HOLIDAY=SUNDAY,
         SPECIAL1=SUNDAY,
         SPECIAL2=SUNDAY,
         SPECIAL3=SUNDAY,
         SPECIAL4=SUNDAY;
       END SCHEDULE;
      TEMPORARY SCHEDULE (CLASS):
         MONDAY THRU FRIDAY =
           (9 TO 11 - 1.0, 11 TO 9 - 0.0),
         SATURDAY THRU SUNDAY = (00 TO 24 - .00),
         HOLIDAY = SUNDAY,
         SPECIAL1=SUNDAY,
         SPECIAL2=SUNDAY,
         SPECIAL3=SUNDAY,
         SPECIAL4=SUNDAY;
       END SCHEDULE;
      TEMPORARY SCHEDULE (OCCAS):
MONDAY THRU FRIDAY = (7 TO 9-1.0,9 TO 11-0.,
                   11 TO 12-1.,12 TO 15-0.0,
                     15 TO 17-1.,17 TO 7-0.),
         SATURDAY THRU SUNDAY = (00 TO 24 - .00),
         HOLIDAY = SUNDAY,
         SPECIAL1=SUNDAY,
         SPECIAL2=SUNDAY,
         SPECIAL3=SUNDAY,
         SPECIAL4=SUNDAY;
       END SCHEDULE;
      TEMPORARY SCHEDULE (MEETING):
         MONDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
```

```
    TUESDAY = (0 TO 24 - 0.0),
    WEDNESDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
    THURSDAY = (0 TO 24 - 0.0),
    FRIDAY = (14 TO 17 - 1.0,17 TO 14 - 0.0),
    SATURDAY THRU SUNDAY = (00 TO 24 - 0.0),
    HOLIDAY = SUNDAY,
    SPECIAL1=SUNDAY,
    SPECIAL2=SUNDAY,
    SPECIAL3=SUNDAY,
    SPECIAL4=SUNDAY;
    END SCHEDULE;
TEMPORARY CONTROLS (COOL):
  PROFILES:
    COOL=( 0.0 AT 66.,-1.0 AT 76.);
  SCHEDULES:
    MONDAY THRU FRIDAY=(0 TO 24-COOL),
    SATURDAY=(0 TO 24-COOL),
    SUNDAY=(0 TO 24-COOL),
    HOLIDAY=(0 TO 24-COOL),
    SPECIAL1=(0 TO 24-COOL),
    SPECIAL2=(0 TO 24-COOL),
    SPECIAL3=(0 TO 24-COOL),
    SPECIAL4=(0 TO 24-COOL);
    END CONTROLS;
TEMPORARY CONTROLS (HEAT):
    PROFILES:
     HEAT=(1.0 AT 69., 0.0 AT 72.);
   SCHEDULES:
      MONDAY THRU SUNDAY=(0 TO 24-HEAT),
      HOLIDAY=(0 TO 24-HEAT),
      SPECIAL1=(0 TO 24-HEAT),
      SPECIAL2=(0 TO 24-HEAT),
      SPECIAL3=(0 TO 24-HEAT),
      SPECIAL4=(0 TO 24-HEAT);
      END CONTROLS;
TEMPORARY CONTROLS (HEAT2):
    PROFILES:
     HEAT=(1.0 AT 70., 0.0 AT 72.);
   SCHEDULES:
      MONDAY THRU SUNDAY=(0 TO 24-HEAT),
      HOLIDAY=(0 TO 24-HEAT),
      SPECIAL1=(0 TO 24-HEAT),
      SPECIAL2=(0 TO 24-HEAT),
      SPECIAL3=(0 TO 24-HEAT),
      SPECIAL4=(0 TO 24-HEAT);
      END CONTROLS;
PROJECT="FORT RILEY, BLDG 8037
         BATTALION HEADQUARTERS
```

```
          GENE MEYER";
  LOCATION=FTRILY ;
  WEATHER TAPE FROM 01FEB THRU 31MAR;
  GROUND TEMPERATURES=(54, 55, 58, 62, 67, 74,
                       72, 68, 64, 62, 58, 55);
BEGIN BUILDING DESCRIPTION;
  BUILDING="BATTALION HEADQUARTERS ";
    NORTH AXIS=-153.;
    SOLAR DISTRIBUTION=-1;
    ZONE 1 "AHU-2 Z1 ":
      ORIGIN:(0.00, 0.00, 0.00);
      NORTH AXIS=0.00;
      EXTERIOR WALLS :
        STARTING AT(0.00, 0.00, 0.00)
        FACING(180.00)
        TILTED(90.00)
        EX99 (16.50 BY 9.00)
          WITH WINGS (9.00 BY 3.50)
            AT (0.00, 0.00),
        STARTING AT(0.00, 24.00, 0.00)
        FACING(270.00)
        TILTED(90.00)
        EX99 (24.00 BY 9.00)
          WITH WINDOWS OF TYPE
          SPWD (2.67 BY 7.00)
            REVEAL(0.50)
            AT (1.33, 2.00)
          WITH WINDOWS OF TYPE
          SPWD (2.67 BY 7.00)
            REVEAL(0.50)
            AT (5.00, 2.00)
          WITH WINDOWS OF TYPE
          SPWD (2.67 BY 7.00)
            REVEAL(0.50)
            AT (16.33, 2.00)
          WITH WINDOWS OF TYPE
          SPWD (2.67 BY 7.00)
            REVEAL(0.50)
            AT (12.67, 2.00);
      PARTITIONS :
        STARTING AT(0.00, 12.00, 0.00)
        FACING(180.00)
        TILTED(90.00)
        WALL-6 (16.50 BY 9.00)
          WITH DOORS OF TYPE
          SWD (3.00 BY 7.17)
            AT (9.33, 0.00);
      INTERZONE PARTITIONS :
```

```
        STARTING AT(16.50, 0.00, 0.00)
        FACING(90.00)
        TILTED(90.00)
        WALL-6 (24.00 BY 9.00)
        ADJACENT TO ZONE (2),
        STARTING AT(16.50, 24.00, 0.00)
        FACING(0.00)
        TILTED(90.00)
        PT19 (16.50 BY 9.00)
        ADJACENT TO ZONE (6);
      SLAB ON GRADE FLOORS :
        STARTING AT(0.00, 0.00, 0.00)
        FACING(90.00)
        TILTED(180.00)
        FL18 (24.00 BY 16.50);
      INTERZONE CEILINGS :
        STARTING AT(0.00, 0.00, 9.00)
        FACING(180.00)
        TILTED(0.00)
        CEILING (16.50 BY 24.00)
        ADJACENT TO ZONE (12);
      CONTROLS=HEAT ,
                0.000 HEATING, 0.0 COOLING,
          0.00 PERCENT RADIANT,
        FROM 01JAN THRU 15MAY;
      CONTROLS=COOL ,
                0.000 HEATING, 16.363 COOLING,
          0.00 PERCENT RADIANT,
        FROM 16MAY THRU 15OCT;
      CONTROLS=HEAT ,
                0.000 HEATING, 0.0 COOLING,
          0.00 PERCENT RADIANT,
        FROM 16OCT THRU 31DEC;
  PEOPLE=2,OCCAS,
     AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
        FROM 01JAN THRU 31DEC;
   LIGHTS=3.48,OCCAS,
     0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
     20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
        FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(15.4 AT 0., 4.7 AT 65.),CONSTANT,
        0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     INFILTRATION=7.4,CONSTANT,
            WITH COEFFICIENTS(.606,.02,.000598,0.0),
                 FROM 01JAN THRU 31DEC;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
```

```
                0. DEL TEMP, FROM 15OCT THRU 31DEC;
END ZONE;
ZONE 2 "AHU-2 Z2 ":
  ORIGIN:(16.50, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (40.50 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (2.50, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (6.17, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (15.17, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (18.84, 2.00)
      WITH WINGS (9.00 BY 3.50)
        AT (40.50, 0.00),
    STARTING AT(40.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (20.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW (2.67 BY 7.00)
        REVEAL(0.50)
        AT (6.67, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (10.33, 2.00),
    STARTING AT(40.50, 20.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    PT19 (8.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SINGLE PANE HW WINDOW (3.00 BY 7.17)
        REVEAL(0.00)
        AT (1.00, 0.00);
```

```
INTERZONE PARTITIONS :
  STARTING AT(13.50, 28.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  PT19 (4.00 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(13.50, 24.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (13.50 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(0.00, 24.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  WALL-6 (24.00 BY 9.00)
  ADJACENT TO ZONE (1),
  STARTING AT(40.50, 28.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (3);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (24.00 BY 13.50),
  STARTING AT(13.50, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (28.00 BY 27.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (13.50 BY 24.00)
  ADJACENT TO ZONE (12),
  STARTING AT(13.50, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (27.00 BY 28.00)
  ADJACENT TO ZONE (12);
INTERNAL MASS: PT23
  ( 554.00 BY 2.00);
CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
```

```
           0.000 HEATING, 19.481 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
             0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=3,OFFICE OCCUPANCY ,
    AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=10.34,OFFICE OCCUPANCY ,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(26.3 AT 0., 8.0 AT 65.),CONSTANT,
        0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=972., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=13.8,CONSTANT,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                 FROM 01JAN THRU 31DEC;
    ELECTRIC EQUIPMENT=.6, OFFICE OCCUPANCY,
                         0.0 PERCENT RADIANT,
            0.0 PERCENT LATENT, 0.0 PERCENT LOST,
            FROM 01JAN THRU 31 DEC;
      END ZONE;
  ZONE 3 "AHU-2 Z3 ":
    ORIGIN:(30.00, 28.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
      STARTING AT(27.00, 0.00, 0.00)
      FACING(180.00)
      TILTED(90.00)
      EX99 (64.00 BY 9.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (7.33, 2.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (11.00, 2.00)
        WITH WINDOWS OF TYPE
        SINGLE PANE HW WINDOW (2.67 BY 7.00)
          REVEAL(0.50)
          AT (38.42, 2.00)
```

```
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (42.00, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (49.34, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (53.00, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (18.25, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (2.67 BY 7.00)
      REVEAL(0.50)
      AT (21.92, 2.00)
    WITH WINDOWS OF TYPE
    SINGLE PANE HW WINDOW (14.22 BY 9.00)
      REVEAL(0.00)
      AT (25.60, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (2),
  STARTING AT(91.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  PT19 (27.00 BY 9.00)
  ADJACENT TO ZONE (4),
  STARTING AT(118.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (11.00 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(118.00, 11.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
  ADJACENT TO ZONE (9),
  STARTING AT(77.00, 11.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
```

```
    WALL-12 (36.00 BY 9.00)
    ADJACENT TO ZONE (10),
    STARTING AT(41.00, 11.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    WALL-12 (41.00 BY 9.00)
    ADJACENT TO ZONE (7),
    STARTING AT(0.00, 11.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (11.00 BY 9.00)
    ADJACENT TO ZONE (6);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (11.00 BY 118.00);
  INTERZONE CEILINGS :
    STARTING AT(0.00, 0.00, 9.00)
    FACING(180.00)
    TILTED(0.00)
    CEILING (118.00 BY 11.00)
    ADJACENT TO ZONE (12);
  CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
    FROM 01JAN THRU 15MAY;
  CONTROLS=COOL ,
            0.000 HEATING, 10.910 COOLING,
       0.00 PERCENT RADIANT,
    FROM 16MAY THRU 15OCT;
  CONTROLS=HEAT ,
              0.000 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  PEOPLE=3,CONSTANT,
    AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
    FROM 01JAN THRU 31DEC;
  LIGHTS=3.48,CONSTANT,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(36.8 AT 0.,11.3 AT 65.),CONSTANT,
      0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
   VENTILATION=1168., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 01JAN THRU 15MAY;
   VENTILATION=1168., CONSTANT, 73 MIN TEMP,
                0. DEL TEMP, FROM 15OCT THRU 31DEC;
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    INFILTRATION=124.,INFILOCC,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                FROM 01JAN THRU 31DEC;
    ELECTRIC EQUIPMENT=1.5,CONSTANT,
                  0.0 PERCENT RADIANT,
            0.0 PERCENT LATENT, 0.0 PERCENT LOST,
            FROM 01JAN THRU 31 DEC;
END ZONE;
ZONE 4 "AHU-2 Z4 ":
  ORIGIN:(121.00, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (40.50 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (0.00, 0.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (19.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (22.67, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (29.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (32.67, 2.00),
    STARTING AT(0.00, 28.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (8.00 BY 9.00),
    STARTING AT(0.00, 20.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX99 (20.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (7.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
```

```
      REVEAL(0.50)
      AT (10.67, 2.00);
 INTERZONE PARTITIONS :
   STARTING AT(40.50, 0.00, 0.00)
   FACING(90.00)
   TILTED(90.00)
   WALL-6 (24.00 BY 9.00)
   ADJACENT TO ZONE (5),
   STARTING AT(40.50, 24.00, 0.00)
   FACING(0.00)
   TILTED(90.00)
   PT19 (13.50 BY 9.00)
   ADJACENT TO ZONE (8),
   STARTING AT(27.00, 24.00, 0.00)
   FACING(90.00)
   TILTED(90.00)
   PT19 (4.00 BY 9.00)
   ADJACENT TO ZONE (8),
   STARTING AT(27.00, 28.00, 0.00)
   FACING(0.00)
   TILTED(90.00)
   PT19 (27.00 BY 9.00)
   ADJACENT TO ZONE (3);
 SLAB ON GRADE FLOORS :
   STARTING AT(0.00, 0.00, 0.00)
   FACING(90.00)
   TILTED(180.00)
   FL18 (28.00 BY 27.00),
   STARTING AT(27.00, 0.00, 0.00)
   FACING(90.00)
   TILTED(180.00)
   FL18 (24.00 BY 13.50);
 INTERZONE CEILINGS :
   STARTING AT(0.00, 0.00, 9.00)
   FACING(180.00)
   TILTED(0.00)
   CEILING (27.00 BY 28.00)
   ADJACENT TO ZONE (12),
   STARTING AT(27.00, 0.00, 9.00)
   FACING(180.00)
   TILTED(0.00)
   CEILING (13.50 BY 24.00)
   ADJACENT TO ZONE (12);
 CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
 CONTROLS=COOL , '
```

```
          0.000 HEATING, 16.364 COOLING,
     0.00 PERCENT RADIANT,
   FROM 16MAY THRU 15OCT;
 CONTROLS=HEAT ,
            0.000 HEATING, 0.0 COOLING,
     0.00 PERCENT RADIANT,
   FROM 16OCT THRU 31DEC;
 PEOPLE=7,OFFICE OCCUPANCY ,
 AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
   FROM 01JAN THRU 31DEC;
 LIGHTS=10.34,OFFICE OCCUPANCY ,
 0.00 PERCENT RETURN AIR, 20.00 PERCENT RAOIANT,
 20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
   FROM 01JAN THRU 31DEC;
BASEBOARO HEATING=(26.3 AT 0.,8.0 AT 65.),CONSTANT,
      0. PERCENT RAOIANT, FROM 01JAN THRU 31MAR;
  VENTILATION=972., CONSTANT, 73 MIN TEMP,
             0. DEL TEMP, FROM 01JAN THRU 15MAY;
  VENTILATION=972., CONSTANT, 73 MIN TEMP,
             0. DEL TEMP, FROM 15OCT THRU 31DEC;
  INFILTRATION=13.8,CONSTANT,
       WITH COEFFICIENTS(.606,.0202,.000598,0.0),
               FROM 01JAN THRU 31OEC;
  ELECTRIC EQUIPMENT=1.5,OFFICE OCCUPANCY,
                           0.0 PERCENT RAOIANT,
          0.0 PERCENT LATENT, 0.0 PERCENT LOST,
          FROM 01JAN THRU 31 DEC;
ENO ZONE;
ZONE 5 "AHU-2 Z5 ":
  ORIGIN:(161.50, 0.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX99 (16.50 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (16.50, 0.00),
    STARTING AT(16.50, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (24.00 BY 9.00)
      WITH WINDOWS OF TYPE
      SPWD (2.67 BY 7.00)
        REVEAL(0.50)
        AT (5.00, 2.00)
      WITH WINDOWS OF TYPE
      SPWO (2.67 BY 7.00)
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      REVEAL(0.50)
      AT (8.67, 2.00)
    WITH WINDOWS OF TYPE
    SPWD (2.67 BY 7.00)
      REVEAL(0.50)
      AT (16.33, 2.00)
    WITH WINDOWS OF TYPE
    SPWD (2.67 BY 7.00)
      REVEAL(0.50)
      AT (20.00, 2.00);
PARTITIONS :
  STARTING AT(0.00, 12.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-6 (16.50 BY 9.00)
    WITH DOORS OF TYPE
    SWD (3.00 BY 7.17)
      AT (9.33, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(16.50, 24.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (16.50 BY 9.00)
  ADJACENT TO ZONE (8),
  STARTING AT(0.00, 24.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  WALL-6 (24.00 BY 9.00)
  ADJACENT TO ZONE (4);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (24.00 BY 16.50);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (16.50 BY 24.00)
  ADJACENT TO ZONE (12);
CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
        0.000 HEATING, 12.468 COOLING,
    0.00 PERCENT RADIANT,
  FROM 16MAY THRU 15OCT;
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    CONTROLS=HEAT ,
               0.000 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=2,OCCAS,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,OCCAS,
     0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(15.4 AT 0.,4.7 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01JAN THRU 31MAR;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 01JAN THRU 15MAY;
     VENTILATION=356., CONSTANT, 73 MIN TEMP,
                 0. DEL TEMP, FROM 15OCT THRU 31DEC;
     INFILTRATION=7.4,CONSTANT,
          WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 01JAN THRU 31DEC;
 END ZONE;
 ZONE 6 "AHU-3 Z3 ":
   ORIGIN:(0.00, 24.00, 0.00);
   NORTH AXIS=0.00;
   EXTERIOR WALLS :
     STARTING AT(0.00, 15.00, 0.00)
     FACING(270.00)
     TILTED(90.00)
     EX99 (15.00 BY 9.00);
   INTERZONE PARTITIONS :
     STARTING AT(0.00, 0.00, 0.00)
     FACING(180.00)
     TILTED(90.00)
     PT19 (16.50 BY 9.00)
     ADJACENT TO ZONE (1),
     STARTING AT(16.50, 0.00, 0.00)
     FACING(180.00)
     TILTED(90.00)
     PT19 (13.50 BY 9.00)
     ADJACENT TO ZONE (2),
     STARTING AT(30.00, 0.00, 0.00)
     FACING(90.00)
     TILTED(90.00)
     PT19 (4.00 BY 9.00)
     ADJACENT TO ZONE (2),
     STARTING AT(30.00, 4.00, 0.00)
     FACING(90.00)
     TILTED(90.00)
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      PT19 (11.00 BY 9.00)
      ADJACENT TO ZONE (3),
      STARTING AT(30.00, 15.00, 0.00)
      FACING(0.00)
      TILTED(90.00)
      WALL-12 (30.00 BY 9.00)
      ADJACENT TO ZONE (7);
    SLAB ON GRADE FLOORS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(180.00)
      FL18 (15.00 BY 30.00);
    INTERZONE CEILINGS :
      STARTING AT(0.00, 0.00, 9.00)
      FACING(180.00)
      TILTED(0.00)
      CEILING (30.00 BY 15.00)
      ADJACENT TO ZONE (12);
    CONTROLS=HEAT ,
              4.84 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 01JAN THRU 15MAY;
    CONTROLS=COOL ,
               0.000 HEATING, 10.152 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16MAY THRU 15OCT;
    CONTROLS=HEAT ,
              4.84 HEATING, 0.0 COOLING,
        0.00 PERCENT RADIANT,
      FROM 16OCT THRU 31DEC;
    PEOPLE=2,OFFICE OCCUPANCY ,
      AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
      FROM 01JAN THRU 31DEC;
    LIGHTS=3.48,OFFICE OCCUPANCY ,
     0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
   INFILTRATION=2.3,CONSTANT,
           WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                  FROM 01JAN THRU 31DEC;
     ELECTRIC EQUIPMENT=.6, OFFICE OCCUPANCY,
                        0.0 PERCENT RADIANT,
              0.0 PERCENT LATENT, 0.0 PERCENT LOST,
              FROM 01JAN THRU 31 DEC;
  END ZONE;
  ZONE 7 "AHU-3 Z1&2 ":
    ORIGIN:(0.00, 39.00, 0.00);
    NORTH AXIS=0.00;
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EXTERIOR WALLS :
  STARTING AT(0.00, 38.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  EX99 (38.00 BY 9.00),
  STARTING AT(71.00, 38.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 9.00)
    WITH WINGS (9.00 BY 3.50)
      AT (71.00, 0.00)
    WITH DOORS OF TYPE
    ALD (6.33 BY 7.16)
      AT (12.00, 0.00)
    WITH DOORS OF TYPE
    ALD (6.33 BY 7.16)
      AT (56.00, 0.00);
INTERZONE PARTITIONS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (30.00 BY 9.00)
  ADJACENT TO ZONE (6),
  STARTING AT(30.00, 0.00, 0.00)
  FACING(180.00)
  TILTED(90.00)
  WALL-12 (41.00 BY 9.00)
  ADJACENT TO ZONE (3),
  STARTING AT(71.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (16.00 BY 9.00)
  ADJACENT TO ZONE (10),
  STARTING AT(71.00, 16.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (22.00 BY 9.00)
  ADJACENT TO ZONE (11);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (38.00 BY 71.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (71.00 BY 38.00)
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    ADJACENT TO ZONE (12);
  INTERNAL MASS: PT19
    ( 361.00 BY 2.00);
  CONTROLS=HEAT ,
             40.1 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 01JAN THRU 15MAY;
  CONTROLS=COOL ,
             0.000 HEATING, 57.526 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16MAY THRU 15OCT;
  CONTROLS=HEAT ,
             40.10 HEATING, 0.0 COOLING,
      0.00 PERCENT RADIANT,
    FROM 16OCT THRU 31DEC;
  LIGHTS=17.27,CLASS ,
  0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
  20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
    FROM 01JAN THRU 31DEC;
  PEOPLE=30,CLASS,
     AT ACTIVITY LEVEL 0.64, 70 PERCENT RADIANT,
     FROM 01 JAN THRU 31 DEC;
   VENTILATION=2428., CONSTANT, 73 MIN TEMP,
              0. DEL TEMP, FROM 01JAN THRU 15MAY;
   VENTILATION=2428., CONSTANT, 73 MIN TEMP,
              0. DEL TEMP, FROM 15OCT THRU 31DEC;
  INFILTRATION=35.5,CONSTANT,
       WITH COEFFICIENTS(.606,.0202,.000598,0.0),
               FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 8 "AHU-1 Z3 ":
  ORIGIN:(148.00, 24.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(30.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (15.00 BY 9.00);
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    PT19 (13.50 BY 9.00)
    ADJACENT TO ZONE (4),
    STARTING AT(13.50, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    PT19 (16.50 BY 9.00)
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   ADJACENT TO ZONE (5),
   STARTING AT(30.00, 15.00, 0.00)
   FACING(0.00)
   TILTED(90.00)
   WALL-12 (30.00 BY 9.00)
   ADJACENT TO ZONE (9),
   STARTING AT(0.00, 15.00, 0.00)
   FACING(270.00)
   TILTED(90.00)
   PT19 (11.00 BY 9.00)
   ADJACENT TO ZONE (3),
   STARTING AT(0.00, 4.00, 0.00)
   FACING(270.00)
   TILTED(90.00)
   PT19 (4.00 BY 9.00)
   ADJACENT TO ZONE (4);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (15.00 BY 30.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (30.00 BY 15.00)
  ADJACENT TO ZONE (12);
CONTROLS=HEAT ,
             4.84 HEATING, 0.0 COOLING,
     0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
              0.000 HEATING, 15.566 COOLING,
     0.00 PERCENT RADIANT,
  FROM 16MAY THRU 15OCT;
CONTROLS=HEAT ,
             4.84 HEATING, 0.0 COOLING,
     0.00 PERCENT RADIANT,
  FROM 16OCT THRU 31DEC;
PEOPLE=6,MEETING ,
AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
FROM 01JAN THRU 31DEC;
LIGHTS=3.48,MEETING,
0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
  FROM 01JAN THRU 31DEC;
 INFILTRATION=2.3,CONSTANT,
     WITH COEFFICIENTS(.606,.0202,.000598,0.0),
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                  FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 9 "AHU-1 Z1&2 ":
  ORIGIN:(107.00, 39.00, 0.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(71.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX99 (38.00 BY 9.00),
    STARTING AT(71.00, 38.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX99 (71.00 BY 9.00)
      WITH WINGS (9.00 BY 3.50)
        AT (0.00, 0.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (9.00, 0.00)
      WITH DOORS OF TYPE
      ALD (6.33 BY 7.16)
        AT (53.00, 0.00);
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    WALL-12 (41.00 BY 9.00)
    ADJACENT TO ZONE (3),
    STARTING AT(41.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    WALL-12 (30.00 BY 9.00)
    ADJACENT TO ZONE (8),
    STARTING AT(0.00, 38.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (22.00 BY 9.00)
    ADJACENT TO ZONE (11),
    STARTING AT(0.00, 16.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    PT19 (16.00 BY 9.00)
    ADJACENT TO ZONE (10);
  SLAB ON GRADE FLOORS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(180.00)
    FL18 (38.00 BY 71.00);
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   INTERZONE CEILINGS :
     STARTING AT(0.00, 0.00, 9.00)
     FACING(180.00)
     TILTED(0.00)
     CEILING (71.00 BY 38.00)
     ADJACENT TO ZONE (12);
   INTERNAL MASS: PT19
     ( 361.00 BY 2.00);
   CONTROLS=HEAT ,
              40.10 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
     FROM 01JAN THRU 15MAY;
   CONTROLS=COOL ,
              0.000 HEATING, 52.111 COOLING,
       0.00 PERCENT RADIANT,
     FROM 16MAY THRU 15OCT;
   CONTROLS=HEAT ,
              40.1 HEATING, 0.0 COOLING,
       0.00 PERCENT RADIANT,
     FROM 16OCT THRU 31DEC;
   PEOPLE=6,OFFICE OCCUPANCY ,
     AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
     FROM 01JAN THRU 31DEC;
   LIGHTS=17.27,OFFICE OCCUPANCY ,
    0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
     FROM 01JAN THRU 31DEC;
    VENTILATION=2428., CONSTANT, 73 MIN TEMP,
               0. DEL TEMP, FROM 01JAN THRU 15MAY;
    VENTILATION=2428., CONSTANT, 73 MIN TEMP,
               0. DEL TEMP, FROM 15OCT THRU 31DEC;
    INFILTRATION=35.5,CONSTANT,
        WITH COEFFICIENTS(.606,.0202,.000598,0.0),
                FROM 01JAN THRU 31DEC;
    ELECTRIC EQUIPMENT=.9, OFFICE OCCUPANCY,
                       0.0 PERCENT RADIANT,
            0.0 PERCENT LATENT, 0.0 PERCENT LOST,
            FROM 01JAN THRU 31 DEC;
END ZONE;
ZONE 10 "RESTROOMS ":
  ORIGIN:(71.00, 39.00, 0.00);
  NORTH AXIS=0.00;
  INTERZONE PARTITIONS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    WALL-12 (36.00 BY 9.00)
    ADJACENT TO ZONE (3),
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  STARTING AT(36.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(90.00)
  PT19 (16.00 BY 9.00)
  ADJACENT TO ZONE (9),
  STARTING AT(36.00, 16.00, 0.00)
  FACING(0.00)
  TILTED(90.00)
  PT19 (36.00 BY 9.00)
  ADJACENT TO ZONE (11),
  STARTING AT(0.00, 16.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  PT19 (16.00 BY 9.00)
  ADJACENT TO ZONE (7);
SLAB ON GRADE FLOORS :
  STARTING AT(0.00, 0.00, 0.00)
  FACING(90.00)
  TILTED(180.00)
  FL18 (16.00 BY 36.00);
INTERZONE CEILINGS :
  STARTING AT(0.00, 0.00, 9.00)
  FACING(180.00)
  TILTED(0.00)
  CEILING (36.00 BY 16.00)
  ADJACENT TO ZONE (12);
INTERNAL MASS: PT19
  ( 390.00 BY 2.00);
CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 01JAN THRU 15MAY;
CONTROLS=COOL ,
           0.000 HEATING, 0.001 COOLING,
    0.00 PERCENT RADIANT,
  FROM 16MAY THRU 15OCT;
CONTROLS=HEAT ,
           0.000 HEATING, 0.0 COOLING,
    0.00 PERCENT RADIANT,
  FROM 16OCT THRU 31DEC;
PEOPLE=1,OFFICE OCCUPANCY ,
  AT ACTIVITY LEVEL 0.64, 70.00 PERCENT RADIANT,
  FROM 01JAN THRU 31DEC;
MIXING=900.00,CONSTANT ,
  FROM ZONE 3, 0.00 DEL TEMP,
  FROM 01JAN THRU 31DEC;
LIGHTS=2.63,CONSTANT,
0.00 PERCENT RETURN AIR, 20.00 PERCENT RADIANT,
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    20.00 PERCENT VISIBLE, 0.00 PERCENT REPLACEABLE,
      FROM 01JAN THRU 31DEC;
BASEBOARD HEATING=(3.99 AT 0.,1.22 AT 65.),CONSTANT,
       0. PERCENT RADIANT, FROM 01FEB THRU 31MAR;
  END ZONE;
  ZONE 11 "MECHANICAL ROOM ":
    ORIGIN:(71.00, 55.00, 0.00);
    NORTH AXIS=0.00;
    EXTERIOR WALLS :
      STARTING AT(36.00, 22.00, 0.00)
      FACING(0.00)
      TILTED(90.00)
      EX99 (36.00 BY 10.00)
        WITH DOORS OF TYPE
        ALD (6.33 BY 7.16)
          AT (10.00, 0.00),
      STARTING AT(36.00, 22.00, 10.00)
      FACING(0.00)
      TILTED(90.00)
      EX98 (36.00 BY 2.50);
    INTERZONE PARTITIONS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(180.00)
      TILTED(90.00)
      PT19 (36.00 BY 9.00)
      ADJACENT TO ZONE (10),
      STARTING AT(36.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(90.00)
      PT19 (22.00 BY 9.00)
      ADJACENT TO ZONE (9),
      STARTING AT(0.00, 22.00, 0.00)
      FACING(270.00)
      TILTED(90.00)
      PT19 (22.00 BY 9.00)
      ADJACENT TO ZONE (7);
    SLAB ON GRADE FLOORS :
      STARTING AT(0.00, 0.00, 0.00)
      FACING(90.00)
      TILTED(180.00)
      FL18 (22.00 BY 36.00);
    ROOFS :
      STARTING AT(0.00, 0.00, 12.50)
      FACING(180.00)
      TILTED(0.00)
      RF99 (36.00 BY 22.00);
     INFILTRATION=15.3,CONSTANT,
       WITH COEFFICIENTS(.606,.0202,.000598,0.0),
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                FROM 01JAN THRU 31DEC;
   ELECTRIC EQUIPMENT=7.5,CONSTANT,
                  0.0 PERCENT RADIANT,
            0.0 PERCENT LATENT, 0.0 PERCENT LOST,
            FROM 01JAN THRU 31 DEC;
   CROSS MIXING=9900,CONSTANT,FROM ZONE 12,
            0.0 DEL TEMP,
            FROM 01 JAN THRU 31DEC;
   CONTROLS=HEAT2,10.6 HEATING,0.0 COOLING,
            0.0 PERCENT RADIANT,
            FROM 01JAN THRU 31DEC;
END ZONE;
ZONE 12 "CEILING PLENUM ":
  ORIGIN:(0.00, 0.00, 10.00);
  NORTH AXIS=0.00;
  EXTERIOR WALLS :
    STARTING AT(0.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX98 (57.00 BY 2.50),
    STARTING AT(57.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX98 (28.00 BY 2.50),
    STARTING AT(57.00, 28.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX98 (64.00 BY 2.50),
    STARTING AT(121.00, 28.00, 0.00)
    FACING(270.00)
    TILTED(90.00)
    EX98 (28.00 BY 2.50),
    STARTING AT(121.00, 0.00, 0.00)
    FACING(180.00)
    TILTED(90.00)
    EX98 (57.00 BY 2.50),
    STARTING AT(178.00, 0.00, 0.00)
    FACING(90.00)
    TILTED(90.00)
    EX98 (77.00 BY 2.50),
    STARTING AT(178.00, 77.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX98 (71.00 BY 2.50),
    STARTING AT(71.00, 77.00, 0.00)
    FACING(0.00)
    TILTED(90.00)
    EX98 (71.00 BY 2.50),
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  STARTING AT(0.00, 77.00, 0.00)
  FACING(270.00)
  TILTED(90.00)
  EX98 (77.00 BY 2.50),
  STARTING AT(0.00, 0.00, -1.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (57.00 BY 1.00),
  STARTING AT(57.00, 0.00, -1.00)
  FACING(90.00)
  TILTED(90.00)
  EX99 (28.00 BY 1.00),
  STARTING AT(57.00, 28.00, -1.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (64.00 BY 1.00),
  STARTING AT(121.00, 28.00, -1.00)
  FACING(270.00)
  TILTED(90.00)
  EX99 (28.00 BY 1.00),
  STARTING AT(121.00, 0.00, -1.00)
  FACING(180.00)
  TILTED(90.00)
  EX99 (57.00 BY 1.00),
  STARTING AT(178.00, 0.00, -1.00)
  FACING(90.00)
  TILTED(90.00)
  EX99 (77.00 BY 1.00),
  STARTING AT(178.00, 77.00, -1.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 1.00),
  STARTING AT(71.00, 77.00, -1.00)
  FACING(0.00)
  TILTED(90.00)
  EX99 (71.00 BY 1.00),
  STARTING AT(0.00, 77.00, -1.00)
  FACING(270.00)
  TILTED(90.00)
  EX99 (77.00 BY 1.00);
INTERZONE FLOORS :
  STARTING AT(0.00, 0.00, -1.00)
  FACING(90.00)
  TILTED(180.00)
  CEILINGS (24.00 BY 16.50)
  ADJACENT TO ZONE (1),
  STARTING AT(16.50, 0.00, -1.00)
  FACING(90.00)
```

```
TILTED(180.00)
CEILINGS (24.00 BY 13.50)
ADJACENT TO ZONE (2),
STARTING AT(30.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (28.00 BY 27.00)
ADJACENT TO ZONE (2),
STARTING AT(30.00, 28.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (11.00 BY 118.00)
ADJACENT TO ZONE (3),
STARTING AT(121.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (28.00 BY 27.00)
ADJACENT TO ZONE (4),
STARTING AT(148.00, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 13.50)
ADJACENT TO ZONE (4),
STARTING AT(161.50, 0.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (24.00 BY 16.50)
ADJACENT TO ZONE (5),
STARTING AT(0.00, 24.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (15.00 BY 30.00)
ADJACENT TO ZONE (6),
STARTING AT(0.00, 39.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (38.00 BY 71.00)
ADJACENT TO ZONE (7),
STARTING AT(148.00, 24.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (15.00 BY 30.00)
ADJACENT TO ZONE (8),
STARTING AT(107.00, 39.00, -1.00)
FACING(90.00)
TILTED(180.00)
CEILINGS (38.00 BY 71.00)
ADJACENT TO ZONE (9),
```

```
        STARTING AT(71.00, 39.00, -1.00)
        FACING(90.00)
        TILTED(180.00)
        CEILINGS (16.00 BY 36.00)
        ADJACENT TO ZONE (10);
      ROOFS :
        STARTING AT(0.00, 0.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (57.00 BY 28.00),
        STARTING AT(121.00, 0.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (57.00 BY 28.00),
        STARTING AT(0.00, 28.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (178.00 BY 27.00),
        STARTING AT(107.00, 55.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (71.00 BY 22.00),
        STARTING AT(107.00, 55.00, 2.50)
        FACING(180.00)
        TILTED(0.00)
        RF99 (71.00 BY 22.00);
  ELECTRIC EQUIPMENT=4.8,CONSTANT, 0.0 PERCENT RADIANT,
              0.0 PERCENT LATENT, 100.0 PERCENT LOST,
              FROM 01JAN THRU 31 DEC;
    END ZONE;
END BUILDING DESCRIPTION;
BEGIN FAN SYSTEM DESCRIPTION;
  MULTIZONE SYSTEM 1
  "AIR HANDLER NUMBER 1 " SERVING ZONES 8,9;
  FOR ZONE 8:
  SUPPLY AIR VOLUME=550.;
  END ZONE;
  FOR ZONE 9:
  EXHAUST AIR VOLUME=1100.;
  SUPPLY AIR VOLUME=2060.;
  END ZONE;
    OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=1.7663;
      SUPPLY FAN EFFICIENCY=.6;
      EXHAUST FAN PRESSURE=0.0;
      EXHAUST FAN EFFICIENCY=1.0;
      RETURN FAN PRESSURE=0.0;
      RETURN FAN EFFICIENCY=1.0;
```

```
  COLD DECK CONTROL=FIXED SET POINT;
  COLD DECK TEMPERATURE=55.5;
  COLD DECK THROTTLING RANGE=10.;
  HEATING COIL ENERGY SUPPLY=HOT WATER;
  HEATING COIL CAPACITY=35.0;
  HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
  HOT DECK CONTROL SCHEDULE=(135 AT 20, 90 AT 65);
  HOT DECK THROTTLING RANGE=10.;
  MIXED AIR CONTROL=TEMPERATURE ECONOMY CYCLE;
  DESIRED MIXED AIR TEMPERATURE=55.;
  OUTSIDE AIR VOLUME=2610.;
  PREHEAT COIL LOCATION=NONE;
  HUMIDIFIER TYPE=NONE;
  COOLING SAT DIFFERENCE=20.;
  HEATING SAT DIFFERENCE=40.;
  AIR VOLUME COEFFICIENT=1.0;
END OTHER SYSTEM PARAMETERS;
COOLING COIL DESIGN PARAMETERS:
   COIL TYPE = CHILLED WATER;
   AIR VOLUME FLOW RATE=2610.;
   BAROMETRIC PRESSURE=407.;
   AIR FACE VELOCITY=490.;
   ENTERING AIR DRY BULB TEMPERATURE=84.3;
   ENTERING AIR WET BULB TEMPERATURE=68.6;
   LEAVING AIR DRY BULB TEMPERATURE=55.5;
   LEAVING AIR WET BULB TEMPERATURE=54.0;
   ENTERING WATER TEMPERATURE=44.0;
   LEAVING WATER TEMPERATURE=55.;
   WATER VOLUME FLOW RATE=3.;
   WATER VELOCITY=275.;
END COOLING COIL DESIGN PARAMETERS;
EQUIPMENT SCHEDULES:
SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
  EXHAUST FAN OPERATION=OFF,FROM 01JAN THRU 31DEC;
  PREHEAT COIL OPERATION=OFF,
                FROM 01 JAN THRU 31DEC;
  HEATING COIL OPERATION=ON,
                FROM 01JAN THRU 15MAY;
  HEATING COIL OPERATION=OFF,
                FROM 16MAY THRU 15OCT;
  HEATING COIL OPERATION=ON,
                FROM 16OCT THRU 31DEC;
  COOLING COIL OPERATION=OFF,
                FROM 01JAN THRU 15MAY;
  COOLING COIL OPERATION=ON,
                FROM 16MAY THRU 15OCT;
  COOLING COIL OPERATION=OFF,
                FROM 16OCT THRU 31DEC;
```

```
    HUMIDIFIER OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    HEAT RECOVERY OPERATION=OFF,
                    FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=MINAIR,
                    FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=CONSTANT,
                    FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                    FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
END SYSTEM;
MULTIZONE SYSTEM 2
"AIR HANDLER NUMBER 2 "
               SERVING ZONES 1,2,3,4,5,10,12;
FOR ZONE 1:
SUPPLY AIR VOLUME=1010.;
END ZONE;
FOR ZONE 2:
SUPPLY AIR VOLUME=1080.;
END ZONE;
FOR ZONE 3:
SUPPLY AIR VOLUME=740.;
END ZONE;
FOR ZONE 4:
SUPPLY AIR VOLUME=1360.;
END ZONE;
FOR ZONE 5:
SUPPLY AIR VOLUME=660.;
END ZONE;
FOR ZONE 10:
SUPPLY AIR VOLUME=1.0;
END ZONE;
FOR ZONE 12:
SUPPLY AIR VOLUME=1.0;
END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=3.32;
    SUPPLY FAN EFFICIENCY=.6;
    EXHAUST FAN PRESSURE=0.0;
    EXHAUST FAN EFFICIENCY=1.0;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=1.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=63.;
    COLD DECK THROTTLING RANGE=10.;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=35.0;
```

```
  HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
  HOT DECK CONTROL SCHEDULE=
                (135 AT 20, 90 AT 65);
  HOT DECK THROTTLING RANGE=10.;
  MIXED AIR CONTROL=FIXED AMOUNT;
  PREHEAT COIL LOCATION=NONE;
  HUMIDIFIER TYPE=NONE;
  COOLING SAT DIFFERENCE=20.;
  HEATING SAT DIFFERENCE=40.;
  AIR VOLUME COEFFICIENT=1.0;
  OUTSIDE AIR VOLUME=200.;
END OTHER SYSTEM PARAMETERS;
COOLING COIL DESIGN PARAMETERS:
   COIL TYPE = CHILLED WATER;
   AIR VOLUME FLOW RATE=4850.;
   BAROMETRIC PRESSURE=407.;
   AIR FACE VELOCITY=490.;
   ENTERING AIR DRY BULB TEMPERATURE=79.9;
   ENTERING AIR WET BULB TEMPERATURE=66.1;
   LEAVING AIR DRY BULB TEMPERATURE=58.5;
   LEAVING AIR WET BULB TEMPERATURE=57.5;
   ENTERING WATER TEMPERATURE=44.0;
   LEAVING WATER TEMPERATURE=55.;
   WATER VOLUME FLOW RATE=3.4;
   WATER VELOCITY=275.;
END COOLING COIL DESIGN PARAMETERS;
EQUIPMENT SCHEDULES:
  SYSTEM OPERATION=OFF,
                FROM 01JAN THRU 15MAY;
  SYSTEM OPERATION=ON,
                FROM 16MAY THRU 15OCT;
  SYSTEM OPERATION=OFF,
                FROM 16OCT THRU 31DEC;
  EXHAUST FAN OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  PREHEAT COIL OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  HEATING COIL OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  COOLING COIL OPERATION=OFF,
                FROM 01JAN THRU 15MAY;
  COOLING COIL OPERATION=ON,
                FROM 16MAY THRU 15OCT;
  COOLING COIL OPERATION=OFF,
                FROM 16OCT THRU 31DEC;
  HUMIDIFIER OPERATION=OFF,
                FROM 01JAN THRU 31DEC;
  HEAT RECOVERY OPERATION=OFF,
```

```
                    FROM 01JAN THRU 31DEC;
    MINIMUM VENTILATION SCHEDULE=CONSTANT,
                    FROM 01JAN THRU 31DEC;
    MAXIMUM VENTILATION SCHEDULE=CONSTANT,
                    FROM 01JAN THRU 31DEC;
    SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                    FROM 01JAN THRU 31DEC;
  END EQUIPMENT SCHEDULES;
END SYSTEM;
MULTIZONE SYSTEM 3
"AIR HANDLER NUMBER 3 " SERVING ZONES 6,7;
FOR ZONE 6:
SUPPLY AIR VOLUME=550.;
END ZONE;
FOR ZONE 7:
SUPPLY AIR VOLUME=2060.;
EXHAUST AIR VOLUME=1100.;
END ZONE;
  OTHER SYSTEM PARAMETERS:
    SUPPLY FAN PRESSURE=1.745;
    SUPPLY FAN EFFICIENCY=.6;
    EXHAUST FAN PRESSURE=0.0;
    EXHAUST FAN EFFICIENCY=1.0;
    RETURN FAN PRESSURE=0.0;
    RETURN FAN EFFICIENCY=1.0;
    COLD DECK CONTROL=FIXED SET POINT;
    COLD DECK TEMPERATURE=55.5;
    COLD DECK THROTTLING RANGE=10.;
    HEATING COIL ENERGY SUPPLY=HOT WATER;
    HEATING COIL CAPACITY=35.0;
    HOT DECK CONTROL=OUTSIDE AIR CONTROLLED;
    HOT DECK CONTROL SCHEDULE=
              (135 AT 20, 90 AT 65);
    HOT DECK THROTTLING RANGE=10.;
    MIXED AIR CONTROL=TEMPERATURE ECONOMY CYCLE;
    DESIRED MIXED AIR TEMPERATURE=55.;
    OUTSIDE AIR VOLUME=2610.;
    PREHEAT COIL LOCATION=NONE;
    HUMIDIFIER TYPE=NONE;
    COOLING SAT DIFFERENCE=20.;
    HEATING SAT DIFFERENCE=40.;
    AIR VOLUME COEFFICIENT=1.0;
  END OTHER SYSTEM PARAMETERS;
  COOLING COIL DESIGN PARAMETERS:
     COIL TYPE = CHILLED WATER;
     AIR VOLUME FLOW RATE=2610.;
     BAROMETRIC PRESSURE=407.;
     AIR FACE VELOCITY=490.;
```

```
      ENTERING AIR DRY BULB TEMPERATURE=84.3;
      ENTERING AIR WET BULB TEMPERATURE=68.6;
      LEAVING AIR DRY BULB TEMPERATURE=55.5;
      LEAVING AIR WET BULB TEMPERATURE=54.0;
      ENTERING WATER TEMPERATURE=44.0;
      LEAVING WATER TEMPERATURE=55.;
      WATER VOLUME FLOW RATE=3.;
      WATER VELOCITY=275.;
   END COOLING COIL DESIGN PARAMETERS;
   EQUIPMENT SCHEDULES:
   SYSTEM OPERATION=ON,FROM 01JAN THRU 31DEC;
     EXHAUST FAN OPERATION=OFF,
                     FROM 01JAN THRU 31DEC;
     PREHEAT COIL OPERATION=OFF,
                     FROM 01 JAN THRU 31DEC;
     HEATING COIL OPERATION=ON,
                     FROM 01JAN THRU 15MAY;
     HEATING COIL OPERATION=OFF,
                     FROM 16MAY THRU 15OCT;
     HEATING COIL OPERATION=ON,
                     FROM 16OCT THRU 31DEC;
     COOLING COIL OPERATION=OFF,
                     FROM 01JAN THRU 15MAY;
     COOLING COIL OPERATION=ON,
                     FROM 16MAY THRU 15OCT;
     COOLING COIL OPERATION=OFF,
                     FROM 16OCT THRU 31DEC;
     HUMIDIFIER OPERATION=OFF,
                     FROM 01JAN THRU 31DEC;
     HEAT RECOVERY OPERATION=OFF,
                     FROM 01JAN THRU 31DEC;
     MINIMUM VENTILATION SCHEDULE=MINAIR,
                     FROM 01JAN THRU 31DEC;
     MAXIMUM VENTILATION SCHEDULE=CONSTANT,
                     FROM 01JAN THRU 31DEC;
     SYSTEM ELECTRICAL DEMAND SCHEDULE=OFF,
                     FROM 01JAN THRU 31DEC;
   END EQUIPMENT SCHEDULES;
 END SYSTEM;
   UNIT HEATER SYSTEM 4 "ZONE 11" SERVING ZONES 11;
     FOR ZONE 11:
     SUPPLY AIR VOLUME=550.;
     REHEAT CAPACITY=0.0;
     END ZONE;
    OTHER SYSTEM PARAMETERS:
     SUPPLY FAN PRESSURE=0.0;
     HEATING COIL ENERGY SUPPLY=HOT WATER;
     SUPPLY FAN EFFICIENCY=1.0;
```

```
        HEATING COIL CAPACITY=10.55;
        SYSTEM ELECTRICAL DEMAND=0.0;
        HEATING SAT DIFFERENCE=50.;
        AIR VOLUME COEFFICIENT=1.0;
       END OTHER SYSTEM PARAMETERS;
      EQUIPMENT SCHEDULES:
        SYSTEM OPERATION=OFF,
                        FROM 01JAN THRU 31DEC;
       END EQUIPMENT SCHEDULES;
        END SYSTEM;
  END FAN SYSTEM DESCRIPTION;
END INPUT;
```

Appendix E

Program to Convert Weather to TRY Format

```
PROGRAM CONVSUM
C     THIS PROGRAM TAKES THE WEATHER DATA IN THE
C     FORMAT COMPILED
C     AT FT. RILEY KANSAS AND CONVERTS IT TO
C     A FORMAT THAT IS THE SAME AS AN ASHRAE TRY TAPE.
C
C     THIS VERSION IS FOR THE SUMMER MONTHS
C
      DIMENSION IDUM1(6),IDUM2(2),CARDS(192)
      INTEGER HOR,HOUR
      DATA IDUM1/99999,99999,99999,99999,99999,99999/
      DATA IZERO/0/
      DATA ISTAN/11111/
      OPEN (7,FILE='JUNE-CHW')
      OPEN (6,FILE='JUNE.TRY')
      DO 99 I=1,504
 1    READ(7,*)TIME,WINDV,WINDDR,DB,DEW,HRAD,P
      IF (TIME.EQ.0.0) GOTO 24
 3    CONTINUE
      IYEAR=1987
      HOR=INT(TIME*100.+.5)
      HOUR=HOR-INT(HOR/100)*100
      IHOUR=HOUR-1
      IDAY1=INT(TIME)
 2    IF(IDAY1.GT.181) GOTO 4
      MONTH=6
      IDAY=INT(TIME)-151
      GO TO 7
 4    IF(IDAY1.GT.212) GOTO 6
      MONTH=7
      IDAY=INT(TIME)-181
      GO TO 7
 6    MONTH=8
      IDAY=INT(TIME)-212
 7    CONTINUE
      IDB=999
      IWB=999
      IWINDDR=999
      IWINDV=999
      IPB=9999
      IRAD=9999
C   THE NEXT LINE CHECKS FOR A VALID WIND SPEED
      IF (WINDV.EQ.-1.0) GOTO 8
C   CONVERTS TO WIND VELOCITY IN KNOTS
```

```
      IWINDV=WINDV*.8684+0.5
8     CONTINUE
C   CHECK FOR VALID WIND DIRECTION
      IF (WINDDR.LT.0.0) GOTO 10
      IF (WINDDR.GT.360.) GOTO 10
      IWINDD=WINDDR
10    CONTINUE
C
C   CHECKING FOR VALID DRY BULB
C
      TEST1=1.0
      IF (DB.EQ.-100.) GOTO 12
      IDB=DB+.5
      TEST1=0.0
12    CONTINUE
C   IF DRY BULB, DEW POINT, OR BARROMETRIC PRESSURE
C   IS BAD, THEN THE
C   WET BULB CALCULATION WILL BE IN ERROR.
C
C   CHECKING FOR A VALID PRESSURE
      TEST2=1.0
      IF (P.EQ.0.0) GOTO 14
C   THE NEXT LINE CONVERTS THE PRESSURE IN MBAR TO IN HG
      PB=P*.030
      IPB=PB+0.5
      TEST2=0.0
14    CONTINUE
C
C   CHECKING FOR A VALID DEW POINT
      IF (DEW.EQ.-100.) GOTO 16
      TEST=TEST1+TEST2
      IF (TEST.GT.0.0) GOTO 16
      CALL WETBULB(DB,DEW,PB,WB)
      IWB=WB+.5
      IDP=DEW+0.5
16    CONTINUE
C   CHECK FOR VALID RADIATION
      IF (HRAD.EQ.-1.) GOTO 18
C   CONVERTS TO RADIATION IN LANGLEYS TO TENTHS
      IRAD=HRAD*60.*10.+0.5
18    CONTINUE
69    CONTINUE
 100  FORMAT(I5,5I3,I4,I1,6I5,I4,10X,I4,I2,I2,I2,1X)
      WRITE(6,100)ISTAN,IDB,IWB,IDP,IWINDD,IWINDV,IPB,
     &  IZERO,IDUM1,
     &  IRAD,IYEAR,
     & MONTH,IDAY,IHOUR
 99   CONTINUE
```

```
24    STOP
      END
C
C   SUBROUTINE WETBULB
      SUBROUTINE WETBULB(DB,DEW,PB,WB)
C
C   THIS SUBROUTINE CALCULATES A WET BULB TEMPERATURE
C   USING DRY BULB (DB), DEW POINT (DEW), AND BAROMETRIC
C   PRESSURE(PB).  THE EQUATIONS ARE FROM THE
C   ASHRAE FUNDAMENTALS, 1985.
C
C   AN INITIAL VALUE OF WB IS ASSUMED.  A NEW DEW POINT
C   IS THEN CALCULATED AND COMPARED WITH THE ACTUAL VALUE.
C   THE WET BULB VALUE IS THEN ADJUSTED AND DEW POINT
V   IS RECALCULATED.
C
      WB=DB
C   CALCULATING SATURATION PRESSURE AT T=WB
    DATA C1,C2,C3/-10214.16,-4.8932631,-.0053769056/
    DATA C4,C5,C6/.19202377E-6,.35575832E-9,.090344688E-12/
    DATA C7/4.1635019/
    DATA C8,C9,C10/-10440.4,-11.2946669,-0.02700133/
    DATA C11,C12,C13/.12897060E-4,-.2478068E-8,6.5459673/
  13  CONTINUE
      TR=WB+459.67
      IF (WB.GT.32.) GOTO 14
      PWSLN=(C1/TR)+C2+C3*TR+C4*TR*TR+C5*TR**3+C6*TR**4
      +C7*ALOG(TR)
      PWS=2.71828**PWSLN
      GO TO 15
  14  CONTINUE
      PWSLN=(C8/TR)+C9+C10*TR+C11*TR*TR+C12*TR**3
      +C13*ALOG(TR)
      PWS=2.71828**PWSLN
  15  CONTINUE
C  CONVERTING FROM PSIA TO IN-HG
      PWS=PWS*2.036
C  CALCULATING HUMIDITY RATIO (WSTAR) AT T=WB
      WSTAR=0.62198*PWS/(PB-PWS)
C  CALCULATING HUMIDITY RATIO (W)
      W=((1093.-.556*WB)*WSTAR-.24*(DB-WB))/(1093
      -(.444*DB)-WB)
C  CALCULATING PATRIAL PRESSURE OF WATER VAPOR (PW)
C     IN IN-HG
      PW=PB*W/(.62198+W)
C  CALCULATING NEW DEW POINT
      ALPHA=LOG(PW)
      IF (ALPHA.LT.-1.72168) GOTO 16
```

```
      DPNEW=79.047+30.579*ALPHA+1.8893*ALPHA**2
      GO TO 17
16    CONTINUE
      DPNEW=71.98+24.873*ALPHA+.8927*ALPHA**2
17    CONTINUE
C   COMPARING NEW DEW POINT WITH OLD.  IF OLD SMALLER,
C   REDUCE ESTIMATE OF WB BY 1/10 DEGREE AND TRY AGAIN.
      IF (DEW-DPNEW)18,19,19
18    WB=WB-.1
      GO TO 13
19    CONTINUE
      RETURN
      END
```

Appendix F

Determination of Outside Air Quantities

In order to determine quantities of outside air, it was necessary to perform a traverse of the three outside air supply ducts. A hot-wire anemometer manufactured by Thermal Systems, Inc., model 1650, was used for this purpose. The anemometer was calibrated in July 1987. The test was performed in October, 1987.

The anemometer used is directional so only the component of air flow parallel to the duct was measured. This was necessary because it was impossible to obtain a sufficient length of straight duct for the flow to stabilize.

The ducts for Air Handlers 1 and 3 are identical in area. They are 12-1/2 inches by 50-1/2 inches. The grid consisted of five divisions along the short dimension and nine along the long dimensions for a total of 45 data points. Spacing of the grid took into account the internal acoustic material thickness of two inches. The grid is shown in Figure F.1. Velocity measurements are shown in Table F.1 and F.2 for Air Handler 1 and 3 respectively.

The grid layout was not well conceived. The areas of the segments are not equal, so areas and flows had to be

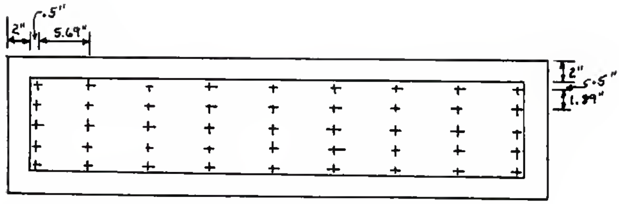

Figure F.1 Air Handler One and Three Outside Air Duct Traverse Grid

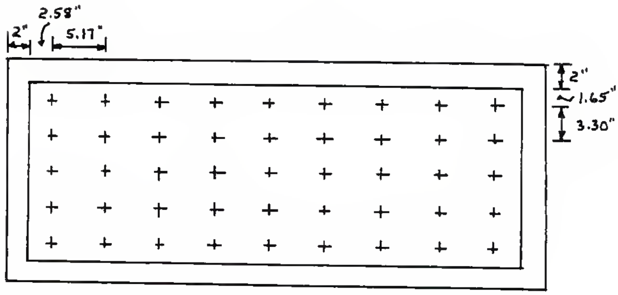

Figure F.1 Air Handler Three Outside Air Duct Traverse Grid calculated for each segment. The flows of each segment were then summed for the total outside air.

The grid for Air Handler 2 was designed to form equal area segments to simplify the calculations. The velocities were averaged and a total flow calculated. Velocities for each segment are shown in Table F.3.

The acoustical material presented some difficulty. It is not attached to the duct in all locations. Some of the data points actually represent air flow between the liner and the duct. In order to assure the flows were not leakages through the access holes, the holes were uncovered one at a time and the probe was sealed to the test hole with a rag.

Table F.2

Velocities in Fresh Air Duct No. 1

Feet per Minute

20	10	2	0	35	55	65	68	60
15	0	0	0	30	50	60	60	55
0	0	0	0	18	40	40	50	42
0	0	0	0	10	30	30	55	25
100	20	0	0	10	5	10	10	8

Table F.2

Velocities in Fresh Air Duct No. 3

Feet per Minute

5	5	8	25	45	45	40	37	30
12	5	2	30	50	42	38	38	20
10	4	2	30	35	43	30	36	12
5	5	5	28	18	25	18	20	5
3	5	2	3	12	5	5	5	5

Table F.3

Velocities in Fresh Air Duct No. 2

Feet per Minute

490	560	625	570	560	450	440	360	360
390	450	500	470	470	410	350	300	280
320	410	460	440	410	360	380	320	290
230	400	450	330	320	250	350	90	280
60	40	25	20	25	20	30	15	20

The fresh air volumes calculated from the velocities are shown in Table F.4.

Table F.4

Fresh Air Volumes

Air Handler	Flow - CFM
AHU-1	64
AHU-2	1703
AHU-3	59

Appendix G

Hourly Temperatures and Loads from BLAST

Temperature Histories

Hourly or daily temperatures are not normally provided as part of BLAST's output. Instead, the maximum and minimum temperatures are provided for each zone, along with the time and date of occurrence.

To obtain hourly temperatures for each zone, the Reports specification must read:

```
REPORTS(21,25);
```

This generates considerable output. One problem encountered was the typical user area on the Harris computer was too small to hold the output. Printing this volume of data would be futile. For a simulation covering 59 days, such as the winter simulation, there will be 1,416 hours of data, with 12 zones reported each hour. Additional user area was obtained for a short period to allow the following procedure.

To handle the volume of temperatures involved, a program was written that reads the output file and picks the temperatures of interest from the data, and writes only these temperatures to another file. In this case, only zones four and seven were monitored.

The file containing the temperatures of interest was down loaded from the Harris computer to a compatible desk top computing system for processing. Post processing of temperature data consisted of averaging the data for daily values as plotted on earlier figures.

Energy Histories

BLAST normally provides only monthly summaries of heating, cooling, and electrical energy use. To obtain hourly values, the Report specification must read:

```
REPORTS(59);
```

This cause an hourly dump of all system energy requirements. A data stripping program similar to the one described above was created to read the energy data and save the necessary information to another file. Again, post processing of the data was performed on a desk top computer.

Description and Validation of a Computer Modeled
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by

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B.S., University of Kansas, 1972

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Abstract

The Construction Engineering Research Laboratory is charged with improving the energy efficiency of new Army facilities. As part of this effort, they have initiated a project entitled "Design, Build, and Operate Energy Efficient Buildings" at Fort Riley, Kansas. One goal is to quantify that newly designed and constructed buildings use less energy than similar buildings built in the early seventies. Another goal is to determine the reasons for the improved efficiency of the new buildings.

As part of this project, building energy use data is being collected on two existing buildings. In addition, weather data for the site is being gathered. This thesis reports the development and validation of a model for one of the existing buildings that accurately predicts the energy use as compared to the monitored energy data.

The model was produced for the BLAST energy simulation program. Site gathered data on occupancy patterns, actual lighting levels and schedules, controls operation, and equipment operation was included in the model. Both winter and summer simulations were run using on-sit collected weather data. The model's energy use predictions were compared with the monitored energy use.

A second model was developed which represented design

characteristics of the building, lighting systems, controls, and equipment operation. This model was prepared for comparison to the newly constructed buildings. It was felt that design schedules and control profiles should be used in making the comparison to the newly constructed buildings rather than use a model that accounted for improper maintenance, calibration, and operation.

The models developed show promise in their ability to predict energy use in existing facilities. The use of such models will allow a determination of not only the magnitude of the energy savings but also will allow a determination of which changes in building design and operation have a significant affect on building energy use.