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Community Federal Office Center – A Unique HVAC System

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COMMUNITY FEDERAL OFFICE CENTER
A UNIQUE HVAC SYSTEM

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Abstract

The Heating, Ventilating, and Air Conditioning system for this ten (10) story (400,000 S.F.) office building is of unique design. The only form of heat in the building is 1400 radiant ceiling panels of 500 watts each located around the perimeter of the building. The supply air for cooling is controlled by a variable air volume system. This supply air is delivered to exterior and interior zones. Variable air volume boxes serve both of these zones and the boxes are controlled by wall mounted thermostats. These thermostats are located on a 30 foot by 30 foot grid system. With this type of control, the HVAC system is able to respond to heat loss or gain of the building due to weather, people, lights, and solar heat gain.

Edison Electric Institute AXCESS Energy Program was run on this building before it was built based on consulting engineers data. These estimated usages for lights and HVAC equipment are given in this paper. The actual metered usage will be compared to this estimated usage. Discussion has been included to explain the differences that exist.

1. INTRODUCTION

Community Federal Office Center is a ten (10) story, 400,000 s.f. office building. The architectural firm of Hellmuth, Obata and Kassabaum, Inc., placed the structural members on a 30 foot by 30 foot grid system. Exterior insulated wall and glass panels were built for these dimensions and hoisted into place. Wall U factors are 0.10 Btus/s.f./hr/°F. Reflective glass was not used but both vertical fins and horizontal over-hang were designed into the structure to provide solar shading in the summer time.

The Heating, Ventilating, and Air Conditioning system was designed to fit into this structural member grid system. The engineering firm of Hayakawa and Associates preformed this function.

2. THE HEATING SYSTEM

The sole source of heat for the building is 1400-500 watt radiant ceiling panels located around the perimeter exterior zones. These panels are two feet by four feet and fit into the ceiling grid system. The panels were sized to offset the heat loss of the wall and glass sections. Radiant energy that comes from the surface of these panels is in the 8-10 micron range and is absorbed by the glass. The watts density directly under the heater is 0.72 w/s.f. at a distance of six feet. Recording thermometers placed under these heaters showed very good temperature control.

The heating system as installed is a perimeter radiation system. Control of this system is provided by the wall mounted thermostats located at 30 foot intervals. One fail-safe control concept is that these heaters will not come on until the exterior zone supply air is zero. This prevents reheating and bucking of energy between the cooling and heating systems. The controlling device that accomplishes this control function is an electro-pneumatic switch located above the ceiling. A temperature control scheme of this type is very energy efficient and will provide good comfort conditions on the exterior zones. This type of control system, will sense the direction of heat flow gain, or loss, through the exterior wall. The HVAC system can respond to weather conditions and solar load by time of day.

3. THE COOLING SYSTEM

Cooling for the building is provided by a variable air volume system. There are four air handling units, two are located in the basement and two on the penthouse. The two in the basement serve floors 1 through 4 and the two in the penthouse floors 5 through 10. One of these air handlers supplies conditioned air to a series of variable air boxes on the exterior (15 feet) zone. The other air handler supplies air to the interior zone boxes. Each air handler has its own supply air fan located inside the ductwork. Return air fans are located outside the ductwork in the mechanical room.

Air is returned above the ceiling and up or down to the mechanical rooms through vertical chases. These return and supply air fans have inlet vanes that are controlled by static pressure devices located in the main ductwork. If thermostats are calling for cooling and have the boxes, either exterior or interior, open, partially or fully, the static pressure will drop below a control valve. This drop in static pressure is sensed and the inlet vanes will open to allow more air to flow. Conversely when the zone is partially or fully on heating, exterior zone only, the boxes will be closed and static pressure will increase above the control point and inlet vanes will close. The centrifugal fan curves indicate that fan horsepower will decrease when air flow decreases. There is a further energy saving design concept.

The cooling coil is located ahead of the supply air fan. The supply air temperature is maintained at 60°F. This is done with outside air if it is below 60°F. When outside air is above 60°F the quantity of outside air goes to a present minimum. With outside air at a minimum the chilled water coil cools the supply air to 60°F. Chilled water is supplied by two - 400 ton Trane centrifugal chillers. Control of the supply air temperature is accomplished by either face and bypasses dampers for supply fans 1 and 3, which serve the interior zones. Supply air temperature control for units 2 and 4 is accomplished by varying the quantity of chilled water going through the cooling coil.

The HVAC system has been in operation since last November (1977). There have been minor equipment problems but the system has worked well. A comparison should now be made to see how well the actual system is preforming energy-wise as compared to the computer estimate.

4. COMPARISON OF ACTUAL USAGE TO COMPUTER ESTIMATED USAGE

Edison Electric Institute's AXCESS Energy Program was used to estimate both lighting and HVAC energy for this building. Data for this study was furnished by Hayakawa and Associates. The results of this study are outlined in Table 1.

There are two loads that are estimated by this program. The base loads (lights, cooling, elevators, and power) are estimated to have a demand of 1185 Kw with a usage of 256,000 Kwhrs to 292,000 Kwhrs per month. HVAC loads are the perimeter ceiling heating panels, air handlers, pumps, air conditioning chillers, and water heaters. This usage varied with weather conditions and hours of operation of equipment.

Initially, the actual usage for both the lighting and HVAC didn't agree well with the estimated usage. Investigation into causes for these differences revealed the following facts. The hours use of lighting demand was quite high, over 500 hours use per month. The reason for this was the belief that lights had to be left on at night and weekends to help heat the building. A graph of lighting demands during the day is shown in Figure 1. This data was taken from actual metered data recorded on a magnetic tape metering device. The date of this data was January 24, 1978, a Tuesday. Lighting demand held constant at 413 Kw from midnight to 7 a.m. As the work day started, the lighting demand increased to 566 Kw at 11 a.m. and held constant to 5 p.m. As the work day ended, demand level dropped down to 413 Kw again at 10 p.m. and held constant until midnight.

After corrective action was taken to control the lights at nighttime, the lighting demands were again plotted for May 10, 1978, a Wednesday. This data is plotted in Figure 2. Peak demand has increased to 810 Kw due to more tenants occupying the building, but demand at night has dropped to 250 Kw. The initial pattern of high lighting demands also occurred on Saturday and Sunday when the building should have been unoccupied. It should be noted that all of the area under the curves represents electrical energy as Kwhrs. So reducing demands will conserve energy.

The lighting demand was lower than estimated, because the building was not fully occupied by tenants. Also, a lighting system design change, to task lighting, caused the lighting levels to be 1.75 w/s.f. instead of 3.0 w/s.f., as had originally been designed. Switches are installed on the lights that are located on desks and file cabinets so lights can be turned off when people are absent (vacation, etc), or the area is not being used for other reasons. There are no lights in the ceiling of this building.

The metered data for the HVAC meter showed that actual usage was twice the estimated usage. A calculation of hours use of the demands was near 700 hours/month. Again, plotting HVAC demands by hour of day and various days of the week showed high demands at night and weekends. The reason for this was the operation of the four air handlers to distribute heat from the lights. This was totally unnecessary and was stopped in March with a reduction of 480 Kw in HVAC demand at night and on weekends. This reduction in hours of operation of the supply fans saved approximately 160,000 Kwhrs per month. Note in Table 1 the close agreement between estimated and actual Kwhrs on the HVAC meter in April.

The lower lighting demand was due to the lower lighting levels that were installed. These lower lighting levels caused the HVAC demands to be lower in the summer since there wasn't as much lighting heat to be removed by the chiller.

5. CONCLUSIONS

The imaginative application of new heating sources by engineers can lead to energy efficient Heating, Ventilating, and Air Conditioning systems. Proper controls have to be designed to control the heating and cooling systems. Also operating personal have to know how the HVAC system works and how to use controls to control it. It is very beneficial to have had a computer program such as AXCESS run on a building of this size to have an idea of what actual metered usage should be. Monthly review of utility bills can show if energy is being used wisely and if demands and usage agree with computer program projections. When engineers become involved in building energy, they can see that it is used wisely and efficently.

BIOGRAPHY

Milton J. Murry is a Project Engineer in the Special Projects Division, Customer Service, at Union Electric. Here he makes computer energy studies for large and small commercial buildings. These studies are made for various types of Heating, Ventilating, and Air Conditioning systems. He earned a Bachelor of Science degree in Electrical Engineering from Missouri School of Mines and Metallurgy in 1964. He is a registered Professional Engineer in the state of Missouri.

ESTIMATED USAGE VERSUS ACTUAL USAGE

	Estimated Usage Axcess Energy Program				Actual Usage Metered Data			
	Lighting		HVAC		Lighting		HVAC	
Month	Demand	Kwhrs	Demand	Kwhrs	Demand	Kwhrs	Demand	Kwhrs
Jan.	1185	292,883	1206	296,026	560.6	282,000	835.4	563,200
Feb.	1185	266,071	1250	266,316	595.2	303,600	837.1	604,000
March	1185	281,050	1443	283,271	725.8	381,600	867.8	574,400
April	1185	291,834	1459	319,546	816.0	334,400	679.7	350,000
May	1185	281,046	1401	356,867	833.3	316,400	608.6	286,400
June	1185	280,000	1612	436,372	791.0	326,400	1167.4	412,800
July	1185	304,717	1623	471,237	817.9	308,000	1086.7	548,000
Aug.	1185	281,046	1680	448,682	785.3	300,000	1006.1	484,800
Sept.	1185	280,000	1599	378,016	796.8	323,200	1044.5	462,400

TABLE I

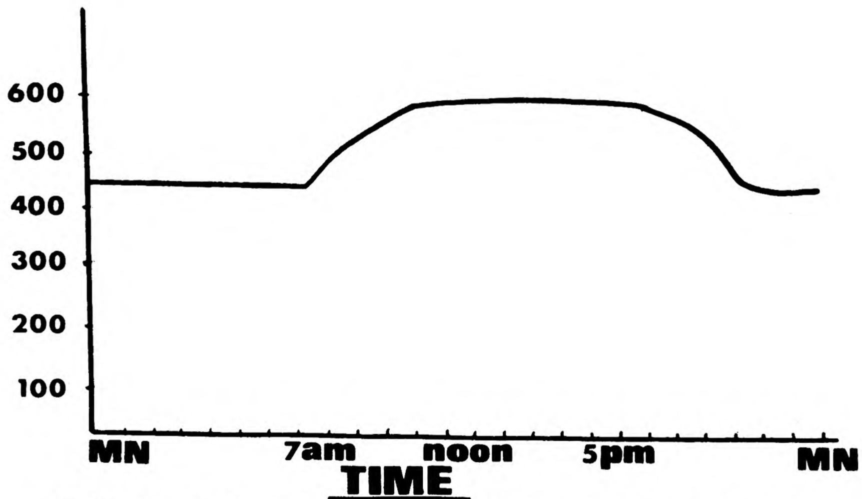

FIGURE I LIGHTING DEMANDS VERSUS TIME OF DAY
Tuesday 1/24/78, Before Reduced Night Time-Weekend Demands

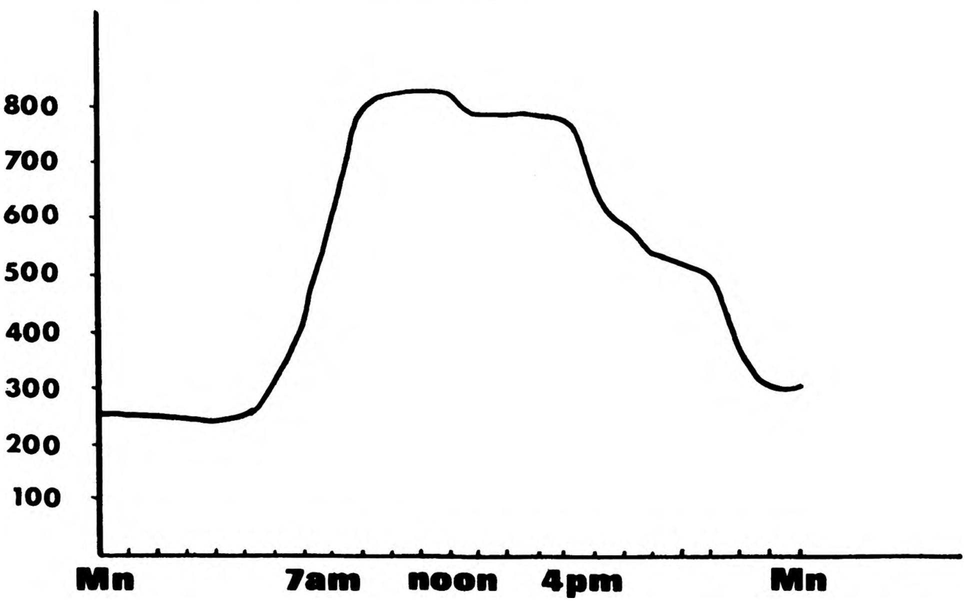

FIGURE 2 Lighting Demands Versus Time of Day - Wednesday 5/10/78 After Reduced Night Time Weekend Demands