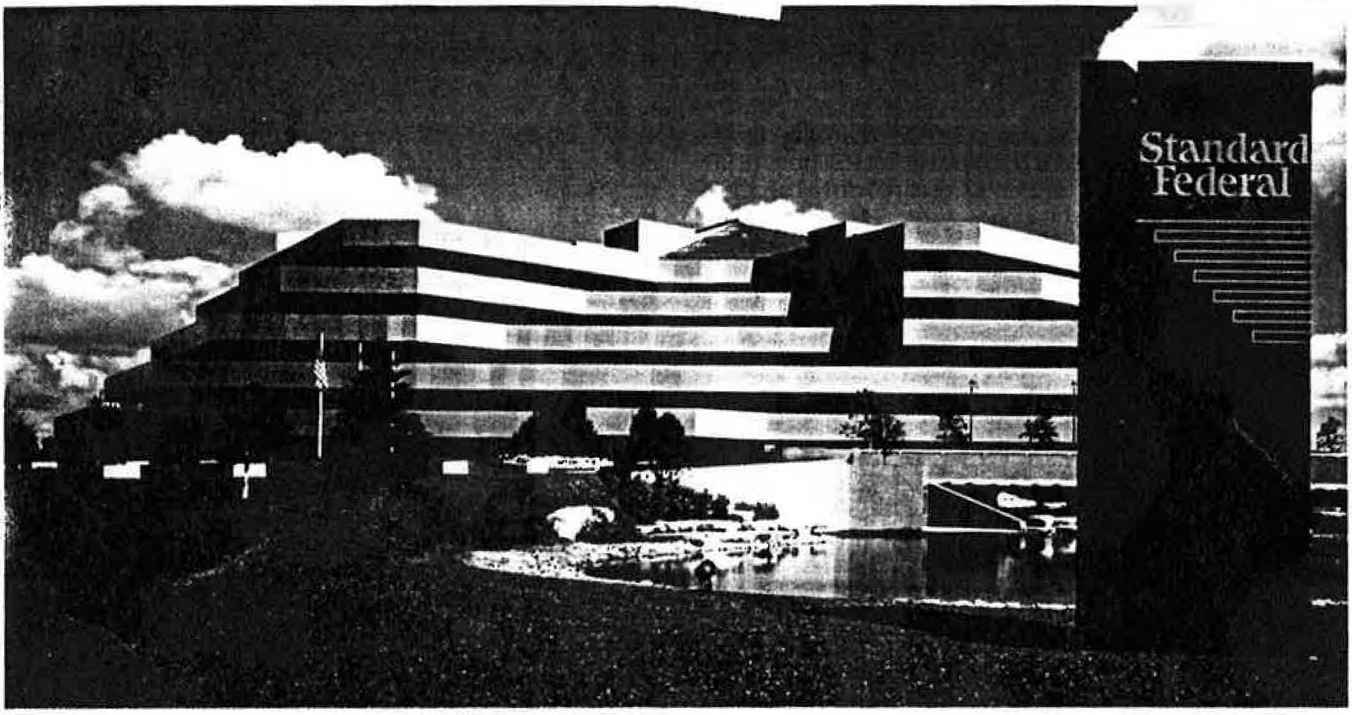


Standard Federal Bank Headquarters Building, Troy, Michigan

HVAC system combines constant air motion and thermal storage

This unique HVAC system provides a high quality indoor environment with cost efficient operations

The HVAC system for the Standard Federal Bank Headquarters Building was designed to provide a healthy, productive and profitable indoor environment for the bank's staff. High indoor air quality was the criteria used to develop an HVAC system able to meet the goals set for this project. While providing this high-quality environment, the building operating costs must be as low as possible on a long-term basis.

The issue of increased occupant productivity is currently being studied by researchers. However, a BOMA study identified that a building's HVAC system could increase occupant productivity by 18% if it provided the proper environment. This study was not scientific in nature, but it did show that building owners recognized the need for a high-quality environment.

As originally designed, the Standard Federal Bank building features 462,000 ft² [42,921 m²] on seven levels. The building skin was 2-in.-thick granite, and the building was insulated to a U of 0.06 Btu/sf/°F. The roof was a single membrane with a U of 0.05 Btu/sf/°F. The windows used were low-E, had a U of 0.38 Btu/sf/°F and had a shading coefficient of 0.33. A ceramic freit coating was used to reduce glare on VDT screens, which also reduced the solar load.

The building schedule was not typical for an office building. The bank's main data center was housed in this building and operated 24 hours per day, seven days per week. Check processing and security operated on multiple shifts and a full-service kitchen was also included in the design.

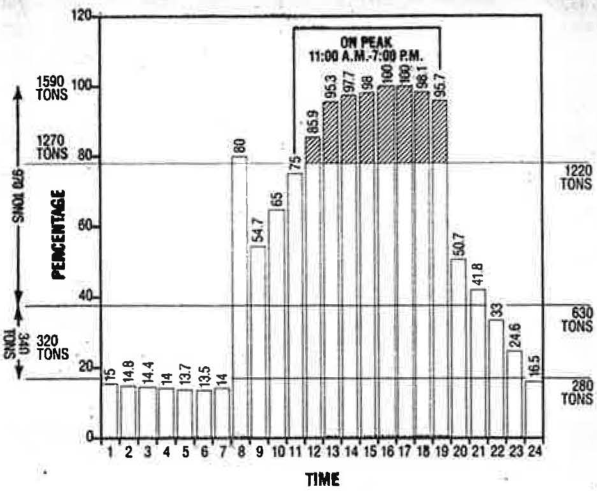


Figure 1. Peak cooling load profile.

After completing the heating and cooling load calculations, it became obvious that major opportunities were available to save operating costs. The cooling load had a high spike during the middle of the day, which made it a candidate for thermal storage (see *Figure 1*). The cooling load bottomed out at 280 tons (986 KW) year-round, which would allow for heat reclaim as a source for building and ventilation heating.

Project design

The criteria used to design the building's HVAC system were as follows:

- Constant air motion;
- Constant ventilation at proper rates;
- Reduction of microbiological contamination;
- Constant humidity levels;
- Constant low RC acoustic levels; and
- Reduction of drafts from the HVAC system.

The concept of constant air motion is somewhat counter to HVAC design in the last 15 years. However, it became apparent that constant air motion is necessary to achieve the desired environmental criteria. This building was designed to be safe for occupants in terms of fire safety. This required interior building materials to have low combustibility and low smoke generation. To achieve these goals, most building materials are treated with chemicals that have unknown effects on human health.

Because the HVAC design must accommodate current and future materials, it was decided that the only reliable way to keep occupants safe from these chemicals was to dilute them with air and remove the air from the building. The design was based on eight air changes per hour as acceptable to dilute potential contaminants.

Constant air motion is also helpful to human physiology as the human body rejects heat better when air is moving. This will help increase occupant productivity by allowing people to stay at a more constant body temperature.

Constant ventilation is a major element in a high-quality indoor environment. The ventilation code at the time of design was 5 cfm (2.5 L/s) per person. This code was felt to be totally inadequate and, after much research, the design was based on 25 cfm (12 L/s) per person.

Because the HVAC system was constant air motion, adding a constant ventilation system was very easy. The only penalty for the higher and constant ventilation was increased energy use. However, this issue was covered by more efficient use of building energy.

The reduction of microbiological contamination was studied. As determined, the best method to control microbiological contamination was to reduce the number of wet coils and filter all air downstream of these cooling coils. This building has only three wet coils for occupied areas, and all air discharged from these air handlers is filtered after the discharge to remove microbiological contaminants.

Occupant comfort is critical to productivity, and this HVAC system focuses on both temperature and humidity. The design temperature is 75°F (24°C) in the summer and 72°F (22°C) in the winter, with a tolerance of ±2°F (±1°C).

A study of human physiology showed that humidity is a very important aspect of comfort and, in some cases, can be as important as temperature. The design requirement for humidity is 50% maximum in the summer and 30% minimum in the winter. Also, humidity levels during any given day would not change more than 5% on that day.

HVAC system acoustics were an important aspect of a high-quality indoor environment. This building did not have a sound-masking system, so HVAC acoustics were very important. The design criteria was to have a NC 32 in open office areas and also in private offices. The sound levels must be constant with a ±1 NC change during any day. This task was simplified by using a constant air motion system.

Avoiding drafts was an important design consideration as drafts can affect the building staff's productivity. The design criteria was to keep the air discharged from diffusers at no lower than 60°F (16°C). This was a problem as 60°F (16°C) is above the dewpoint of the air identified in the design conditions.

Project implementation

The system selected to meet the design criteria is a constant volume coil terminal system. The system's basic operation begins with the constant air motion fan units that heat or cool the air to meet sensible space conditions. Axial flow fans move the air quietly and efficiently and, by controlling the sound at the source, kinetic floors are not required in the main fan rooms.

The outdoor primary air units introduce ventilation air to the fan units on a constant volume upstream of the filter units to remove any microbiological contaminants. This air is heated to 50°F (10°C) in the winter and is cooled to 45°F (7°C) in the summer (see *Figure 2*). During summer months, this 45°F (7°C) air has a very low humidity content, and provides the building with a constant dehumidification effect. During winter months, humidity is added by electric canister-type humidifiers to keep humidity levels at or above minimum.

A digital control system controls the temperature, humidity and system components. It allows operations staff to see and correct problems before they affect occupants. This system meets all the criteria set forth in the program. However, some of these concepts have an energy penalty in the use of primary energy.

To avoid the energy penalty and increased system operating costs, the heating and cooling effects were evaluated to find ways to reduce energy consumption. The increased ventilation raised the use of energy for heating outdoor air. However, the waste heat available in the building was sufficient to meet this increased heating load. Likewise, the increased ventilation would increase the cooling load, and the local electric utility had time-of-day rates, a demand charge and a ratchet clause.

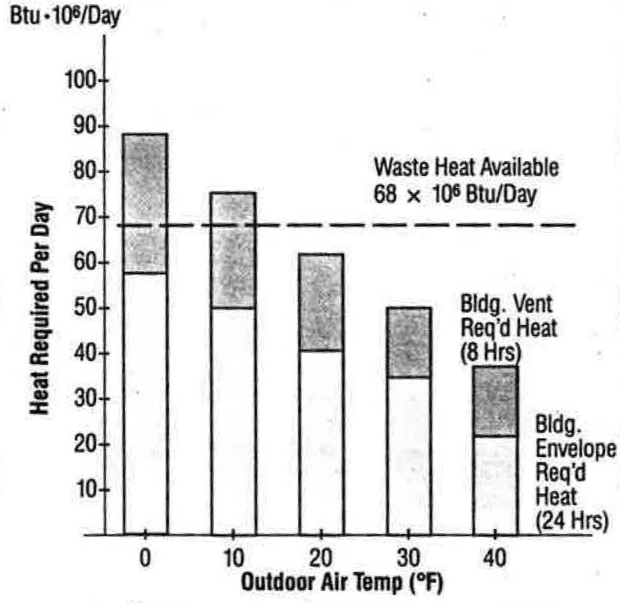
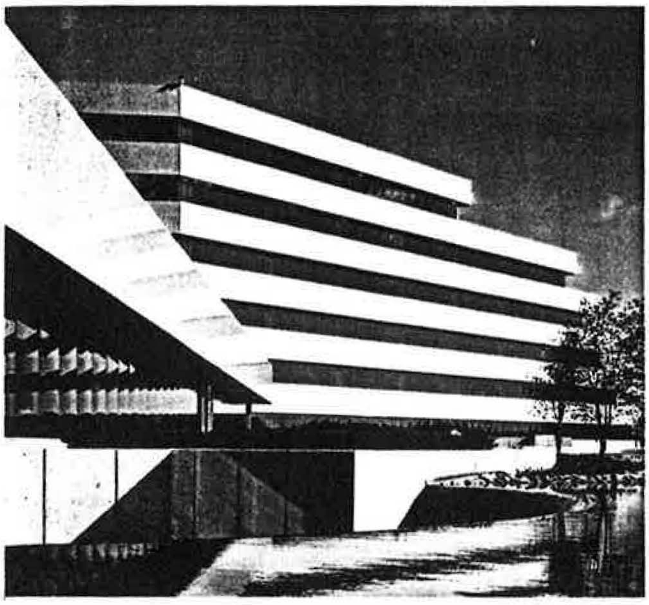


Figure 2. Heat required per day operation versus outdoor air temperature.



The high mass granite exterior, together with the ice thermal storage system, reduces the building's operating cost.

By using thermal storage, the additional cost of cooling ventilation could be reduced. The thermal storage system also had an added effect by using the 34°F [1°C] water/glycol mixture to cool the outside air to 45°F [7°C]. Therefore, the building's sensible cooling system could operate at higher chilled water temperatures for lower energy use. Using outdoor air for dehumidification allowed the discharge air temperature to be raised to 60°F [16°C] to avoid drafts.

The heating and cooling system uses variable speed pumping to the coil terminal units and constant volume pumping to the chillers. A decoupler pipe allows the use of both variable and constant flow pumping. The chillers were sized for low energy use in the 0.6 kW/ton range. The ice-building chillers can build ice at 0.78 kW/ton, which is very low for this function. A 1,000-ton [3,520 kW] winter-free cooler removes the building heat not needed for heating the building when the temperature is below 55°F [13°C] outside.

The basic chiller plant is comprised of one 280-ton [986 kW] heat reclaim chiller, one 340-ton [1,197 kW] cooling-only chiller and two 300-ton [1,056 kW] ice chillers used for ice building at night and building cooling during the day [see *Figure 3*]. The thermal storage system uses 20 vat-type tanks for 3,100 ton-hrs of storage to be used for dehumidification and building cooling. Heating is provided by the 280-ton [986 kW] heat reclaim chiller, which has a backup of two 2,000 MBH gas boilers. The boiler is needed only when outdoor temperatures are below 15°F [−9°C].

Because operations and maintenance comprise a large cost to a building owner, Standard Federal Bank headquarters was designed to reduce this cost to a minimum. The digital building automation system finds problems before a major failure occurs. The use of valves for temperature control as opposed to dampers reduces maintenance. The ability to service major equipment from the floor speeds maintenance and assures that preventive maintenance will be accomplished. Value engineering was done to find components that will have a 20-year life without a major increase in first-cost.

The system economics showed the additional cost to add thermal storage and heat reclaim to be $205,000, and it would save $62,000 per year. This translates to a simple payback of 3.3 years. The additional first-cost for a constant volume coil terminal system is $1,400,000.

The estimated savings from increased productivity is $1,250,000 per year. This combines with the thermal storage/heat reclaim savings to show $1,400,000 in total additional first-cost and yearly savings of $1,312,000, for a simple payback of 1.1 years. These excellent economics made the owners' decision simple and straightforward to justify this high quality system.

Conclusion

The result of this design is an HVAC system that has low operating costs and very high indoor air quality. The predicted energy use was 115,710 Btu/sf/year, and the first occupied year's energy use was 105,620 Btu/sf/year. There have been no occupant complaints related to indoor air quality.

Any simple measure of productivity would not be scientific in nature. However, it is apparent that productivity has increased in this building, and Standard Federal Bank is providing its stockholders and employees with a healthy, productive and profitable environment. ■

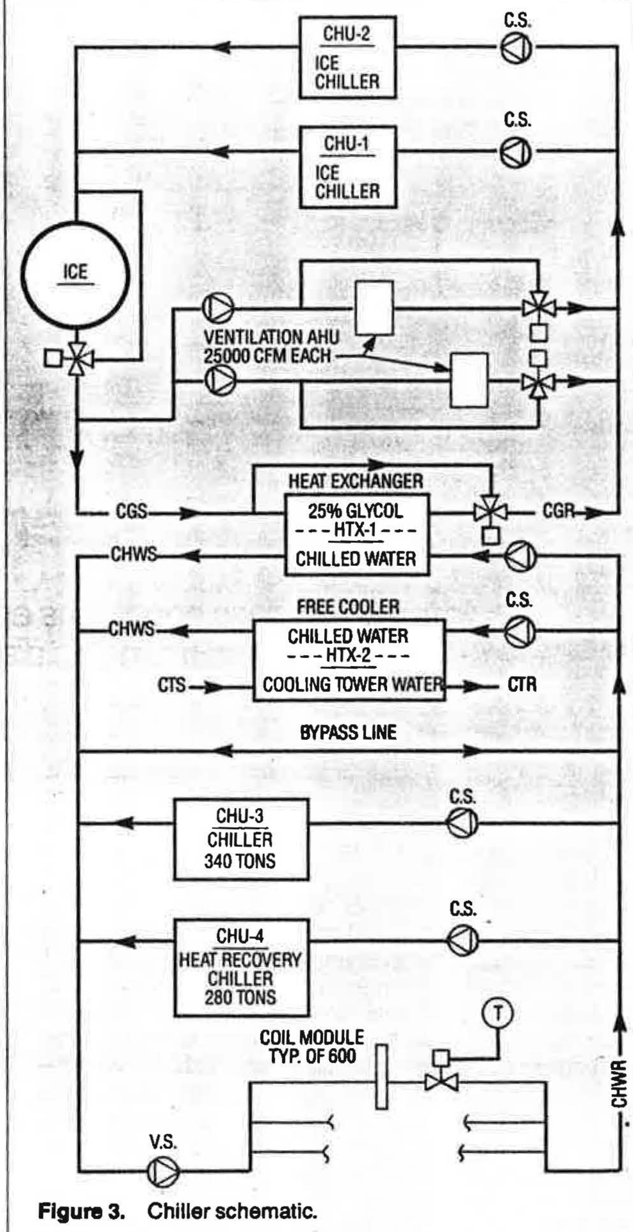


Figure 3. Chiller schematic.