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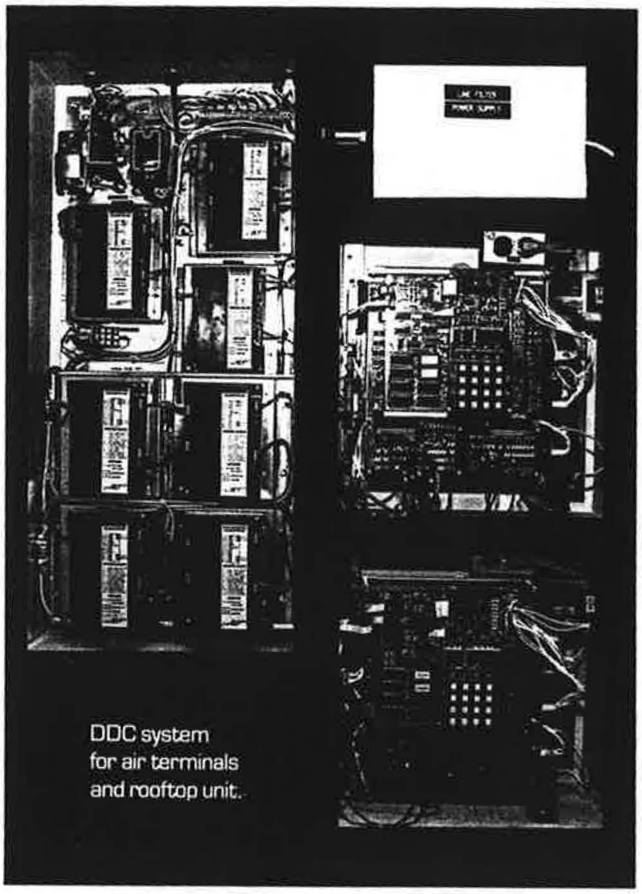
Category I

Commercial Buildings

(New and Existing)



DDC system for air terminals and rooftop unit.

Second Place

Existing Building

Facility

Parkview Medical Office Building

Little Rock, Arkansas

Entrants

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Rooftop HVAC system offers optimum energy efficiency

Improved indoor conditions and reduced operating costs resulted from this distinctive renovation

The Parkview Medical Office Building is a 48,000 ft² (4,460 m²) office building located on the campus of St. Vincent Infirmary Medical Center. Owned by a limited partnership of 16 physicians, the building was constructed in 1979.

Prior to the recent renovation, the building's HVAC system was a constant volume electric reheat type. The primary components of the system were six rooftop air conditioning units of 120 tons (422 kW) total capacity and approximately 162 electric resistance duct heaters (approximately 450 kW total capacity).

In early 1989, a comprehensive study of the building's HVAC system was initiated because of excessive energy costs and operational problems. A comparison of Parkview's energy costs with 30 similar office buildings in Little Rock had been very disturbing. The comparison revealed that Parkview's annual energy costs per square foot were more than twice the survey average and 58% higher than the highest building in the survey. It was clear that significant energy cost savings had to be achieved.

The study identified numerous deficiencies and recommended a complete renovation of the building's HVAC system. The study also indicated that the project's cost could be easily financed by its resultant energy cost savings. The study recommendation was accepted and final project design was begun.

Project design and implementation

A consulting engineering firm was retained to provide project design, drawings, specifications and construction supervision. A general contractor was selected at the beginning of the design process. This contractor provided firm pricing for various system alternatives and participated in all aspects of the design process. Construction began in January 1990 and was substantially completed in March 1990.

The renovation consisted of the following: removing the six existing rooftop units and duct heaters; installing a single rooftop unit rated for 133 tons (468 kW); installing 100 parallel fan powered variable air volume (VAV) terminals equipped with electric heat (zones were consolidated whenever possible to reduce project costs); sealing and insulating all of the building's supply air ductwork; and installing a direct digital control (DDC) system.

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The work was accomplished in phases primarily at night between 5:00 pm and 1:00 am when the building was unoccupied. The first phases included removing the duct heaters, installing the VAV terminals and sealing and insulating the supply air ductwork. This work was accomplished on a suite-by-suite basis starting on the top floor and finishing on the bottom floor.

The next step was installing the new rooftop unit. After the new unit was installed and operational, the existing units were removed two at a time. Their supply and return-air ductwork was then connected to the new unit.

Energy efficiency

The new rooftop unit was designed for optimum energy efficiency. Energy conserving features include water-cooled compressors, intertwined refrigerant coils, supply fan with inlet cone air modulating device, economizer cycle and relief fans. The supply fan inlet cone is modulated as required to maintain the supply air static pressure at 0.75 in. w.g.

The economizer and the compressors are sequenced as required to maintain the supply air temperature at 55°F (13°C). Compressor operation is locked out at 60°F (16°C) outside air temperature and below. The unit has a cooling efficiency of 0.79 kW/ton at full-load and an outside air wet bulb temperature of 80°F (27°C). This cooling efficiency includes tower fans, spray pump, compressors and controls.

Each VAV terminal is controlled by a DDC terminal controller and an electronic thermostat. The thermostat setpoint is adjustable from 70° to 80°F (21° to 27°C). The primary air damper is modulated from the programmed maximum air flow on an increase in space temperature. Space heating is accomplished by positioning the primary air damper for minimum air flow, starting the terminal fan and sequencing the electric resistance heat.

Each DDC terminal controller and the rooftop unit DDC panel are connected to the building's central energy management system. Each suite has a separate occupied/unoccupied schedule.

When a suite is in the occupied mode, the VAV terminals in that suite function in their normal manner. When a suite is in the unoccupied mode, the terminal primary air dampers are completely closed and the fan and electric heat are sequenced to maintain a space temperature 10°F (5.5°C) below the setpoint of the thermostat. No cooling or ventilation air is provided during the unoccupied mode.

The rooftop unit is started and operated whenever any one of the 16 suites is in the occupied mode. Average suite occupied operation is 65 hours per week, and average rooftop unit operation is 75 hours per week.

The building's annual energy use and cost before and after the renovation are illustrated in *Table 1*. It should be noted that, based on current pricing for electricity and natural gas, the building can be heated less expensively by electric resistance heat than by natural gas because of KVA demand charges applicable to buildings heated by electricity.

Table 1. Comparison of Annual Energy Use and Cost

Item	Before	After	Savings	% Reduction
Electric use (kWh)	2,379,000	786,000	1,593,000	67
Avg. monthly demand (kW)	410	234	176	43
Electric cost ($)	164,373	67,216	97,157	59
Cost ft^2 (\$/ft^2)	2.92	1.40	1.52	52

Operation and maintenance

The renovation corrected many serious maintenance and operating problems inherent in the original system:

- The original rooftop units did not have sufficient air flow and cooling capacities to meet the conditioning needs of the building.
- The supply air ductwork (except for the risers) was not insulated. As a result, condensation had ruined many ceiling tiles, carpets and other interior items. The heat gain from the ceiling cavity (return air plenum) also aggravated the air flow shortage. The duct heat gain frequently exceeded 5°F (2.7°C).
- The supply fans in the original units had been selected for an external static pressure of only 0.5 in. w.g. However, the actual static pressure requirements of the duct systems were in excess of 2.0 in. w.g. To obtain capacity air flow, it was necessary to increase the fan speeds and motor sizes to the maximum limits allowed by the equipment manufacturer.
- The supply air ductwork was not adequately sealed for the medium pressure conditions resulting from the increase in fan speeds and motor sizes. These ducts leaked substantial amounts of conditioned air into the ceiling cavity. The upper floors received adequate amounts of supply air, while the lower floors did not.
- The air flow in many zones was so low that the air flow switches in the duct heaters would not allow the heaters to operate. Many switches were also disabled. This allowed the heaters to operate, but it also removed a necessary safety feature.
- The compressors in the rooftop units were failing at a rate of three per year. Because they were totally enclosed hermetic compressors, they could not be economically repaired. Complete compressor replacements were required.
- The duct heaters were sized for building heat loss requirements only. The reheat function of the heaters was not considered. Accordingly, during periods of low outside air temperature, many zones could not be heated to comfortable levels.
- The original 10-year-old rooftop units were in poor condition.

Besides correcting these deficiencies, the renovation also included many features intended to reduce maintenance costs and improve system reliability. For example, the rooftop unit is equipped with three compressors and three intertwined direct exchange evaporator coils, each on an independent circuit. If one compressor fails, the remaining compressors can provide 80% of the total unit capacity because of the extended surface area provided by the intertwined coils. The water-cooled compressors will provide greater reliability and longer life.

The compressors and all unit controls are mounted in a large conditioned work area inside the rooftop unit. A telephone was installed in this area to allow communications with remote service and maintenance personnel without leaving the roof. The rooftop unit is also equipped with lights inside all work areas, large access doors to all moving parts and control components, automatic chemical treatment system for the cooling tower, heat tape on all exposed water piping and cooling tower sump heaters. The rooftop unit and all the exposed ductwork on the roof were mounted at least two feet above the roof to allow repairs and maintenance.

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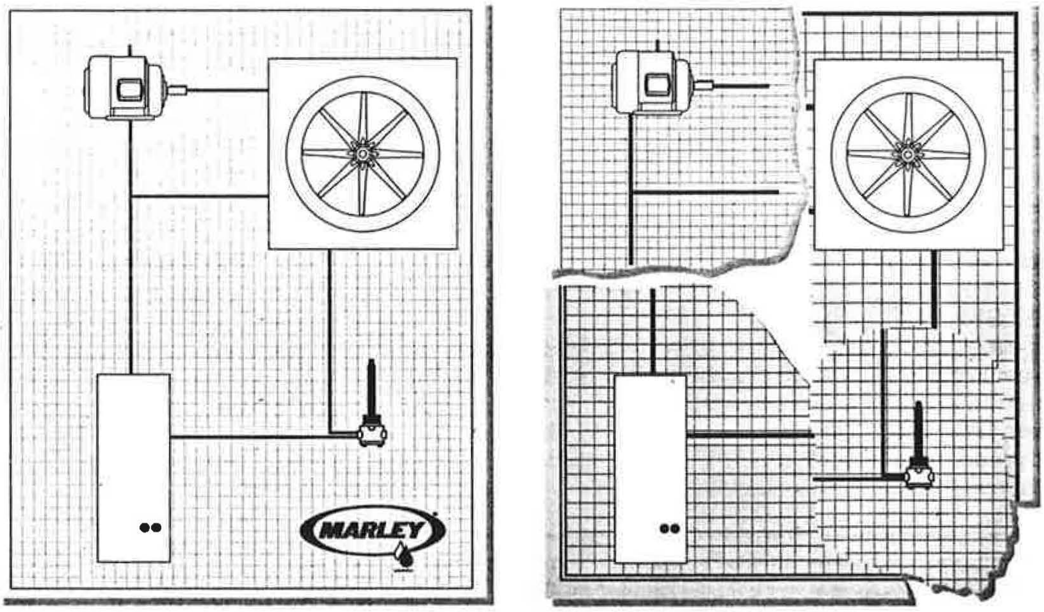
THE MARLEY SYSTEM VERSUS THE MISMATCHED SYSTEM



INTRODUCING PERFORMANCE-MATCHED COOLING TOWER CONTROLS FROM MARLEY

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The new DDC system allows remote monitoring and control of all VAV terminals and the rooftop unit. Air flows, temperatures, lockouts, control algorithms and other factors can be displayed, trended, printed and adjusted from the hospital control room. Graphic displays were also developed that illustrate all aspects of the HVAC system including floorplans, thermostat locations and schedules. Most system problems can be diagnosed and corrected from the control room.

Spare parts were purchased and stored for all components critical to system operation and deemed likely to experience an unpredicted failure. No unscheduled shutdowns or equipment failures were experienced during the first year of operation.

Cost effectiveness

Financing for the project was provided by St. Vincent Infirmary Medical Center. The total cost of the project, including contractor payments, engineering fees and construction period loan interest, was $449,664. This amount was financed at 9.5% interest for 76 months, yielding a monthly payment of $7,897.

Because the average monthly utility cost savings of $8,024 exceeds the amount of the loan payment, the operating cost assessed to each suite was actually decreased from $8.15 per ft^2 in fiscal year 1989 to $8.12 per ft^2 in fiscal year 1990. The assessment will decrease an additional $1.97 per ft^2 at the end of the 76-month loan repayment period.

Conclusion

Acceptable indoor air quality is maintained in the building by outside air ventilation at a rate of 20 cfm per person in accordance with *ASHRAE Standard 62-1989*. The outside air is introduced into the building through a minimum position on the rooftop unit outside air damper and is exhausted by four exhaust fans through the building's toilets and restrooms. The exhaust fans and the rooftop unit are shut down when the building is not occupied.

The renovation has resulted in a significant improvement in the building's environmental conditions. Occupant complaints and HVAC service calls have declined by 50%. This is primarily because several chronic maintenance and operating problems in the original HVAC system were corrected. The present system can control the space temperature in any zone at any temperature between 70° to 80°F (21° to 27°C).

The renovation and its financial success were made possible through innovative design, installation and financing. The design of the project included several innovative features:

- The reuse of the existing low pressure ductwork for medium-pressure service by sealing all joints with high-quality adhesive tape resulted in substantial cost savings.
- The use of water-cooled compressors allowed a substantial increase in total rooftop unit cooling capacity and the reuse of the existing rooftop electrical service. The full-load amperage of the new unit is less than 50% of the combined full-load amperage of the original units.
- The use of single rooftop unit rather than individual unit replacements yielded a lower first-cost and improved energy performance.
- The use of fan-powered VAV terminals allows space heating during unoccupied periods independently of the rooftop unit.

The installation was also accomplished in an innovative manner. Because the work was performed in an occupied and operational building, each phase was fully coordinated with the occupants. System shutdowns were kept to a minimum in both number and duration by using a variety of temporary measures and connections.

For example, two compressors in the original units failed during the project. The replacement of these compressors was avoided by temporarily interconnecting the original units. Significant cost savings were also achieved by using hospital maintenance personnel to install the DDC system.

Project financing was provided for the building owners by St. Vincent Infirmary Medical Center in an innovative and nontraditional manner. The hospital paid all costs related to the project through a loan to the building owners. Loan payments are made each month by the building owners using the utility cost savings. ■