FORM 80.38/901

The custom comfort cure

Kaiser Medical Office Building – San Francisco with:
1065 TF-HC
66 TB-EST
72 TL
THERMA-FUSER™ thermally powered vav diffusers

If each room could have its own controls, patient and staff comfort would be enhanced – but how can that be done given limited construction budgets?

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Most importantly, complaints from building occupants have been significantly lower than other similar facilities without individual room control.

— Jeffrey Blaevoet, P.E.

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Thermally powered variable-air volume (vav) diffusers historically have been used in retrofits to provide additional zoning. This article describes one of the first significant new medical office buildings in the country using such diffusers as the basis of design. It also discusses an innovative direct digital controls (ddc) approach, and illustrates why medical office buildings in particular can benefit from this type of system.

BY JEFFREY BLAEVOET, P.E.

Located in San Francisco's Geary campus, Kaiser's new, $60 million medical office building is an eight-story high rise with an atrium. Its 260,000 sq ft of occupied space was completed in 2000. There are also five levels of below-grade mechanically ventilated parking, which constitute an additional 160,000 sq ft of construction.

Program elements and departments include a cancer center, surgical specialties, neurology, orthopedics, otolaryngology, urology, dermatology, podiatry, imaging, physical therapy, and materials management, as well as a pharmacy, large data/ telecom room, cafeteria, and conference/ education center.

SYSTEM OVERVIEW

The facility uses a high-efficiency, 490-ton chilled water plant, which serves two roof-mounted interior and two roof-mounted exterior Temptrol air-handling units (AHUs), as well as supplemental and 24-hr cooling loads on each floor. Flexibility for technology and load changes is provided by chilled water stubouts on each side of the building on every floor. The 24-hr loads are efficiently handled by a 50-ton Carrier chiller, which is part of the primary circuit alongside two 220-ton chillers.

Run and standby secondary chilled-water pumps with variable-frequency drives (vfd's) and two-way valves keep pumping costs low. Fiberglass cooling towers are used to resist the aggressive ocean fog climate. The custom AHUs have full outside air economizer controls, and they supply a total of 222,000 cfm to the building. Two boilers provide heat to the building, one sized at 1,600 MBtuh output and the other sized at 4,000 MBtuh output.

A 15,000-gal water storage tank is provided along with diesel and electric fire pumps, combination stand pipes, and full sprinkler systems. High-rise stair pressurization, vestibule ventilation, and atrium exhaust systems on emergency power are included. Double containment fuel oil storage with duplex pumps in the garage feed the roof-mounted emergency generator and day tank. Domestic water booster pumps, gas-fired domestic water heaters, medical and control air compressors, and medical vacuum pumps round out this highly serviced building.

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WHY MEDICAL OFFICE BUILDINGS?

Medical office buildings contain a labyrinth of doctors offices, exam rooms, and special procedure rooms, with dressed and partly dressed patients. Since medical office buildings usually are provided with reheat on interior as well as exterior zones, conventional vav boxes with reheat are expensive to group anything less than three to six rooms per zone. If each room could have its own temperature controls, the comfort of patients and staff would be enhanced – but how can that be done given limited construction budgets?

During schematic design, Kaiser expressed interest in considering vav diffusers, since they had used some which had was

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Initially, the project team thought individual room control could not be achieved within budget, but a cost study revealed thermally powered vav diffusers as a viable option.

hand-held remote controls in a small project. A cost study was undertaken with the contractor, and it showed that "wired" or remote-controlled vav diffusers cost more than the budget allowed, but that thermally powered vav diffusers could be provided for the same cost as a conventional vav reheat system.

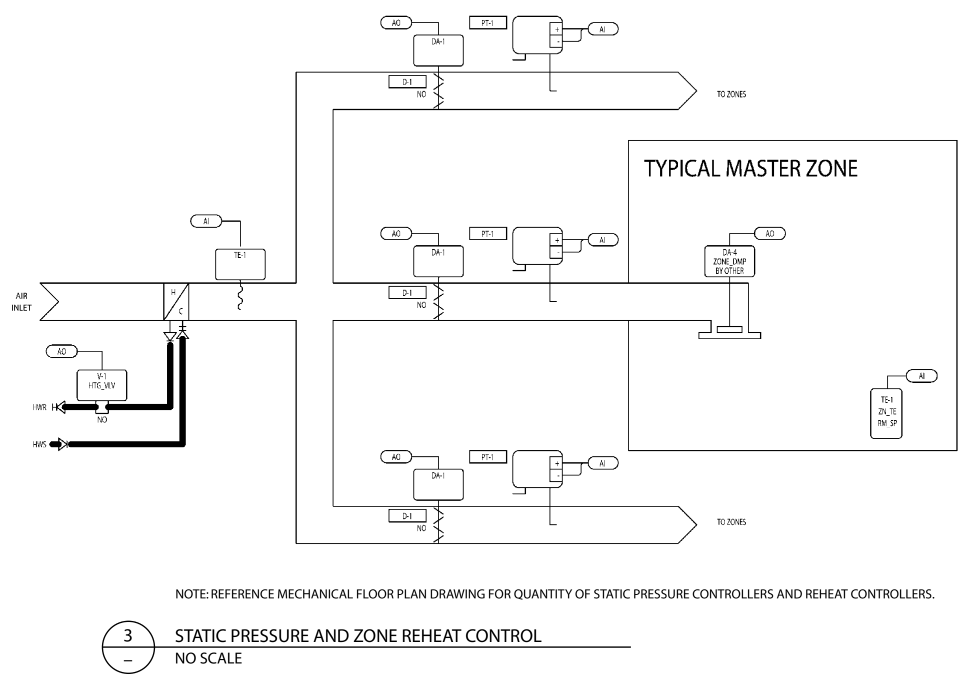
> The other critical issue is static pressure control. Unlike regular vav boxes, the diffusers must operate in a range of 0.15 to 0.25 wg.

Thermally powered diffusers have built-in vav dampers and a thermostat. The thermostat/actuator is a small brass cylinder containing petroleum-based wax that responds to room temperature by expanding and contracting, which in turn modulates a damper actuator in the diffuser that regulates air volume. Usually, the damper movement results in a constant discharge velocity, which improves part-load air distribution by maintaining throw and avoiding cold air dumping, which can occur at low discharge velocities.

Room return air is induced by the supply air and routed over the self-contained thermostat to sense room temperature for control. There are no external connections (other than sheet metal duct) required for operation. Thermally powered diffusers have been reliably in service for over twenty years.

THERMALLY POWERED DIFFUSERS: CONTROLS AND OTHER FACTORS

The cost of ddc-controlled diffusers that require power and control wiring to operate is usually prohibitive, and the objective



Sequence of Operation

Static Pressure:
The ddc system shall modulate the supply air damper to maintain its associated duct static pressure at setpoint (adjustable).

Reheat Control:
The master zone controller shall modulate the diffuser damper to maintain zone temperature at setpoint. If the diffuser is at minimum position and the zone temperature is still below setpoint, then the ddc system shall modulate the reheat valve to maintain the zone temperature at setpoint.

Note: The ddc system shall close the static pressure dampers which serve electrical rooms when the air-handling unit is in morning warmup mode.

FIGURE 1. A reference diagram from this Kaiser medical office project, addressing design for static pressure control and zone reheat control.

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As seen in this typical floor of the Kaiser facility, medical office buildings contain a labyrinth of doctors' offices, exam rooms, and special procedure rooms. This variety of physical circumstances makes truly effective zoning a challenge.

was to provide accurate control of each room for the same cost as a conventional system with vav boxes and reheat. However, in using thermally powered diffusers, supply air temperature control must be resolved. Simultaneous heating and cooling is, of course, not possible, so each group of diffusers must have the same type of load — either heating or cooling.

In a large, new building, this is most practically accomplished by means of hot water reheat coils for each exposure and interior space. Individual AHUs for exposure and interior space would be better, but that's usually difficult to integrate into the building economically. In the case of the subject project, Kaiser has a policy of providing separate air-handling systems for interior and perimeter areas, which provide a good zoning basis for optimum supply air temperature control.

Most importantly, complaints from building occupants have been significantly lower than other similar facilities without individual room control

The main challenge to date has been how to control the reheat coils. Previous designs have the thermostat in a room with a fixed diffuser, but then energy is wasted reheating that zone at full volume and, worse, supply air temperature can be raised more than other zones would like. Other designs have the thermostat in a room with a thermally powered diffuser, and although this can work by having the room thermostat setpoint within a heating/cooling vav diffuser deadband, the initial setup may not be maintained.

The other critical issue for thermally powered diffusers is static pressure control. Unlike regular vav boxes, they must operate in a static pressure range of 0.15 to 0.25 wg. If the duct pressure at the neck of the diffuser is below that range, less than the rated cfm will be delivered. Above 0.25 wg, the diffuser will become noisy. In a large system, there may be multiple static pressure control dampers downstream of the reheat coils.

In this case, a conventional ddc vav reheat sequence was preferred, and this was accomplished by providing an electrically operated, ddc-controlled master zone vav diffuser. Full volume reheat is avoided, and damper position feedback is provided to control the reheat coil. Other benefits such as central monitoring, optimized supply air temperature reset, and morning warm-up scheduling are also provided. Working with Johnson Controls and Acutherm, factory mock-ups were prepared and tested.

IMPLEMENTATION AND OPERATION

Following the successful mock-up and testing of the master zone ddc controls with the control and diffuser manufacturers, construction, testing and balancing, and commissioning proceeded smoothly. Balancing vav diffusers is accomplished by unhooking the tension spring that connects the thermostat/actuator and the blades so the blades are full open constant volume, setting the static pressure controls to the correct range, and adjusting the duct-mounted balancing dampers for design cfm at the diffuser.

Feedback from facilities staff at the medical office building is that the system had few teething problems and has performed very well over the past year of operation. The main problem was the failure to reconnect some of the actuator mechanisms after initial balancing had occurred. There have been no malfunctions of the vav diffusers and the system has been easy to maintain.

Most importantly, complaints from building occupants have been significantly lower than other similar facilities without individual room control. Service calls that were placed were quickly resolved by adjusting the diffuser setpoint. The chief engineer was pleasantly surprised and has already recommended the system to other medical facilities. **ES**

Blaevoet is a principal with Guttman & Blaevoet, a consulting engineering firm based in San Francisco. It specializes in highly engineered systems for such complex project types as hospitals, laboratories, theaters, museums, aquariums, and multimedia facilities. For more info, visit www.gb-eng.com.