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ENERGY IDEAS THAT WORK

FEATURED IN THIS ISSUE:

ASHE Feature

Chilled Beams

Can they work in U.S. hospital patient rooms?

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PHOTO COURTESY OF TROX USA

Active chilled beams maintain a sufficient discharge velocity to maintain a fully mixed room air distribution.

Chilled beams are a type of convection HVAC system designed to heat or cool large buildings. They have been employed successfully in Europe for more than 20 years, but in the United States their use is limited. Within the past few years, however, interest in using chilled beams has grown, fueled by the technology's energy-saving potential, ease of use, and minimal space requirements.

Chilled beams can be active or passive. Climate zones in the contiguous United States are ranked from one to seven, with seven being the least humid and with the lowest average summer temperatures (see map on page 27). This air is injected through a series of nozzles within the beam to entrain room air. An active chilled beam induces room air through a high free area section within its face and through the integral heat transfer coil, where it is conditioned in response to a space thermostat demand. The conditioned air then mixes with the ducted (primary) air and is discharged into the space by means of linear slots located along the outside edges of the beam.

Active chilled beams are typically mounted above the occupied zone and maintain a sufficient discharge velocity to maintain a fully mixed room air distribution. They employ a dilution ventilation strategy that manages the level of airborne gaseous and particulate contaminants. Variations of the standard active chilled beam also exist that may be mounted at low level to drive a displacement-style air distribution.

The Facility Guidelines Institute's 2010 *Guidelines for Design and Construction of Healthcare Facilities* references ASHRAE Standard 170: *Ventilation of Health Care Facilities*, which permits active chilled beams for secondary air movement in patient rooms.

Passive chilled beams use natural air currents in a room rather than forced induction. While good for other types of buildings, they are not ideal for health care facilities because the air change rates are far lower than those needed to comply with health care building codes. This article focuses on active chilled beams and their use in health care patient rooms.

Chilled beams have the same properties as overhead ventilation—the air is moved upward in a natural convection pattern similar to displacement ventilation.

Use in U.S. climate zones

There are several current U.S. patient rooms with chilled beam installations, including the University of California at Davis; Yale University Hospital Expansion in Connecticut, Wellmont Health Holston Valley Medical Center in Tennessee, and Vanderbilt University Medical Center in Tennessee.

Most of the chilled beam installations in U.S. patient rooms have heretofore been in relatively mild and dry climates. Climate zones in the contiguous Unisted States are ranked from one to seven, with seven being the least humid and with the lowest average summer temperatures. The first two facilities mentioned above (in California and Connecticut) are located in climate zone four and five, The last two projects (both in Tennessee) are notable due to the fact that they are located in climate zone three, a mixed/humid climate, which provides more challenges in terms of potential condensation.

The benefits

The benefits of chilled beams include improved indoor air quality, lower operating costs, less maintenance, thermal comfort, lower noise, and a simplified technology that results in a reduction in the size of equipment.

In addition, chilled beams can offer significant energy savings. Studies have shown that up to 75 percent of the energy use of traditional HVAC systems is associated with fan energy. Reduction of energy consumption in health care buildings supports improved health care delivery as well as reducing carbon and other greenhouse gases associated with energy production and consumption. In some cases, potential energy reduction can be as high as 30 to 40 percent, depending on climate, space type, hours of operation, and thermal comfort requirements.

Chilled beam systems use less energy than traditional HVAC systems in three primary ways. First, they require less fan energy since room air is induced as opposed to a traditional HVAC system that uses fan power

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A Successful Installation

Mazzetti Nash Lipsey Burch partnered with Holston Valley Medical Center, a medical center in Kingsport, Tenn., with more than 500 beds. The medical center is part of the Wellmont Health System, which includes eight facilities in Tennessee and Virginia. The goal was to work with the staff at Holston Valley to review the benefits, barriers, and energy use impacts of an active chilled beam installation in a patient room. "We like to think ourselves as forward thinking, supportive of ASHE, and extremely proactive when it comes to efficiency and saving energy, which a chilled beam application in our facility has the potential to do," said Jim Moore, vice president of facilities for Wellmont Health System.

Also participating in the study were Trox USA, Thermal Resource Sales, Comfort Systems Mechanical Contractors & Controls, KAE Electric, and the Tennessee Department of Health.

The team wanted to explore implications for maintenance costs and patient comfort in addition to energy savings. The team also wanted to test the system as a way to provide more data to support regulatory agencies' consideration of chilled beams in health care settings.

For the installation, Holston Valley Medical Center chose an obstetrics wing general medicine surgical room with a southern-facing exposure and recent upgrades to the glazing/skin of the building, as this would challenge a beam's thermal performance.

To assure proper room temperature, humidity, and ventilation, ASHRAE 55 and ASHRAE 62 prescriptive testing occurred during the testing period. The ASHE *Health Facility Commissioning Guidelines* were used for the commissioning procedures.

A two-pipe linear active chilled beam was installed in the ceiling grid above the foot of the patient bed without the use of a final filter. As a proxy to a dedicated outdoor air unit, the beam was served by an existing constant volume four-pipe (hot water and chilled water) fan coil unit. The chilled water was piped from existing building chilled water supply and return with a constant volume circulation pump, bridge, and three-way thermostatic mixing valve with temperature probe/control to maintain minimum 55 degree chilled beam cooling loop supply temperature.

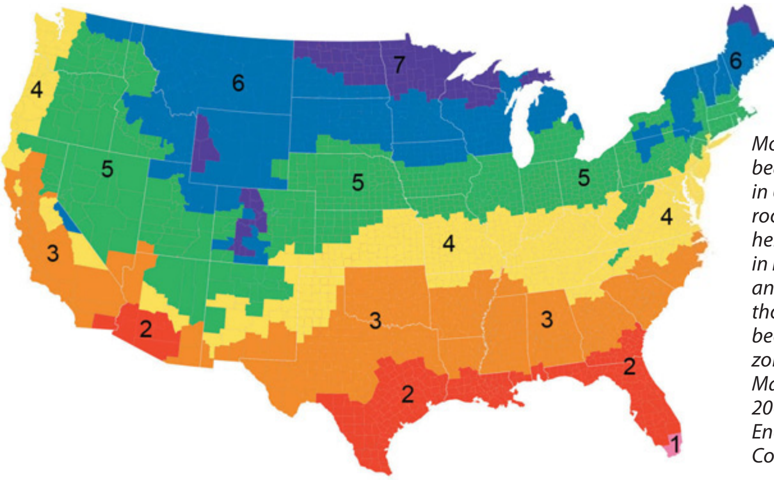
Once the chilled beam was installed, a control system was set up to trend space temperature and humidity, space heating and cooling set point, space dew point, chilled water supply temperature and valve position, chilled beam supply air temperature, and dedicated outdoor air unit supply air temperature

The initial results from this installation are very promising. The team noticed improved air circulation around the beam and the patient bed compared to the previous system, which had an overhead diffuser and return located at the door. Not a single patient complaint was recorded or reported to the maintenance staff, even though complaints had been received about the room's thermal comfort previously, and patients in other rooms continued to experience thermal comfort problems. The beam even provided the ability to overcool the room, which could not be done previously.

The success of the project was measured by ASHRAE 55 and ASHRAE 62 and the performance of the chilled beam system was validated through room environmental performance trending data through the building automation system.

Since the successful test, Holston Valley Medical Center has decided to install a larger-scale chilled beam system on its campus. The data confirmed first cost and lifecycle cost savings as well as energy savings based on eliminating the fan coil motor once the dedicated outdoor air system dehumidification cycle and neutral air modifications were completed. Warmer chilled water temperatures also provide energy savings, but were not quantified in this study.

"Given the immense cost pressures to deliver health care today, we absolutely need to take advantage of technologies, such as chilled beams, that reduce first, energy, and life cycle costs within our facilities," Moore said.



Most of the chilled beam installations in U.S. patient rooms have heretofore been in relatively mild and dry climates, though some have been installed in zone three. Credit: Map based on 2009 International Energy Conservation Code.

to move air. Second, they use less energy for cooling since the beams can use warmer water than a traditional chilled water plant. Third, chilled beams can be readily combined with heat recovery technologies, which reduce heating energy.

The simplified technology in chilled beams results in smaller ductwork and air handlers and may even result in reduced maintenance costs. The primary airflow for chilled beams is often less than half of that needed for traditional variable air volume (VAV) systems. In addition, chilled beam technology requires no airside economizing-associated components for air handling units.

Barriers

The primary concern with chilled beam use is potential condensation. However, these systems have shown that they can operate successfully in many climate zones, including many humid environments. The key is in proper design and installing the right controls. If the design and controls are working, these beams do not condense.

Chilled beam systems will drip (condense) if environmental control in a room is comprised. For example, a recent chilled beam installation in a patient room began to sweat when a family member opened a window. However, this can also occur in overhead distribution systems. Managing the "people" element of building performance with chilled beam systems is key to success, just as it is with other kinds of ventilation systems.

Cost can also be a concern, especially in areas where chilled beams have not been widely installed and there is little experience with their use. In areas of the country where chilled beams have been used more frequently, there is often little to no premium cost over a similar traditional HVAC system. According to Turner Construction, one of the nation's largest construction firms, the cost varies based on regional factors, including labor costs and experience with installing chilled beam systems.

Turner has modeled a total-cost-of-ownership life cycle cost analysis comparing chilled beam systems with traditional

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chiller VAV systems. A recent internal analysis by Turner for a facility in the Southeast indicated that a chilled beam system was about 1 percent less expensive in project first costs. The maintenance and repair costs over seven years (without adjustments) were about equal to traditional systems. Of course, the cost effectiveness of any system will vary by region, labor costs, and regional factors, and the actual life cycle costs will likely vary from projected costs. However, this modeling demonstrates that chilled beam systems can be cost-neutral or even cost slightly less than traditional systems if they are designed and installed correctly. Proper design and installation requires greater due diligence applied to the HVAC system selection process, coupled with experiential knowledge-sharing of lessons learned from other sites.

Overcoming these barriers and challenges will require more reporting on successful installations. As more installations occur and the benefits become widely known, more and more chilled beams systems will be installed in facilities in nearly every energy climate zone.

What's next?

Mazzetti Nash Lipsey Burch has undertaken a research project at Holston Valley Medical Center [see "A Successful Installation" on page 25] to look at all aspects of chilled beam technology, including infection risks, overall patient and staff safety, energy consumption, and comfort. There is a need for the health care industry, regulatory bodies, and the policy community to understand the maintenance and service aspects associated with chilled beam systems, and there is a need for compiled and analyzed data on chilled beam technologies. Preliminary results are positive but will continue to be monitored to assess the following information over time:

1. Room temperature and humidity levels
2. Airflow and room particle movement patterns surrounding the patient bed in various patient/staff/family manikin arrangement scenarios.
3. Accumulation of dust, debris, dander, etc., on the chilled beam

Testing results will be shared with ASHE in an effort to coordinate knowledge about these technologies.