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Chilled Beams Get a Warm Reception

Alex Hof, a service technician with Wellington Controls in Guelph, Ontario cleaning the chilled beam coil and calibrating the temperature sensor for the supply water to the chilled beam.

A new form of radiant cooling – long established in Europe and Asia – has entered the North American market: chilled beams. With these systems, chilled water circulates through tubing embedded in a metal ceiling fixture to wick away heat.

What makes this technology so interesting is its broad applicability for commercial structures and extreme energy and thermal efficiency. A key advantage is that a chilled beam system requires very little ceiling space and height or, in the parlance of commercial architects and designers, it conserves *interior real estate*.

Another key advantage, functionally and financially, is that water – the main transporter of thermal energy, and much denser than air – permits very high energy carrying capacity and a smaller transport system: pipes. A forced air system is, by its very nature, greatly less efficient because of the inherently low density of air and requires large ducts to transport BTUs.

Overall radiant cooling/chilled beam system contribute uniquely through:

- Greater comfort because radiant cooling/chilled beam systems circulate less air and do not create drafts or evaporative cooling on occupant's skin.
- Less noise than air systems such as VAV because they circulate less air.
- Lower energy consumption because fan use is minimized.
- Reduction in floor-to-floor building height; use of space is optimized because chilled ceilings/chilled beams don't need large ductwork and fans.
- Lower up-front cost and additional space saving.

The ultimate integration of hydronics + forced air

Because chilled beams are ceiling-mounted and do not use drain pans, the chilled water supply temperatures must be above the ambient dewpoint. As a result, dehumidification, or latent cooling, is handled by a separate 100-per cent dedicated outdoor system (or DOAS) supplying dry, conditioned air to the space.

Passive chilled beams employ natural convection while active chilled beams employ forced convection. Passive chilled beam systems supply the DOAS airflow through a separate diffuser or grille in the room. An active chilled beam supplies the DOAS airflow through the chilled beam thereby increasing the capacity of the cooling coil through forced convection.

The amount of outside air required to operate a typical chilled beam system is much less than that needed for a forced air system. A chilled beam system typically needs only one air change per hour, using outside air to pressurize the space to prevent the infiltration of outside air. With a forced air system, that need grows to 8 to 10 air changes of recirculated (and fresh) air to cool a space.

Also reduced is the ceiling space typically required for ductwork. The amount of air circulated by the central system is also dramatically reduced, often **80-90% less** than with conventional, all-air systems. Of course, this also dramatically reduces the horsepower to circulate air within interior spaces.

The net result is **lower energy consumption and operating costs**. Studies have shown – in typical commercial buildings – that fan energy is often second only to lighting in the energy consumption. With active chilled ceiling and chilled beam systems, energy to operate fans is dramatically reduced due to the relatively small amount and low pressure of the primary air being circulated by the central system.

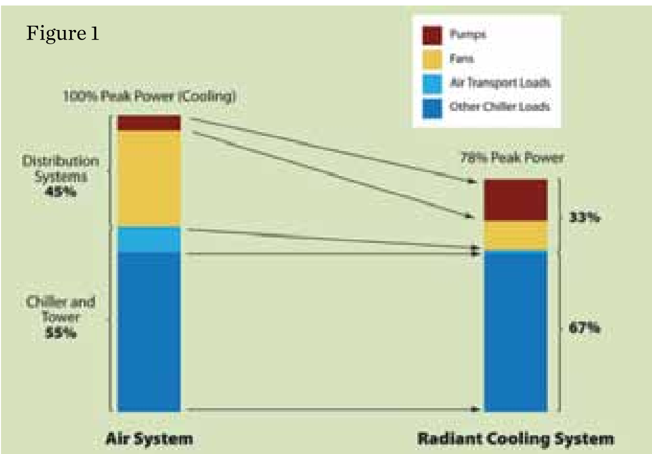


Figure 1

Go with the Flow

In a radiant chilled ceiling system, about 50 to 60 percent of the heat transfer from a chilled panel is radiant, and 40-50 percent is convective. It has been found that the chilled water temperature must be above dew point to prevent condensation from forming on the underside of the panels. This is typically in the range of 55º to 60ºF. The driving force or temperature difference between the chilled water and a room at 75ºF is therefore reduced, falling within the range of 15 to 20ºF as opposed to a conventional chilled water system using 40 to 45ºF chilled water and a range of 30 to 35ºF temperature difference.

As a result, higher chilled water flow rates are required to achieve reasonable capacities. These flow rates are in the range of 4.5 to 6 gpm per ton using chilled water delta Ts of 4º to 5º F as opposed to conventional chilled water systems of 2 to 3 gpm per ton using delta Ts of 8º to 12º F. The chilled water flow rate for chilled panels and ceilings is therefore approximately double that of conventional chilled water systems.

Even with higher flow rates, the capacity of radiant chilled panels and ceilings is relatively low, in the range of 20 to 40 btuh/sq. ft. While this is within the range of cooling loads for interior spaces, it may not be adequate for interior spaces with exterior walls. For the European experience in the 1980s, some cooling was better than none.

The Europeans discovered from their experience that by lowering the chilled panel below the ceiling that the convection

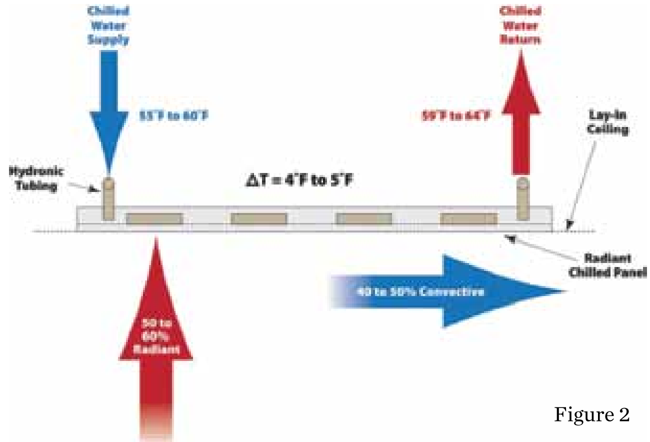


Figure 2

cooling component of the individual panels could be increased; this satisfied the increased cooling loads from increased use of computers seen in the 1990s. Also, there was a desire to provide higher cooling capacities for exterior zones to provide better overall comfort.

By lowering the panel below the ceiling and making it an open coil, as shown in Figure 3 the capacity of the chilled panel can be increased to approximately 120 to 150 btuh/sq. ft. This configuration has been designated a "passive chilled beam" by the industry. It resembles a beam when mounted below the ceiling. It is passive since the convective cooling component is natural convection.

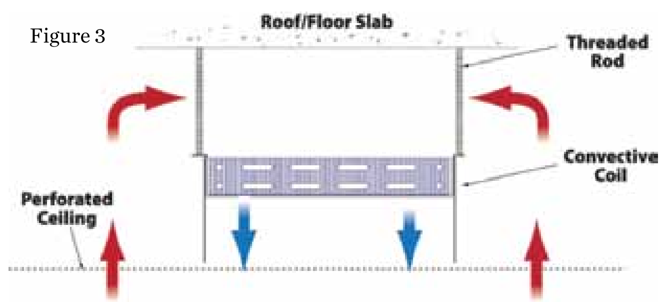
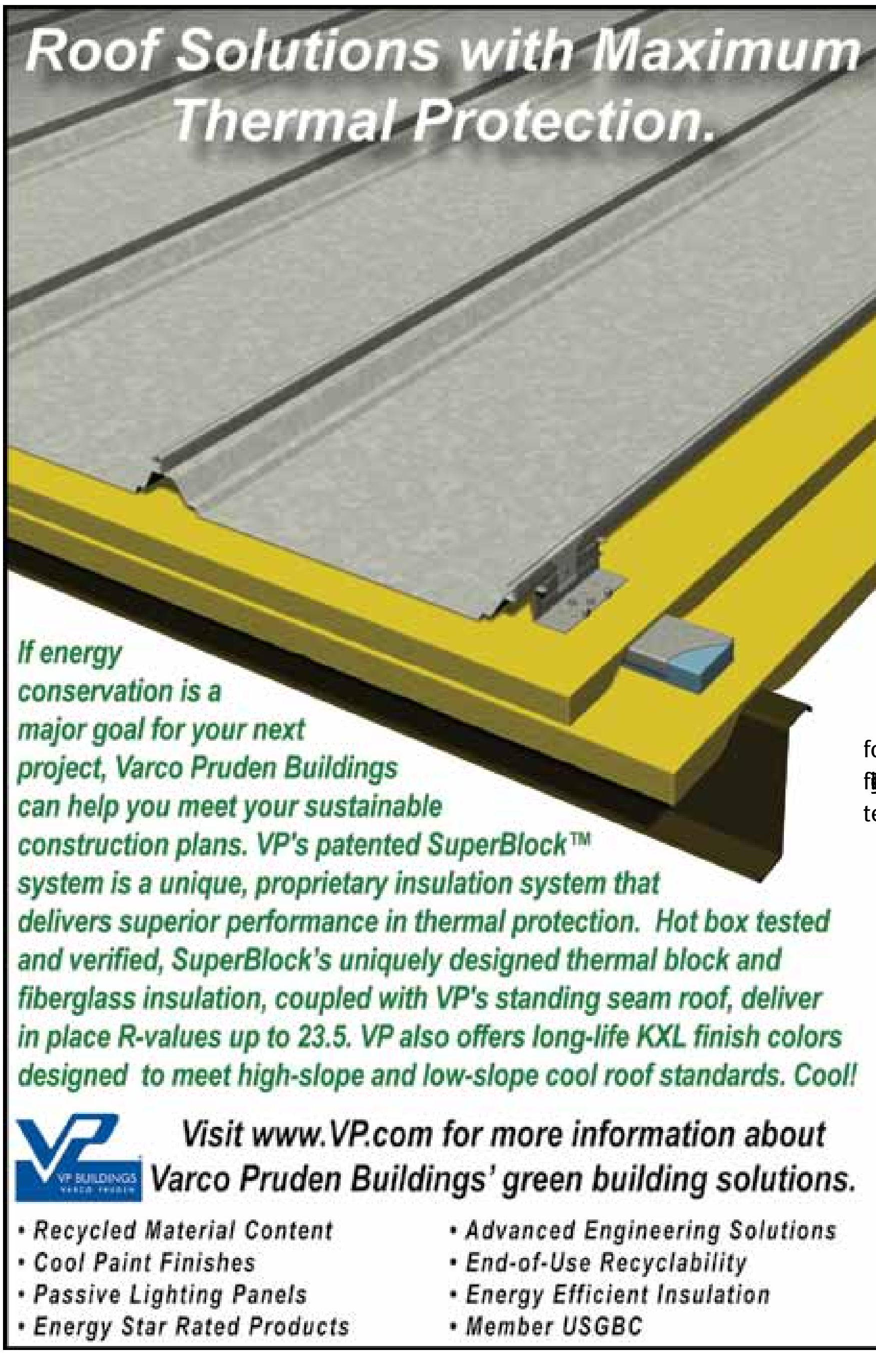


Figure 3

Passive chilled beams require ventilation air to be delivered by a separate air handling system. With *active* chilled beam systems – sometimes referred to as "induction diffusers – a building's ventilation air is continuously supplied to chilled beam terminal units by a central air handling system. Ventilation air is cooled or heated to partially handle temperature-driven sensible loads, while in the summer being sufficiently cooled and dehumidified to handle all of the internal moisture-driven latent loads. With active chilled beams, air from the chilled beam is introduced into the space through a slot diffuser, creating a Coanda effect: the tendency of a fluid jet to be attracted to a nearby surface or, in this case, the ceiling.

Inducing warm room air to blow through the chilled coil substantially increases the capacity of the chilled beam. Active chilled beam capacities are in the range of 350 to 600 btuh/sq. ft. for the coil. Added to this is the capacity of the primary air from the DOAS. Depending on the temperature and quantity of this primary supply air, this can add up to 300 btuh/sq. ft. of capacity. An active chilled beam can deliver from 500 to 900 btuh/sq. ft. between the chilled coil and the primary air (see a chilled beam configuration in Figure 4).

Primary/ventilation air is introduced into the active chilled beam through a series of nozzles. This induces room air into the chilled beam and, in turn, through a water coil. Induced room air is cooled and/or heated by the water coil, then mixed with ventilation air and released, controlling room temperature.



The technology works in tandem with a central air system which is calibrated to circulate only the amount of air needed for ventilation and latent load purposes. The chilled beams providing the additional air movement and sensible cooling and/or heating required through the induced room air and secondary water coil.

With an active beam, ventilation air is delivered to the beam by a central air system through ducts. The beam unit itself, then, is not unlike an induction unit turned upside down, mounted to the ceiling. Ventilation air moves through ductwork, forcing room air to make contact with the cooling coil. This air then mixes with the primary ventilation air and delivers it through linear diffusers.

Linear slot diffusers have been used for a number of years in VAV systems. Their primar[illegible] [illegible] [illegible] [illegible] [illegible]stems.

GBD

Technology Focus

Injection Mixing Systems

Although radiant cooling and chilled beams reduce fan electrical energy demand and consumption up to 10 times from an all-air HVAC system, the pump energy demand doubles. With Taco's new, award-winning LOFlo® injection mixing system pump energy is reduced achieving significant energy savings. Injection pumping has been used for a number of years in radiant heating systems by mixing-down the higher temperature boiler water (at 180º F) to that needed for a radiant floor panel (100º to 120ºF). This same principal can be applied to a radiant cooling system, only in reverse – to mix-up low temperature chilled water (40ºF to 45ºF) to that required by a chilled ceiling panel or beam (55º F to 60ºF).

In this injection piping system, instead of the primary chilled water flow being double that of a conventional chilled water system, it requires only one-quarter of the flow. Here, the primary chilled water system temperature difference is now 16ºF instead of a radiant cooling/chilled beam system of 4ºF and a conventional system of 8ºF.

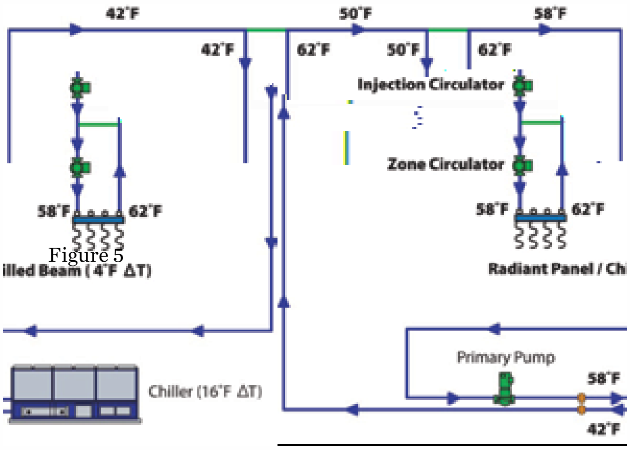


Figure 5

This system reduces the electrical energy demand of an all air system by almost 30 percent, thus reducing the transport energy to only 20 percent of the total HVAC system. This recent introduction by Taco, Inc., promises to be one of the most efficient HVAC systems to become available on the market. It combines hydronic heating and cooling energy transport with injection radiant heating and cooling energy delivery in the conditioned space.

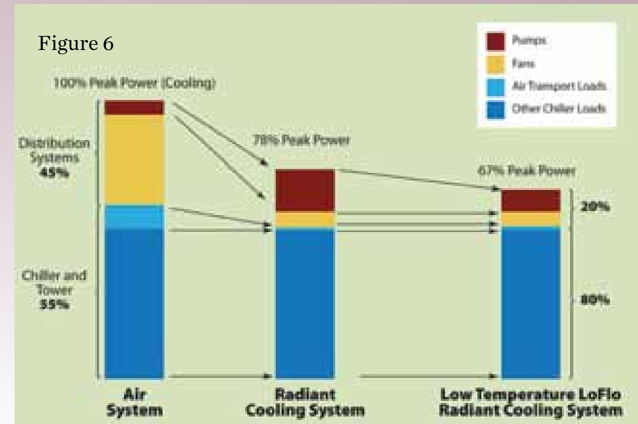


Figure 6

Further, Taco's new LOFlo® Mixing Block (LMB), a prepackaged unit consisting of a variable speed injection circulator and constant-speed zone circulator, is working to create still more positive change. The variable speed injection circulator is controlled by a sensor that monitors incoming water temperature to a radiant panel (floor, wall or ceiling) or chilled beam (ceiling). The constant-speed zone circulator is controlled by the room thermostat.


Figure 7

The bottom line on these devices is that whether its Europe, Asia or North America, huge savings in heating and cooling are being made through Chilled Beam related technologies. And, with savings showing impressive returns building owners are finding this hot new methodology very cool indeed. **GBD**