

The Chilled Box for DOAS Systems

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A Supplement or Alternative to Chilled Beams

ASHRAE is advocating that energy use in buildings be reduced 30% below the base system outlined in Standard 90.1. The base system is the traditional VAV, distributed by well mixed diffusers located in the ceiling. In an effort to meet this, engineers are considering alternate systems for conditioning occupied spaces. This has led to the increased development and installation of Under Floor Air Distribution (UFAD), Displacement Ventilation (DV) and Chilled Beam (CB) systems.

Increases in required quantities of outdoor air are causing engineers to consider the use of Dedicated Outdoor Air Systems (DOAS) to meet both ventilation and humidity requirements in buildings. With these systems, the quantity of outdoor air typically is kept at a minimum to control building energy consumption.

One of the systems that work well with DOAS and has received much of the new found attention is chilled beams. This follows from the success and popularity of chilled ceilings seen in Europe over a decade ago. In practice, a chilled beam system is a form of supplying sensible cooling at the ceiling in the form of convection devices. A large part of the success for chilled beams is attributed to the inherent energy savings they can provide. Part of the energy savings is based on transferring energy though water is more efficient than transferring energy though air and with chilled beams water is being used as the main source of cooling from the chilled beam. The other energy savings that a chilled beam system can deliver is related to the rest of the system.

An active chilled beam is a device which provides sensible cooling at the ceiling using induction to draw room air across a low pressure drop coil supplied with cool water that is above the dew point in the building. With passive beams, no air is supplied, and negative buoyancy causes air cooled by the coil to fall into the space. Active beams employ air which typically comes from a DOAS air handler, and are designed to handle all latent loads and ventilation requirements for the building. Passive beams require a second system to provide ventilation air and handle latent loads; both device types must be located in the immediate vicinity of the load.

A chilled beam system can provide significant floor and ceiling plenum space savings for a building. The system no longer requires an air handler sized to provide the entire supply air for the building. Instead a smaller DOAS rooftop unit is used to provide the conditioned air to the zone. Since the DOAS rooftop is sized to only handle the ventilation and latent load for the building, the footprint and energy usage of the unit is significantly reduced. The height of most chilled beams is less than 9" and typically has a 5" duct connection which allows for shorter ceiling plenum depths. The one perceived drawback for a chilled beam system is the first cost of the units. Chilled beams are typically more expensive at the zone when compared to a traditional VAV system. The first cost of a unit can approach \$1000 or more (the higher cost if active and/or lighting is included), not including installation. However when evaluating a chilled beam system, the entire system needs to be examined. In a chilled beam system, there are significant cost and more importantly energy savings elsewhere in the system that makes it a sustainable solution.

When properly designed, sensible and latent loads can be managed at low room velocities and especially important in schools, low sound levels. A number of projects using both active and passive chilled beams are successfully operating in Europe, as well as in the US. Passive chilled beams only handle sensible cooling loads, and are reported to be especially economical in laboratories.

With any chilled ceiling designs, however, great care must be taken to assure that the surfaces do not go below local dew point temperature, or condensation will occur. As a result, in addition to several layers of humidity protection including condensation sensors on the coils, the building must have an excellent infiltration control construction.

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In colder climates, an alternate means of treating morning warm-up and perimeter skin losses in winter is probably required. Active chilled beams can be designed to handle heating demand, provided the demand is low. It is unlikely that these systems will comply with the Table 6.2, Standard 62.1 requirements for overhead heating, without additional ventilation air. Building envelopes are getting better all the time, but most designs and climates may require supplementary perimeter systems.

In a chilled beam design, there may be some sections of the building that may not be ideal for chilled beams. Areas with high ceilings, high humidity, or high perimeter heat load requirements are some examples of applications that are not suited for chilled beams. For these areas another solution should be considered.

Enter the Chilled Fan Powered Terminal Unit for DOAS, or “Chilled Box”.

It has been realized that the benefits of DOAS and the need for a non-condensing cooling coil to handle additional loads can be combined with modern systems of overhead air delivery. The Chilled Box functions much like a conventional series fan powered terminal unit, with two important exceptions. The primary inlet of the Chilled Box is supplied from a DOAS air handler and is sized to only provide ventilation air in the space resulting in a smaller inlet. Second, a cooling coil, located on the unit’s induced air inlet, provides additional cooling to handle the sensible loads in the space. The Chilled Box comes standard with an ECM motor which provides additional energy savings and controllability. To complete the offering, other options include standard hot water reheat, staged and proportional electric reheat, and a MERV 8 filter to name a few.

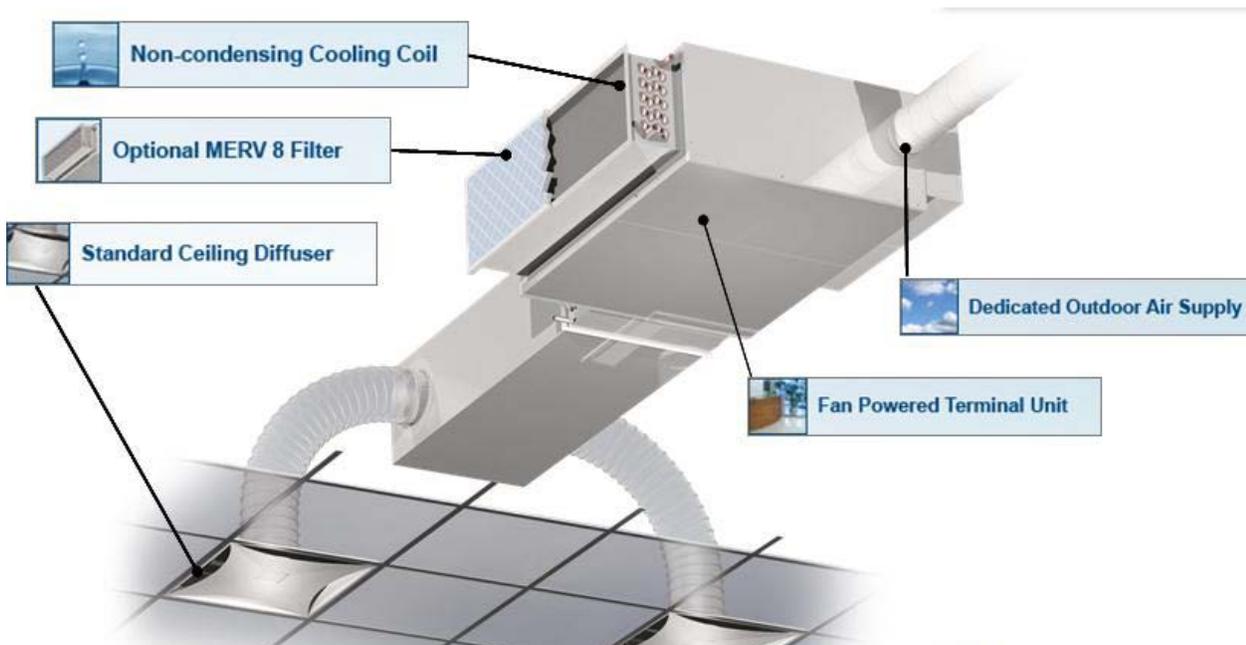


Figure 1: KLPS-D Chilled Fan Powered Terminal Unit

Air can be ducted by traditional means to several spaces from a single cold water / power / DOAS connection, greatly simplifying installation and flexibility (and thus providing for a more sustainable installation). The installing contractors and building maintenance personnel will be dealing with known technology. Conventional ceiling air distribution is then employed to distribute conditioned air to the space at a significantly lower zone cost, and with far greater flexibility.

Supplement solution for a Chilled Beam System

The Chilled Box can be used as the sole solution for the comfort conditioning for a space or it can be used to supplement a chilled beam design. The Chilled Box is a natural partner of chilled beams. Both systems use the same entering watering temperatures for the cooling coils and the same ventilation air. Perimeter zones in colder climates are a challenge to handle the high heat demand due to the external pressure limitations inherent in a chilled beam, but can easily be managed with a fan terminal. In Figure 2 shown below, chilled beams are providing the air for the interior while the Chilled Box is providing air along the perimeter using a linear slot type diffuser.

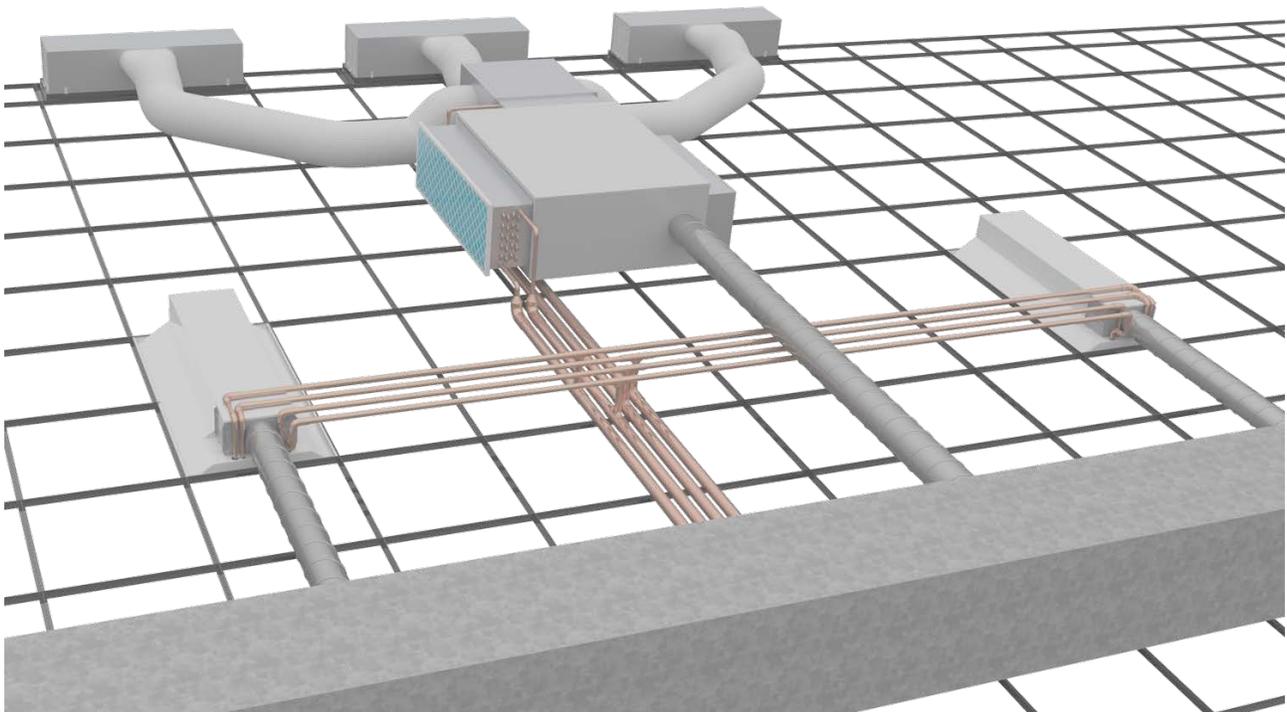


Figure 2: Chilled Box used in perimeter application with Chilled beams on interior

Options and Ideas

There are several design options to be considered to implement this system. The controls can be simplified through the use of a two (or more) position pressure independent analog control for the primary (now ventilation) air valve. The “on” position is tied to the fan relay in the unit so it defaults to minimum ventilation settings whenever the fan is activated. Additional optional ventilation settings can be activated by contact closures from the DDC system, CO2 sensor, a light switch, or other means. A standard DDC fan coil controller is used to control the fan and cooling (and heating) water valves. It can also be used with electric heat. This allows a single unit to both heat and cool, and provide required ventilation air. Additionally, with the high capacity of the fan powered terminal unit, a single unit can feed several closed offices.

The ECM motor used in the Chilled Box provides the ability to vary the total airflow to the space through the DDC system. By operating as a variable volume system, the minimum ventilation air can be regulated based on demand, and sub-cooling can be avoided by inducing more plenum air without needing any reheat.

Innovative control strategies can be employed to produce the best combination of air flows and discharge temperatures, with a broad array of diffuser styles to meet both comfort and aesthetic concerns, especially in perimeter areas. As mentioned before, a DDC Fan Coil controller and a self-contained pressure independent DOAS air valve controller with up to 4 air flow settings (one would likely be ‘off’) set through contact closures and connection to the fan relay will provide an essentially off-the-shelf control package for this design. An analog input would allow any desired ventilation airflow setting, but likely adds control costs. Most importantly, with the emphasis on sustainable design, this concept provides a very flexible system which can be easily modified as space needs change. Finally, as VAV fan powered terminal units are in common use, both installation and maintenance will be familiar to all concerned.

Summary

Active Chilled Beams are becoming a popular option of providing both ventilation and cooling to spaces. The Active Chilled Beam system can provide significant energy savings and can be a good solution for a building, but there may be applications where the chilled beams may have limitations. Applications that are not ideal for chilled beams include areas that have high ceilings and/or high humidity levels such as lobbies or atria. There may also be cases where a chilled beam may not be able to effectively meet the heating demand in winter conditions without supplemental heating equipment at the perimeter. In these challenging applications a Chilled Fan Box, used in conjunction with Chilled Beams, can provide a complete solution to ventilation and comfort control in a building.

It may be possible to get all the advantages of both non-condensing cooling coils and high ventilation rates without the use of chilled beams at all. The Chilled Fan Box offers a promise of sustainable, flexible year-round air delivery, at the lowest installed cost.

With either alternative, the use of a Chilled Fan Box can provide yet another solution to the complex design decisions facing the engineer today.