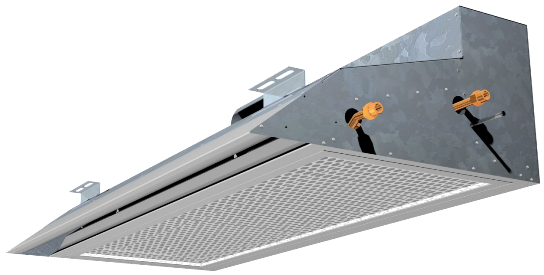
DADANCO

Breathing Life Into Your Building

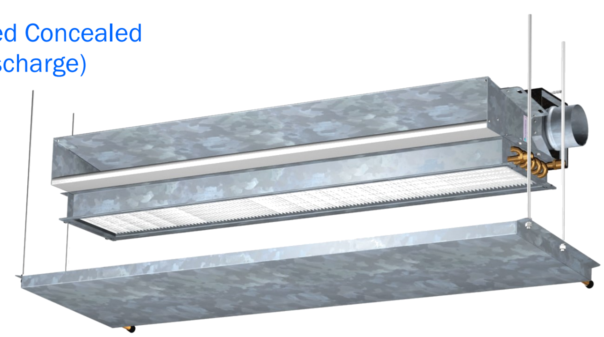
Active Chilled Beams

ACB40 Ceiling-Mounted Cassette
(2 — way discharge)



ACB50 Ceiling-Mounted Cassette
(1 — way discharge)

ACB30 and 35 Ceiling-Mounted Concealed
(1 — way and 2 — way discharge)



ACB10 Bulkhead-Mounted Concealed
(Horizontal discharge)

Frequently Asked Questions

ACTIVE CHILLED BEAMS FREQUENTLY ASKED QUESTIONS

The following are frequently asked questions (FAQ's) on DADANCO ACB™ Active Chilled Beam systems. To assist you in finding an answer to your question, the FAQ's have been put into the following groupings:

1. Introduction to DADANCO Active Chilled Beam Systems
2. Comparing Active Chilled Beam and other System Alternatives
3. Air-side Application Considerations
4. Water-side Application Considerations
5. Heating
6. Installation
7. Controls, Commissioning and Maintenance

To gain the most benefit from the FAQ's, please take the time to read them all. This will provide a far better understanding of Active Chilled Beams systems in general, and specifically DADANCO unit characteristics and performance. If you have a question that is not covered here, please feel free to contact us at (413) 564 – 5657.

1. INTRODUCTION TO DADANCO ACTIVE CHILLED BEAM SYSTEMS

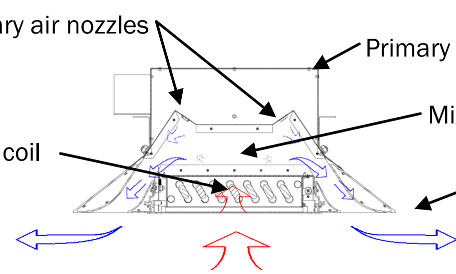
1.1 What is an Active Chilled Beam?

An Active Chilled Beam is a combination air-water system that uses the energy conveyed by two fluid streams (air and water) to achieve the required cooling or heating in a space.

The air supplied by the central air handler to the Active Chilled Beams is called **primary air.** The primary air is supplied to the Active Chilled Beams at a constant volume and at a relatively low static pressure (typically under 0.5" w.c.).

Within the Active Chilled Beam unit the primary air is discharged from the primary air plenum into a mixing chamber through a series of nozzles. A zone of relative low pressure is created within the mixing chamber, thereby inducing room air through the secondary water coil into the mixing chamber. The induced room air is called **secondary air.** The secondary air mixes with the primary air, and the mixed **supply air** is delivered to the room.

In the cooling mode the primary air is normally delivered cool and dry, satisfying a portion of the room's sensible load and all of its latent load. The secondary water coil within the Active Chilled Beam is supplied with chilled water to satisfy the remaining sensible load of the room. The chilled water temperature is always provided above the room design dew point temperature to preclude sweating/condensation on the water coil.



1.2 Isn't an Active Chilled Beam an induction unit?

Yes – well sort of. Active Chilled Beams operate on the basis of the same well established induction principle. The main differences is that the Active Chilled Beams utilize very low primary air static pressures (typically below 0.5" w.c. at the unit's inlet) and often less primary air. Also Active Chilled Beams are installed in the ceiling as opposed to floor/wall-mounting. In addition to energy savings, the lower static pressures greatly reduce the noise generated.

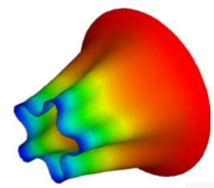
1.3 What is the entrainment ratio?

Entrainment ratio is the ratio of secondary (induced) air volume to primary air volume. This ratio is typically in the order of 2.5 to more than 4 for better performing Active Chilled Beams. This ratio should be taken into consideration when evaluating the performance of different Active Chilled Beams.

It should be noted, however, that the entrainment ratio is directly affected by the fin density of the secondary water coil. DADANCO Active Chilled Beams use coils with 12 fins per inch, typically at least twice the fin density of units from others, while providing comparable or greater entrainment ratios.

1.4 Why are DADANCO's entrainment ratios higher and noise levels lower than others?

DADANCO Active Chilled Beams utilize unique nozzle and unit fluid dynamics technology. This patented technology provides very high air entrainment ratios. DADANCO can typically provide unit selections with either higher capacity or reduced size. This often results in cost savings through the use of smaller and/or less units. DADANCO Active Chilled Beams also have an added advantage with respect to noise levels. The patented multi-lobed DADANCO nozzles are generally much quieter than Active Chilled Beams from others due to this unique nozzle configuration.

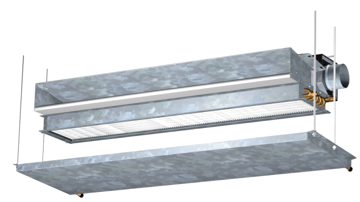


1.5 What type of Active Chilled Beam models are available?

Ceiling-mounted 1 or 2-way discharge cassette models are the most common. Ceiling and bulkhead-mounted concealed models are also available.

Ceiling-mounted Cassette

Ceiling-mounted Concealed



Bulkhead-mounted Concealed

1.6 What are common applications of Active Chilled Beams?

Active Chilled Beams are ideal for buildings and zones with medium-to-high sensible cooling and heating load densities. The reduction in primary airflows as compared to conventional "all air" systems such as VAV in these situations is dramatic -- often 70 – 80% less. Common applications include offices, laboratories, universities, hospitals, schools and libraries for both new construction and existing building renovations.

Buildings that have low noise level requirements are good candidates due to the very low noise levels of Active Chilled Beams.

Also, buildings where there is concern about indoor air quality are ideal candidates. Active Chilled Beam systems are constant volume and provide proper ventilation air and humidity control to the zones at all times and under all sensible load conditions.

Buildings most affected by space constraints where the reduction in the size of the central air handlers and ductwork system serving the terminal units can greatly simplify and facilitate the installation are also ideal candidates.

Finally due to the dramatic energy savings possible with Active Chilled Beam systems, probably the most common application is in those buildings that are striving to achieve LEED certification (as developed and administered by the US Green Building Council). There are a number of areas where Active Chilled Beams can help achieve LEED credits including energy efficiency, indoor air quality, individual temperature control and thermal comfort.

2. COMPARING ACTIVE CHILLED BEAM AND OTHER SYSTEM ALTERNATIVES

2.1 How do you compare an Active Chilled Beam system with an "all-air" system like variable air volume (VAV)?

Both systems will generally have the same installed refrigeration and heating and as a result, common chiller and boiler plants. The main differences are in the air handling systems. With the greatly reduced primary airflows and static pressures of Active Chilled Beam systems the fan energy savings over "all air" systems can be dramatic, particularly in buildings with relatively high sensible load densities. While this is true for both single duct and fan-powered VAV systems, the savings are even more dramatic in the latter case as all the fans and motors in the VAV terminal units are eliminated.

With respect to the installed cost of Active Chilled Beam systems, the terminal units normally cost more as typically more of them are required. There are, however, offsetting installed cost savings in the system. The size and cost of the central air handlers and ductwork/risers in the Active Chilled Beam system are significantly reduced due to the reduced in primary airflows. The cost of the building's overall electrical infrastructure may also be reduced due to much lower fan power requirements. Wiring expenses are reduced as there are no main power connections to the Active Chilled Beams. Controls are also often less expensive as the Active Chilled Beams are controlled by simple low voltage zone valves.

In addition there are also ongoing maintenance cost savings. The Active Chilled Beams have no moving parts and do not require regular maintenance (other than infrequent vacuuming of the unit's coil as required).

The following are major points of comparison:

	VAV	ACB	Net for ACB
Installed Costs			
Central air handlers size	Much Larger	Much Smaller	+ + +
Ductwork/risers size	Much Larger	Much Smaller	+ + +
Ceiling space required	Larger	Smaller	+ +
Water piping	Slightly Smaller	Slightly Larger	-
Control system complexity	Higher	Lower	+ +
Operating Costs			
Fan energy	Much Higher	Much Lower	+ + +
Pump energy	Slightly Lower	Slightly Higher	-
Maintenance	Higher	Lower	+ +
Comfort			
Thermal control	Same/Slightly Worse	Same/Slightly Better	+
Humidity control	Much Worse	Much Better	+ + +
Noise levels	Higher	Lower	+ +
Air Movement	Variable/Worse	Constant/Better	+ +
Other			
Contribution to LEED credits	Little	Significant	+ +

2.2 Are the fan operating pressures in Active Chilled Beams systems comparable with "all air" systems ?

Yes. When comparing the two systems, it is necessary to take into account the pressure losses in the central air handlers, (coils, filters, dampers, etc.), supply ductwork, the terminal unit and its downstream ductwork/outlets and the return air ductwork.

The pressure losses of the VAV terminal unit, downstream ductwork and supply outlets will be very close to or higher than the Active Chilled Beam units (which are typically selected at 0.5"w.c or less inlet static pressure).

With respect to the other losses as the duct system for the Active Chilled Beam system is much smaller, it is possible (and quite common) to design the duct system at lower velocities and lower resultant pressure losses with no concern about space constraints.

2.3 How specifically can DADANCO help reduce the installed cost of an Active Chilled Beam system?

There are many areas where DADANCO units can reduce system installed costs when compared to Active Chilled Beams from others including:

- Shorter unit lengths fitting into conventional T-bar ceiling modules
- Less number of units to cover a specific area
- Potentially less primary air resulting in smaller ductwork system and central air handlers

2.4 When comparing the energy savings of an Active Chilled Beam system with other systems, what items are not subject to energy savings?

In most cases the chiller, cooling tower and boiler sizes are essentially the same in either case. Additionally the size and energy usage related to other equipment such as the exhaust fans, condenser water pumps, etc. are unaffected.

While the size of the chiller would normally not change, its effective hours of operation (or loading) could be significantly less if the system employs a water-side economizer to serve the Active Chilled Beams. This is due to the relatively warmer secondary water temperatures (typically 56 — 58 ºF) used by the Active Chilled Beams which allows the cooling load to be satisfied for more hours using the water-side economizer.

Also, if separate chillers are serving the central air handlers and the active chilled beams, the COP of the chiller serving the Active Chilled Beams would also be much higher due to the relatively warmer water temperatures used by the Active Chilled Beams.

2.5 When comparing the energy savings of an Active Chilled Beam system with other systems, what items are subject to significant energy savings?

The power used by the fans is the main difference. With the Active Chilled Beam system the central air handler supply (and return) fans are handling much less air, and therefore requiring much less energy. Also chiller operating hours/ loading can be reduced if a water-side economizer is employed to serve the Active Chilled Beam secondary water loop.

2.6 The major energy savings with Active Chilled Beam systems is in fan power. What is the situation with pumping energy?

There is typically an increase in total pump energy related to the lower water temperature rise (typically 4 — 6 ºF) used in the secondary water loop serving the Active Chilled Beams. However, while the total pump energy for Active Chilled Beam systems (primary and secondary water loops) is typically higher than an all-air system, it does not significantly offset the energy savings achieved through the major reduction in fan power.

3. AIR-SIDE APPLICATION CONSIDERATIONS

3.1 Does the primary airflow chosen for each zone always equal the ventilation air requirements?

No. While the general intent in an Active Chilled Beam system design is to use the minimum quantity of primary air, there will be cases where the primary airflows may need to be increased to induce sufficient airflow through the secondary water coil to provide the sensible cooling capacity required.

Also, there will be cases where the primary air quantity will be driven by the zone latent load requirements which must be satisfied solely by the primary air. At a typical 55 ºF primary air temperature the amount of primary air required to satisfy the latent loads is often more than that prescribed by ASHRAE 62 for ventilation air purposes (particularly in zones with medium-to–high occupancies). In these cases the primary air quantity may have to be increased or (preferably) the temperature of the primary air lowered to increase its latent cooling capacity to satisfy the zone’s latent load.

3.2 What can happen if insufficient latent cooling capacity is being provided by the primary air?

Nothing good. If the latent load in a zone is not satisfied over time its relative humidity will rise. Accompanying the increase in relative humidity will be a corresponding increase in the zone's dew point temperature. Left unchecked the room dew point temperature can rise above the temperature of the chilled water being circulated to the Active Chilled Beams. This can lead to condensation on the secondary water coil in the Active Chilled Beams.

3.3 Should there be concerns about infiltration and the resultant moisture migration into the building from outdoors?

Yes. While there are no concerns about applying active chilled beam systems in hot, humid climates as the latent and sensible cooling loads of the outdoor air are being handled at the central air handler, there would be concerns if uncontrolled moisture-laden outdoor air was allowed to infiltrate into the building. This could cause condensation concerns.

In general it is particularly important with Active Chilled Beam systems that the quality of construction of the building enveloped by tight and sealed. Also the amount of ventilation airflow must be sufficient to maintain the building under adequate positive pressurization. For this reason Active Chilled Beam systems are not recommended for use in zones/buildings with operable windows.

(Note: There are active chilled beam models that are equipped with drain pans/drip trays that can capture condensation and operate properly without condensation concerns. For more information, please contact DADANCO).

3.4 Should one air handling unit serve all of the Active Chilled Beams on a floor?

This is not the ideal solution. The best method is to zone the central air handling units to serve each exposure and the interior zones separately. This will allow for the primary air temperature to be reset to suit each zones requirement.

If separate air handlers by perimeter exposure and interior are not possible, there is the potential for overcooling some rooms at low part loads while others are at closer to their design cooling loads. This can be the case in systems where the primary is being delivered cold and dry, providing a certain portion of the sensible cooling capacity to the zones. One approach is to add reheat coils upstream of the Active Chilled Beams to prevent overcooling. This can often lead, however, to energy waste if new energy is used to provide the reheat.

In these cases another often much more preferable approach is to provide a sensible heat recovery device (i.e. heat wheel, plate heat exchanger, coil run-around loop) downstream of the cooling coil in the air handling unit. Heat from the exhaust air is recovered and used to provide "free reheat" of the primary air.

In this arrangement the primary air is provided at or close to a thermally neutral, but dry condition to the Active Chilled Beams. The room neutral dry primary air would satisfy the room latent loads and the sensible load would be satisfied entirely by the active chilled beams. This method would minimize or eliminate the times when reheating the primary air would be potentially required. This will add some additional static pressure to the central air handling unit due to the pressure drop across the heat recovery device, but this is far better than requiring significant re-heat to minimize over-cooling of low load zones.

3.5 What is the effect of the fan motor heat pick-up on the primary air in a draw-through air handling unit?

The effect is to raise the temperature of the primary air leaving the central air handler. This temperature rise needs to be factored into the system design, as the primary air condition actually being delivered to the Active Chilled Beams must be that used in the unit selection process.

3.6 Can Active Chilled Beam units be connected in series?

This is not recommended. The limiting factor is the volume and velocity of the primary air entering the first unit's plenum. Too high a velocity can generate unwanted noise and excessive pressure drops. Generally the layout of Active Chilled Beam systems does not lend itself to series connections. If a design layout demands that units be connected in series, contact DADANCO to discuss the possible need for larger primary air inlet connections and larger primary air plenums.

4. WATER-SIDE APPLICATION CONSIDERATIONS

4.1 How low can the secondary chilled water temperature serving the Active Chilled Beams be without causing condensation?

The basis for deciding on a secondary chilled water temperature is to relate it to the room design dew point temperature. In theory, a surface at the room dew point temperature has the potential to condense water vapor from the air. At a 75 ºF 50% relative humidity room design condition, the dew point temperature of the room air is 55 ºF. In theory the moisture in the room air would begin to condense on the secondary water coil in the Active Chilled Beam when the water temperature serving the Active Chilled Beams was 55 ºF or below.

In reality, however, the thin film of air on the fin of the secondary water coil in the Active Chilled Beam will act as a layer of insulation, allowing the temperature of the surface to drop below the room dew point before condensation commences. This typically has the effect of reducing the “apparent room dew point temperature” by about 2 — 3 ºF. Therefore for a room dew point temperature of 55 ºF, the minimum secondary water temperature is about 53 — 52 ºF before condensation occurs on the coil’s fins.

(The insulating effectiveness of the air film depends on the velocity of the air over the coil fins and the water velocity within the coil tubes. Higher air velocities over the coil and lower water velocities inside the tubes of the coil minimize the potential for coil sweating).

We do not recommend using water temperatures this low as we feel a significant margin of safety is prudent to avoid condensation concerns. Many designs in Europe use a secondary chilled water temperature of 55 ºF. We generally recommend secondary chilled water temperatures of 56 – 58 ºF to provide an additional margin of safety and to mitigate the risk of condensation forming when unforeseen transient room conditions can occur (mopped floors, wet clothing, etc.).

4.2 What about the system shutting down at night? Won’t the humid outdoor air infiltrate into the building and cause a condensation problem at morning start-up?

If the HVAC system is operated to maintain a reset set point temperature during the unoccupied periods, the system can and should be cycled at night with the outdoor air dampers closed to maintain the setback set-point temperatures. In some climates this could cause some infiltration of humid air during this unoccupied period as the building is not being maintained under a relative positive pressure. In Singapore for example, our experience has been that the humidity within the building can increase by as much as 10 – 15% over a weekend shut down.

To address this, at start-up after an unoccupied period the primary air system is first operated while the secondary water system remains off. Gradually the primary air system dries out the building and lowers the humidity level. Once the humidity level has been reduced to an acceptable level, the secondary water system is started. During this “dry-out cycle” operation of the cooled and dehumidified primary air flushes the moisture out of the building before the secondary chilled water system is started. Our experience has been that the “dry-out” cycle is often less than 30 minutes.

4.3 What proportion of the sensible cooling load is handled by the primary air and what proportion by the secondary water coil?

In all cases the primary air must satisfy all of the internal latent cooling loads. Also the sensible and latent loads of the outdoor air are being satisfied at the primary air handler.

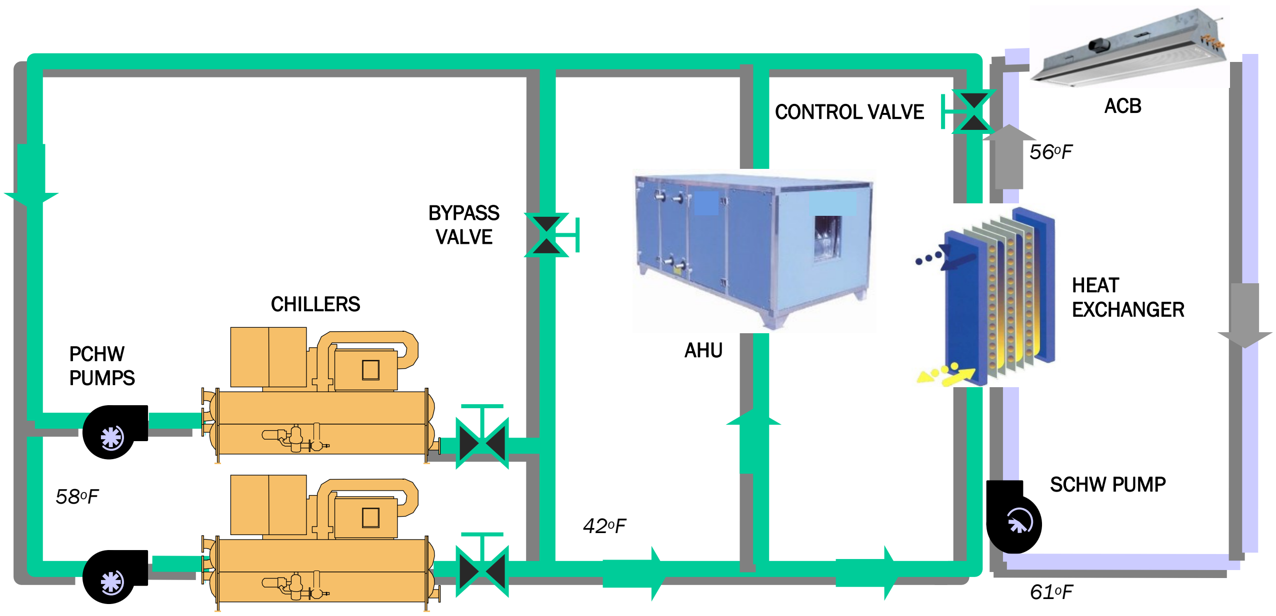
With respect to the zone sensible loads, from an energy standpoint savings will be maximized to the extent that the secondary water coil in the Active Chilled Beam does as much as possible of the zone sensible cooling. If the primary air is to be delivered at a cold and dry condition, design the system to allow for the primary air to satisfy the perimeter transmission sensible loads. The remaining zone sensible cooling loads (people, lights, office equipment and solar load) would be satisfied by the Active Chilled Beam’s secondary water coil. In general this often results in the primary air system providing 25 — 30% of the sensible cooling capacity to the zones, with the secondary coils in the Active Chilled Beams providing the remaining 70 — 75%.

Remember this is assuming that the primary air is being delivered cold and dry to the Active Chilled Beams. If the primary air is being delivered at a relatively room neutral temperature (i.e. 65 — 68 ºF), the secondary water coil in the Active Chilled Beams would provide essentially 100% of the zone sensible cooling capacity.

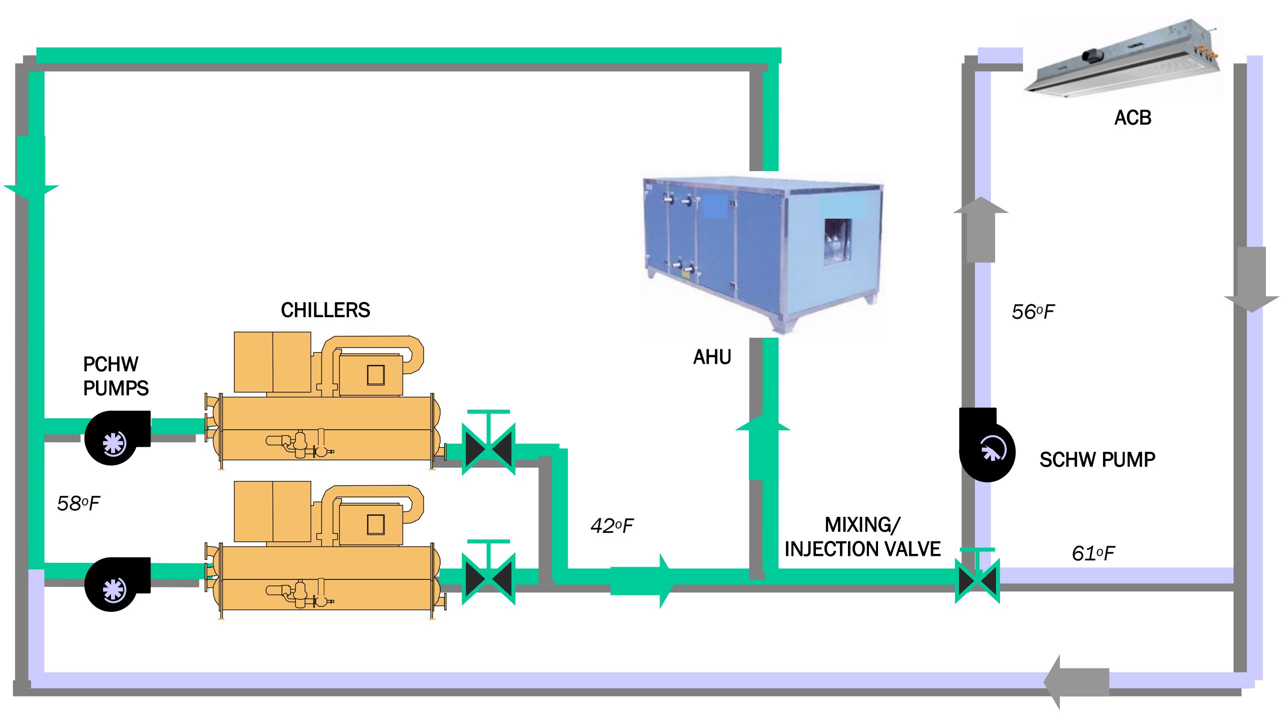
4.4 How do you maintain the secondary water temperature serving the Active Chilled Beams?

There are three methods for maintaining the temperature of the secondary water temperature loop as follows:

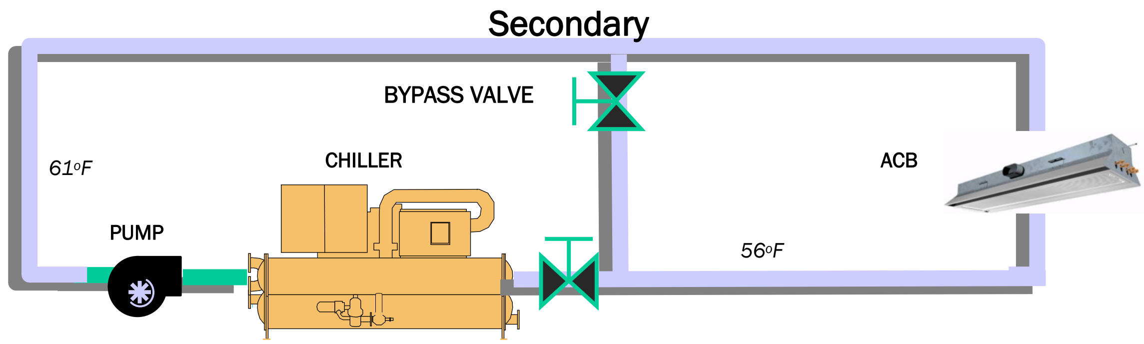
1. By circulating primary chilled water through one side of a water-water heat exchanger with the secondary water passing through the other side of the heat exchanger. A secondary water pump circulates the secondary water through one side of the heat exchanger while a modulating valve controls the primary water flow to achieve the design secondary water temperature. A sensor at secondary water outlet controls the modulating valve.

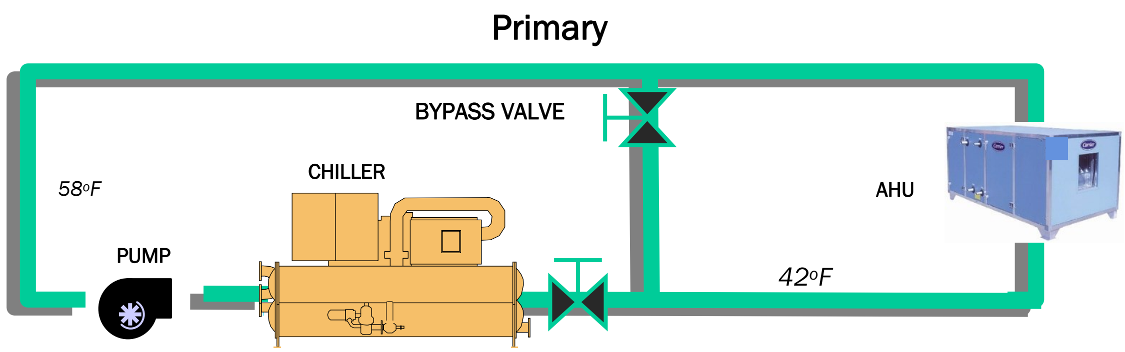


2. By using a mixing valve that allows primary water into the suction side of the secondary water circulating pump. There needs to be a connection back into the primary water loop to return a quantity of water equal to that introduced to maintain the secondary water temperature. A sensor on the leaving side of the secondary water pump controls the mixing valve.



3. By using separate dedicated chillers for the primary and secondary water loops. This option provides the ultimate energy efficiency of the chiller plant but typically has higher installed cost. The primary chiller serves the primary air handling units only. A second dedicated chiller serves the secondary chilled water from the Active Chilled Beams. The second chiller will operate at a much higher COP due to the relatively warmer water temperatures used to serve the active chilled beams.





4.5 Are water-side economizers typically employed in Active Chilled Beam systems?

Yes, this is very common. In most climates the energy savings realized by minimizing the operating hours/loading of the chiller serving the secondary water loop can be dramatic due to the relatively warmer water temperature used to serve the Active Chilled Beams.

While water-side economizers can provide a similar benefit on the water loop serving the primary air handlers, the saving are less significant as the water temperature serving the primary air handlers is normally lower in order to adequately dehumidify the primary air. This will require the chiller serving the central air handlers to operate more hours when outdoor air conditions are not conducive for the operation of the water-side economizer.

5. HEATING

5.1 Can Active Chilled Beams be used successfully to provide heating from the ceiling or should heat from under-the-window (i.e. finned-tube radiation) be used?

This is a common question. The use of overhead heating from the ceiling as opposed to under-the-window heating is dependent on the buildings envelope and not directly related to the choice of an Active Chilled Beam system. Research tests on this subject compared comfort levels using five alternative methods for distributing the heat as follows:

- Discharging the heated air horizontally into the room through a one-way slot located at the ceiling above the window
- Discharging the heated air vertically down the window though a liner slot located at the ceiling above the window
- Discharging the heated air horizontally both into the room and into the window from a 2-way discharge linear slot located 2 1/2 feet away from the window
- Radiant ceiling panels located above the window
- Finned tube radiation located below the window

While the results varied depending on the outdoor winter design conditions and the extent of glazing, the results generally indicated that there are no concerns with any of the methods tested if the heat loss along the perimeter is 300 Btu/lineal foot or less. Between 300 and 400 Btu/lineal foot heating from overhead was found acceptable only if the heated air is delivered toward the window horizontally (and hits the window at a velocity of around 75 feet per minute) or from below the window. Above 400 Btu/lineal foot the research found only finned-tube radiation or some other method of delivering the heat from under the window could be used to provide adequate comfort due to down draft issues.

This guidance applies not only to Active Chilled Beam systems, but to any system (such as an all air VAV system) when considering the use of overhead versus under-the-window heating.

6. INSTALLATION

6.1 Do you need to insulate the return water line in the ceiling plenum?

Within ceiling plenums used for the return air, this is generally not required as it relates to condensation concerns. The humidity level of the return air in the ceiling plenum will be the same as the room air, while the return water temperature will typically be 4 – 6 °F warmer than the water entering the coil in the Active Chilled Beam. The temperature in the ceiling plenum used by the return air would typically be about 77 — 78 ºF (due to heat pick-up from the lights), but its dew point temperature would equal that of the room air (typically 55 ºF).

If the pipe is to be insulated, remember the insulation is to reduce thermal gains and not prevent condensation. Also in this case a vapor barrier is not required.

7. CONTROLS, COMMISSIONING AND MAINTENANCE

7.1 How many Active Chilled Beam units can be controlled from one control valve?

A single control valve can control several units in the same zone, with a single thermostat controlling that valve. The piping and valves after the control valve should be such that the water flow to each unit is at the required design flow.

7.2 Should dew point temperature sensors be used to detect when condensation could occur?

It certainly can't hurt, but reliance on these type of controls to reset the secondary chilled water temperature upwards when the relative humidity rises will deny cooling and not provide adequate comfort when it is required. (Its akin to closing the door after the horse has left the barn). The proper design of the primary air system to assure adequate latent cooling capacities and control of humidity levels in every zone should be the priority in any Active Chilled Beam system design.

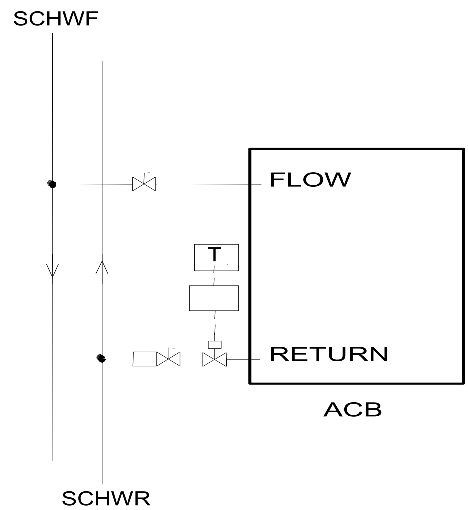
When dew point temperature sensors are employed and detect higher room dew point temperatures, the control system should first reset the temperature of the primary air downward to increase its latent cooling capacity to remove the moisture form the space. If after a set amount of time satisfactory conditions are not achieved then the last resort is to reset the secondary water temperature upwards and alarm be raised to the operating personnel.

7.3 How is the primary airflow to the Active Chilled Beam measured?

The way to accurately measure the primary air flow into an Active Chilled Beam is by reading the static pressure from the commissioning sampling tube on the unit. A primary air flow versus static pressure chart is provided for each unit. Do not utilize static pressure readings in the duct near the unit's inlet and presume it will be the same as that in the primary air plenum for commissioning purposes. This measurement could be up significantly different (often as much as 0.3" w.c.) from that measured through the commissioned sampling tube.

7.4 How important is it to accurately commission the water flow serving the Active Chilled Beam?

Accurate commissioning of the water flow is very important. Remember, typically 70 — 100% of total sensible cooling capacity is delivered by the Active Chilled Beam's secondary water coil. Also, the water through the coil is typically at relatively low flows (2.4 GPM and lower) and velocities (4 feet per second and under). A drop in water flow rate to the unit from that used in the design can have a significant impact on the capacity delivered by the unit. We recommend commissioning the waterside for each unit using a balancing valve/circuit setter or automatic flow control valve at each unit to assure the unit receives the design water flow.



7.5 Are inspections of the coil necessary, and if so, at what frequency?

The coil should be inspected once a year and vacuumed if needed. In practice we find that vacuuming of the coil is seldom required.

7.6 Do I need to use lint screens in the Active Chilled Beams?

The use of lint screens is a legacy from the older floor/wall-mounted induction systems where the coil was at the floor and exposed to carpet lint, dirt and debris. With the Active Chilled Beams being installed in the ceiling and with face velocities over the dry coil of less than 100 feet per minute, the coils are not exposed to a build-up of lint or dirt. (As with fan-powered VAV terminals, the coils seldom need cleaning). While not needed, however, lint screens are available.

DADANCO

Breathing Life Into Your Building

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DADANCO—MESTEK Joint Venture LLC (DADANCO)

is jointly owned by subsidiaries of Dadanco Pty Ltd headquartered in Adelaide, Australia and Mestek, Inc. headquartered in Westfield, MA. Mestek is a diversified manufacturer of HVAC products with sales of over $400m. Mestek's HVAC companies include Smith Cast Iron Boilers, Hydrotherm, RBI Boilers & Water Heaters, Sterling, Vulcan, Airtherm, Applied Air, Anemostat, Air Balance, Arrow United, L. J. Wing, Lockformer and many others.

MESTEK, INC.

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