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Design Bulletin 4

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Considerations for Active Chilled Beam Designs

Unit Spacing & Primary Air Strategies

This design bulletin deals with questions and considerations on unit spacing and Primary Air strategies for Active Chilled Beams

What is the minimum distance between any two Active Chilled Beams?

There is no standard answer for this complex subject. It can be any value depending on how much air is being delivered by the ACB's, how long each ACB is for the air quantity, the height of the ACB in relation to the occupied space and how close the next ACB is positioned.

Placing ACB units with high air quantities too close together can result in air collisions in the air path of the two ACB units and resulting higher than acceptable terminal velocities, or draughts, in the conditioned space. This air collision is sometimes referred to as turbulence intensity.

a. The distance between ACB's is a function of air throw per ACB, and air throw is a function of the primary air plus secondary air quantities (total air) plus consideration for how long the ACB unit is since this will influence supply air grille velocity. Since the total air quantity for a typical 600x1200mm ACB can be anything from 79 to 165 L/s, depending on the primary air quantity, it is easily visualised that the minimum and maximum air quantities will have different nominal throw distances.

b. Height of the unit in relation to the conditioned space is also an important factor. If an air collision occurs at a higher level, the air stream will likely be warmed up and diminished by the time it reaches the occupied space. Therefore, closer spacing for higher air quantities is more tolerable where higher ceilings are used.

c. As the ACB unit induces, or aspirates, more room air at the edge of the ACB supply air stream than it does in the centre of the airstream, shorter ACB units actually suffer less from air collisions than do longer ACB units for a given air quantity. Air mixing with the warmer room air is important in eliminating air draughts in the conditioned space.

d. Coanda also contributes to air collisions relative to the occupied space. Where good horizontal ceiling planes are present, Coanda is improved at higher levels versus spaces with no ceiling plane that encourage air to drop faster than it would if a ceiling plane were present. If the air drops faster than it travels horizontally, the air collision between two ACB units will occur closer to the conditioned space making the air collision or draught problem seem worse than it really is.

If the loads are high, it means there will either have to be a higher air quantity per ACB unit or more ACB units selected for a given space to handle the cooling loads. The designer must be aware of loads versus air quantity, just as you would for any all-air system design.

It is only practical to assess each ACB individually based on the loads, air quantities and proposed layout if there is concern for air turbulence or air collisions in the occupied space.

Can Active Chilled Beams be used where high outside air exposure or infiltration is likely?

Generally, No unless the exposure is limited in severity or duration.

See comments in the next question on page 2 of this design bulletin regarding latent capacity and dew point control strategies.

A dew point strategy can minimise the risk of condensation. Where ambient air exposure is likely to be intermittent, some deterioration in sensible cooling delivered will be evident during and immediately following a period of high ambient air exposure until the primary air strategy can restore latent capacity and eliminate the dew point conflict.

If outside air and/or humidity exposure is likely to be continuous, sufficient latent capacity must be provided for in the primary air design strategy or perhaps the application is not a good application for Active Chilled Beams unless condensate trays are fitted (possible only with some ACB configurations).

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Can Active Chilled Beams use an economy cycle strategy where ambient dry bulb temperatures are suitable for the primary air value?

Yes, but with some caution regarding latent capacity requirements. See comments in Design Bulletin 2 regarding primary air design considerations.

Where lower ambient temperatures are used as economy cycle primary air in cooling mode it is important to maintain the design absolute humidity differential between the room condition and primary air condition to ensure latent capacity is delivered. As these coincidental conditions are probably low in frequency or unlikely during occupied hours, the primary air handler control algorithm is the safest way to ensure latent performance is not sacrificed for small sensible capacity chiller energy gains by using outside air in an economy air mode.

Assume the primary air latent capacity requirement for a given zone is 2955W for a primary air quantity of 670 L/s; 12ºC & 90%rh is the primary air design condition and the room design condition is 24ºC & 50%rh.

24ºC & 50%rh room air has an absolute humidity value of 9.34 g/Kg

12ºC & 90%rh primary air has an absolute humidity value of 7.88 g/Kg

The absolute humidity differential (Δw) is therefore 1.46 g/Kg

The (Δw) of 1.46 g/Kg is required to ensure design latent capacity is delivered for 670 L/s

If primary air at ambient conditions of 12ºC & 70%rh is delivered, the new primary air absolute humidity will be 6.11 g/Kg suggesting latent capacity requirement will be exceeded if the primary air quantity remains as 670 L/s since the Δw value has now been increased to 3.23 g/Kg.

However, if primary air at ambient conditions on a rainy day of 12ºC & 98%rh is delivered and the primary air quantity of 670 L/s remains, the new primary air absolute humidity will be 8.59 g/Kg suggesting latent capacity requirement will not be delivered as the absolute humidity differential (Δw) is now 0.75 g/Kg versus the design Δw of 1.46 g/Kg. Sensible capacity delivered in primary air is unaffected but latent capacity will be insufficient for the design latent load.

Remember, the primary air component of an ACB (Primary Air AHU) may have the highest enthalpy differential on a psychrometric chart, however the primary air capacity is based on a relatively low mass flow rate. Trying to save energy on the 30% of capacity delivered by primary air can be detrimental to the chiller capacity required to operate secondary water where primary air cannot satisfy sensible loads in the conditioned space.

Compromising on primary air capacity may also lead to dew point conflicts and further reductions in sensible cooling as discussed in Design Bulletin 6 - Control Strategies (dew point strategy).

Can Active Chilled Beam primary air be thermally neutral in temperature?

Yes, this can be advantageous where hot water heating in the secondary coil will be used but should be viewed with some caution regarding latent capacity requirements and sensible cooling in the cooling mode. See comments above and in Design Bulletin 2 regarding primary air design considerations.

a. Thermally neutral primary air is difficult to ensure latent capacity is adequately delivered unless primary air is first cooled down to a sufficiently low absolute humidity value and then reheated to room temperature.

b. Thermally neutral primary air contributes nothing in sensible cooling to the space. This limits ACB sensible cooling performance by placing all sensible cooling on the secondary heat exchanger, resulting in a lower than necessary sensible cooling capacity per unit and potentially a greater number of units required to satisfy the design load.

Colder primary air ensures latent capacity is delivered and makes a positive contribution to sensible cooling capacity delivered to the conditioned space.

Providing for some cooling in the primary air also allows a degree of part-load cooling to be delivered by the primary air only when secondary water flow is terminated at part-load conditions.

For more design considerations, see other issues of the Design Bulletin

This series of design bulletins is provided by Dadanco in the interest of sharing design experience with those interested in learning more about Active Chilled Beam design fundamentals

ACTIVE CHILLED BEAM

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