



Considerations for Active Chilled Beam Designs

What About Coincidental Heating / Cooling?

This design bulletin deals with the Active Chilled Beam scenario of **Coincidental Heating & Cooling**

Can ACB's deliver secondary cooling while primary air is in the heating mode?

Yes. Coincidental cooling / heating, sometimes referred to as 'Re-Cooling', occurs when the primary air is in heating mode and an increase in internal loads causes an occupied zone to enter the cooling mode.

Scenario:

Let's assume a building designed for multiple uses has low to mid level floors with high occupancies and corresponding high ventilation primary air rates while the same building has upper floors with higher heating loads, lower occupancies and lower ventilation primary air requirements.

NOTE: The upper floors with lower occupancies and ventilation primary air rates will require higher primary air heating temperatures than the lower floors. When the lower floor rooms are suddenly occupied, the internal loads of lighting, people and equipment exceeds the building fabric losses and heating capacity sending the room into the cooling mode despite the additional heat still being delivered to the room by the primary air.

A perimeter room with 5650W building fabric heat losses is delivered with 335 L/s of 35°C primary air from 4 ACB units equating to 5650W of heating capacity; sufficient only to satisfy the building fabric losses of the unoccupied room at 21°C.

When occupied, 5725W of sensible heat load from people, lights and equipment increases the temperature of the space causing the room to enter the cooling mode and assume a new higher set-point temperature of 24°C. The sensible cooling load is therefore 5725W while the latent load from occupants is 1920W.

As the occupied room temperature increases, the system initiates circulation of 13.5°C secondary chilled water to the ACB's in an attempt to stabilise temperatures. The ACB system is now in heating mode in the primary air and cooling mode at the secondary heat exchanger. The primary air system remains in heating mode since the upper floors have not entered the cooling mode.

Cooling Loads:

Sensible Loads - 5725W of room sensible load is handled by the 4 ACB units each delivering 1430W of sensible cooling from the secondary cooling coil operating with 176 L/s of 24°C secondary air and 0.06 L/s of 13.5°C secondary water flow each.

Latent Loads - Since 35°C heating primary air is sufficiently far from the saturation temperature of room air at 24°C, and the coincidental absolute humidity value of winter ambient air is relatively low compared to the absolute humidity value of 24°C room air, there is minimal risk of condensation occurring at the ACB secondary coils during coincidental heating/cooling operation.

What Really Happens

Technically, when secondary air from the coil mixes with 35°C primary air; the resulting mixed air temperature is only marginally cooler by 1°C than the room condition of 24°C. Therefore, the mixed air stream delivers only 315W of sensible cooling capacity to the space.

The mixed air condition can be calculated from the standard energy equation as:

$$\begin{aligned} & ((\text{primary air L/s} / \text{total supply air L/s}) * \text{Primary Air Temp}) + ((\text{secondary air L/s} / \text{total supply air L/s}) * \text{Coil off Temp}) \\ & ((335 \text{ L/s} / 1040 \text{ L/s}) * 35^\circ\text{C}) + ((176 \text{ L/s} / 1040 \text{ L/s}) * 16.3^\circ\text{C}) = 23^\circ\text{C} \end{aligned}$$

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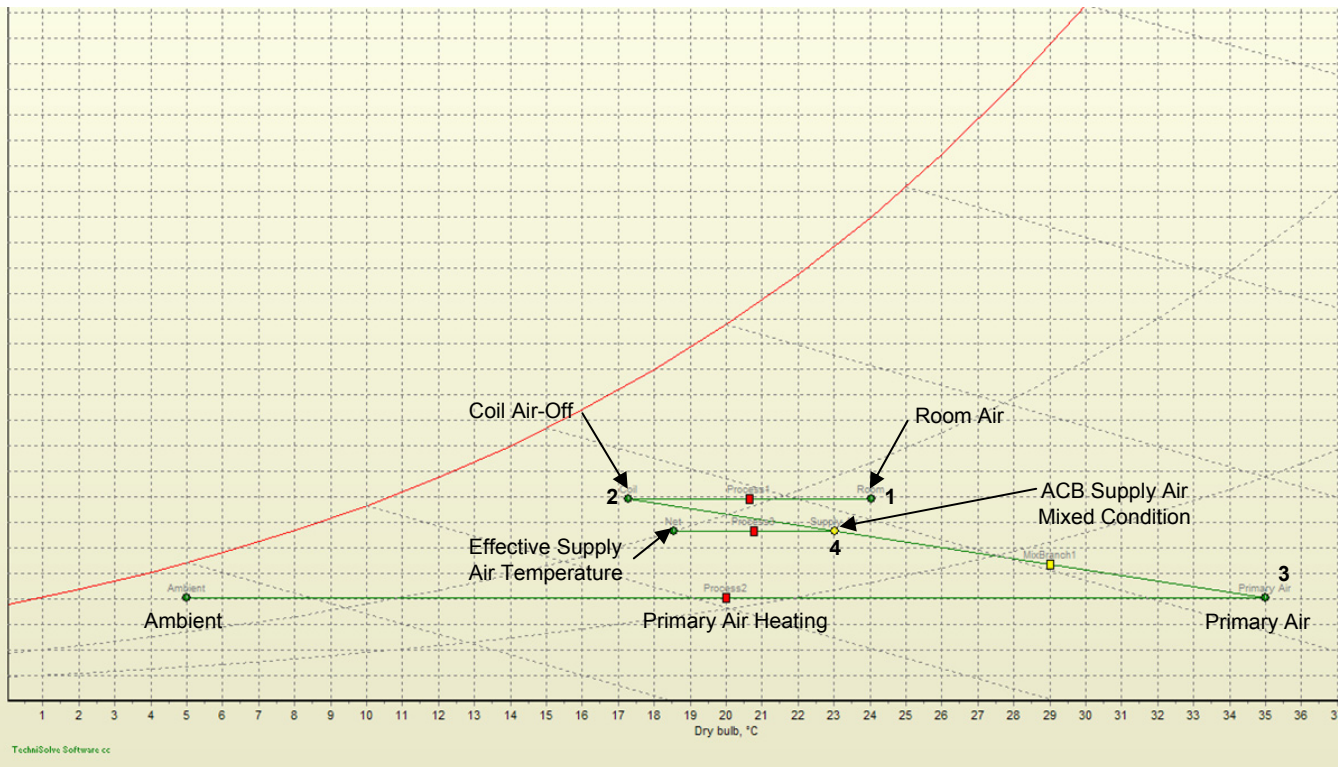
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Considerations for Active Chilled Beam Designs

Coincidental Cooling / Heating (Continued)



In the psychrometric chart above

Room air (point 1) is cooled to the secondary coil air off temperature of 17.3°C (point 2) by the circulating 13.5°C secondary chilled water.

Heating air of 35°C (point 3) is mixed with the secondary coil air off temperature (point 2) at the ratio determined by the entrainment ratio of the ACB to point (4) 23°C.

The heating fabric losses of 5650W must be reduced from the mixed air temperature of 23°C at point 3 to achieve the effective supply air temperature of 18.5°C.

The sensible cooling capacity delivered to the space is therefore the difference between the room condition of 24°C and the effective supply air temperature of 18.5°C at the total supply air quantity of the 4 ACB units.

$((24^{\circ}\text{C} - 18.5^{\circ}\text{C}) \times 1.213) \times 1040 \text{ L/s} = 6938\text{W}$ sensible cooling delivered.

The above value includes the 315W sensible cooling delivered by the mixed air condition of 23°C.

As the room set point temperature of 24°C is achieved, secondary water will cycle On/Off as it would in any cooling call scenario to maintain the room temperature.

However as the secondary coil cooling terminates, the primary air heating temperature of 35°C mixes with room air of 24°C to result in a mixed supply air temperature of 27.5°C which delivers heating capacity to the space.

Some potential for temperature 'hunting' exists while the system swings between heating and cooling modes due to somewhat rapid changes in supply air temperature.

The relative shape of the psychrometric processes clearly indicates the primary air temperature to be lower in absolute humidity than the room air, eliminating potential risk of secondary coil condensation even if colder secondary water temperatures than 13.5°C are used.

To enable this 'Re-Cooling' process, the secondary chilled water must be enabled and the secondary water circuit cannot be used for heating water supply.

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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

