Introduction to Active Chilled Beams

How Does an Active Chilled Beam Work?

This design bulletin deals with a simple explanation of the functionality of an Active Chilled Beam.

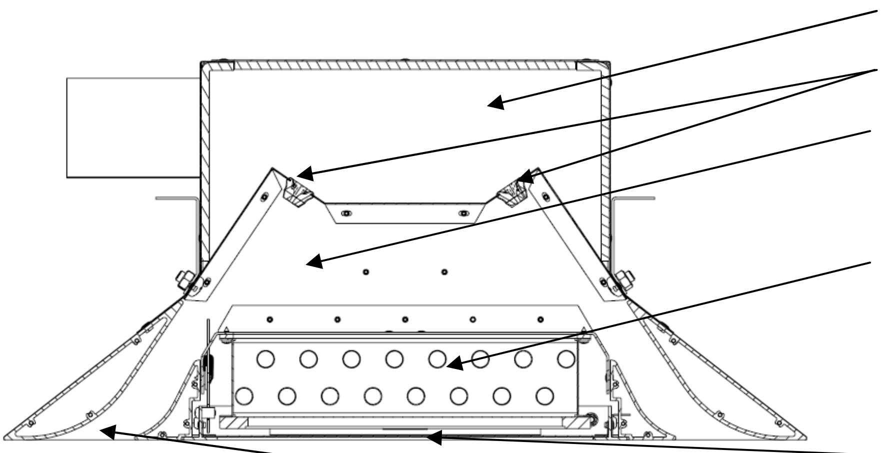
Introduction

An Active Chilled Beam (ACB) is an air terminal device used to provide localised cooling by inducing room air over a chilled water heat exchanger located in the space to be conditioned.

An ACB relies on the use of primary air as the motive force for inducing air over the secondary heat exchanger. This primary air is conditioned at a conventional air handler and distributed to the ACB's through conventional air ductwork.

ACB's can be configured to suit a variety of applications or designs. For the purpose of visualising the following explanations, a typical 2-way discharge ceiling mounted unit will be used.

Figure 1: Typical Construction



The ACB is configured of an insulated well sealed primary air plenum containing a primary air connection spigot and an array of primary air nozzles through which the primary air is delivered.

The lower part of the unit is comprised of a sheetmetal air mixing chamber which houses the secondary cooling coil and supply air outlet chambers. The supply air chambers are formed by smooth extrusion shapes on either side of the unit and are open to the conditioned space.

The secondary air cooling coil is centrally located in the mixing chamber of the unit and is accessible through a perforated metal return air grille panel. The coil and mixing chamber are separated from the primary air plenum by the nozzle plate to ensure the mixing chamber is exposed only to room air from the space to be conditioned.

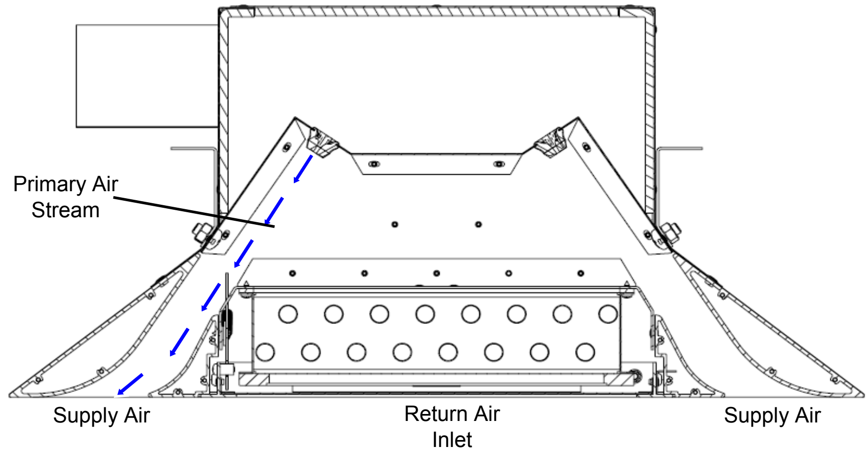
The unit is fitted with mounting brackets to facilitate installation and to permit the unit height and fore & aft attitudes to be adjusted during installation.

ACB's can include return air lint screens although this is not an essential component.

……Continued on Page 2

The Induction Process

Figure 2: Primary Air

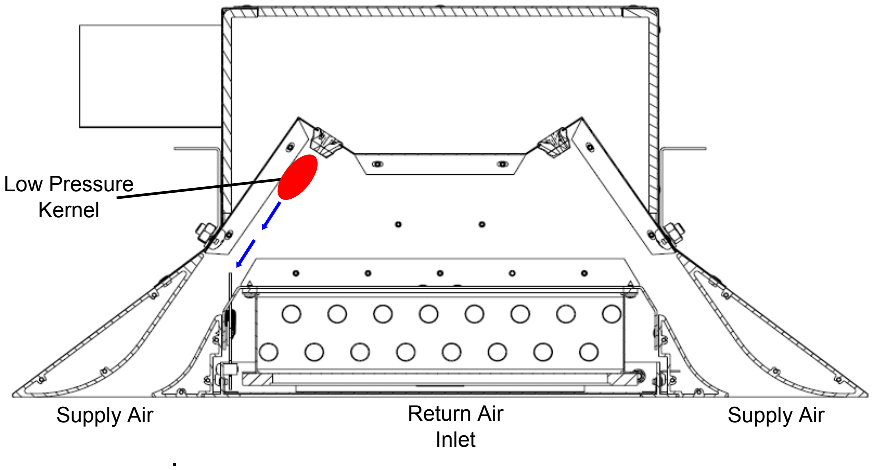


Primary air is delivered into the primary air plenum and out through the nozzles into the mixing chamber on its way to the conditioned space.

The motive force in an ACB is the induction process created by the induction nozzle and primary air stream delivered through the induction nozzle.

The primary air can be any temperature but it is beneficial to use lower temperature primary air to ensure adequate latent capacity is delivered in the primary air and to permit the primary air to deliver a proportion of the required sensible cooling to the space.

Figure 3: Low Pressure Kernel

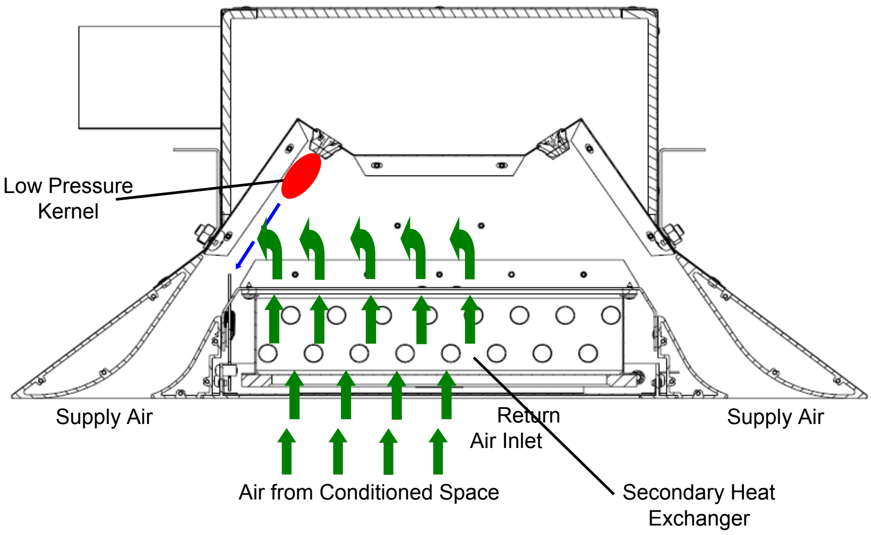


In the primary air stream, at the outlet of the nozzle, is a 'Low Pressure Kernel' which is created as the pressure at the nozzle is degraded as air flows through the nozzle.

All pressure degradation occurs at the primary air nozzle, resulting in a low pressure area immediately at the nozzle outlet.

This low pressure area is only slightly lower in pressure than the surrounding room air.

Figure 4: Induced Secondary Air



The low pressure kernel, or area, attracts the surrounding air which is at a slightly higher pressure than that of the low pressure kernel.

Air from the room (conditioned space) known as 'Secondary Air' is drawn or 'Induced' into the low pressure kernel.

A secondary heat exchanger coil is imposed in the path of the room secondary air, forcing the induced air to pass through the heat exchanger on its way to join the low pressure kernel.

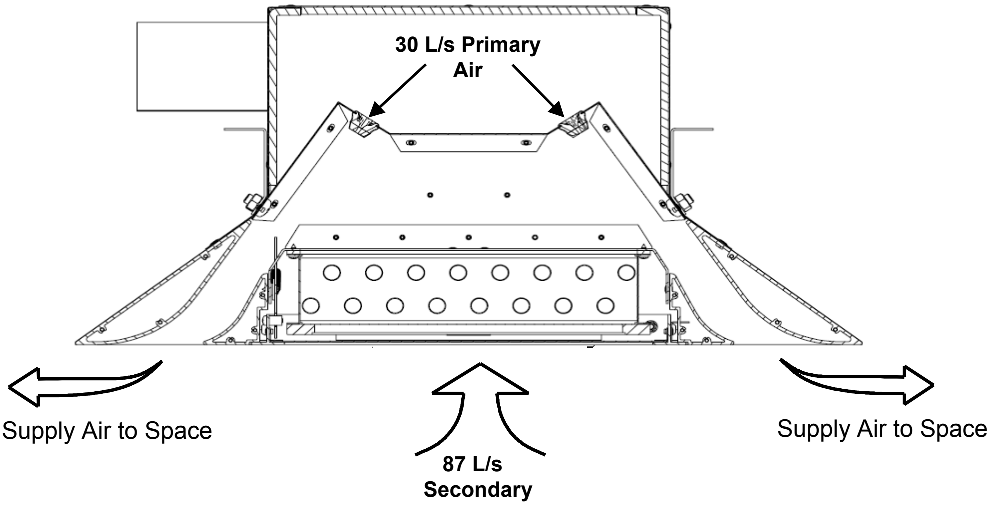
The efficiency of the induction process is dependent on the number, size and efficiency of the induction nozzles plus the density and geometry of the secondary cooling coil.

This secondary air from the local room space to be conditioned is induced, or moved, across the heat exchanger (cooling coil) for no fan energy requirement whatsoever. This is a significant contributor to the energy reduction potential of Active Chilled Beams.

.... Continued on Page 3

What Really Happens

Figure 5: Operating Details

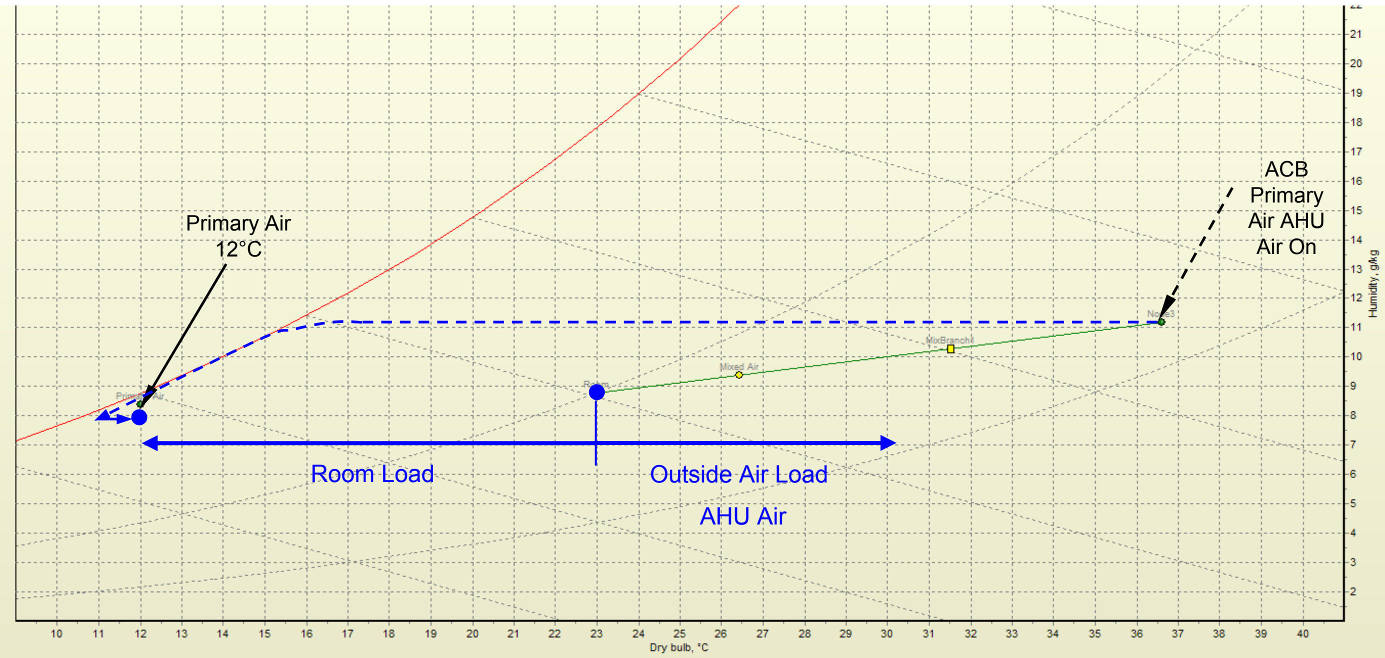


Induced Air from Room Space

Typically, an active chilled beam can induce secondary air of up to 3 times the primary air quantity. Secondary air is routed through a chilled water heat exchanger, producing cooling to be delivered to the space for no fan energy requirement.

As the primary air and secondary air are mixed in the ACB prior to delivery to the space, the total supply air quantity delivered by the ACB is the sum of the primary and secondary air quantities. Primary air sensible cooling capacity, usually around 25-35% of the ACB sensible capacity, is a function of the primary air quantity and temperature difference between the primary air and room air temperatures. The secondary air cooling is ideally a strictly sensible cooling process and usually represents 65-75% of the ACB sensible cooling capacity, not because of its higher air quantity but the result of having passed this relatively small secondary air quantity over a localised cooling coil operating with 13-14°C chilled water.

Figure 6: Primary Air



Primary air is processed at the AHU to be delivered to the ACB at the design conditions specific to the project. In these examples, 12ºC & 89%rh primary air will be used.

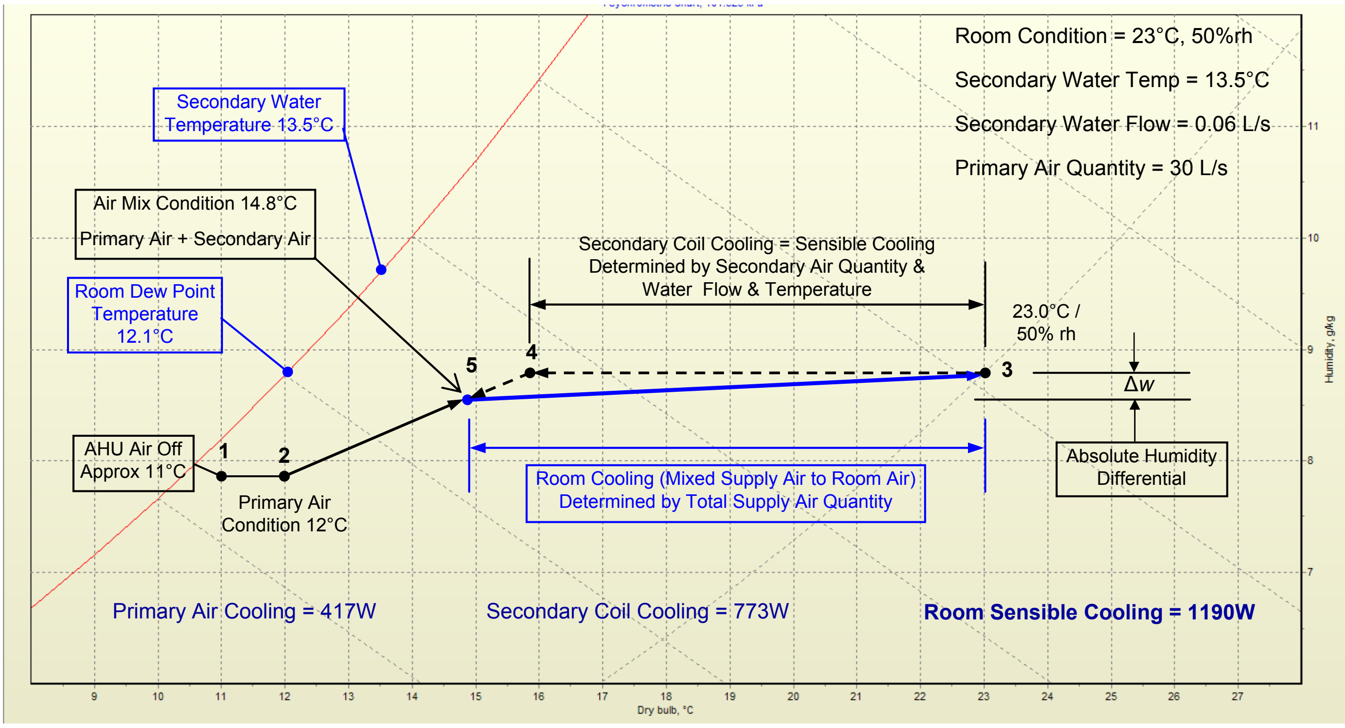
For determining primary air sensible cooling capacity, only the difference between the primary air and room air temperatures are used. Any loads higher than room loads are to be included in the AHU loads since the ACB is a room terminal device and should only be related to room cooling loads.

…. Continued on Page 4

How Does an Active Chilled Beam Work?

The following describes the psychrometric process lines associated to and Active Chilled Beam or induction unit cooling process at the operating parameters listed.

Figure 7: Process Lines



In the psychrometric process lines above, primary air condition of 12ºC & 89%rh (point 2) is achieved from an assumed AHU air off condition of 11ºC (point 1). The primary air is delivered through the ACB to the conditioned space. It is important that the primary air temperature be expressed as the terminal temperature, not AHU air leaving temperature.

Room air of 23ºC & 50%rh (point 3) is induced through the secondary cooling coil and sensibly cooled to 15.8ºC (point 4) by the 13.5ºC secondary water circulating in the cooling coil. The capacity of the secondary coil will be a function of the secondary air quantity, secondary water temperature and secondary water flow rate.

The primary air and secondary air streams are mixed in the ACB (point 5) at the ratio determined by the amount of secondary air to primary air known as the entrainment ratio. Entrainment ratio is determined by fixed unit selection parameters and cannot be site adjusted for a given primary air quantity. In the example above, the mixed air condition is 14.8ºC.

Mixed supply air (point 5) is delivered to the conditioned space (point 3) representing the total cooling capacity delivered to the conditioned space by the ACB. The mixed supply air condition (point 5) will also determine the latent cooling delivered by the ACB based on the absolute humidity differential (Δ*w*) between points 3 & 5 on the psychrometric chart. Generally, since the secondary cooling coil process is a sensible cooling process, the absolute humidity condition at point 5 will be determined by the absolute humidity of the primary air at point 2.

Using too warm or too moist a primary air condition will result in insufficient latent cooling delivered resulting in difficulty maintaining the design room condition at point 3.

In the above example, primary air cooling (417W) represents 35% of the sensible cooling delivered by the ACB, meaning the ACB is capable of being turned down to 35% part-load cooling by simply isolating the secondary water flow.

The amount of sensible cooling delivered by the secondary heat exchanger can also be varied by modulating secondary water flow if required.

This series of design bulletins is provided by Dadanco in the interest of sharing information and design experience with those interested in learning more about Active Chilled Beams.

For design assistance or further information, contact:

Dadanco Pty Ltd
89 South Road
Hindmarsh, S.A. 5007
Australia
P: +618 8346 3588
F: +618 8346 7822
info@dadanco.com.au
www.dadanco.com.au

Breathing Life Into Your Building