This Factfile gives the reader an insight into the colour shift and efficiency problems that can be encountered when choosing an integrated lighting and cooling solution for an office development. Lamps and LED arrays are designed to give their optimum output and stated colour temperature at a given atmospheric temperature. If lamps are cooled below this temperature, their colour will shift and their and their output will change. This can result in the lighting installation delivering below its design intentions.

**Cooling methods**

Traditionally, mechanical cooling in office spaces has been dealt with by either cooling air before it is supplied into a room, or by using local cooling units that employ a fan to force air across a cool surface. Either method can result in differing temperatures across an office ceiling.

**Centralised Cooling Systems**

In large buildings, the air supplied to its office space can be chilled centrally and supplied via insulated ductwork to where the cool air is needed. This method will result in supply diffusers being positioned within the ceiling and air supplied via them at typically 6 to 8 degrees centigrade below the ambient temperature of the space being cooled. Extract from these spaces can be via dedicated extract grilles or via a plenum ceiling incorporating perforated ceiling tiles.

Whilst such a system has no obvious connection to the lighting within the space, care should be taken to not position luminaires too close to supply diffusers due to the Coanda effect. First applied by Henri Coanda, this phenomenon results in air which leaves a confinement such as through a supply diffuser, tracking a surface close to its exit point, such as a ceiling. As long as the surface remains smooth, the effect can carry air across a ceiling for some distance depending on its discharge rate. Where a luminaire is recessed into a ceiling and has a smooth curving reflector, it is possible for air to flow into the luminaire and across the lamp.

Where air is extracted via a ceiling plenum, the rate of any air flow through the ceiling will depend on the location of the extract ductwork above it. For example, a space 20 metres long and 7 metres wide with an extract point above the ceiling at one end of the room will see a higher extract air flow close to that end. The end of the room farthest away will have a consequently lower level of extract.

Again, this may not appear to be related to the lighting installation, however higher extract airflow at one end of a room can result in the luminaires, particularly if they are open, being subject to different ambient conditions across the space. This leads to slight changes in light output and possibly colour from the lamps in these luminaires.

*Image of supply diffuser and suspended luminaire*

**Fan Coil Units**

The principal of operation is to run a cooling medium such as chilled water through a series of finned pipes, similar in look to a car radiator and known as a cooling coil. A fan is then used to push air across that cooling coil and into the space to be cooled.

These units are usually referred to as fan coil units (FCU) and whilst they can be wall or floor mounted, they are usually hidden away in ceiling voids with only their supply diffusers and sometimes, extract grilles, readily visible. Often, the system will supply air to a space via supply diffusers and extract it to ceiling voids through perforated ceiling tiles in the same way as for centralised systems. This latter method can give a more balanced flow of air across the luminaires in a space than can be achieved through specific extract grilles and differs from the possible problems with single point extract in central systems because each FCU deals with a proportion of the air.
**Image of lighting & mechanical services coordination**

**The Natural Cycle**

By its very nature, cool air will fall to the ground and displace warm air which will rise. If the supply of cool air is maintained, then a cycle will develop. It is not simply a case however of providing a space with cool air at any given point and expecting such a cycle to begin and be effective at providing cooling to the whole space. Inevitably such an approach would lead to localised stagnation and the cooling effect would not be uniform. In addition, any pipe or duct carrying a cooling medium such as chilled water or air, would find condensation building up on its outer surface if the coolant temperature was too low. Any condensation finding its way into luminaires could lead to component failure in addition to the associated safety concerns.

**Chilled Beams**

In order to gain the benefit or not running fans constantly within fan coil units, and to take advantage of the natural cycle created by falling cool air, the chilled beam concept is becoming more popular in office developments.

Essentially, a chilled beam is a cooling coil which is stretched into a linear section of flow and return pipework, each with a series of radiating fins attached. Because the cooling surface is spread over a much greater area, uniformity in the cooling effect can be achieved without the need to use energy in the running of fans. The risk of condensation on the cool pipework still exists however and to ensure it doesn’t form, the cooling medium cannot run at temperatures as low as those used in fan coil units.

In addition, the humidity within the space has to be carefully controlled to make sure any potential water source for condensation formation is limited.

For more information about the mechanical aspects of office cooling solutions, please see CIBSE Guide B - Heating, Ventilating, Air Conditioning and Refrigeration or BSRIA Illustrated Guide to Mechanical Building Services.

**Integrated Services**

In much the same way as lighting has to be carefully placed in a ceiling to optimise the use of luminaires, components associated with the supply and extract of air from a space also require careful placement. This can often lead to the preferred location of luminaires and supply diffusers being in the same place.

When additional services such as fire alarm smoke detectors, public address speakers, sprinkler heads, and movement detectors are added into the equation, it is easy to see how a ceiling can become congested with the inevitable need for compromise.

The need for mechanical services and luminaires to optimally be in the same locations within ceilings, along with the architectural preference for minimal ceiling congestion, has led to the development of integrated cooling and lighting solutions.

**Image of integrated chilled beams being installed**

**Air Handling Luminaires**

Where cool air is provided from a fan coil unit, it is sometimes possible for the air return path to pass through a recessed modular luminaire. This combining of extract point and luminaire has the advantage of reducing ceiling congestion and placing both luminaire and extract point at preferred positions.

Care should be taken however when selecting such luminaires and consideration should be given to a number of factors as poor design can lead to lamps running below their optimum temperatures when air flows across them.

1. The type of lamp used and its operating temperature. T5 lamps for example, operate efficiently at a higher temperature than T8 lamps. LED systems operate more efficiently at lower temperatures.

2. The air path through the luminaire. Air should ideally pass through the sides of the luminaire and not over the lamps.

**Integrated Chilled Beams**

The nature of chilled beams means they occupy a large proportion of ceiling space and so integrating lighting into them is sometimes the only option.

A number of manufacturers offer chilled beams with integrated lighting and presence/absence control.

The issues of integrating lighting are similar to those of air handling luminaires, the difference being that lamps may be subject to cold air falling from the chilled pipework within the beam rather than the return air temperature.

**Impact on Lighting**

Light sources, be they fluorescent, LED or any of the high pressure lamp types are designed to operate optimally within a specific temperature range. Moving outside of these ranges will affect the efficiency of the lamp, resulting in a lower output, and a change in the colour of light emitted (colour temperature).
The effect of temperature on lamps is well known and can be accommodated for at the installation design stage provided the interaction of the various design elements is understood.

Differences in ambient temperature across a ceiling can be caused by either predetermined control of mechanical systems, or by unplanned interaction such as unbalance extract from an office space.

Where a number of luminaires are installed in a common space and are subject to overall control, then drifts in colour temperature and output will not be readily noticeable. However with the advent of better and more precise control of heating and cooling systems, particularly in large open plan spaces, the effect on lighting can be quite pronounced.

Integrated chilled beams are usually controlled independently of each other which allows the temperature around any integrated lamps to differ depending on whether the chilled beam is operating or not. Because the lamps are so close to the chilled water circuit within the beams and may be subject to falling cold air passing over them, they are likely to suffer a change in colour temperature.

### Typical Operating Temperatures

<table>
<thead>
<tr>
<th>Fan coil unit air supply</th>
<th>Typically 60 C to 80 C below the ambient temperature in the space to be</th>
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<tbody>
<tr>
<td>Chilled beam surface temperature</td>
<td>Typically 140 C to 180 C</td>
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<tr>
<td>T5 lamp optimum operating temperature</td>
<td>Typically 350 C around the lamp</td>
</tr>
<tr>
<td>T8 lamp optimum operating temperature</td>
<td>Typically 250 C around the lamp</td>
</tr>
<tr>
<td>LED optimum operating temperature</td>
<td>Typically 250 C</td>
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</table>

Beams can be viewed simultaneously, differences in colour temperature will be noticeable.

The build-up of dirt within luminaires is a known problem and will degrade light output over time. Where there is natural ventilation in a building or where there is no filtration on the air supply, it is usually better to ensure air either passes through the luminaire rapidly to avoid dirt deposition or avoid air paths through the luminaire at all. Where poor design or manufacture results in air slowing within the luminaire and dropping dust over the lamp and reflecting/transmitting surfaces, dirt will build up quickly resulting in the need for more frequent cleaning.

When designing or advising on the use or installation of systems that integrate lighting with mechanical chiller services, the location of lamps within the air handling luminaire or chilled beam and the air path should be carefully considered.

Whilst not directly related to lighting design, the control of the mechanical systems should be clarified and where fluctuations in temperature of adjacent chilled beams is likely to occur, careful selection of integrated chilled beams should be made.

The following graph shows typical performance curves for T5 and T8 linear fluorescent plus LED systems over the ambient temperature range that is likely to be encountered in cooled office space.

It can be seen that the output of T5 lamps is affected to a greater extent than T8 or LED as the temperature around the lamp falls. If integrated cooling/lighting solutions are not properly designed, there could be a noticeable difference in illumination levels depending on whether the mechanical systems are cooling the space at any given time.

For detailed information and specific lamps characteristics, consultation with the lamp manufacturer should be made.

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Typical performance curves for T8, T5 & LED drivers.