27. AIRBORNE INDOOR CLIMATE SYSTEMS

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WHAT IS AN AIRBORNE INDOOR CLIMATE SYSTEM?

What is the first thing you think about when you hear the expression 'climate system'? Most people usually think of the sun, wind, sea, air and the atmosphere, now being destroyed by mankind. This is not at all strange, as we are constantly reminded in the media about the dangers to which our global outdoor environment is being subjected. Far fewer people think about how *indoor* climates affect us. It's perhaps sufficient to point out that living in modern society means that we spend more and more time indoors, in fact, as much as 90% of our time. We can note that our daily intake of food is 0.75 kg and we drink about 1.5 l of liquids. This can be compared to the 15 kg or so of air that pass through our lungs every day. These intakes affect our health and the more pollutants and poisons we consume, the more our purifying systems will have to do. If we consider the possible contents of the air we breathe and what happens in our body cells when blood is oxygenated, it is clear that it would be a good idea to make sure that the air we breathe indoors maintains a sufficiently high quality. Ensuring this quality is one of the most important tasks of an airborne indoor climate system and this and other functions of such systems are discussed in this chapter.

An airborne indoor climate system is a system in which conditioned ventilation air in a building is the carrier of the cooling and heating energy required to provide a correct indoor climate and to satisfy the occupants' needs for a good indoor climate. It must ensure that all the different rooms in a building are provided with an adequate climate with respect to air quality and the thermal environment. And, of course, it must also provide an acceptable acoustic environment.

Practical applications

Airborne indoor climate systems are often used in industrial buildings and shops, especially outside Scandinavia, but they are much less common in other types of commercial buildings and residential buildings. Here, heating is often achieved by using radiators under windows or underfloor heating systems. However, the opportunities for using air as an energy carrier are increasing, as buildings are being developed to meet requirements for less heating. An argument against heating using ventilation air is that it is not sufficiently efficient. A critical factor is the ability of a system to meet temperature demands along the insides of external walls. Today, there are many good examples of office buildings where this has been achieved. An office building often has a sufficiently large heat surplus during the whole of the year, while the building is in use, which means that heating is only required while the building is empty. An important condition, however, is that critical building components, such as external walls and windows, have adequately large thermal insulation properties. Another important condition is that the HVAC system has effective and efficient supply air terminal devices, ATDs, that can discharge air at an over temperature in an efficient manner. Finally, a good control system is required. Both full-scale tests and field tests have shown that airborne indoor climate systems work extremely well, if all the requirements are properly analysed and the plant installed can work in conjunction with the structure of the building and the materials used.

In the following, we will concentrate on how airborne indoor climate systems work in individual rooms.

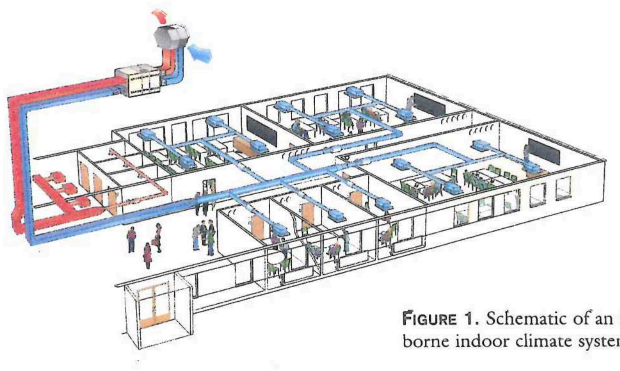

FIGURE 1. Schematic of an airborne indoor climate system.

THE CLIMATE IN A ROOM

A building is a structural envelope in which people can live and work. If rooms are to be used for their intended purposes, a number of technical climate factors must be kept within suitable limits. The first three factors in the following list are directly dependent on the air handling system:

- Air quality
- Thermal climate
- Acoustic environment
- Visual environment

These factors and the effects they have on people's health, comfort and work performance are described in Chapter 1/Health and well-being in indoor environments, and the chapters in Part D/The indoor environment – in a wider sense.

THE DISTRIBUTION OF AIR IN A ROOM

In the parts of a room that are occupied by people, it is important that the speed of the air is not too high and its temperature not too cold, so that no uncomfortable draughts are experienced. To be able to provide the correct temperature and ventilate a room at all, zones are required into which air can be supplied. This is why the concept of a so-called occupied zone has to be defined. There are a number of definitions and the following is taken from the Swedish Building Regulations:

An occupied zone in a room is limited by two horizontal planes, one 0.1 m above the floor and another 2.0 m above the floor, and by a vertical plane 0.6 m from the external wall or other external limit, or 1.0 m from a window or door.

In practice, the size of the occupied zone is greatly dependent on the choice of supply air system and, above all, by the type of ATDs used.

Air speeds within the occupied zone must not, as a rule, be allowed to exceed 0.15 to 0.25 m/s. The speed of the air, at which it can be regarded as accepable, will depend on its temperature. The lower the temperature, the more its speed has to be limited. Speed limits can, therefore, be different in summer and winter.

ATD manufacturers supply data for so-called throws, sizes of near zones, functional distances etc, so that air speeds in the occupied zone can be taken into account during the planning phase of a project. These details describe the spread of the air jet from the ATD into a room or space. The spread is often defined as the boundary distance at which the air speed has fallen to 0.2 m/s. Figure 2 shows the throw for a mixed

flow ceiling mounted device, where the air speed beyond the boundaries is less than 0.2 m/s.

Figure 3 shows an example of the spread in the near zone across a floor from an ATD used in a thermally controlled displacement ventilation system.

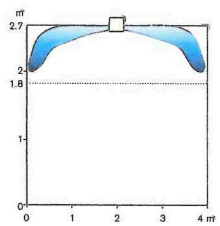

FIGURE 2. The throw of a ceiling mounted ATD.

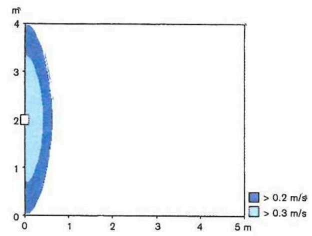

FIGURE 3. Horizontal near zone spread pattern.

Air jets

Three main types of air jets are normally used in comfort ventilation systems. In free radial and axial jets, the supply air jet will follow the surface of the ceiling or a wall. In jets like these, the supply air is discharged at high speed and the room air is inducted into the air jet. At the other end of the scale are jets with low speeds and low momentum, into which the room air is not inducted.

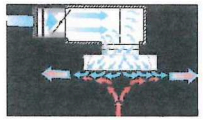

FIGURE 4. Radial free air jet.

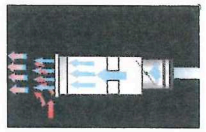

FIGURE 5. Axial free air jet.

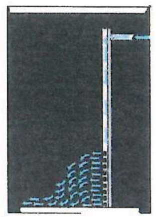

FIGURE 6. Low momentum air jet.

As cold air is denser than warm air, it is important when designing supply air systems to choose terminal devices with correct throws, to prevent draughts from being created in the occupied zone. Here, it is a question of being able to control the direction and spread of the air flow in a room. If there are a number of ATDs in the same room, this feature will be even more important. And, just as in acoustics, there are additive effects of air jets placed close to each other. Jets colliding with each other or with walls, pillars, fittings and ceiling beams etc must, of course, also be avoided. Collisions like these normally lead to the air jets being deflected into the occupied zone, resulting in annoying draughts.

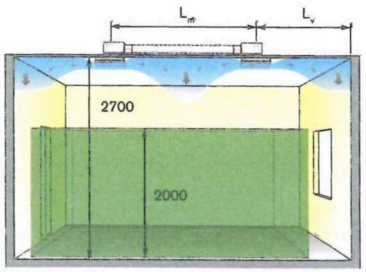

FIGURE 7. Collision risks between air jets. The green volume represents the occupied zone.

The safest way to introduce an air jet at high speed is to direct it parallel to the ceiling, or the walls, in the room. This will create an under pressure above, or behind, the air stream, helping it to cling to the adjacent surface. This effect is often called the ceiling effect or Coanda effect, after the Rumanian scientist Henri Coanda (1886–1972).

VENTILATION PRINCIPLES

There are three different ways in which an airborne indoor climate system can ventilate a room. The two most common are based on the properties of mixed flows and thermally controlled flows. In very special instances the air flows can be created by so-called piston flow, which is used in clean room applications. To get a picture of how good these different flow techniques work, a number of efficiency concepts can be used, such as ventilation efficiency, air change efficiency and temperature efficiency. These different efficiencies and how they can be determined are discussed in Chapter 16/Air change and air flow.

To achieve suitable air flows with high degrees of efficiency, the design engineer must pay great attention to the following parameters:

- Where the terminal device is mounted
- The type of supply or extract air terminal device
- The speed of the supply air
- The temperature difference between the supply air and the extract air
- Obstacles in the room, heat sources, type of activities, sizes of windows etc.

Figures 8 and 9 illustrate the air flow principles for mixed flow ventilation and thermally controlled ventilation. Thermally controlled ventilation can be divided into two types: displacement flow ventilation and so-called equalizing ventilation.

Mixed flow ventilation is characterized by the room air being inducted into a high-speed air jet. When displacement ventilation is used supply air at low speeds is discharged into a room close to floor level. The supply air must be cool so that it can spread across the surface of the floor. When the air is subsequently heated by heat sources in the room it will rise towards the ceiling, carrying with it pollutants from the occupied zone. In equalizing ventilation systems the room air is mixed with the supply air. This means that the supply air gains a temperature level close to that of the room air. The different air flow principles are discussed later on in this chapter.

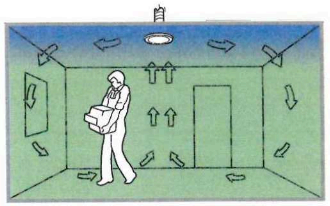

FIGURE 8. Mixed flow ventilation.

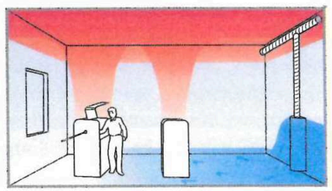

FIGURE 9. Thermally controlled displacement ventilation.

When can the air in a ventilation system be used as a cooling medium?

COOLING WITH AIR

To achieve a cooling effect using the ventilation air, the supply air temperature must be lower than the room air temperature. As mentioned above, there are limits regarding how cold the air can be without it causing discomfort in the form of draughts.

The risk of draughts increases the higher the air flow. A typical temperature of the supply air in a mixed flow ventilation system is about 8 °C below the room temperature. In displacement ventilation systems, the supply air temperature might have to be limited to being 3 or 4 °C below.

An alternative to airborne cooling is to remove the heat surplus in a room using cold water in ceiling mounted cooling coil units, so-called chilled beams. Systems like these are discussed in Chapter 28/Waterborne indoor climate systems. Both methods have advantages and limitations.

Advantages of using air as a cooling medium:

- In large parts of the northern hemisphere, it is possible to make use of so-called free cooling, as the outdoor air is sufficiently cold for most of the year
- No extra water systems are required, i.e. no extra piping, pumps or control systems.
- The same system is used to meet the requirements for good air quality and good thermal comfort.

Disadvantages of using air as a cooling medium:

- Larger air flows than otherwise are needed, if the ventilation is only designed with respect to the quality of the air. This, in turn, requires larger diameter ducting.
- Great care is required when choosing the correct size and type of air terminal device, so that draughts can be avoided.

Different ventilation principles have different surplus heat removal properties.

Table 1 shows a number of recommended values for maximum cooling powers when using different types of ventilation. The table is for a room with a ceiling height of 2.8 m and an occupied zone as in Figure 10.

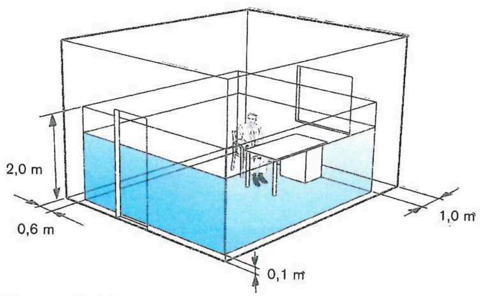

FIGURE 10. The occupied zone.

TABLE 1. Recommended values for cooling powers for different ventilation principles, expressed in W/m^2 floor area.

Ventilation principle	Max. cooling power W/m^2
Mixed flow ventilation	
Ceiling mounted with nozzles	90 to 120
Other ceiling mounted types	60 to 80
Rear wall mounted	50 to 60
Front wall mounted	60 to 70
Window sill	50 to 70
Displacement ventilation	
Floor mounted	30 to 35
Wall mounted, base 0.6 m above floor level	35 to 40
Equalizing ventilation	
With induction unit, 1.2 m above floor level	40 to 45

A distinction is made between CAV, constant air volume, systems and DCV, demand controlled ventilation, systems. The principles governing these systems are described in detail in Chapter 17/Demand-controlled ventilation.

To ensure a comfortable indoor climate and good air quality without wasting energy, the ventilation flows must be utilized as efficiently as possible. A good way of doing this is to install a DCV system. This type of system ensures that proper ventilation is achieved where it is required and that air flows are minimized, if temporarily not required. This, combined with the fact that it is now possible to make these systems self-regulating and self-diagnosing, means that it is now possible to design very energy-efficient indoor climate systems.

To create a well-functioning ventilation system, user-friendly, purpose built and reliable components will be required. The components in the central air handling unit, for example, heat exchangers, fans and filters, can, in principle, be the same, irrespective of whether they are used in a CAV or a DCV system. Components like these are discussed in other parts of this book. When it comes to components for flow control these can often be simpler in CAV systems than in DCV systems. These components are discussed briefly below.

Components for flow control

To attain the correct size of air flow, it must be possible to measure, balance and control it. This is done using different types of components:

- Sensors for measuring pressure, flow, temperature and air quality.

- Regulators and room thermostats etc.
- Dampers for balancing and flow control.
- Air terminal devices with built-in measuring and control functions.

Components used in ducting systems must be fitted with dampers so that excess pressures can be reduced while keeping the noise level to a minimum. It must be possible to lock the damper in the required position and clearly see the setting. The functions for measuring pressure and air flow must be reliable even at low flow rates. To achieve acceptable measuring accuracy, straight and uninterrupted sections of ducting are required before the measuring point. It is, of course, best, if these straight sections are not required to be too long. The components should also be easy to install.

The room components should be user-friendly with respect to those authorized to use them and it should not be possible for unauthorized persons to change their settings. It must also be easy to reset desired values. Even these components should be easy to install.

Examples of components for flow control in CAV and DCV systems are shown in Figures 11 and 12.

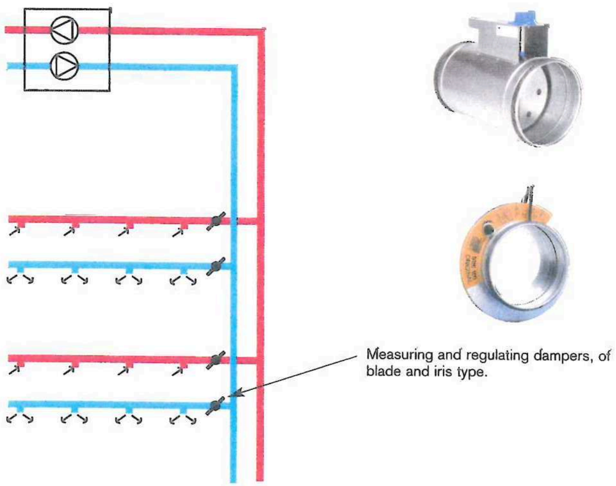

FIGURE 11. A CAV system.

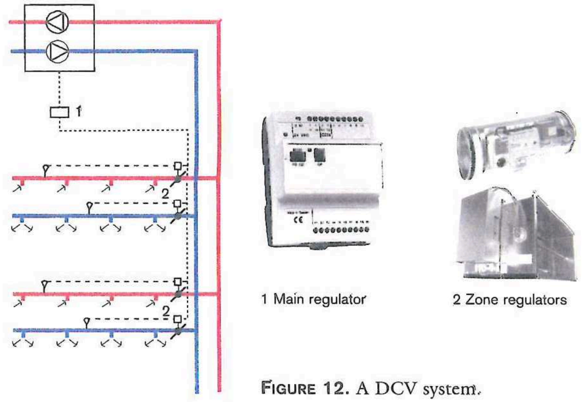

FIGURE 12. A DCV system.

Examples of system solutions using room products in a DCV system are shown in Figures 13 and 14 below.

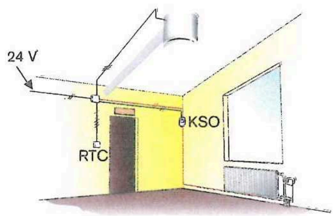

FIGURE 13. An active ATD with an external room thermostat and sequentially controlled radiator valves.

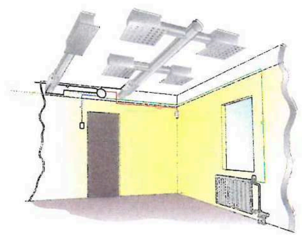

FIGURE 14. Passive nozzle diffusers with centrally controlled flows governed by duct dampers, air quality sensors and sequentially controlled radiator valves.

In addition to the solutions shown in Figures 13 and 14, there are a large number of other solutions that can be used when there is a central communications system.

No matter what the conditions, it is very important that the systems are simple to install, to use and to maintain.

Locating supply ATDs in mixed flow ventilation systems

LOCATING TERMINAL DEVICES

Room air can be well-mixed in a number of ways. Most important to remember, however, is that it must be done in a controlled way. This is why this section concentrates on supply and extract mechanical ventilation systems. Natural ventilation and extract air ventilation systems, in which the outdoor air is admitted via trickle ventilators/slot air valves above or below windows, is not discussed.

Centrally placed, ceiling mounted, built-in supply ATDs
The ceiling is the best place to mount a mixing or swirl diffuser, as the air can be discharged over 360° with an excellent Coanda effect. This means that air at an under temperature can be used without any great risk of causing draughts. The jets must be prevented from colliding with obstacles such as surface-mounted light fittings, ceiling beams etc. Otherwise there is a risk that the flows will be directed into the occupied zone, with draughts as a result. If there are a number of diffusers on the ceiling in the same room, care must be taken so that the jets cannot collide with each other. This is avoided in most modern ceiling diffusers by using deflecting vanes. Convective flows from radiators, office equipment etc must also be taken into account.

Another great advantage of ceiling mounted diffusers is that there is sufficient space for the connecting ducts. And the straighter the ducting leading into the diffuser, the quieter and more precisely adjusted the air flow will be.

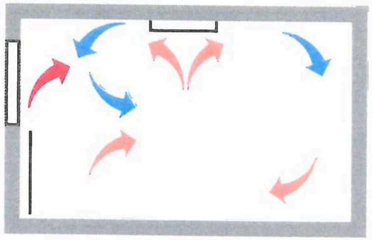

FIGURE 15. A centrally placed, ceiling mounted, built-in diffuser.

Front wall, ceiling mounted, built-in supply ATDs.
In this case the device is mounted close to an external wall, i.e. far from the corridor wall. Even this is one of the best locations. Air cannot be discharged over 360°, only over 180°.

As the diffuser is far from the back wall, the throw has to be somewhat longer than for a centrally placed, ceiling mounted device.

When air at an under temperature is used a design throw that is slightly greater than the depth of the room is recommended, so that the jet will not deflect down into the occupied zone too soon.

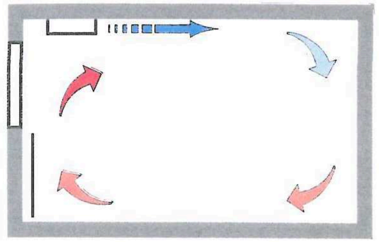

FIGURE 16. A front wall, ceiling mounted, built-in diffuser.

Back wall mounted, built-in supply ATDs
Sometimes it is not possible to mount the diffuser on the ceiling. An economical way of solving this problem is to mount it on the back, or corridor, wall immediately next to the ventilation ducts in the corridor.

As wall diffusers do not have the same performance characteristics as ceiling devices, it is essential to choose the correct type of device for this application. The throw here is very important. When air at an under temperature is discharged into a room it is recommended that the throw be at least 75% of the depth of the room. The device should preferably be placed 100 to 200 mm below the ceiling and its air jet directed at about 45° towards the ceiling, to attain the best possible Coanda effect. In this application, there is hardly any space at all for connecting the ducting to the device in a satisfactory way and this must be taken into consideration

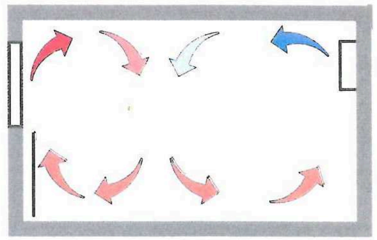

FIGURE 17. A back wall mounted, built-in diffuser.

at the planning stage, so that no unnecessary noise or poorly balanced terminal devices are created.

Built-in supply ATDs for windowsills and floors

Office buildings are sometimes fitted with so-called perimeter systems, which are, briefly, systems in which cooled or heated air is discharged vertically towards the ceiling via a windowsill. In most solutions, the air is distributed via an induction unit placed under the windowsill. In this application, it is important to keep an eye on the temperatures of the supply air and the surface of the window. If both these temperatures are lower than the room temperature, there is a risk that cold down-draughts will be created in the occupied zone closest to the window, i.e. next to the workplace. This means that perimeter systems must have sufficient pressure to ensure that the air jet has a suitably long throw, so that the risk of draughts can be eliminated.

Locating supply ATDs in thermally controlled ventilation systems

As the air in these systems is often discharged directly into the occupied zone, it is important that the supply air diffuser is positioned correctly. The position is, in many cases, dependent on the type and intensity of the activities taking place in the room as well as the type of room. People who work sitting down should not be placed too close to the diffusers.

In premises where pollutants are generated to a relatively high degree, it is even more important that the displacement diffusers discharge air at low speeds and with a minimum of induction of the room air. It is also important that premises like these have high ceilings. The higher the ceiling, the more space for the polluted air to collect above the occupied zone.

Floor mounted ATDs for thermally controlled displacement ventilation systems

The supply air in these systems is discharged at low speed from the whole surface area of the diffuser.

As the air is at a slight under temperature, it will fall onto the floor relatively quickly. How quickly this occurs depends on the flow rate and the temperature of the air. In normal cases, at a distance of 0.5 to 1 m from the diffuser, the air jet will have spread out over the surface of the floor to a depth of 50 to 70 mm above the floor. If the diffuser is fitted with a function for adjusting the spread pattern after installation, this is, of course, an advantage, as the diffuser is actually in the occupied zone.

The under temperature of the supply air is normally between 3 and 6 °C, depending on the type and intensity of the activities in the room.

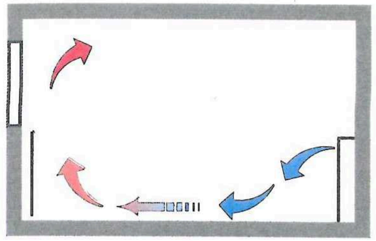

FIGURE 18. Floor mounted supply air diffuser in a thermally controlled displacement ventilation system.

Floor and wall mounted ATDs for thermally controlled equalizing ventilation systems

In these systems, a certain amount of return air is used. This is achieved either by integrating an induction unit into the diffuser or by placing the diffuser high up in the room, or by combining both these solutions.

Sometimes both mixing and displacement supply ATDs are used in the same system, for example in conference rooms. If the cooling power has been designed based on the mixing function, then there must be some sort of compensatory function for the displacement diffusers, as these cannot manage as low supply air temperatures as the mixing diffusers. This is achieved by fitting the displacement supply ATDs with re-heaters or an induction unit, which is most probably the most cost-effective solution.

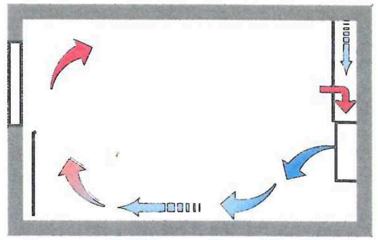

FIGURE 19. A wall mounted supply ATD in a thermally controlled equalizing ventilation system.

If an induction unit is used, the primary air can be allowed to have an under temperature of 6 to 9 °C.

When the primary supply air flows through the unit, the room air is inducted into the diffuser. In this way, the temperature of the air that is blown into the device is evened out. The air is then discharged into the room at a low speed from over the whole surface of the diffuser. The diffuser then functions as a normal, floor mounted, displacement supply ATD.

SUPPLY ATDS FOR MIXED VENTILATION SYSTEMS

FIGURE 20. A ceiling mounted supply ATD in an office environment.

A wide range of supply and extract ATDs are available on the market today. Supply ATDs should be able to:

- Discharge large volumes of air without causing draughts.
- Measure and regulate air flows.
- Operate at low noise levels.
- Change their spread patterns.
- Offer aesthetically pleasing designs for greater acceptance by architects.
- Offer simple and cost-efficient installation, commissioning and maintenance.

In order to fulfil these requirements, the ATD must have:

- A high induction capacity for room air to reduce draught risks at low supply air temperatures.

- Adjustable deflector vanes or nozzles that can be set even while in operation, to offer flexible spread patterns.
- Air flow measuring points for adjustment and control.
- An integrated air flow adjustment damper, to reduce the risk of having a poorly balanced system.
- A connection box with effective noise attenuation, to reduce the risk of crosstalk via the ducting system.
- A design that complies to building standards to reduce building costs.

To be able to fulfil all these functional requirements, the ATDs often comprise a diffuser and a ducting connection unit, the latter in the form of a plenum box with built-in functions for air flow regulation, noise attenuation, air distribution and air flow measuring. If only the diffuser element is used, it will not be possible to control the discharged air.

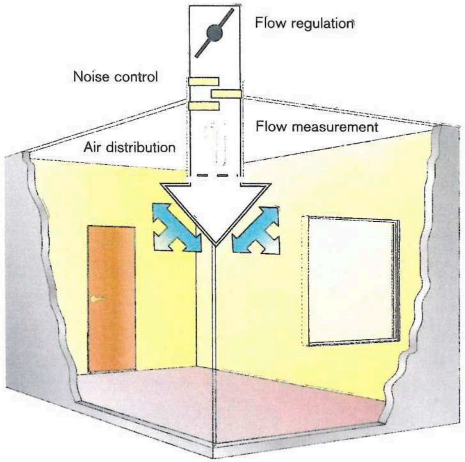

FIGURE 21. Supply ATD with adjustable functions.

Passive supply ATDs

The simplest types of supply air diffusers have constant discharge areas. This means that if the air flow is reduced, it will be difficult for the air jet to support the air above the occupied zone over a sufficiently long distance. There are, however, passive devices that can accommodate quite large variations in air flow.

Active supply ATDs
In recent years, two types of variable or active supply air terminal devices have come onto the market. Their different functions are described below.

Active ATDs with automatic direction change of the air jet. These are supply air diffusers for premises with high ceilings. They are used to supply air either at an under or over temperature, using the same device. The diffuser is fitted with an electric or thermal motor that drives a damper arrangement to change the direction of the air jet, depending on the temperature of the supply air. The main areas of use include arenas, large shops, industrial buildings etc.

Active ATDs with automatic continuous regulation of the discharge area. These are supply air diffusers for premises with normal ceiling heights and are used exclusively for demand-controlled ventilation systems. The continuously variable regulation of the discharge area has two functions. Firstly, the discharge area is always optimized to suit the flow at any given time, which eliminates the risk of draughts. Secondly, the variable discharge area works as an air volume regulator. Active devices are most often used in office buildings and schools.

There are many different types of ATDs and this is due to a number of reasons, though all of them are related to room parameters, such as:
- Use – Residential, office, industrial etc.
- Ceiling height – High ceilings require special terminal devices.
- Thermal climate – Air at under or over temperatures requires special terminal devices.
- Air quality – Demand-controlled air flows require terminal devices that can manage variable air flows.
- Design – Specially designed terminal devices might be required, choice of colours etc.
- Type of ventilation system – Perimeter and floor mounted systems require special terminal devices.

ATDs are normally categorized depending on where they are placed in a room:
1. Ceiling diffusers
2. Wall diffusers
3. Window sill diffusers
4. Floor diffusers

1a. Passive ceiling diffusers

Nozzle diffusers
Nozzle diffusers referred to here are ATDs with a number of individually adjustable, aerodynamically designed plastic nozzles that interact to provide an optimal and flexible air jet.

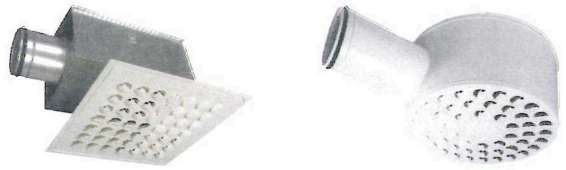

FIGURE 22. Nozzle diffusers.

Important features:
- The design of the nozzle creates an evenly distributed air flow across the whole surface area of the device, ensuring a low noise level and even spread pattern in the room.
- A high degree of induction. The nozzles help to quickly and effectively mix the room air with the supply air jet, allowing the temperature difference between the room air and supply air to be greater than for other types of devices, without causing draughts in the room. This makes the device very suitable for handling cooled air.
- The flexible spread pattern can be easily changed, without the set flow, pressure drop or noise level being changed in the room.

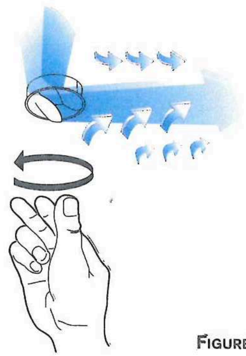

FIGURE 23. Flexible spread patterns.

- Can manage supply air at large under temperatures.
- Can manage variable flows, as low as 20% of normal flows rates, thanks to excellent induction properties.
- Both short and long throws can be achieved, both horizontally and vertically. Combined horizontal and vertical spread patterns are also possible. This type of diffuser can be used in rooms with relatively high ceilings.

Disadvantages:
- The air flow capacities are not as great as those in perforated ATDs.

Swirl diffusers
These devices are characterized by discharge openings shaped so that the air stream swirls like a horizontal vortex. This gives the diffuser an extremely good induction capacity.

FIGURE 24. A swirl diffuser.

Important features:
- The design of the discharge openings creates of an effective circular and tangential spread pattern.
- High induction capacity. The spread pattern facilitates effective mixing of the room air into the supply air jet. This makes it very suitable for handling cooled air.
- Can manage large under temperatures.
- The high induction capacity means that the device can easily manage variable flows, down to 30% of normal air flows.

- Some versions of swirl diffusers have adjustable discharge gaps, making them also suitable for use in rooms with high ceilings.

Disadvantages:
- Limited flexibility with regard to spread pattern.
- Do not have as large air flow capacities as perforated devices (with the exception of some of the devices adapted to industrial ventilation applications).

Perforated diffusers
The advantage of a perforated diffuser is that it can distribute large air flows over relatively small areas without causing draughts.

Despite its large air flow capacity, this type of diffuser has a comparatively small throw. Perforated diffusers are mostly used in rooms with ceiling heights lower than 3 m.

FIGURE 25. A perforated diffuser.

Important features:
- Can supply large air flows to rooms with ceiling heights lower than 3 m.
- Short throws.
- Can manage supply air at quite large under temperatures.
- Can provide flexible spread patterns.

Disadvantages
- The discharge opening is not flush with the ceiling.
- Limited flexibility with regard to spread pattern when compared to the nozzle diffuser.

Linear slot diffusers
Above all, linear slot diffusers provide an excellent solution where the appearance of the diffuser and the ability to match the design of the room are the most important properties. This type of diffuser is often used in countries where architects have high status.

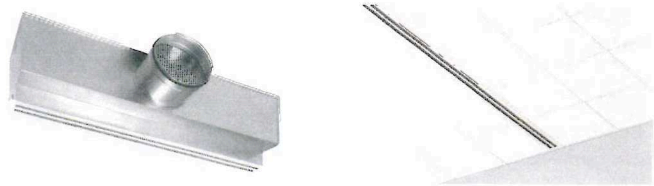

FIGURE 26. A linear slot diffuser, also shown installed in a suspended ceiling.

Important features:
- Ability to match the interior design.
- High degree of induction of room air.
- Ability, to a certain extent, to manage supply air at under temperatures.
- Can be joined together to form long continuous slots.
- Ability, to a certain extent, to provide flexible spread patterns.

Disadvantages:
- Limited air flow capacity.
- Difficult to supply an even flow along the whole of the diffuser.
- Long throws despite high degree of induction.

Circular and square slot diffusers

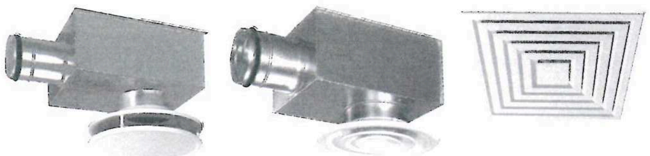

FIGURE 27. Circular and square slot diffusers.

This type of diffuser can be divided into two groups: single-slot diffusers and multi-slot diffusers. The narrower the slots, the better the induction of the room air. Generally speaking, this type of diffuser has the highest capacity with respect to air flow rates.

Important features:
- Can manage large air flows.
- High degree of induction when narrow slots are used.
- Relatively large under temperatures can be allowed.

Disadvantages:
- Long throws.
- Limited opportunities for flexible spread patterns.

Jet diffusers
Jet diffusers are used in premises with very high ceilings. They are often used in industrial buildings, airports and shopping centres etc.

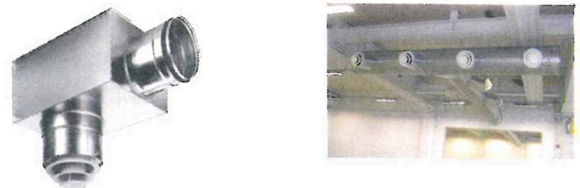

FIGURE 28. A jet diffuser, also shown installed in visible ducting.

Important features:
- Can manage large air flows.
- High degree of induction.
- Supply air at relatively large under temperatures can be used.
- Extremely long throws (required in large premises).

Disadvantages:
- Most often have to be motorized to attain directional flexibility (often mounted high up).

Duct diffusers
When supply ATDs are required in rooms without suspended ceilings, duct diffusers often provide a suitable solution. These combine ventilation ducting and diffuser features so that they can be assembled in long

uninterrupted lengths. The most common type is the circular duct diffuser with different types of openings for discharging the air. Flexible duct diffusers made of textiles or plastic are also available.

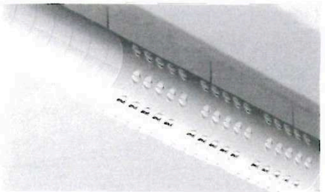

FIGURE 29. Duct diffuser fitted with adjustable nozzles.

FIGURE 30. Duct diffuser installed in a restaurant.

Important features:

- The design of the duct diffuser allows an evenly distributed air flow across the whole of the face area of the diffuser and ensures a low noise level and even spread pattern.
- Duct diffusers that are fitted with nozzles offer a high degree of induction. The nozzles facilitate quick and effective mixing of the room air in the supply air jet. This makes it possible to have a temperature difference between the room air and supply air that is larger than for most other types of diffusers, without creating draughts. The diffuser is therefore well suited for use with cooled supply air flows.
- The induction properties of duct diffusers fitted with nozzles means that they can manage variable flows as low as 20 % of normal flows.
- The spread pattern for a duct diffuser with rotatable nozzles can be easily changed while in operation without the set flow, pressure drop or noise level being changed. In addition, short or long throws can be set. Horizontal or vertical, as well as combined horizontal and vertical, spread patterns can be created. This type of diffuser is suitable for relatively high rooms.
- Available in models that can be mounted in corners of ceilings.
- Flexible textile or plastic ducts are light and can be easily repositioned to suit different furnishing alternatives.

Disadvantages:

- The cross-sectional area of the main duct connection can be a limiting factor with respect to the full flow capacity of the diffuser.

1b. Active ceiling diffusers

Active diffusers have openings that are continuously variable between fully open and fully closed. The openings are controlled by signals from room thermostats, presence sensors or CO_2 sensors. This type of diffuser is specially designed for use in demand-controlled ventilation systems.

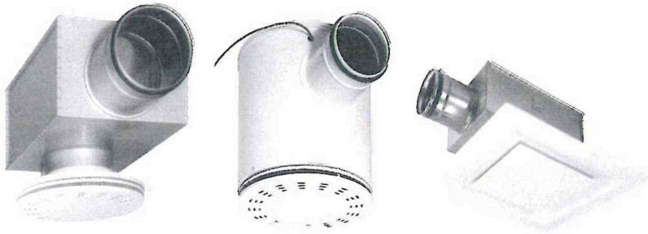

FIGURE 31. Different types of active ceiling diffusers.

Important features:

- Always correct throw, irrespective of air flow.
- Manages very large under temperatures.
- Very high degree of induction.
- Very quiet in operation.
- Air flows can be preset in the factory.

Disadvantages:

- Require electric power.
- In certain cases the throws can be regarded as being excessively long but, as the flow rates vary, experience has shown that this, as a rule, is not a problem.

2., 3. and 4. Wall, windowsill and floor mounted diffusers

Back wall diffusers

Back wall diffusers are always mounted on the rear walls of a room and discharge towards the external wall, hence their name. They often offer an economical solution from an installation point of view, as the supply ducts are located in the corridor ceiling behind the back wall. Long throws are required when back wall units are used and a rule of thumb says that they should be about 75 % of the depth of the room. The air jet should also be directed slightly upwards to make full use of the Coanda effect. This will also require a space greater than 100 mm between the top of the diffuser and the ceiling. It is also important that the air jet is not directed at 90° towards the ceiling.

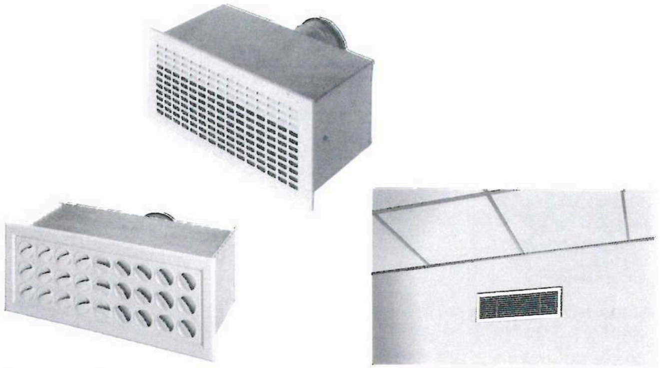

FIGURE 32. Back wall diffusers.

Important features:
- Nozzle diffusers offer very flexible spread patterns and can be mounted eccentrically on a wall and still achieve an acceptable spread pattern by adjusting the nozzles.
- The throw can also be adapted to the required distance by adjusting the nozzles.

Grille diffusers for wall, floor and windowsill mounting
Grille diffusers have very low pressure drops and poor induction properties and are therefore not suitable when supply air is required at under temperatures. The grilles are available with fixed or adjustable vanes. Windowsill grilles are often used together with built-in perimeter induction units to cover the outlet opening and to control the direction of the air.

Important features:
- Can manage large air flows.

Disadvantages:
- Very poor induction capacity.
- Long throws.

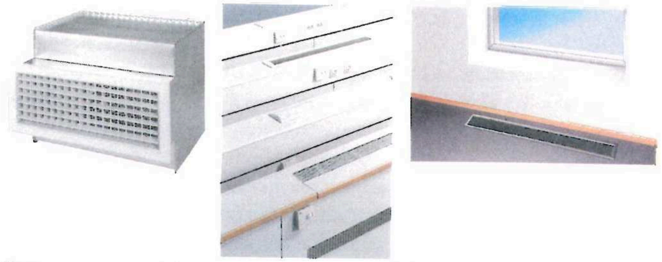

FIGURE 33. Grille diffusers. Wall, window sill and floor mounted.

SUPPLY ATDS FOR THERMALLY CONTROLLED VENTILATION SYSTEMS

Supply ATDs for thermally controlled ventilation systems – known as displacement diffusers, low speed ATDs or low momentum ATDs – are also available in a number of different types. Again, we have to ask ourselves the question, "What are the requirements that good displacement diffusers must fulfil?" They should be able to:
- Discharge large volumes of air without creating near zones that are too large, which reduces the risk of draughts.
- Provide an even distribution of the air at low speeds across the whole of the discharge area, to reduce the risk of draughts and to reduce induction and noise levels to a minimum.
- Measure and regulate the air flow.
- Regulate the air flow in DCV systems.
- Change their spread patterns.

FIGURE 34. A thermally controlled, wall mounted displacement diffuser.

- Offer aesthetically pleasing designs to increase acceptance by architects.
- Withstand mechanical loads when place in the occupied zone.
- Offer simple and cost-efficient installation, commissioning and maintenance.

This means that the diffusers must have the following features:
- Air deflectors or adjustable nozzles for flexible spread patterns.
- A measuring outlet for measuring air flows for adjustment and control.
- A damper for adjusting the air flow.
- Effective internal noise absorption, to reduce the risk of cross-talk via the ducting system.
- A design that complies with building standards to reduce building costs.
- Flexible and adjustable spread patterns to facilitate different furnishing arrangements.
- Sufficiently robust construction, for positioning within the occupied zone.
- Aesthetically pleasing design for increased acceptance by architects.
- Robust mechanical construction.

When it comes to measuring and regulating the air flow, most displacement diffusers have a built-in measuring outlet and an adjustment damper in the connecting ducting is used to regulate the air flow.

The air should be discharged into a room at low speed through the whole of the face area of the diffuser, in order to eliminate unnecessary noise and undesirable induction of the room air, as well as to achieve the best possible distribution of the supply air.

As the air jets from displacement diffusers do not have to carry cold air, as they do in mixed ventilation diffusers, they are insensitive to variations of air flow. These diffusers are therefore well-suited for use in variable flow displacement ventilation systems. The variations in the air flow can be controlled by a motor driven damper installed in the duct connecting to the diffuser.

In the case of supply ATDs used in equalizing ventilation systems, the same applies as above, except that an induction unit is also included. This makes it possible to create a certain amount of mixing of the room air. Here, it is important to position the induction unit as low as possible

in the ATD, to keep the "clean" zone in the occupied zone as high as possible.

Displacement ventilatipon works best in premises with high ceilings. Typical types of premises include industrial buildings, shops, atriums, lobbies, classrooms, assembly halls, lecture theatres, cinemas, theatres, conference halls, arenas, sports centres etc.

In premises with lower ceiling heights, such as conference rooms, open areas in office landscapes, lounges etc, the diffusers can be used as a complement to other ventilation systems.

A wide variety of displacement diffusers is available, with the different designs depending on, among other things, the use of the premises, ceiling heights and room layouts, as well as the structural design of the building in question.

Flexible spread patterns

As displacement diffusers are normally placed in the occupied zone, it can be difficult to find suitable positions because of the locations of workstations or other pieces of furniture, the allocation of the floor area, etc. One way of making it easier to position displacement diffusers is to fit them with devices so that the spread pattern can be adjusted after the unit has been installed.

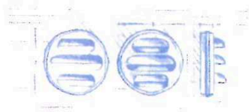

FIGURE 35. Rotatable air vanes in a displacement diffuser.

FIGURE 36. Adjustable spread patterns.

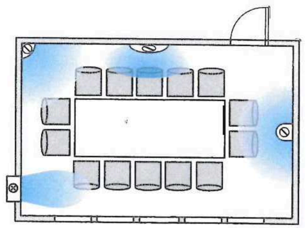

FIGURE 37. Standard spread patterns in a conference room.

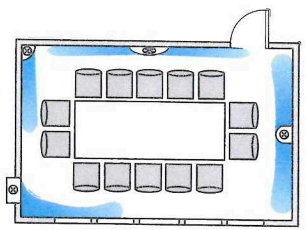

FIGURE 38. Adjusted spread patterns in a conference room.

Diffusers for use in displacement ventilation systems

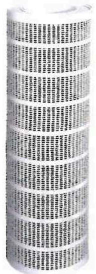

FIGURE 39. Circular diffuser.

FIGURE 40. Semicircular diffuser.

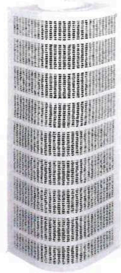

FIGURE 41. Quadrant diffuser.

Diffusers used in thermally controlled displacement ventilation systems can be designed in a number of different ways, for example, they can be completely circular, semi-circular or quadrant-shaped, as shown above. Diffusers like these can be designed so that the near zone is kept shallow. For example, there are semi-circular diffusers that discharge sideways rather than straight into a room. The diffusers can also be fitted with rotatable air deflectors behind the front panels. This means that completely circular diffusers do not have to discharge air radially over 360°, but can direct the flows precisely where needed.

Other types of displacement diffusers include bow-shaped and integrated wall units. Diffusers like these cannot discharge air sideways to any great degree, which means that they have a somewhat deeper horizontal spread pattern. On the other hand, they do not require as much floor space.

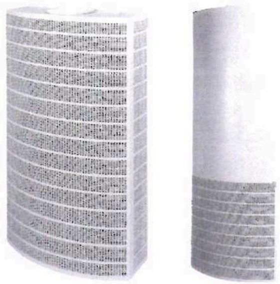

FIGURE 42. Bow-shaped diffusers.

FIGURE 43. A diffuser built into a wall.

Displacement diffusers are also available in a range of models to suit different needs in buildings with large open spaces, such as sports centres and industrial plants. These diffusers are more robustly built than those presented above but otherwise function in similar ways.

Diffusers are also available for ventilation systems in which the supply air can be discharged into the space under raised floor structures. These diffusers are used to supply air from a number of points equally distributed over the whole of the floor surface. This is a commonly used solution in cinemas, theatres, assembly rooms and congress halls etc.

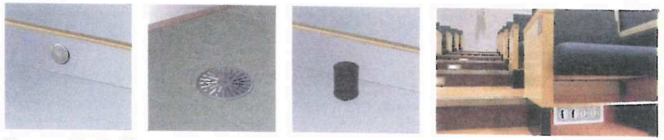

FIGURE 44. Different types of displacement diffusers installed in raised floors.

Diffusers for use in equalizing ventilation systems

Equalizing ventilation systems were briefly discussed at the beginning of this chapter. These systems are used when the supply air temperature is too low to be used in a pure displacement ventilation system but where it would still be viable to use some of the advantages of displacement diffusers. The simplest way of doing this is to place the diffuser high up in the ventilated space and let the cold air entrain the room air as it falls into the occupied zone. A disadvantage here is that polluted air, due to the high position of the diffuser, is also drawn down into the room. In other words, it is very important to consider what type of activities can be allowed in the premises.

To ensure that the inducted room air is brought from the clean zone of the room, it might be necessary to fit the diffuser with a mechanical induction unit.

Previously in this chapter, we could see that it is not possible to supply air at an over temperature when displacement diffusers are used. There is, however, a special type of diffuser that is designed to do just this. The application requires the diffuser to be mounted high up and to be fitted with a supply air control function for variable temperature. The diffuser has two discharge settings, for horizontal or vertical flows, and these are chosen depending on the temperature of the supply air. The

FIGURE 45. Displacement diffusers with both horizontally and vertically oriented spread patterns.

change in setting from vertical to horizontal discharge is regulated by a thermostat in the ducting and a damper in the diffuser or by a thermally controlled damper in the diffuser. This type of diffuser is mostly used in industrial applications. Further information about thermally controlled ventilation systems can be found in the REHVA handbook, Displacement Ventilation in Non-residential Premises.

SUMMARY

People spend up to 90% of their working and recreational time indoors. Together, we must ensure that indoor climates are both comfortable and healthy for all occupants in all types of buildings.

The type of space to be treated is always the starting point when designing an indoor climate system. All equipment installed in an indoor climate system is for the benefit of its users and their activities. This is why every individual product manufacturer must regard a building, to a greater extent than today, as a system. It is no longer sufficient to be an expert on the technology used in one's own products. We must become better at understanding how our own products affect, and are affected, by the other systems and services in a building and how we should develop our products so that the overall functioning of the building will be better. In other words, it's time to look beyond the traditional interfaces of engineering contracts. Every party involved in the building process must expand their views. It's not enough if each tends to their own. We must work together and from an earlier stage in the building process. In order to create satisfactory and cost-effective buildings with low energy requirements and comfortable indoor climates, all players must assume joint responsibility and analyse the consequences of the effects that their products and systems have on each other – not only from a technical point of view but also from a cost and energy use point of view.

Only by working together can we find the key to creating perfect indoor climates.