IMPROVING AIR CONDITIONING FROM THE FLOOR UP

back to the overview

date 30.11.2022

rubric company / market / press / products

Article by Tim Tanner, TROX UK product technical manager - air diffusers and attenuators

The priorities of today's building owners and occupiers have changed since the pre-COVID period, placing new emphasis on air quality. At the same time, the escalating costs of energy are adding urgency to the ever-present need for best practice environmental performance. These factors have led to a renewal of interest in floor grilles and displacement ventilation. These long-established techniques were often overlooked in the past, but changing priorities have led to a reappraisal of their benefits. Tim Tanner, product technical manager - air diffusers and attenuators at TROX UK has considered the potential advantages of adopting these approaches, and provides advice on the design of systems employing floor grilles and displacement ventilation. This includes tips on the types of project most likely to benefit, and key technical factors such as load testing and air movement strategies. Finally, Tim provides an update on the latest developments in the design of floor grilles/diffusers.

COMPARISON OF MIXED-AIR AND DISPLACEMENT APPROACHES

When a mixed air distribution system is installed, the air (this could be for either heating or cooling) is delivered at relatively high velocity from diffusers at ceiling level. As long as the ceiling diffusers have been selected and positioned correctly, this high velocity air will not result in occupant discomfort. This is because it is delivered outside the occupied zone and, as it moves along the ceiling due to coanda effect, it reduces in velocity before entering the occupied zone. This is necessary to prevent problems such as draughts, or 'dumping' of cool air (if the velocity is too low). See Figure 1 below.

FIGURE 1 - Mixed air ventilation

By contrast, underfloor air distribution systems typically employ a displacement air movement strategy. Cool air is delivered at reduced velocity into the room from the floor void, through specially-designed floor grilles. As the supply air is always cooler than the room air, it moves slowly across the room. When the cooler air comes into contact with a heat load, such as a room occupant, it rises towards the ceiling, where the system will include equipment for extraction. See Figure 2 below.

FIGURE 2 - Displacement air ventilation

BENEFITS OF UNDERFLOOR AIR DISTRIBUTION

Designing the air conditioning in this way can deliver valuable energy efficiency benefits, in addition to contributing to improved air quality and increasing the flexibility of the building. Firstly, depending on the application, a displacement ventilation strategy can be a valuable way of reducing energy consumption. In mixed air distribution systems, air needs to be supplied into the room at higher velocities in order to achieve the necessary coanda effect. If the velocity is too low the air will enter the occupied zone too soon, creating problems such as 'dumping' or draughts. Higher velocity of supply air, of course, has an impact on energy

consumption. By contrast, when supplying air via floor grilles, the air velocities are lower, as there is no need to achieve coanda effect. This in turn can offer improved acoustics. In addition, the air supplied to the occupied zone does not have to be reduced to the lower temperatures necessary for mixed air distribution. In fact, for commercial premises, the temperature would typically be in the region of 19°C, just slightly cooler than the design temperature of the occupied zone. In addition, it may be possible to reduce cooling loads as only the occupied zone needs to be supplied with conditioned air. This can be particularly beneficial in rooms with high ceilings. These lower cooling loads reduce the demand placed on chillers and other energy-consuming components across the HVAC system. Plus, there is no longer a need for fans/motors within secondary terminal units such as fan coil units. There may also be increased opportunities for “free cooling" (using fresh air) for a large proportion of the year. An academic study in 2002 quantified potential energy savings of underfloor air distribution as being between 5% and 35%.

Secondly, displacement approaches can deliver air quality benefits. As the air pools along the floor, rising when it meets a heat source (such as a person), it can take certain contaminates upwards, out of the occupied zone for ceiling level extract. There are, of course, a number of factors to consider in this regard. For example, floor diffusers and grilles coupled with displacement air strategies may not be suitable for applications where the contaminates will be heavier than air.

Further benefits arise from the fact that, depending on the building design, a raised floor can allow the floor void to be pressurised and act like a plenum, with the air being balanced at each diffuser. This can mean that the requirement for ductwork is reduced.

Lastly, there are practical advantages for those installing and maintaining building services, as well as for building owners and occupiers. As the equipment is installed into the floor and floor void, the requirement to work at height is removed, reducing health and safety risk for contractors and service engineers. Furthermore, as floor grilles are typically installed into floor tiles (or designed as replacement 600 x 600 tiles, in the case of the TROX AFG), reconfiguration of spaces is made easier. Since there is little or no ductwork involved, the floor tiles can be easily rearranged, and the tiles incorporating diffusers can simply be moved to different locations to suit each new configuration. Given the frequency and cost of 'churn', this increased flexibility is extremely valuable to building owners and occupiers throughout the lifecycle of the equipment.

APPLICATION DO'S AND DON'TS

It is essential, of course, to be aware of the limitations of this air movement strategy, and to have an understanding of how best to harness these valuable benefits. Importantly, the approach described, employing floor grilles and displacement air management, is NOT always suitable for heating of spaces, depending on the room strategy. It is common with traditional displacement systems that the room is served by a few large units with the air entering the room in laminar flow. If warm air is supplied at floor level in laminar flow into a cold room, the fresh air will rise and be extracted at ceiling level, in effect short circuiting the occupied zone and failing to achieve the desired effect.

The REHVA Guidebook on Displacement Ventilation guidance is as follows:

[Displacement ventilation] has proved to be superior to mixing ventilation in:
• Restaurants
• Meeting rooms [offices]
• Classrooms

Displacement ventilation is usually preferable in the following cases:

• Where the contaminants are warmer and/or lighter than the surrounding air

• Where the supply air is colder than the ambient air
• In tall rooms, e.g. where the room heights are more than 3 metres
• Where large air flows shall be supplied in small rooms

Displacement ventilation may be less preferable than mixing ventilation in the following cases:

• Where surplus heat is the main problem, and not air quality
• Where ceiling heights are lower than approximately 2 – 3 metres
• Where disturbances to air flows are strong
• Where the contaminants are colder/denser than the ambient air

Added to this, applications such as laboratories/science campuses and so on require specialist air management systems. TROX's LabControl systems are purpose-designed for these applications.

An additional important point to consider is the final usage of the space. It is vital to load test the floor grilles/diffusers to ensure that they can support the weight of any person or object that may be moved across them after installation. TROX provides data on load testing and the standardised ratings of floor grilles to assist you in product selection. The TROX AFG floor grille, for example, has been designed specifically for extra heavy duty applications.

IMAGE: TROX AFG floor grille

DESIGN TIPS

The initial questions to consider when designing the system and specifying components include the following:
• Is the system to operate on a mixed ventilation strategy or a displacement strategy?
• Would vertical or horizontal grilles/diffusers suit the application best?
• How much air needs to be supplied through the device?
• How close will occupants be situated in relation to the grilles/diffusers?
• How much load will the grille or diffuser need to support?

Having addressed these questions, the key aspects to consider include the following:

Total cooling load - Displacement ventilation is typically recommended for cooling loads less than 40 W/m² for comfort, however individual applications must be investigated to ensure comfort is achieved. Therefore, before selection, ensure the project requirements are within achievable limits. It is important to consider how utilizing a displacement ventilation strategy will influence the cooling load compared to a mixed ventilation system. For example, heat gains from lighting can largely be ignored as the heat is extracted at high level, rather than entering the occupied zone. This heat gain from lighting could be in the region of 15 W/m2 (The importance of office internal heat gains in reducing cooling loads in a changing climate, D.P. Jenkins) can be reduced from cooling loads, when using a displacement system, saving on energy costs and possibly allowing HVAC components to be downsized for further savings. This will depend on the light fixture as well as the type of lighting used. For example, LEDs do not generate radiant heat, only convective, whereas fluorescent bulbs emit 35-40% of their heat as radiant heat. (Effect of LED lighting on the cooling and heating loads in office buildings, Byung-Lip Ahn, Cheol-Yong Jang, Seung-Bok Leigh, Seunghwan Yoo, Hakgeun Jeong) This means when considering LED heat gain, with a displacement system, the effect of the cooling load can largely be ignored assuming lights are mounted at high level 2.8m+.

Heating requirement – Displacement ventilation requires the supply air to be cooler than the room air. So, this approach is only suitable for cooling with a supply temperature range of -2K to -4K. As a general rule, heating is not recommended using displacement ventilation. The TROX FBA floor diffuser incorporates a swirl unit, this causes high induction and allows for heating, as long as the temperature

differential is kept to a minimum. In order to maximize the effectiveness of this heating, the FBAs should be evenly spread throughout the floor plate.

IMAGE: TROX FBA floor diffuser

Room height - The height of the room is an important factor in displacement ventilation design since there can be a considerable amount of mixing in the region below the ceiling. This arises due to the interaction between upward and downward moving buoyant air flows. Hence, it is better to have high ceilings. Generally, buoyancy-driven ventilation is less effective where ceiling heights are low, for example less than 2.5 m.
Adjacent zones – Displacement ventilation diffusers are ideal for spaces in which occupants move through the zone (transient). However, this air movement strategy involves cool air moving along the floor in a stratified flow with a relatively constant depth (typical depth is about 200mm) with the maximum velocity in the stratified flow around l0% of this depth (approximately 20mm from the floor). So, an occupant sitting at a desk in the 'non-comfort' zone adjacent to the displacement ventilation diffuser, for example, could therefore sense cool air at ankle level. As a result, furniture layout and zone occupation need to be determined before the unit type is selected.

Acoustic performance – When designing a system using floor grilles/diffusers it is important to consider that these will be within the occupied zone and, most likely, will be much closer to any occupants than a ceiling/wall diffuser would be. Another point to consider is that floor grilles/diffusers will open up a sound path between rooms sharing the same floor void. TROX is happy to assist customers with all aspects of system design, including sound attenuation, and can arrange demonstrations of air movement characteristics at its laboratory in Thetford.

PRODUCT SELECTION

TROX UK manufactures three types of floor grille/diffuser. These include the AF (linear bar grille), the AFG (600 x 600 tile replacement grille), and the FBA (floor-mount swirl diffuser). As a general rule the AFG is the best option for data centres and other applications involving high cooling loads. It is designed for the supply of large volumes of air and is available with zinc-whisker free construction for added peace of mind in data centres. It is suitable for stringer widths of up to 40mm and pedestals of up to 90mm in diameter. The AF and FBA are ideal for sites such as offices, auditoria, airport concourses, theatres, cinemas, conference rooms, hotels, sports halls, fitness rooms, restaurants, shops and factories.

IMAGE: TROX AF linear bar grille

The AF model is typically installed around the perimeter of the occupied space, to discharge cold air up the glazing to mitigate any solar gains. The FBA is designed to be employed for maximum coverage across the rest of the floorplate.

All TROX floor grilles/diffusers are designed for ease of commissioning/balancing and maintenance. The AF and AFG models incorporate dampers that can be adjusted, through the grille face, using a flat blade screwdriver. For the FBA model, the volume can be adjusted by changing the position of the dirt trap. The discharge of the FBA can be switched from horizontal to vertical (and vice versa) by simply changing the position of the swirl element, providing a useful option for the management of local conditions. Throughout their lifetimes, the TROX floor grilles/diffusers are

maintenance free. If the floor void needs to be accessed the products can simply be lifted out of the recess. The FBA model incorporates a dirt trap to prevent any debris falling into the floor void.

For more information, please contact:

Debbie Giggle, Lighthouse PR

Tel: 01847 831609 Email: Lhousepr@btinternet.com

Neil Bond, Marketing Manager, TROX UK

Tel: 01842 754545 Email: marketing@troxuk.co.uk

About TROX Group

TROX is a global leader in the development, production and sale of components, units and systems for the ventilation and air conditioning of rooms. With 34 subsidiary companies in 29 countries on five continents, 20 production facilities, and importers and representatives, TROX is present in over 70 countries. Currently, the TROX GROUP has around 4,600 employees worldwide and generates revenues of around EUR 600 million.

About TROX UK

TROX UK was established in 1962 in London, UK, as the first international subsidiary of TROX GmbH, and since 1971 has been based at its manufacturing facility and offices in Caxton Way, Thetford, Norfolk, currently with approx. 150 employees. TROX UK is a manufacturer of air conditioning, ventilation and fire safety products and has the most efficient and flexible range of air distribution systems in the UK market. Working closely with architects, developers and consultants, TROX UK has supplied its products and services to many of the UK's most prestigious buildings and commercial developments.