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Protection Against Liability For Poor Diffuser Selection

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The manner of achieving an acceptable Air Diffusion Performance Index (ADPI) has been well understood for more than 20 years. Unfortunately, complaints of discomfort abound. It is not uncommon for building occupants who work in the same space to complain that they are "too hot" and "too cold."

Many unconventional designs and new technologies have been used to correct this apparent problem, including displacement ventilation, underfloor pressurized plenum air distribution, occupant task conditioning systems, etc. While all of these strategies assume that conventional overhead air distribution is unable to provide acceptable environments, this appears to be a false premise.

According to data and to technical papers as early as 1976, given a properly selected set of overhead ceiling diffusers, and an HVAC supply system capable of meeting the loads in the space, it is possible to devise a system of either VAV or constant volume air distribution than can respond to variations in localized loads from 20% to 100% of designed maximum loads at a variation in space temperature that most occupants will not notice.[1] This same system also will provide a ventilation effectiveness of 100% (all the ventilation air supplied at the ceiling will be delivered to the occupants). Heating performance with ceiling located diffusers also is well documented.

Int-Hout

So why are building occupants complaining they're uncomfortable? The likely culprit is improper diffuser selection,[2] which can lead to a number of problems. The first is "dumping." At low airflows, diffuser velocities may not be high enough to create the "Coanda effect" necessary to overcome the negative buoyancy of the cold air being discharged. This causes cold air to drop into the space. As a result, it's cold under the diffuser, warm at the midpoint between diffusers, and cold air puddles at the floor creating a vertical stratification in the space. Another problem occurs at very high airflows. Jets collide at the midpoint between diffusers, causing cold airstreams to drop into the space (where it was hot earlier). The increased induction at the recently cold spot under the diffuser now creates an upflow, warming that location.[3]

At the perimeter (where closed executive offices often are located) even worse things can happen. In winter, air is being discharged at 15% of cooling velocities at discharge temperatures of 105°F (41°C).[4] Since the warm jet has too much buoyancy and too little projection to mix with cold air that will spill down the window, there will be an 8°F to 10°F (4.4°C to 5.6°C) temperature difference between 6 in. and 6 ft (0.1 m and 1.8 m) from the floor in the middle of the room (contrary to the minimum requirements of ASHRAE Standard 55, *Thermal Environmental Conditions for Human Occupancy*). In summer, heat rising from the window stratifies at the ceiling. Cold air from the diffuser, which is often set to blow down,[5] stratifies at the floor. In both cases, at 43 in. (1.1 m) above the floor, where the thermostat is located, it is 75°F (24°C).

Problems like these can lead to liability and exposure. Here are just a few examples. In a Baltimore condominium complex with two-story living rooms, the designer supplied air from the ceiling. Since the air was too hot in cold weather, it stratified at the ceiling, resulting in a temperature of 50°F (10°C) at the ankles and 80°F (27°C) at the head. The condominium owners sued the engineer. The case was eventually settled, but not until after the engineer incurred fees and costs for attorneys and experts. A similar problem occurred in a one-story bank in Pennsylvania. This time, the case went to trial and the jury returned a sizeable verdict against the engineer. The expert witness fees alone exceeded the amount in issue in the lawsuit.

Improper diffuser selection can also lead to problems for owners. For example, in an office building in New Jersey, a tenant successfully broke its lease after complaining about comfort problems relating to ceiling diffusers. Indeed, according to the Building Owners and Managers Association, thermal comfort related issues (often misdiagnosed as IAQ problems) were the No. 1 reason for non-renewal of leases in 2002.

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Finally, in a case involving county courthouse in Illinois, more than 500 diffusers that did not meet the requirements of the *ASHRAE Handbook—Fundamentals* were replaced with longer throw diffusers.[6] In addition, diffusers that were improperly designed and installed had to be modified to provide the proper horizontal discharge pattern designed by the engineer. The defendant A/E firm spent millions of dollars defending itself in the case.

So how do you protect yourself?

• First of all, select and place diffusers in accordance with Chapter 32 of the *ASHRAE Handbook—Fundamentals*, which will very likely be deemed the standard of care in a negligence case.[7]

• Select a diffuser that can maintain constant temperature year round, that will provide uniform air distribution throughout the occupied zone, and that will provide excellent ventilation mixing. Many diffuser types can perform in this manner. The difference in cost between a diffuser that works, and one that doesn't (as defined by ADPI performance) is minimal. It doesn't cost anything to put a diffuser in the right place to begin with, or to adjust it.

• Comply with ANSI/ASHRAE Standard 62.1-2001, *Ventilation for Acceptable Indoor Air Quality,* Addendum *n*, Table 6.2 on Air Change Effectiveness, which spells out rules for overhead heating. Standard 62 is being referenced in most mechanical codes, including all addenda, starting in 2003.

• Adhere to *2001 ASHRAE Handbook—Fundamentals*, Page 32.16 for recommended maximum discharge temperature for heated air of 15°F (8°C) above room temperature for outlets in or near the ceiling.

• Reference proper diffuser adjustments on drawings.

• Make sure that diffusers are installed and adjusted in accordance with drawings.

• If an architect or building owner directs you not to follow the Handbook, Standard 62.1, any other standard and/or drawings, be sure to provide the architect's or owner's direction in writing and send them a copy.

An uncomfortable environment is not just a problem for the individuals who occupy the space. It may also be a problem for engineers who have the information they need to provide acceptable spaces, but fail to use that data in their designs.

Endnotes

1. Thermal comfort studies have concluded that if a constant, uniform space temperature is maintained, apparent differences in thermal preference can be minimized, first because occupants will adapt to the constant condition and, secondly, because they can wear comfortable clothes. However, when local temperatures and airspeeds vary throughout the day and throughout the space, occupants cannot adapt, which leads to complaints of discomfort.

2. While room partitions (which are essential for privacy in open plan offices) often are blamed for poor room air distribution, when diffusers are properly selected, partitions as high as 7 ft (2.1 m) have actually been shown to assist air-distribution patterns, independent of diffuser/partition location.

3. In both circumstances, the thermostat is satisfied because the air temperature at the edge of the space (where it is located) is in the "thermocline," or mid-stratification zone, and hasn't changed. Accordingly, the DDC system reports to the central computer that all is well.

4. This is contrary to the ASHRAE recommended maximum discharge temperature of 15°F (8°C) above room temperature (90°F [32°C] in a 75°F [24°C] room).

5. Diffusers are set to blow down when shipped by the manufacturer. If they are not adjusted, they will continue to function in that manner.

6. The court presumed that the ADPI selection criteria contained in *ASHRAE's Handbook—Fundamentals* constituted the standard of care.

7. The author provides a simplified method of diffuser selection based on ADPI and airflow rates in *ASHRAE's IAQ Applications,* 1(1):12–16.

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