
Dan Int-Hout

Conditioning Challenges: Lobbies and Atriums

BY DAN INT-HOUT, FELLOW ASHRAE

Conditioning spaces with large vertical walls is a challenge for design engineers, especially when it has to be coordinated with an architect's aesthetic concept. As is often the case in lobbies or atriums, these areas are composed of glass and can be anywhere from 12 to 18 ft (3.6 m to 5.4 m) high. While people do not typically occupy the space next to the window for long lengths of time, it is still important that proper air distribution and comfort conditions be maintained.

ASHRAE's thermal comfort standard (Standard 55-2013) states "the *occupied zone* is to be between the floor and 6 ft (1.8 m) above the floor and more than 3.3 ft (1.0 m) from external walls/windows or fixed heating, ventilating, or air-conditioning equipment and 1 ft (0.3 m) from internal walls."

While this implies that the space close to the window is outside the "comfort zone," it does not mean that it may not affect or impact the airflow patterns within the occupied area, nor does it mean that occupants will not pass through or spend shorter durations in the space.

To adequately offset such heating and cooling demands in these applications, one must understand that hot air rises and cold air falls. Surprisingly, this basic notion is largely overlooked by many design engineers. It is not only what allows one to control air delivery, but also take advantage of it. Listed here are a couple of "rules of thumb" that can be used to assist in the understanding of air distribution dynamics and may help save energy in the process.

1. A jet of air delivered by a ceiling diffuser is typically affected by buoyancy and can be described through this simple equation: The throw to 75 fpm (0.37 m/s) is increased or decreased by 1% divided by degree ΔT. (ΔT being the difference between the thermostat setting, which is the average of the occupied zone temperature and the jet discharge temperature, in °F).

2. The direction of the effect is determined by buoyancy, so cold air that is directed down will travel farther, but hot air will not travel as far. On the other hand, hot air directed along a horizontal surface will travel farther, and a cold jet will travel less distance. A horizontal jet with no adjacent surface will rise or fall at the isothermal 75 fpm (0.37 m/s) throw distance by about 1% divided by °F.

Pretty simple, huh? These rules of thumb work surprisingly well in practice, but there are a couple of other details that need to be considered.

1. The throw to 150 fpm (0.76 m/s) is not measurably affected with less than 25°F (14°C) ΔT.

2. A return slot located at the top of the window will remove the heat that rises from the window and will not have to be included in the room load that the HVAC system must handle. (Of course, the warmer plenum air will likely be returned to the A/C equipment.)

To deliver air to the space without creating any unwanted drafts, it is important to understand the vertical air patterns from overhead. In most manufacturers' catalogs, a downward jet will have published isothermal throw values at 50 fpm and 100 fpm (0.25 m/s and 0.51 m/s) terminal velocities. The 75 fpm (0.38 m/s) terminal velocity will be in between these values.

If a 20°F (11°C) ΔT cooling is assumed, this value will be increased by 20% because cold air wants to fall. If

Dan Int-Hout is a chief engineer at Krueger in Richardson, Texas. He is a member of SSPC 55, SPC 129 and consultant to SSPC 62.1.

a 20°F (11°C) ΔT heating is assumed, the throw will be reduced by 20% because hot air wants to rise. This means that there will be a 40% change in downward projection moving from heating to cooling. However, the problem is that the hot air needs to penetrate the occupied zone. Using this design example, the cooling air will likely create drafts by hitting the floor and moving toward the interior. How can this be prevented?

One solution is to reduce the airflow in cooling, but in doing so, it is unlikely that the cooling demand loads will be met. Instead, it is recommended that an array of air outlets be established that extends into the interior zone supplying the required cooling airflow. The interior diffusers should be selected so that they have short throws to prevent excessive jet collisions at maximum design cooling airflow rates, which could produce unacceptable drafts. Interior diffusers are then shut off when heating, using a single duct VAV box, which will increase the air delivered to the perimeter.

It is strongly recommended to keep the heating ΔT as low as possible to avoid excessive stratification and occupant discomfort. ASHRAE Standard 62.1-2013 states that when discharging warm air from the ceiling at more than 15°F (8.3°C) above room temperature, the ventilation rate must be increased by about 20% (divide the value by 0.8). Standard 62.1 also demands the 150 fpm (0.76 m/s) throw value reach within 4.5 ft (1.4 m) from the floor, or again, increase ventilation.

By understanding the physics of air distribution and following these rules of thumb, a design engineer can successfully design a diffuser layout and provide air quantities and temperatures that are not only able to meet thermal loads, but also deliver the comfort requirements and ventilation needs of the space. ■