ENGINEERING CORNER BLOG

Designing for Comfort per ASHRAE Standards 55 and 62.1

The goal of a room air-distribution system is to provide thermal comfort and a healthy living environment for occupants in the space. ASHRAE Standard 55-2010 Thermal Environmental Conditions for Human Occupancy and ASHRAE Standard 62.1-2010 Ventilation for Acceptable Indoor Air Quality provide designers with the guidance to optimize health and comfort in building spaces. Many codes, including LEED 2009, require compliance with these ASHRAE Standards. This article will outline the goals of these standards and illustrate how to comply with these requirements.

The occupied zone as defined by Standard 55-2010 reads: "The region normally occupied by people within a space, generally considered to be between the floor and 6 ft. level above the floor and more than 3.3. ft. from outside walls/windows or fixed heating, ventilation, or air-conditioning equipment and 1 ft. from internal wall." The space from the interior walls inward 1 ft. serves as a mixing zone where room air is entrained into the supply-air jet and mixes to provide thermal comfort in the occupied space. When designing underfloor air-distribution (UFAD) or thermal displacement ventilation (TDV) systems, the occupied area around the outlets may be excluded to a boundary where the total air jet from the outlet contains velocities greater than 50 feet per minute (fpm). These areas may also be known as the "clear zone," "adjacent zone," or "near zone."

Any design must also include an adequate supply of ventilation air to the breathing zone of the space. ASHRAE 62.1-2010 defines ventilation air as "that portion of supply air that is outdoor air, plus any recirculated air that has been treated for the purpose of maintaining acceptable indoor air quality." The breathing zone is "the region within the occupied space between planes, 3 and 72 inches above the floor… ." We will discuss additional requirements for ventilation air later in this article.

The primary factors to be considered when determining conditions for thermal comfort in the occupied space are: 1) Temperature, 2) Air velocity, 3) Humidity, 4) Clothing insulation, and 5) Activity level of the occupants. All of these factors are interconnected when determining the general occupant comfort of a space. The ideal temperature in a space (operative temperature) is where the occupant will feel neutral to their surroundings, neither feeling any heat loss or heat gain from the space. While the range of acceptable operative temperatures may vary depending on other conditions, it is a requirement of ASHRAE 55 that the "Allowable Vertical Air Temperature Difference-Between Head (67") and Ankles (4")

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is limited to 5.4 F (3.0 C)". Ideal air velocity in the space can vary with other factors, but, in general, the goal is to keep spatial velocities less than 50 fpm during cooling mode and less than 30 fpm during heating mode. For many years, Titus has recommended maintaining the relative humidity level in the space between 25-60%. ASHRAE 55 does not define a lower limit and requires the dew-point temperature be less than 62.2 degrees (F). Another factor affecting comfort is the clothing insulation level of the occupant. In most office environments, the Clo level for occupants is between 0.5 and 1.1, where .5 would be a person wearing no socks, sandals, short-sleeve shirt or blouse, and shorts or a skirt. The 1.1 Clo level would include long pants, socks, long-sleeve shirt, and a dress coat or sweater. The range of operative temperatures where both 0.5 and 1.1 occupants are in the same space is very narrow. The final item of consideration for design comfort is the intended activity level of the occupant in the space. In most office environments, the metabolic (MET Rate) is between 1.0 and 1.3. This includes occupants who are sedentary to casual movement about the space.

The three common methods of room air distribution used in commercial buildings in the United States are fully mixed (e.g. overhead distribution), fully stratified (e.g. displacement ventilation), and partially mixed (e.g. most underfloor air distribution systems). Since interior zones usually have adequate heat loads from occupants and equipment, in addition to few heat losses, the discussion for interior spaces will be cooling only. For the perimeter spaces, the discussion will be how to meet the requirements for heating and cooling from the same overhead outlet. Design methods for cooling an interior zone and heating a perimeter zone vary with each method.

For fully mixed systems, the pattern of the air delivered to the space must be considered when selecting an air outlet. Ceiling diffusers typically exhibit flow in a circular (radial) or cross-flow (directional) discharge air pattern. The circular pattern usually provides shorter throw, higher mixing and tends to maintain ceiling effect to low velocity before turning back on itself. This pattern is ideal for variable air volume (VAV) cooling by providing less drop and more uniform temperatures in the space. The cross-flow (directional) air pattern has longer throw, but with less induction may lose ceiling effect, creating drafts in the occupied zone. Plenum slot diffusers typically discharge air in a directional air pattern, but some are available with "spreaders" to produce a more radial discharge pattern. Sidewall grilles equipped with vertical deflectors can be adjusted from zero degree (directional pattern) to a 45-degree spread (radial pattern). So, regardless of the desired type of outlet, the air pattern can be either radial or directional to best meet the comfort requirements of the space. Proper selection for comfort can be insured by using the ADPI selection program in TEAMS.

Typically, for perimeter applications where the same outlet is being used for both heating and cooling, a linear slot diffuser or plenum slot diffuser is employed. When a fixed air pattern diffuser is used, it is typical to supply half of the air across the ceiling for cooling and half down the glass for heating. For perimeter heating, the requirements for table 6-2 of ASHRAE Standard 62.1-2010 must be considered. The intent of table 6-2 is to ensure that the ventilation air supplied to the space be delivered to the breathing zone as well. For ceiling supply of warm air with a ceiling return, the requirements for heated air are to reach a terminal air velocity of 150 feet-per-minute to within 4.5 ft. of the floor. To a terminal velocity of 150 fpm or more, air is temperature independent, which means the distance air will travel will be the same for isothermal air (catalog values), warm air and cool air. This means that during heating, ventilation air will be pushed down into the breathing zone with enough heat energy to meet Standard 55's requirement for a temperature gradient of less than 5.4 degrees. In addition, the differential temperature between warm supply air and space temperature with a ceiling return must be 15 degrees or less. Thus, the maximum supply-air temperature for a 75-degree room would be 90 degrees. When the heating supply-air temperature exceeds the 15 degree limit, the ventilation air volume must be increased by 25%.

Choosing an auto-changeover diffuser like Dynafuser or EOS does not change the Standard 62.1 requirements, but will lower energy costs and improve comfort in the space. Delivering all the warm air down the glass during heating will save energy. With a fixed-pattern diffuser, half of the warm air will be discharged across the ceiling and with a ceiling return can be short-circuited without reaching the occupied space level. Additionally, higher comfort will be realized in the space since the heated air can be designed to deliver warm air all the way to the floor. Comfort may be increased during cooling as well, as the cool air will be projected across the ceiling eliminating the potential for drafts from the jet protected down the glass with a fixed pattern diffuser.

For partially mixed air-distribution systems (typically UFAD), the core area usually experiences even loading throughout the occupied area. The goal of partially mixed systems is to save energy by comfort-conditioning the lower occupied level in the space and allowing the upper level of the space to stratify. Occupant comfort is achieved by delivering cool conditioned air from the plenum under the floor through swirl diffusers or rectangularly shaped outlets near the occupants' work area. Individuals can enhance their personal comfort by adjusting the damper at the outlet near their workspace. For common areas such as hallways and break rooms, outlets can be equipped with actuators that are controlled by a common thermostat located in the space.

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Perimeter zones for partially mixed systems create a greater challenge, as the loads are dynamically changing due to outdoor solar and air temperature changes. A common method for perimeter zone control is locating a low-profile fan-powered terminal unit under the floor near the perimeter supplying air to linear bar grilled. The fan-powered terminal can be equipped with an electric or hydronic coil. Cool plenum air can be supplied to the outlets when cooling is required and the coil can be employed to warm the air as required during heating conditions. The design challenge is selecting outlets that will limit the throw of the air pattern so that air will not bounce off the ceiling and create drafts in the adjacent occupied area.

Energy to operate the fan terminals can be eliminated and higher comfort can be achieved on the perimeter by using the TAF-L perimeter distribution outlets. With a 6" wide custom design TAF-L bar grille located along the perimeter of the space, the modular 4' long TAF-L-V (cooling), can be attached to provide up to 225 cfm (at 0.07" plenum pressure) per 4' unit of cooling. The TAF-L-V damper is controlled by a space thermostat to provide cooling as required. The special arrangement of bars in the grille is designed to limit the throw from the outlet during cooling. The 4' long TAF-L-W or TAF-L-E heating module can be attached to the TAF-L grille to supply up to 3,000 Btu heat to the perimeter. The heating units operate by combining the cool convection currents from the glass with the warm currents on the floor. The mixture is induced through the heat exchanger with warm air being discharged through the grille and up the glass. Space temperature is controlled by a room thermostat controlling the water flow or electric current flow to the electric heating element. The modular design allows the system to be custom designed for use in multiple climate regions.

A fully stratified design (typically TDFV) conditions a space by discharging cool supply air through an outlet located at floor level. This happens near or in a wall or may be centrally located in the open space. Low velocity air (<80 fpm) is discharged horizontally across the floor. Air moves with little mixing across the floor until it contacts a heat source such as an occupant or a piece of warm equipment in the space. Cool air will mix with the radiant heat, form the source, and stratify toward the ceiling. The return is usually located at or near the ceiling. The area between the outlet and where the air speed reaches 40 fpm is the "clear zone" and should not be included in the occupied area. Titus provides units with adjustable air patterns so the clear zone can be controlled to meet project requirements for space occupancy. ASHRAE Standard 62.1 (Table 6-2) provides a 20% bonus for TDV systems. This means that ventilation air can be reduced by 20% or the 20% can be used toward the 30% required for an additional LEED IEQ credit 2.

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While TDV systems typically require a separate system for heating, Titus has introduced the Plexicon heating/cooling diffuser. A standard rectangular outlet is located near or mounted in a wall that discharges cool air from the upper chamber. When heating is required, an internal baffle is moved to change the flow of air from the upper chamber into the lower chamber where it flows through a linear bar grille to satisfy heating requirements.

Regardless of which type of system you are using on your project, studies have shown that occupants whom are comfortable are more productive. Designing for comfort, keeps paying back dividends forever.

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