

Overhead air distribution is one of the most common ways of distributing conditioned air into a space. When done properly, it mixes cool supply air with warmer room air to create a comfortable, tempered environment for occupants. The process, however, does not come without moving fine dust particles, which may contribute to a phenomenon known as “ceiling smudging”.

Devices used in traditional overhead systems, such as ceiling diffusers and grilles, typically throw air at a high velocity. This rapid movement creates a low-pressure area, whereby the supply air begins to mix with the room air while it adheres to an adjacent surface (ceiling or wall). It continues this path long enough to avoid falling into the space and producing unwanted drafts.

While the supply air moves along different surfaces, it is entraining dust particles into the room air. In high areas of turbulence, these particles can accumulate, creating unsightly smudges. This is seldom the result of dirt particles located in the supply airstream, as they are moving parallel to the surfaces, mixing with room air, never having much of a chance to accumulate.

Means to alleviate this phenomenon rarely come without causing occupant discomfort from drafts, so it is important to understand exactly what is happening before attempting to resolve the problem.

- Any jet of air will exhibit a lower static pressure than the air around it. This is due to conservation of energy and the rapid expansion of air leaving a restriction. While the mathematics may seem complicated, it is easy to demonstrate. In a visual respect, it may seem like a jet of air is drawing in or “entraining” the surrounding slow moving room air. What is really happening is that air molecules are moving from a region of higher pressure to a region of lower pressure. The greater the pressure difference, the greater the effect, which is to say that the higher velocity jet is not drawing in room air, but rather the room is pushing air into the low-pressure jet.

As this happens, dust particles begin to accelerate as they get closer to the jet. The jet, moving perpendicular to the pressure gradient, causes the accelerated dust particles to impinge themselves on a nearby surface instead of turning at right angles to their pressure induced direction. The result is a pattern of smudging, often at the areas with the greatest turbulence.

- There have been several proposed concepts to address ceiling smudging.
 - a. One such concept is the “smudge ring”. This is a raised surface at the discharge of an air device that prevents air from flowing along the ceiling right next to the outlet, where velocities are greatest. The idea is that the jet will re-entrain a short distance away. With VAV systems, however, there is a risk that cold air could fail to re-entrain at low room air flows (and low loads), resulting in “excessive drop” or “dumping”.
 - b. Another concept is a foam gasket around the back of the frame of a grille or register. While this may seem to reduce smudging in some instances, it is likely because air is not flowing out of the unit as it should. Instead, leaking from the duct connection, exiting between the frame and the surface to which it was mounted.
 - c. A third concept is a clear plastic collar around a ceiling diffuser that directs the air downward. Such collars are often found in high traffic locations and fast food establishments. While it may prevent soiling of the adjacent surface, it will most certainly create a draft under the outlet. Only if the ceilings are high enough and the airflow low enough, might this be acceptable.

In short, soiling is a byproduct of proper air distribution. Perforated diffusers, in particular, will exhibit soiling on the face of the diffuser rather than on the adjacent surfaces. In such cases, one should remove and clean the diffuser surfaces regularly. When using other overhead air distribution devices, the best remedy is to keep the environment clean and routinely vacuum the areas near diffusers.