CEILING SMUDGING

KRUEGER

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. This process; however, moves fine dust particles, which may contribute to a phenomenon known as "ceiling smudging".

Devices used in traditional overhead systems, such as ceiling diffusers and high wall grilles, typically throw air at a high velocity. This high velocity air creates a low static pressure region around the air jet, which is due to the conservation of energy and the rapid expansion of air leaving a restriction. Shown in **Figure 1** are the air molecules moving from a region of higher pressure to lower pressure. The greater the pressure difference, the greater the effect. The higher velocity jet does not draw in room air, but rather the room air pushes the supply air into the low-pressure jet. This results in the high-velocity air clinging to the adjacent ceiling, preventing the cool, supply air from falling into the space and producing unwanted drafts.

While the supply air moves along different surfaces, it entrains room air and dust particles. In areas of high turbulence, these particles can accumulate, creating unsightly "smudges". This is seldom the result of dirt particles located in the supply airstream, since they are moving parallel to the surfaces, never having much of a chance to accumulate. The jet moving perpendicular to the pressure gradient is what causes the accelerated dust particles to impinge themselves on a nearby surface instead of turning at right angles to their pressure induced direction as shown in **Figure 2**. 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, including the below list of suggestions.

1. 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, as shown in **Figure 3**, 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 velocity airflows (and low loads), resulting in "excessive drop" or "dumping".
2. 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, the air leaks from the duct connection, exiting between the frame and the surface to which it was mounted.
3. A third concept is a clear plastic collar around a ceiling diffuser that directs the air downward to have vertical throw into the space instead of horizontal throw along the ceiling, as shown in **Figure 4**. Such collars are often found in high traffic locations and fast-food establishments. While it may prevent smudging 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.

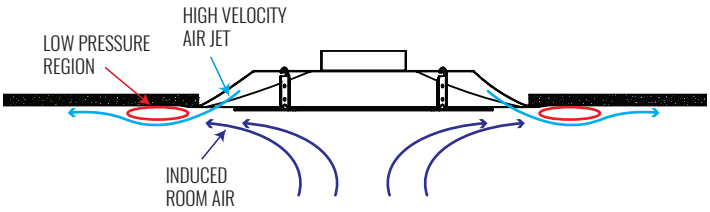


Figure 1: Ceiling Diffuser Air Movement

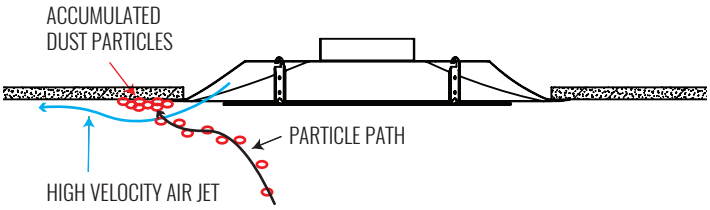
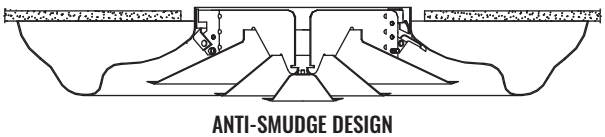


Figure 2: Dust Particle Movement



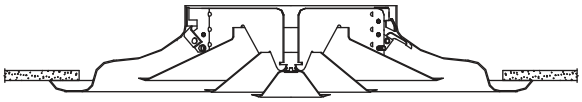


Figure 3: Smudge Ring Design

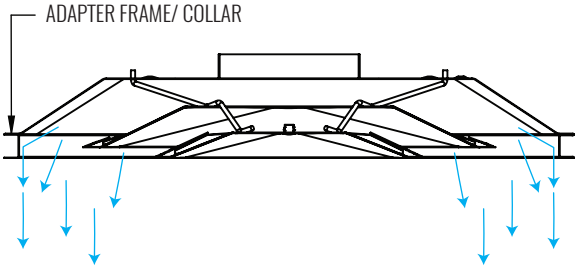


Figure 4: Diffuser Collar at Face Design

4. A fourth concept is to consider the ceiling surface. Textured ceiling surfaces can accumulate more dirt particles over time compared to a smoother surface.

5. A fifth concept is to specify perforated diffusers, which tends to localize smudging on the diffuser face. This is caused by the negative pressure areas created by the perforated holes.

6. Along the same lines as option five is our last concept, which is to consider diffuser selection. Directional diffusers generally produce a less uniform air pattern across the ceiling, resulting in air jets going in several directions. This can lead to heavy smudging along the edges of each jet, which is very noticeable, as shown in **Figure 5.** A plaque type diffuser distributes air in an even, uniform circle around the diffuser, which results in smudges occurring in a more uniform pattern across the ceiling, which can allow for longer times between cleanings, as shown in **Figure 6**.

In summary, ceiling smudging is ultimately a biproduct of well-mixed overhead air distribution used in an unclean room. There are several products and applications to minimize or contain ceiling smudging; however, the best way is to address the occurrence is to ensure rooms are regularly cleaned to reduce the amount of dust in the space.

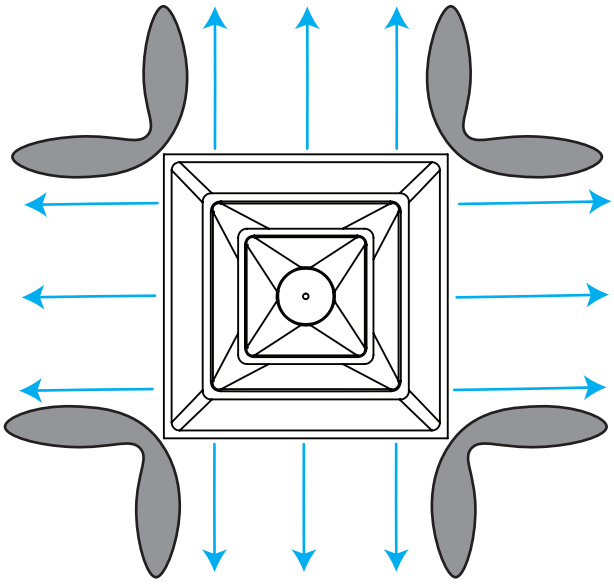


Figure 5: Louvered Diffuser Smudge Pattern

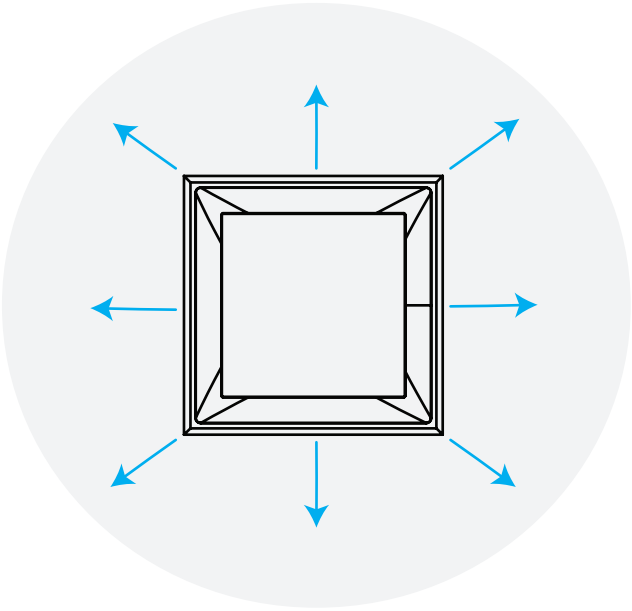


Figure 6: Plaque Diffuser Smudge Pattern