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WHAT CAUSES DIRT STREAKS AROUND DIFFUSERS?

The first reaction, or accusation, by customers when they see dirt streaks coming off diffusers is poor filtration. This seems like an obvious conclusion and may be true.

However, there are other factors at work in a room that generally are the primary cause, not the inefficiency of the filters. You can get dirt streaking around diffusers even where HEPA filters are used.

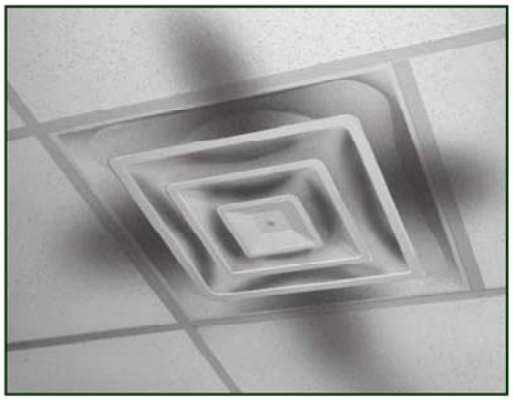
The primary culprit is turbulence caused by air coming out of a diffuser at high velocity. The churning of air continually collides with the ceiling. Any particulate caught up in that turbulence has many opportunities to come in contact with the ceiling. Each time that happens, some percentage of the dirt particles will be deposited, or impinge on the ceiling.

A major factor in how much particulate is caught up in this churning turbulence is dependent on what is going on in the room. People, carpeting, copying machines, opening of doors and windows, or some kind of process all contribute to particles being picked up in this turbulence - eventually to be deposited on the ceiling.

Other contributing factors include temperature differential, which contributes to air currents; condensation, which makes the particulate more sticky; and static electricity, which causes the particulate to be attracted to the ceiling.

Here is a simple inspection to determine if the dirt is coming into the room through the ductwork or is being generated within the room. Remove the diffuser and check to see if there is dirt on the diffuser and in the ductwork leading up to it. If there is, then dirt is being transmitted through the air handling system. The filters may or may not be doing an adequate job of collecting dirt. There could be leaks in the ductwork or dirt could be entering the system through other sources.

If the ductwork leading to the diffuser is fairly clean, then the dirt streaks are caused by dirt generated within the room.



Does Poor HVAC Air Filtration Equal Dirty Diffusers and Ceiling Tiles?

Rex Wilhoite, CAFS, Air Filter Sales and Service, Company

Not Necessarily! Anyone involved in the cleaning and maintenance of buildings, from owners and design engineers to the custodial staff, have witnessed supply diffusers and ceiling tiles that are stained, discolored and dirty. Usually the blame for this phenomenon is placed on the HVAC air filters and sometimes on the air filtration salesperson. The industry term applied to this phenomenon is *dirt streaking*.

The source for *dirt streaking*, of course, can be from a poorly filtered HVAC system; however, streaking can and does occur in areas where the supply air is filtered by High Efficiency Particulate Air Filters (HEPAs). HEPA filters have a minimum rated efficiency of 99.97% on particles the average size of a single smoke particle (0.3 microns)[1]. Since this phenomenon occurs even in rooms supplied by HEPA filtration, to understand how this can occur, we need to look at the typical concentration and sources of indoor contaminants and the dynamics of indoor air currents. Except in indoor areas where the source of airborne contaminants is obvious, such as a welding shop or some other manufacturing process, the major portion of dirt and dust particles found in a room are due to air infiltration through cracks around doors and windows. A second major source of indoor air contaminants is the activities of people within the room, such as smoking or cooking, etc. Table A shows the concentration of particles emitted by people at differing levels of movement.

PARTICLE EMISSION FROM HUMAN ACTIVITY

Activity	Particles Emitted per Minute Larger Than 0.3 Micron Diameter
Sitting or standing, no movement	100,000
Sitting - Light hand & arm movement	500,000
Sitting - Average body movement (crossing legs, etc.)	1,000,000
Changing positions -Standing	2,500,000
Slow walking	5,000,000
Average walking 3 - 5 mph	7,500,000
Fast walking 5 mph plus	10,000,000
Physical exercise	15,000,000 to 30,000,000

Table A

Studies have shown that a typical cubic foot of indoor air can contain as many as 30,000,000 airborne particles[2]. This, of course, will differ depending on the type of room; whether the room is a church or a bingo hall will make a difference. Studies have also shown that the makeup of indoor air pollution will vary in size from gases with a size of .0001 micron to particles approximately 100 microns in diameter[3]. In normal room air currents, particles greater than 100 microns in diameter with a corresponding length greater than one millimeter will be too large to remain suspended in the air. Graph A on page 7 provides a breakdown of various particle sizes and their typical airborne suspension times by particle size.

To show a more graphical relationship of various particle sizes, Graph B (also on page 7) provides a reference to show the average size range of common atmosphere contaminants and their size relationship to a human hair.

The American Society of Heating, Refrigeration and Air Conditioning Engineers, (ASHRAE) through their Standard 62, have set guidelines for weight limitations on airborne dust per cubic meter to assure good indoor air quality. Per their Standard, indoor air quality is unacceptable if the concentration of particles over 10 microns in size exceeds 50 micrograms per cubic meter as an annual average. Other organizations, such as OSHA, the EPA, the World Health Organization (WHO) and the American Conference of Governmental Industrial Hygienists (ACGIH) have all established standards for acceptable indoor air.

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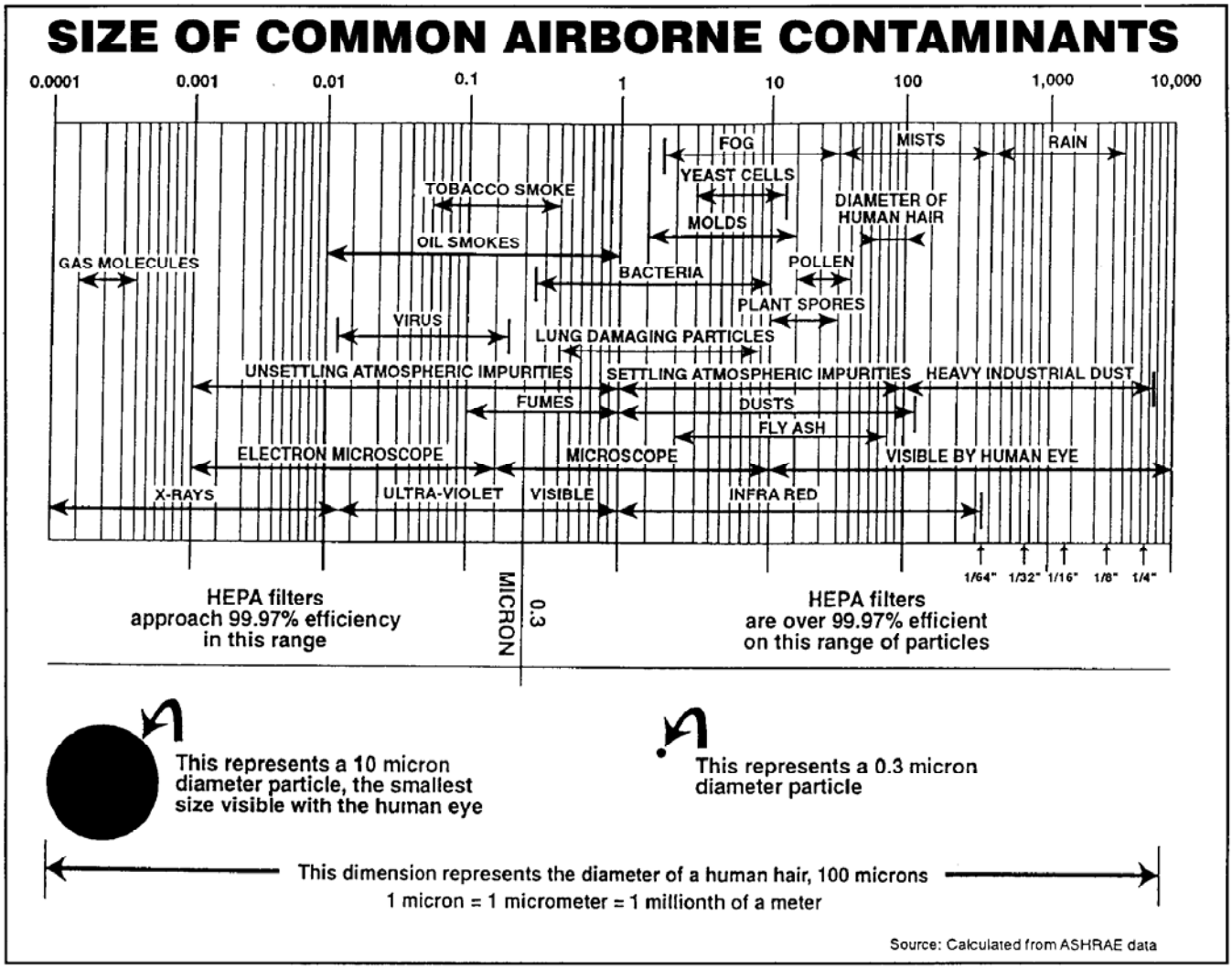
[1] IES-RP-CC-001-86; *Inst. Of Env. Sciences Recommended Practices for HEPA Filters.* B.I.3.

[2] ASHRAE, *1993 Handbook*, Chapter 11, p.2, Suspended Particles.

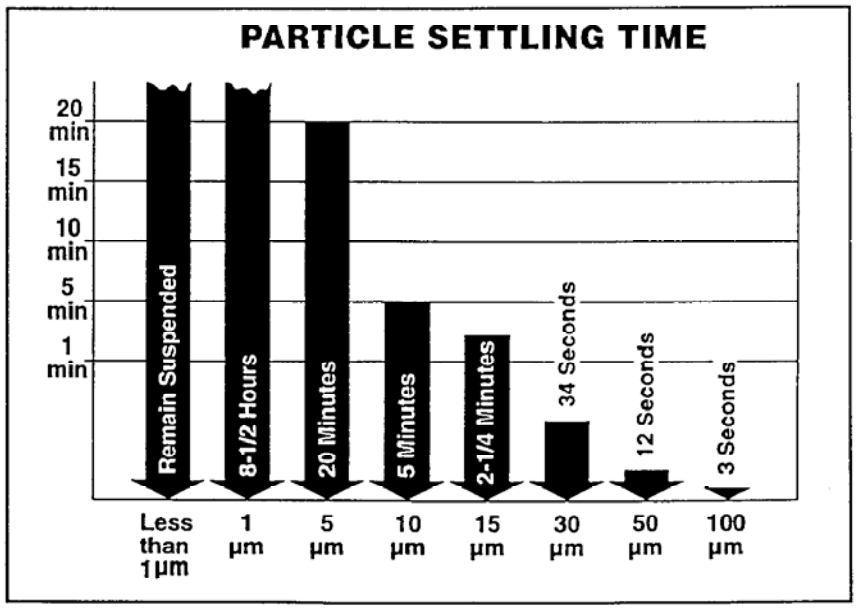
[3] ASHRAE, *1993 Handbook*, Chapter 11, p.3.



Graph A: Size of Common Airborne Contaminants

Now that we have identified some of the sources that provide airborne particles that cause streaking, we can look at the science that explains this effect. Regardless of the type of HVAC supply system, the primary forces that cause airborne particles to collide with walls and ceilings are turbulent and molecular diffusion. The primary forces that cause airborne particles to stick to surfaces are friction and electrical attraction.

Air diffusion, the term applied to the various air mixing processors, includes turbulent diffusion and molecular diffusion. Turbulence occurs when air streams having different velocities collide. Molecular diffusion happens because molecules of air collide with one another, transferring heat and momentum. Particle movement caused by diffusion can be enhanced by thermal and electrical forces. It is also important to note that molecular diffusion primarily affects the smallest and lightest airborne particles. Combining these forces of science explains why the area around the ceiling diffuser and the ceiling diffuser itself are



Graph B: Particle Settling Time

usually where dirt streaking is the most prevalent.

When there is a difference in temperature between room air and the surrounding walls and ceilings, warm air will be drawn to the cool surfaces. Suspended airborne particles become entrained in this air movement and are captured on the surfaces by condensed water and electric forces explained by van der Waal's theory of diffusion[4]. As these particles move across the diffuser and ceiling, turbulent forces, both thermal and electric, take over, pulling these particles from the air and depositing them on both the diffuser and ceiling.

Coupling these air movement principles with a force we will call thermal induced adhesion provides the explanation of how streaking can occur even in rooms with exceptionally well-filtered supply air. Thermal induced adhesion occurs when microscopic dust particles come in contact with a surface containing moisture which has condensed from the air on a cool surface. They then cling to the surface they contact due to physical differences such as wetness or because of electrical polarity differences. The greater the temperature difference between warm air and cold ceilings, the greater the amount of deposition on that surface.

Except for a true cleanroom environment, where the airborne particles are minimized, dirt streaking is possible. However, dirt streaking can be minimized with good design practices. This includes proper and adequate insulation, sizing equipment to allow the building operators to maintain a positive building pressure, and providing the owner with an adequate air filtration system. The level of filtration will be determined by the location of the building and by its intended use.

Good maintenance practices should also be encouraged as a deterrent to dirt streaking. When the tell-tale signs of streaking begin to occur, both housekeeping and engineering should explore why it is occurring and work together to see if it is preventable. If not preventable, then just a regular cleaning will stop this unsightly phenomenon from becoming an indoor eyesore.

Technical collaboration for this article was provided by Joe Boatman, Ph.D., AE Associates, Greeley, Colorado. ■

[4] *Van Nostrand Scientific Encyclopedia.*