The Importance of Dust Control during Construction and Remediation Projects

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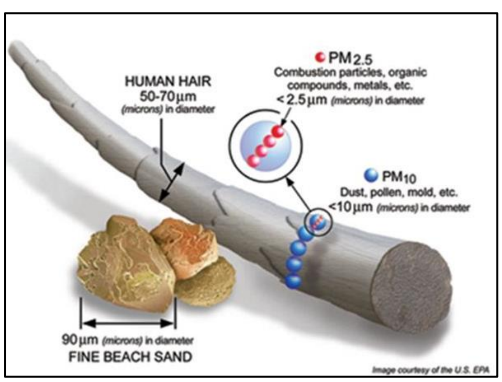
Although they may not seem to have much in common at first glance construction work, restoration and remediation efforts, and commercial cleaning activities are connected in a big way by the smallest of the items -- dust. Even though the construction industry has a history that is millennia old, it is constantly evolving and the expectations of how work should be done in a way that minimizes the potential of cross-contamination are constantly evolving. In contrast, the cleaning and restoration industries are newer and have been going through a more rapid maturation phase which is putting more emphasis on meeting customer expectations. The evolving expectations from clients in all of these industries are for the project to be completed in a manner that keeps dust to a minimum.

The Science of Dust

Although a review of dust would seem to be fairly straightforward, the science is not as simple as the word. Dust is the term that is applied to small particulates, particularly those that settle out of the air. Therefore, the simplest explanation is that dust consists of tiny solid particles carried by air currents. Dust is formed naturally by erosion, burning, and shedding; as well as by mechanical means such as drilling, sanding, sawing, etc.

Dust is generally measured in micrometers (commonly known as microns). Scientists have applied many gradations to dust based on the size. "Coarse dust" generally refers to particles that are temporarily suspended in the air but are too large to remain airborne for very long. Coarse dust settles quite quickly while dust of a smaller size, generally distinguished by the term “particulate matter” (PM), can remain in the air indefinitely. Government agencies such as the Environmental Protection Agency (EPA) are typically most concerned with the smallest particles[2]; those classified as PM 10 and PM 2.5 because of the health consequences of such material. These would be particles smaller than 10 microns and smaller than 2 1/2 microns.



Until the advent of the chemical age[3] most dust, particularly that which accumulated in buildings, was an amalgam of natural, organic materials. Back in the "good old days" dust was primarily made up of soil particles, plant matter, insects, skin cells, hair, and clothing fibers. While these constituents still make up a good share of dust, we now know that our modern dust contains a number of products that are substantially different from its historical predecessor. In particular, dust now contains measurable quantities of microscopic plastic particles, heavy metals, and even "legacy pollutants" such as DDT and PCBs[4].

With many of these newer, chemical, dust constituents the volume or weight compared to the other components does not adequately represent the risk. For example, plasticizers that volatilize or shed from everyday products like cosmetics, food containers, electronics, or vinyl flooring accumulate over time in the dust. The most common plasticizer, known as DEHP (di, 2-ethylhexyl phthalate), is a confirmed hormone disruptor in small quantities which is why it is considered one of the most significant chemical compounds in dust from a health perspective[5]. Phenol-based preservatives, residue from fragrances, flame retardants, and stain repellents all contribute to chemical contaminants in dust. While not often thought of as a chemical, the man-made product we call fiberglass has been implicated in a number of high profile cases of health complaints traced back to the building environment[6].

Construction and restoration projects no longer create dust that is a combination of natural materials. Sawing and sanding is now more likely to be done on a composite wood material than on lumber. Working with plywood, OSB, particleboard, engineered beams, laminate flooring, and similar products produce chemical laden sawdust rather than just wood dust. Drilling or cutting pressure treated lumber can release a variety of chemicals depending on the particular treatment method used for the wood; including arsenic, copper, chromium, quaternary ammonium compounds, boric acid, pentachlorophenol, creosote, ammonia, naphtha compounds, and others[7].

Nor should we forget that interior dust contains a number of "natural" materials that can cause problems. Asbestos is a naturally occurring mineral and some of those fibers found in studies of interior dust come from an accumulation of fiber entering buildings naturally from the outside air. Of course, having damaged asbestos containing products, such as spray on fire proofing or pipe insulation, in a structure greatly increases the likelihood and level of asbestos fibers found in the dust. Mold spores, fragments, and mycotoxins are also "all-natural" but can be very detrimental. Bacteria and viruses are also recovered from interior dust. Health and medical specialists have learned that these microorganisms cling to dust particles to more easily travel around a building which is why they focus on dust control as a key component of reducing infections.

Different conditions in the building can also impact the level and type of dust. One of the biggest contributors to dust loads in both the short-term and long-term are fires. Even "controlled fires" related to smoking can cause problems long after the smoking stops[8]. Unless properly remediated, smoke and soot residue can contribute to the dust by adding both physical particles and chemical contaminants through the off-gassing of VOCs which are reabsorbed by the dust.

Matching Science with Increased Awareness

Using science to understand what interior dust is actually composed of is only part of the challenge facing construction, restoration, and cleaning contractors. If client demand was not pushing for a more extensive level of cleanliness as part of normal janitorial services and specific building projects then the makeup of dust would be nothing more than trivial information. In addition to the improvements in the area of infection control that has focused attention on dust control, there are a number of other more general societal trends that have led to increased demands for contractors to control dust on their projects.

Two of the biggest factors forcing contractors to build more dust control efforts into their projects is connected to the information age that we live in and efforts at public education/awareness of indoor air quality (IAQ) issues. It has been a long time since someone had to actually go to the library to look up information on a particular subject, but now they do not even need to go into a building to access a computer for such information. Being able to download reports from around the globe on a tablet or smartphone mean that individuals can instantly learn about any particular issue. When this ability is coupled with public awareness programs from agencies like the EPA, the American Lung Association, and World Health Organization (WHO), contractors need to expect that their clients are going to have real information about the detrimental impacts of allowing dust to accumulate because of poor janitorial practices or cross-contaminated spaces from work projects.

The aging of the population and an overall increase in people's concerns about health and medical issues are two more trends that are leading people to be concerned about indoor dust levels. Older occupants tend to have more underlying health issues and a desire to prevent additional problems from developing.

As mentioned in the previous section, over the last 40 years there has been a virtual "revolution" on how buildings are constructed. In tandem with the development and installation of more sophisticated HVAC systems was the explosion of new construction materials and technologies. Metal, wood, nails, plaster, and paint were integrated with, or replaced by, adhesives, plastics, urethanes, particle board, and many other chemically based products. The use of new construction materials helped to resolve some problems such as asbestos pipe insulation and lead in paint, but replacement of regulated contaminants brought their own set of problems such as fiberglass shedding and off-gassing of volatile organic compounds (VOCs).

Three additional factors that are contributing to a continued emphasis on clean indoor air can be characterized by the word “more”. There is more research being conducted on specific aspects of dust as the cause or carrier of problems in buildings. There is also more media attention to the results of the research that is being conducted. This research and publicity generally result in more involvement of the legal community. A good example of this combination is a recent study of dust from 1,200 US homes. The researchers determined that the dust in each home contained an average of more than 5,000 species of bacteria and 2,000 species of fungi[9]. This led to some additional research with a controversial possible connection between different types of contamination in house dust and occupant obesity[10]. Imagine the cry for dust avoidance and cleaning if the findings that house dust can make a person fat is supported by further studies!

Recognizing the Dangers of Dust through History

Even before some of the new science was publicized, people understood inherently that exposure to too much dust was not healthy. Elevated levels of dust without modern chemicals can cause problems from both irritation and allergies. Sawdust from many hardwood trees contain irritating oils and toxic compounds to the point where farmers have known for hundreds of years to avoid using wood shavings from black walnut trees as bedding for horses[11]. Silicosis from the dust generated by cutting, drilling, or polishing stones has also been well-documented for centuries; including the Italian Dr. Bernardo Ramazzini in the early 1700s[12].

One of the earliest areas where science focused on the dangers of dust was in the medical community. Going all the way back to Florence Nightingale, doctors and nurses learned that higher levels of airborne dust allow for more effective transmission of natural pathogens from one area to another. Numerous studies have shown that bacteria (MRSA, C-diff), fungal spores/fragments/mycotoxins, and viruses (noroviruses to Ebola) tend to migrate farther in dusty air than in clean air[13].

The science focused on identifying and evaluating modern contaminants in dust which pose hazards is really just in its infancy. Fire retardants, PCBs, plasticizers, and now nanoparticles are all being looked at as potentially serious components of indoor dust. This historical research led the Canadian Center for Occupational Health and Safety (CCOHS), to publish an easy to read fact sheet entitled: *What are the Effects of Dust on the Lungs?* As part of that document the Canadian group compiled a table that showed the different sorts of lung disease that are a result of exposure to specific types of dust. Such publications make it clear that controlling dust exposure for workers is critical whether their work is done in a factory setting or as part of projects done in homes and commercial buildings.

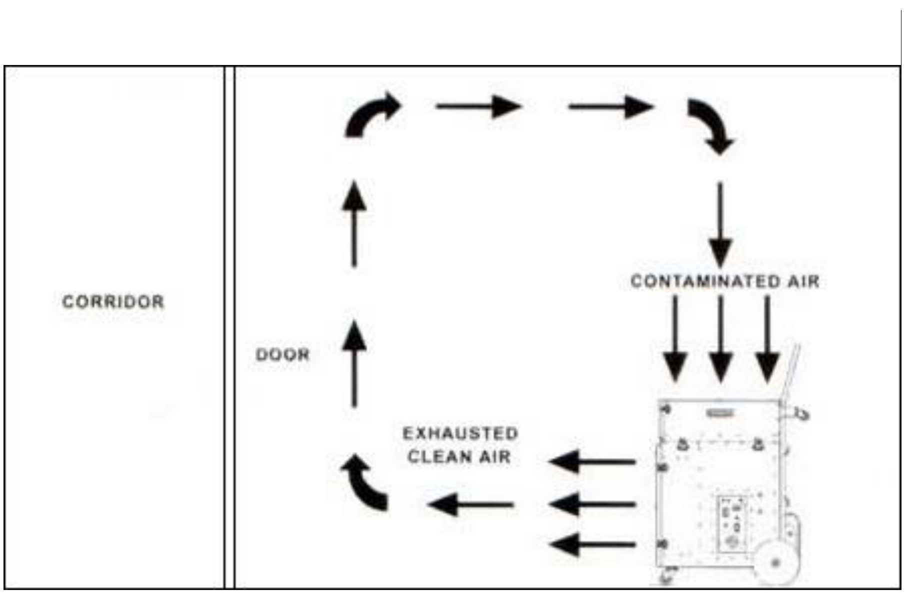
SOME TYPES OF PNEUMOCONIOSIS ACCORDING TO DUST AND LUNG REACTION		
INORGANIC DUST	**TYPE OF DISEASE**	**LUNG REACTION**
Asbestos	Asbestosis	Fibrosis
Silica (Quartz)	Silicosis	Fibrosis
Coal	Coal Pneumoconiosis	Fibrosis
Beryllium	Beryllium Disease	Fibrosis
Tungsten Carbide	Hard Metal Disease	Fibrosis
Iron	Siderosis	No Fibrosis
Tin	Stannosis	No Fibrosis
Barium	Baritosis	No Fibrosis
ORGANIC DUST	**TYPE OF DISEASE**	**LUNG REACTION**
Mouldy hay, straw and grain	Farmer's lung	Fibrosis
Droppings and feathers	Bird fancier's lung	Fibrosis
Mouldy sugar cane	Bagassosis	Fibrosis
Compost dust	Mushroom worker's lung	No Fibrosis
Dust or mist	Humidifier fever	No Fibrosis
Dust of heat-treated sludge	Sewage sludge disease	No Fibrosis
Mould dust	Cheese washers' lung	No Fibrosis
Dust of dander, hair particles, dried urine of rats	Animal handlers' lung	No Fibrosis

The Push towards Dust Control

Dry stripping, or even just burnishing, a waxed floor, remodeling a kitchen, or completing a fire restoration project all involve dust generation. As such, more and more customers are demanding that dust be controlled as part of the work process. Whether it is simple redecorating/remodeling or specific contaminant abatement, dust control is key. Typically this involves up to six different approaches:

1. Installation of isolation barriers to segregate the work area from other parts of the structure
2. Creation of negative pressure inside the work area in order to keep dust generated during the project from migrating to other areas of the building
3. HEPA filtration of the air being removed from the work area or being collected in vacuums
4. Dust collection at the point of creation by utilizing shrouds on power tools or vacuum nozzles in the immediate vicinity of the work
5. Detailed cleaning of all surfaces in the works zone
6. The use of effective cleaning methods during the detailed cleaning in order to ensure that small dust particles are captured and removed rather than just being pushed from one place to another

Effective cleaning procedures can incorporate a variety of old and new technologies. Using filters to remove particulates from the air is an idea as old as wrapping cloth around a person's nose and mouth. The advent of new filtering media enhances the impact of what is known as "air scrubbing". This term refers to a work area where an air filtration device is allowed to operate inside the work zone without exhausting outside the isolation barriers. The setup does not produce negative pressure but does allow the air in the work area to cycle through the filtration mechanisms multiple times in an effort to reduce the particulate levels. The following diagram illustrates the concept of air scrubbing while the photo shows an air scrubber working inside a contained area with a diffuser hose attached to the exhaust. The plastic "lay flat" has been perforated to allow the air to diffuse throughout the room.



Products such as microfiber cloths can be used to improve dust collection from surfaces. Such measures are used as a complement to negative pressure and air scrubbing since some particles will eventually settle due to gravity. Using a wiping system for final cleaning that incorporates microfiber cloths can capture small particles that even HEPA vacuuming leaves behind because of the electrostatic cling between the particle and the surface.

Fogging For Particle Control

A method to enhance air scrubbing is to incorporate fogging. By adding micro droplets of liquid to the air forces the smallest dust particles to coalesce into larger bits. Also, increasing particle size (and weight) the airborne material is more likely to either settle out or move toward the air scrubber. There is an extensive history of fogging for particle control in both outdoor and indoor activities. Some of the more common uses of water sprays, mists, or fog for dust control include:

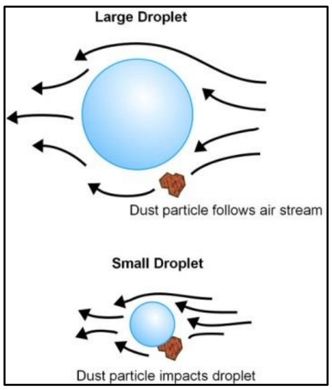
- explosion control
- water spray trucks during highway construction
- sprayers on the building during the demolition (see photo below)
- smokestack wet scrubbers
- manufacturing dust control
- paint booth overspray control
- asbestos lockdown
- deodorizing after fire damage (see photo below)

Keys to Effective Fogging

As with dust in general, there is quite a science to fogging. Indeed, scientists have identified four different characteristics of the fogging process that determine its effectiveness in controlling airborne particles:

1. droplet size
2. droplet charge
3. droplet dispersion
4. droplet "cling"

When using fogging to assist with particle control, the first concern is to get the droplets of the material being fogged the proper size. While large droplets will collide and combine with bigger dust particles in the air (larger than PM10), forcing them to settle quickly, large droplets are not as effective with smaller particles. The small, light, particles move with the air and actually bypass the larger droplets as illustrated in the following diagram. In a general sense, droplet size needs to be similar, or smaller, than the particles that are being removed from the air.



Generally, restoration contractors and cleaning companies utilize thermal foggers or ultralow volume (ULV) foggers (as shown in the photo) to produce a dust cleansing fog that has droplets of the proper size. The ULV foggers use special air-atomizing nozzles that can be adjusted to produce a wet fog with larger droplets or a very dry fog with tiny droplets to agglomerate and remove airborne dust particles. With such devices the dry fog setting tends to produce droplets in the 1 to 10 micron size; which is even effective for removing dust in the PM 2.5 range from the air.

Many dust particles have an electrical charge associated with them which is a result of their composition or the fact that they picked up an "induced charge" by passing near a charged surface. Indoors this induced charge of dust particles most typically comes from an electronic appliance such as television or computer. Since some small particles can have a negative charge and others can have a positive charge, creating fog droplets that have both negative and positive electrical charges helps to cleanse the air as the dust particles and water droplets follow the maxim that "opposites attract".

Although many factors impact the ability for droplets to disperse, the primary determinant as to how well fog droplets spread into an area is whether uniform droplet sizes are created. Ultralow volume foggers are fairly good at creating droplets in a relatively small size range, but sprayers or foggers that utilize tips that employ ionizing or ultrasonic technology can create droplets in a tighter size range which allows them to disperse farther into room air.

The term, "droplet cling," refers both to the solubility of the drops as well as its electrostatic charge[14]. Generally, chemicals known as surfactants are added to water to improve the ability of the foggers to create smaller droplets and results in droplets that are more easily soluble. Choosing different additive materials can also result in small droplets that have a particular electrostatic charge depending on the chemical makeup of the surfactants that are added.

Project Control Includes Dust Control

Whether construction, restoration, and commercial cleaning contractors want to accept it or not, dust control as part of their everyday work operations will continue to grow in importance. Dust control to assist a chemically sensitized occupant, reduce the spread of hazardous contaminants, or improve the efficiency of the final cleanup should involve isolation of the work area, control of dust producing activities at the source, negative pressure and/or air scrubbing, and fogging to improve the efficiency of particle removal from the air.

End Notes

1. Financial support for the research and development of this paper was provided by Bad Axe Products.
2. Small particles are considered to be the greatest concern from a public health perspective because particles below the PM10 threshold are small enough to be inhaled into the deepest parts of the lung. See public health education materials such as the California air resources Board document *Air Pollution -- Particulate Matter Brochure.*
3. The term "chemical age" is used to define the time period when the investigation, development, and use of chemical compounds began to have a more pronounced effect on society. Although there is no debate that we now live in a chemical age, the starting point for this aspect of human history varies by a number of decades. Some scientists place the beginning of the chemical age back to the 1870s or 1880s, while most researchers in this area tend to prefer a start date of the 1920s-1930s.
4. See *Tracing the Chemistry of Household Dust* by Janet Pelley in Chemical and Engineering News, volume 95, issue 7, February 13, 2017.
5. Ibid

6. Although fiberglass in indoor air in residential and commercial structures may not rise to occupational levels that cause fibrosis of the lungs, even slightly elevated levels leave occupants with the perception of poor indoor air quality. See *Individual and Occupational Correlates of the Sick Building Syndrome* by Alan Hedge, William A. Erickson, and Gail Rubin in the March 1995 issue of the International Journal of Indoor Environment and Health
7. See *What's In Pressure Treated Wood*, Techline publication from the United States Department of Agriculture, Forest Service, Forest Products Laboratory, revised 12/2005
8. See the article entitled *Households Contaminated by Environmental Tobacco Smoke: Sources of Infant Exposure* published in the Journal Tobacco Control in March 2004
9. See the article from the proceedings of the Royal Society B entitled *The Ecology of Microscopic Life in Household Dust*, published in the August 2015 issue.
10. See *What Dangers Are Lurking in Your Household Dust?* from Mercola.com dated September 12, 2015
11. See *Black Walnut and Butternut Poisoning of Horses* from the Ontario Ministry of Agriculture, Food, and Rural Affairs; last modified January 4, 2016
12. See *Work Safe with Silica* from silica-safe.org
13. See chapter 6 of the World Health Organization's occupational safety manual entitled: *Hazard Prevention and Control in the Work Environment: Airborne Dust*
14. See numerous documents from the United States Department of the Interior, Geological Society (USGS), Water Science School, such as *Adhesion and Cohesion of Water*.