Managing Metalworking Fluid Mist Hazards in Modern Machining

The best mist control solution considers your shop's specific processes.

Modern machining centers are different from those of past generations. Today's machines offer much faster tool speeds with metalworking fluids delivered at higher pressures. This generates elevated levels of smaller mist particles (2 microns and smaller) that need to be captured. All of these smaller particles are more difficult to filter effectively. If not managed properly, metalworking fluid (MWF) mist can pose health and safety hazards, not to mention making it difficult to attract and retain employees. Understanding the differences among mist-collection technologies can help you design a mist control system optimized for your specific processes, creating a safer work environment.

What Makes **Mist Hazardous?**

Metalworking fluid mist is formed when the metalworking fluid is subjected to mechanical forces during machining or grinding. The mist becomes airborne due to the high delivery pressure, the high-speed movement of machine tools, and the friction between the tool and the workpiece. This mist can be released into the surrounding air in the workspace, posing an inhalation risk or causing eye irritation. The small size of today's MWF mist particles increases the potential risk of inhalation because, in some cases, submicron levels of particulate can make their way deeper into the lungs.[1]

Extended exposure to MWF mist can lead to a variety of health issues, including respiratory conditions. In fact, work-related asthma is one of the most prevalent occupational disorders, resulting in significant costs in healthcare and workers' compensation.[2]

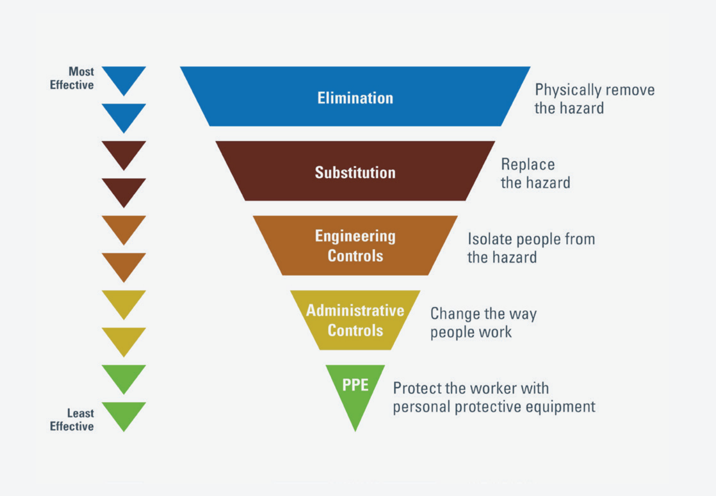
The Occupational Safety and Health Administration (OSHA) recognizes these hazards and regulates allowable exposure limits to certain types of mist, which means employers must carefully control air quality to ensure OSHA compliance.

[1]United States Environmental Protection Agency: Health and Environmental Effects of Particulate Matter (PM)
[2]Centers for Disease Control and Prevention: The National Institute for Occupational Safety and Health (NIOSH): Metalworking Fluids

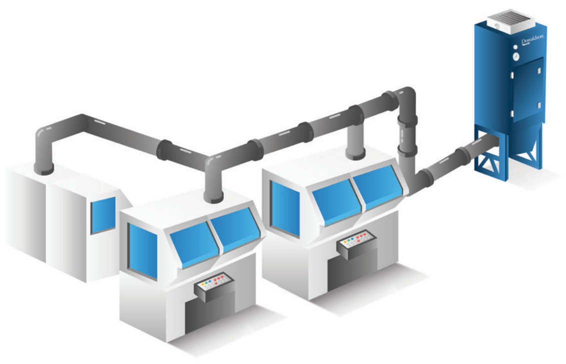
Risk Mitigation

The National Institute for Occupational Safety and Health's recommended Hierarchy of Controls method can provide a roadmap for implementing effective controls against MWF mist hazard exposure.

Applying this hierarchy, the company should implement feasible Engineering Controls, like a local exhaust ventilation system, to reduce exposure if a process cannot eliminate or substitute the hazards.



The National Institute for Occupational Safety and Health (NIOSH) Hierarchy of Controls identifies and ranks safeguards that can be used to protect workers.



Example of a cellular system (1:3 collector-to-machine ratio) for exhaust ventilation.

Examples of local exhaust ventilation systems for metalworking fluid mists include:

- **Single system**
- **Cellular system**
- **Centralized system**

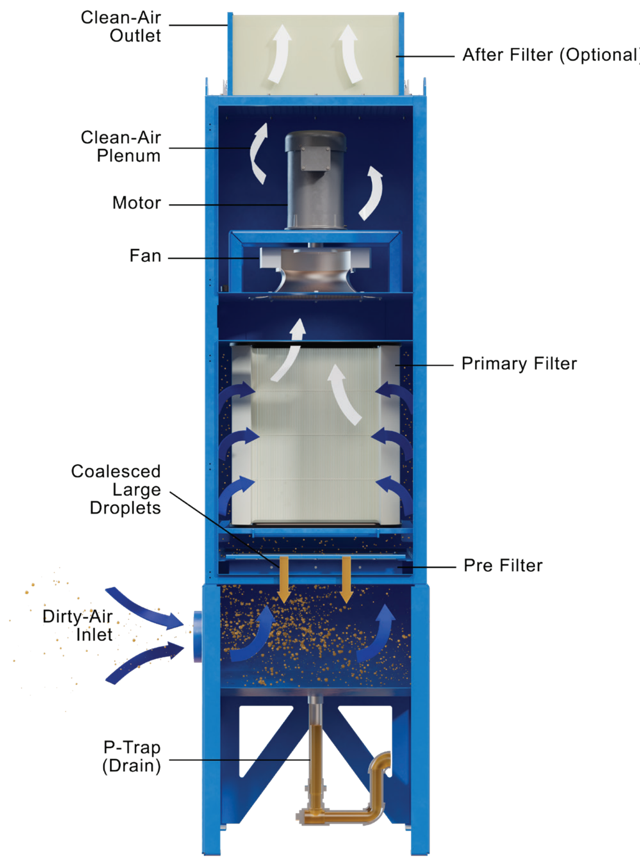
It is prudent and recommended to leverage available and well-informed resources to evaluate and select the appropriate engineering control system that will be efficient enough to meet the standards initially and over time. If the local exhaust ventilation system is changed in any way, the engineering control system should be re-evaluated.

How Mist Collectors Work

A mist collector's primary function is to remove mist and droplets from the airstream. To accomplish this task, a collector must draw and coalesce small drops into larger ones and effectively drain the collected fluid. Mist droplets can be captured from an airstream in several ways including staged media, electrostatic precipitation, and inertial separation. Due to the need for more efficient collection of smaller mist particles, media-based filtration has replaced older technologies and become the standard solution for many process owners.

Collectors that use filter media as the primary mechanism for mist removal typically employ multiple phases of gravitational draining. This allows for the selection of specific filter media at each stage based on the amount and particle size of the droplets generated.

One of the challenges of mist filtration is balancing the need for collection efficiency with the need for droplets to drain. Higher filtration efficiencies can be achieved with smaller, tightly packed fibers, however, smaller fibers in most off-the-shelf filters require resins to hold them together, and resins prevent coalesced liquid from effectively draining.



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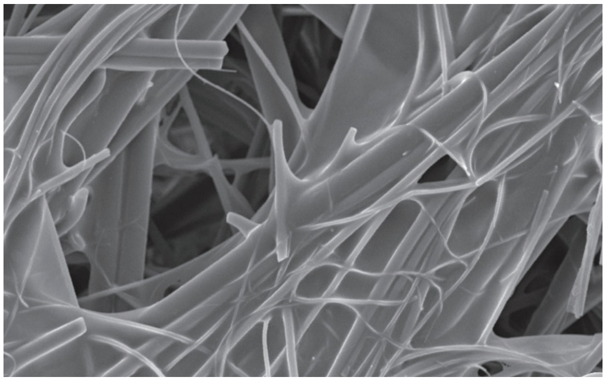

Figure 1. SEM image of polyester/glass filter media at 500 times shows resin "webbing" between fibers.

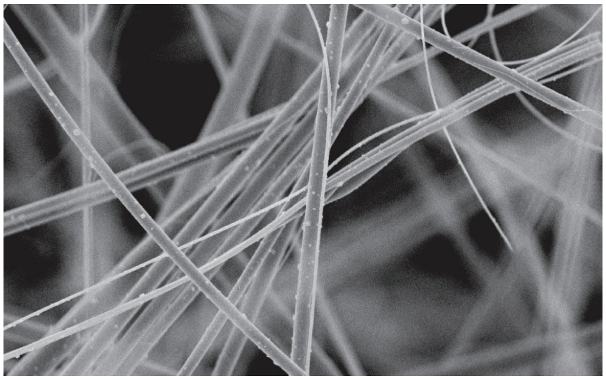

Figure 2. SEM image of all-glass, resin-free media magnified 1,000 times.

This can be a problem since filters made from small, tightly packed fibers can easily plug up with captured particles, leading to a higher pressure drop, lower capture velocities, and shorter filter life (Figure 1).

When filter media is made from large fibers, the draining characteristics are vastly improved, but the ability of the media to capture mist droplets (especially smaller ones) is severely compromised. Advanced filter media engineered with an all-glass blend of small and large fibers with resin-free bonding provides superior draining (Figure 2).

Stages of Filtration Media

One way to help achieve the desire for both high efficiency and effective draining is by utilizing layered stages of filtration. If any of these filter stages drain poorly, they may plug up, causing a reduction in capture.

1 Many mist collectors have a pre filter layer, which is typically comprised of generally large fibers, mesh, or screens that capture the biggest droplets and let them drain easily.

2 A second or primary layer captures most of the remaining droplets with a higher efficiency media while maintaining proper draining characteristics.

3 A final/after filter is typically a HEPA filter (99.97% efficient on 0.3-micron particles) or a DOP filter (95% efficient on 0.3 micron particles).

Some fibrous media collectors use lofted media in bag-type filters. These filters do not contain a lot of resin, so they drain effectively with swarf or sticky mist and have decent efficiency. However, their structure is not very stable. Over time, the fibers in the media will collapse together, which leads to increases in pressure drop, lower airflow, and a reduction in the filtration efficiency.

Mist Collection System Design

Even when HEPA after filters are in use for the highest levels of efficiency, it's critical to have a properly designed total system. To design a local exhaust ventilation mist collection system that meets the needs of your specific processes, consider these factors:

- **Hours of operation**
- **Cycle time**
- **Type of metal and process**
- **Type of metalworking fluid**
- **Fluid pressure**
- **Presence of swarf**
- **Type, size, and amount of mist**
- **Efficiency and mist mitigation goals (CFM needs)**
- **Collector configurability and options (features)**
- **Facility needs**

The goal is to design a system that captures mist-laden air with the least amount of airflow necessary. If airflow is too low, insufficient capture results and mist-laden air can seep out of open doors and into the air or areas of the workspace. If airflow is too high, energy is wasted as excess air is pulled through the collector and filter life can be greatly reduced. To help optimize the airflow, it's important that the fan be properly sized to maintain appropriate hood capture velocity while overcoming the static losses through the system.

Sizing Methods

A key factor in ensuring efficient operation and consistent mist capture is to size the collector's fan to achieve the specified airflow and static pressure requirements of the system. This is typically measured in Cubic Feet per Minute (CFM) and inches of water column. There are various methods used for determining the required airflow:

Air Exchange

Used for closed-door mist containment on enclosed machines.

Calculation: Machine enclosure volume ft^3 x 3-5 exchanges per minute = Total airflow CFM

Open Area Sizing

Used for closed- or open-door containment on enclosed machines.

Calculation (vertical door): All open areas ft^2 x 50 FPM = Total airflow CFM

Calculation (vertical door with roof): All open areas ft^2 x 75 FPM = Total airflow CFM

Ambient Area Sizing

Used only when source capture systems are not an option.

Calculation: Room volume ft^3 x 10/20 minutes per exchange = Total airflow CFM

The best sizing methodology for enclosed machines is determined by desired performance. For instance, achieving mist containment and levels of visual clarity with the machine doors closed favors the air exchange method. Conversely, the open area method sizes for containment by maintaining a negative air pressure inside the machine even with open doors or areas. Additional application or design considerations may need to be factored into the equation. An industrial air consultant can provide additional guidance for specific applications.

What does this all mean to the purchaser of a mist collection system?

There are many factors to consider when deciding how to best control mist and protect employees. By better understanding how mist is being generated and the associated hazards, you can evaluate various mist collection systems, choose the best one for your specific processes, and make sure that the entire system is optimized for ongoing efficiency. Don't hesitate to turn to a qualified professional or engage Donaldson for product and application support to help ensure you have the optimal mist mitigation solution for your application.

More Resources

Metalworking Fluids - Standards | Occupational Safety and Health Administration (osha.gov)

Industrial Ventilation: A Manual of Recommended Practice (ACGIH 1998) provides general guidelines for recirculating exhaust air.

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