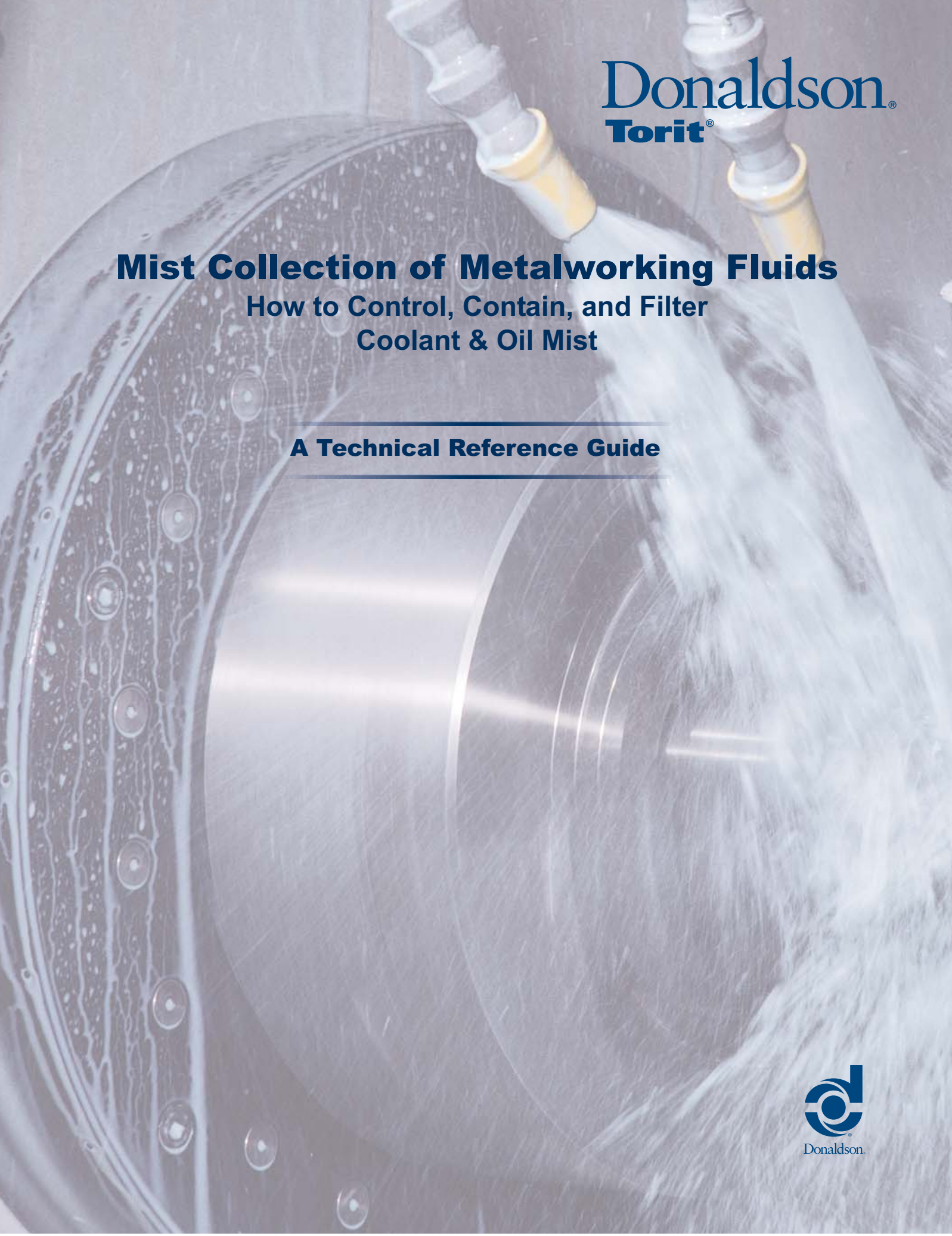


Donaldson®
Torit®

Mist Collection of Metalworking Fluids

How to Control, Contain, and Filter Coolant & Oil Mist

A Technical Reference Guide

Donaldson.

Table of Contents

This reference guide was written to present accurate and authoritative information in the area of oil mist filtration and related subject matter. Neither Donaldson Company, Inc. nor the author assumes any responsibility for any inadvertent misinformation, errors, omissions, or the results produced by the use of this reference guide.

WHY Mist Collection?

For over 50 years, manufacturers of metal products have been purchasing and installing mist collectors on their mills, drills, lathes, grinding, casting, and other metal cutting, metal forming, and related machines to:

- Provide clean air for their workers, reducing the adverse affects of exposure to metalworking fluids and mist.
- Comply with local, state, and federal indoor air quality standards.
- Minimize accidents and maximize worker effectiveness.
- Reduce maintenance costs.
- Improve quality.

In selecting the mist collector, the purchasing manager often must rely on sales presentations from mist collector manufacturers. Perhaps they browse through brochures and test reports showing that each product available is best for their situation. Not an ideal way to ensure that what is purchased is the right solution.

This manual has been put together to address common questions involved in purchasing a mist collector, such as:

- Which filtration technology is the best?
- Individual machine-mountable units or large central systems?
- Ambient filtration or point source capture?
- How do I determine how much airflow I need?
- Are there proper/improper ways to install a mist collector?

This guide is written to provide you the knowledge you need to purchase the right mist collector, to know that what you designed or had designed for you will work, and to provide you with useful tips that will save maintenance time and money.

Start with the Basics

What is Mist?

Mist is commonly thought of as a small liquid droplet, but in different industries, the definition is more refined. For this guide, mist is defined as:

- A **liquid particle** 20 microns or smaller.

This manual focuses primarily on applications that use oil and water-soluble lubricants, coolants, and detergents that during use generate a mist and require the control of a mist collector. These applications include, but are not limited to:

- metal cutting
- metal forming
- metal grinding
- part washers
- lube oil systems

What is Smoke?

Smoke is commonly thought of as that gray to black cloud emitted from burning wood, out of the smoke stack on a semi truck, what you see and smell when someone is smoking a cigarette, and what is produced when you weld two pieces of steel together. This is not the type of smoke that we are referring to:

In this guide, smoke is defined as:

- A **liquid particle** that condenses from a vapor to a liquid, typically 0.07 to1 micron in size.
- Thermally-generated mist.
- Oily smoke.

The smoke discussed here is generated by a process that heats up and/or compresses a liquid under high pressure and generates a vapor that condenses back to a liquid and forms what looks to be a cloud. Common applications that generate a liquid smoke are:

- Cold heading
- Machining hard metal alloys with straight oil
- Lube oil reservoirs on large generators
- Heat treating
- Plastic forming

This manual will address the most common applications that generate mist, mist with “liquid” smoke, mist with “dry” smoke, mist with vapor, and mist with dust.

Applications predominately generating dry dust, fume, “dry” smoke, acid gases, and vapor filtration will not be addressed in this manual.

History of Mist Collection

Since the industrial revolution, greases, oils, and lubricants have been used to improve manufacturing quality, increase production output, cool tooling to increase tool life, and provide lubrication to reduce machine tool wear and maintenance. As the demand has grown for higher quality parts with tighter tolerances at higher output rates and all at a lower cost, the amount of coolant and lubricant, the pressure at which coolants and lubricants are delivered, and the speed of the machining tools have increased. With each increase in amount used, delivery pressure and tooling speed, the quantity of mist generated has increased while the particle size of mist has decreased. This results in manufacturing plants having ever decreasing indoor air quality, requiring new controls to reduce airborne mist levels.

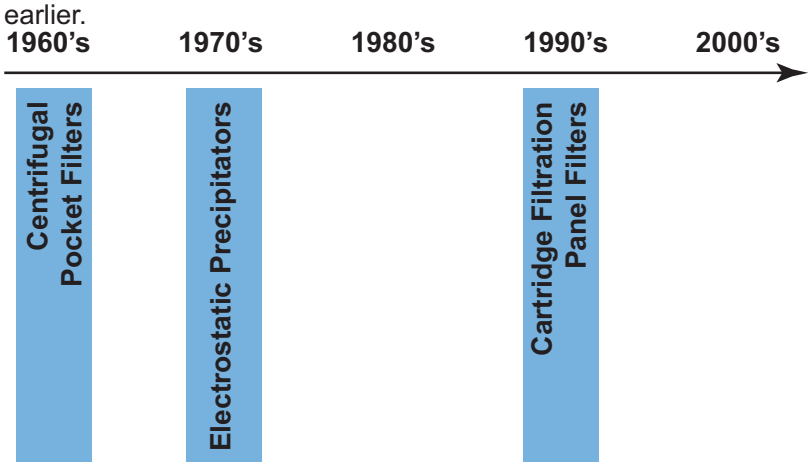
For over 50 years, the government and other organizations have studied the risks of exposure to the greases, oils, and lubricants commonly used in metal cutting and forming. Numerous studies have shown that repeated exposures to these materials through dermal contact, oral ingestion, and inhalation are possibly carcinogenic. Other studies have proven these materials to be irritants to the eyes, nose, and throat.

Due to exposure risks and concerns, government agencies and organizations such as the Occupational Safety and Health Administration (OSHA), American National Standards Institute (ANSI), and American Conference of Governmental Industrial Hygienists (ACGIH) have studied and developed recommendations and laws governing the maximum exposure to airborne concentrations (mist) of the various oils, greases, and lubricants used. For more information on the health concerns pertaining to oils, greases, and lubricants, or other health hazards, contact OSHA, ANSI, ACGIH, or your local healthcare provider.

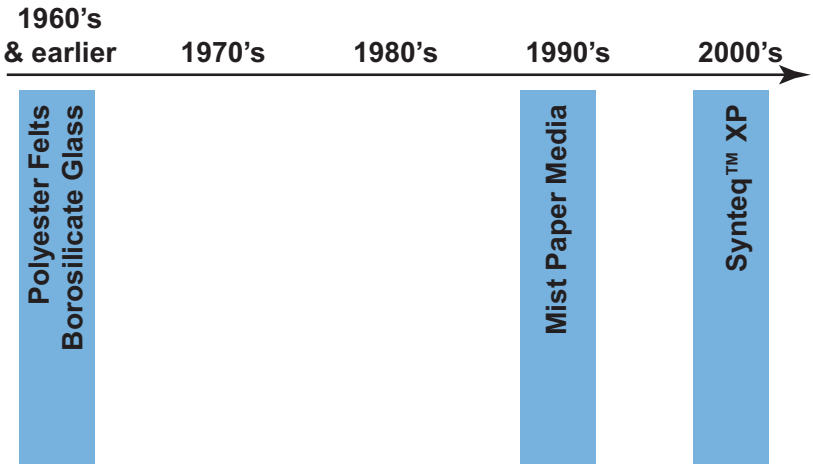
ANSI, ACGIH, and other organizations recommend the maximum exposure to workers, developed through studies, tests, and historical data. OSHA is the only organization that creates standards that are enforceable by law. Today, the OSHA standard for the airborne concentration of metalworking fluid is less than 5.0 mg/m^3 (5 milligrams per cubic meter of air) over an 8 hour period. Since the late 1990's, there have been organizations petitioning OSHA to lower their 8 hour exposure standard for metalworking fluids to 1.0 mg/m^3, 0.5 mg/m^3, 0.2 mg/m^3, and even lower exposure limits.

The laws and health concerns surrounding metalworking fluids drive the need for mist collection. Having a cleaner work environment that reduces accidents, minimizes sick time, and maximizes output has had many companies develop more stringent requirements – down to as low as 0.1 mg/m^3 exposure limits.

There are several mist collector technologies and mist filtration medias available, each with their advantages and disadvantages, each designed for specific filtration needs and requirements, such as an indoor air quality of metalworking fluids below 1 mg/m^3. Some of these technologies are new and some date back to the 1960's and earlier.



A) Industrial Mist Collector Timeline



B) Industrial Mist Filtration Media Timeline

When we review mist collectors and filtration media technologies, we see older technologies tend to have the shorter filter life and higher maintenance costs, although the initial purchase cost of the older technologies is lower. With rising energy costs and increasing LEAN initiatives, the trend now is to maximize filter life, reduce maintenance costs, and increase the overall efficiency of mist collectors. There may not be a need for you to buy a new mist collector just because there's new technology available; in some cases, the oldest technology may be best for your application, depending upon your facility, operation practices, and type of application.

Steps to Selecting the Right Mist Collector

The more experience you have with mist collectors, the more likely you will choose a mist collector technology that has caused you the least number of problems. Although this may seem a safe method most of the time, it may leave you stuck with a technology that isn't the best fit, has higher purchase cost, has higher installation cost, has higher maintenance costs, or that requires more maintenance time, resulting in machine downtime.

Take the following steps when selecting a mist collector before making a purchase. It will assist you in making the best choice for your facilities specific requirements.

The remainder of this manual is written in the following order:

1. Determine Your Needs
   A. Types of Machine Generating Mist
   B. Types of Lubricants and Coolants
   C. The Purpose of a Mist Collector
   D. Determining Airflow
   E. Selecting a Mist Collector Based on Calculated Airflow
   F. Location of Mist Generated
   G. Combining Mists
2. Types of Collector Installations
   A. Machine-Mounted Systems
   B. Ducted Single Machining Center Systems
   C. Ducted Cellular Systems
   D. Ducted Central Mist Systems
   E. Ambient Mist Filtration Systems
3. Installing the Mist Collector
   A. Locating the Mist Collector – Indoors vs Outdoors
   B. Hooding Designs
   C. Maching Center Pick-Up Point Location
   D. Ducting Types
   E. Ducting Do's and Don'ts
   F. Electrical Controls
   G. Drains
   H. Gaskets and Caulking
4. Select the Right Mist Filter Media & Collector Configuration
   A. Filter Media Technology
   B. HEPA/95% DOP Filter Media Technology
   C. Mist Collector Technology
5. System Operation
   A. Start-Up Procedures
   B. Balancing the Airflow
6. Troubleshooting Common Problems

1. Determine Your Needs

1A. Types of Machines Generating Mist

Many types of machines generate mist. You will make a better mist collector choice when you understand how these machines operate, how mist is formed, how much is formed, the particle size of the mist, and how best to capture it.

Metal Cutting Operations – Mills

Types of Mist	Water-Soluble	Oil	Smoke
Typical Sizes	2 to 20 microns	0.5 to 10 micron	0.07 to 1 microns

Milling operations include vertical and horizontal mills (photos C & D), boring, honing, hobbing, and drilling operations. Mills have a rotating tool, with the part being manufactured secured to a movable table. The tool cutter cuts from the end (end mill) or from the side (side mill), depending on the type of cut desired.

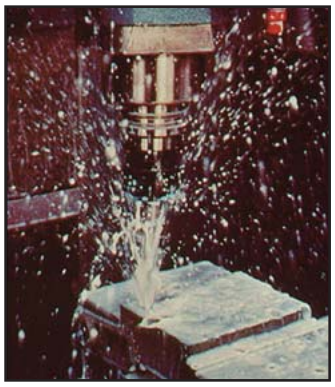
These operations use water-soluble coolants or oil lubricants, generating mist ranging in size from 20 microns down to submicron. The water-soluble coolants create the larger mist, while oils produce smaller mist sizes and sometimes smoke. Milling operations can be final processes to meet tight tolerances, such as honing operations, or can remove large amounts of metal, as in hobbing applications.

Mist can be formed by impaction or thermally.

- When coolant or oil impacts the cutting tool, the tool spins the liquid off at high speeds, creating mechanically formed mist.
- When there are high temperatures at the cutting surface, mist is generated thermally. This is smoke.

By observing inside the enclosure of the machine, you should be able to see if it's only mist or both mist and smoke being generated. While any operation can generate smoke, it is common for boring and hobbing operations to generate smoke. The color of the chips generated by these processes may indicate if there is sufficient heat to produce smoke. Look for "blue" coloring on the edges of steel chips. This indicates sufficient heat to produce smoke. If smoke is present or signs of smoke are present, you will most likely need a final filter on the mist collector unit.

Fine mist between 0.5 and 2 microns will be present in large quantities when straight oil is delivered to the cutter at pressures above 800 psi. At high pressures, there is sufficient mechanical energy to break up straight oil into very fine mist. When this occurs, there are sufficient quantities of mist below 1 microns, and a final filter is typically required.



C) Typical Vertical Mill

D) Typical Horizontal Mill

Metal Cutting Operations – Turning

Types of Mist	Water-Soluble	Oil	Smoke
Typical Sizes	2 to 20 microns	0.5 to 10 microns	0.07 to 1 microns

Turning operations include screw machines, turning centers and lathes, (photos E, F, & G). In these machines, the part being manufactured rotates at low to high speeds. Oil or water-soluble coolant is sprayed on the rotating part and tool to keep the part and the tool cool, lubricate the cutter, remove chips and swarf, and to prevent chip whip and marring of the part surface.

These operations generate all sizes of mist ranging from:

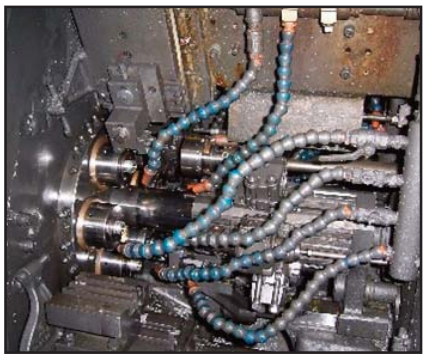
- large mist droplets up to 20 microns in size from water-soluble coolants on low speed turning operations, to
- thermally-generated submicron mist from straight oil on hard steels and alloys, as well as high speed lathes and oil delivery pressure over 800 psi.

The dust, chips, and swarf typically remain in the turning centers and are not usually a concern for mist collection.

Turning operations are typically well enclosed and by looking at the mist in the enclosure, you can easily tell if thermally-generated mist or smoke is present. These operations can remove a lot of material and, therefore, chip conveyors are almost always seen. Look at the chips and swarf in the conveyor and if the steel chips have started turning blue, you have a “hot” process that is producing smoke. If smoke is present or signs of smoke are present, use of a final filter to handle smoke is recommended.

Fine mist between 0.5 and 2 microns is present in large quantities when straight oil is delivered to the cutter at pressures above 800 psi. At high pressures, there is sufficient mechanical energy to break up straight oil into very fine mist. When this occurs, there are sufficient quantities of mist below 1 micron, and a final filter is typically required.

E) Acme Gridley RA 6 Screw Machine



F) Internals of Acme Gridley Screw Machine

G) Lathe

Metal Grinding Operations

Typical Type of Mist	Water-Soluble
Typical Size	2 to 20 microns

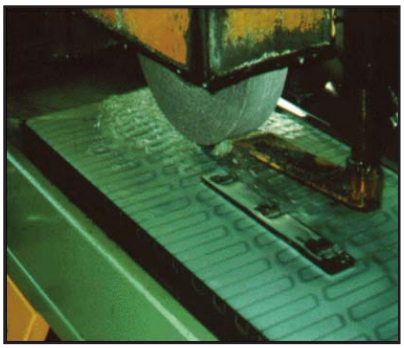
Grinding applications include surface grinding (photo H), profile grinding (photo I), centerless grinding, and cylindrical grinding to name a few.

Grinding is different from cutting in that it uses an abrasive wheel to remove material instead of cutting it away with a sharpened tool. Grinding wheels may be smaller than 1 inch or larger than 100 inches in diameter, depending upon the purpose and size of the grind. In most grinding operations, as with mills, the part is typically affixed to a movable table with a grinding wheel turning at low-to-high speeds. Most grinding operations use water-soluble coolants at low pressures to keep the surface cooled, flush dust and chips away from the grinding wheel, and provide some lubrication. These operations typically generate mist larger than 2 microns. Unlike milling and turning operations, dust can be a problem for mist collection on grinding applications. The best approach to collecting mist from these operations is to located your hood so that the least amount of dust is collected. This can be done using deflectors, by sizing hood capture velocities below 1000 feet per minute, and locating hoods so heavier grinding dust drops out of the air and only mist is captured.

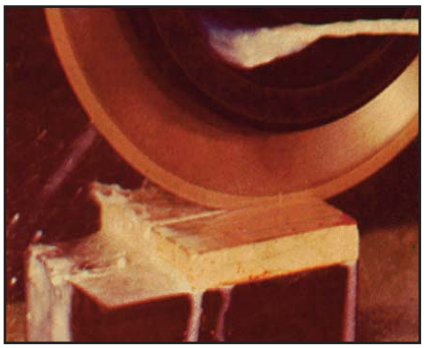
Grinding operations are not always well enclosed, especially surface grinders. Visual inspection of grinding operations will clearly show where the mist is being thrown and capture of the mist can be done fairly easily at that point.

- Small surface grinding tables typically have good shielding around the perimeter of the table and the end shield makes a suitable pick-up point, as much of the mist is directed towards the end shield.
- On larger grinders such as Blanchards, the large grinding wheels generate a fan effect that pushes the mist – to the left wall on grinders smaller than 60 inches, and to the left & rear walls on grinders larger than 60 inches.

Additional details about capturing mist from grinding operations can be found in *Chapter 1D, Determining Airflow*.



H) Surface Grinder

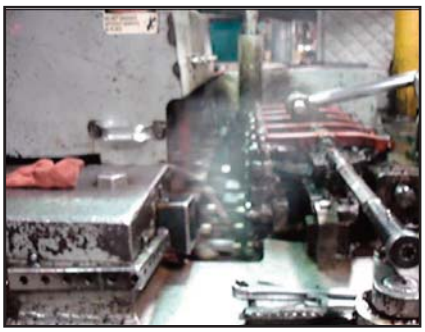


I) Profile Grinder

Metal Forming Operations – Heading and Stamping

Typical Types of Mist	Oily mist, smoke
Typical Size	0.07 to 2

Heading and stamping operations are forming applications (photo J). A piece of metal is repeatedly hit with one or several dies until formed into a final shape. These operations require a great deal of pressure, which generates much heat, fine mist, and smoke. A high efficiency mist collector with a final filter will be required on these applications.



J) Cold heading with smoke generated

Metal Forming Operations – Casting

Types of Mist/Fume	Water-Soluble with paraffin wax	Metal Fume
Typical Sizes	2 to 50 microns	Less than 1 micron

A cast part is formed by pouring molten metal into a die mold and letting it cool. Aluminum, zinc, and magnesium are the most commonly used metals in die casting. A water-based die lubricant is sprayed onto the die between each casting operation to create a barrier between the die and cast part, so that the cast part is easily removed from the die. This lubricant is essentially half paraffin wax and half water, resulting in the mist containing mostly wax and water vapor (steam). A metal fume is also generated when the molten metal is poured into the molds. This fume also needs to be controlled.

Although mist collectors are used, it is difficult to describe what is collected as mist. Due to the high concentration of wax used as a release agent and lubricant for the dies, the mist quickly becomes sludge like. Below is a picture of a prefilter impinger (photo K) and vee-bag (photo L) used to collect the mist from a die cast operation. Notice the collected matter is solidified.

K) Impinger used to collect die casting mist

L) A vee-bag after collecting die casting mist

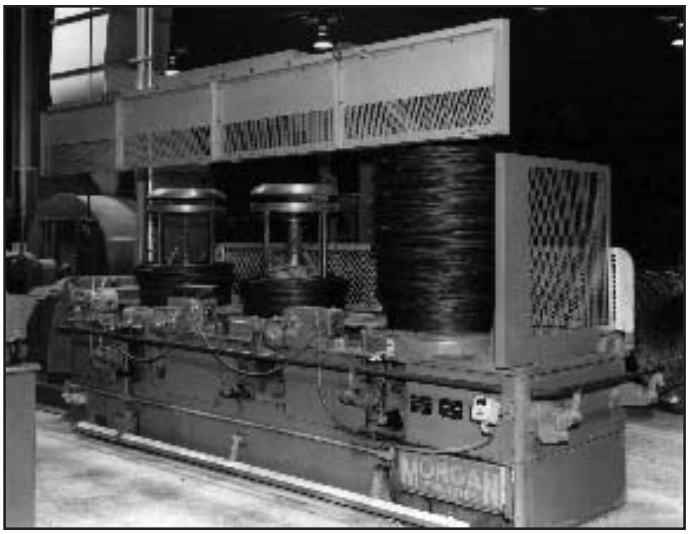
These applications require several rows of mechanical prefilters, such as impingers, to remove the majority of the wax in the die casting mist. Use of high loft filters with high holding capacity for solids is recommended for the primary filter, and the use of a final filter is recommended for filtration of the fine metal fumes generated from the molten metal pored into the dies.

Drawing Operations

Types of Mist/Fume	Water-Soluble	Oil	Smoke
Typical Size	1 to 20 microns	0.5 to 2 microns	0.07 to 1 micron

Drawing operations (photo M) are ones in which metal rods are pulled (drawn) through a series of dies that reduce the rod in diameter to form wire, for example. These operations generate heat and commonly use a water-soluble, wax-based or soap-based lubricants, or straight oil.

Drawing generates lots of smoke, and when a water based lubricant is used, mist is similar to that of casting operations. Mist collectors utilizing filters with good holding capacity for solids is required. Although the solids generated are significantly less than casting operations, the use of multiple impingers and other prefilters are recommended for removing the waxes and soaps, which can cause the primary filter life to be short.



M) A 3-block Morgan Wire Drawing Machine

Heat Treating

Types of Mist/Fume	Water/Oil/Brine	Smoke	Metal Scale/Fume
Typical Size	0.8 to 5 microns	0.07 to 1 micron	0.5 to 2 micron

Heat treating, annealing (photo N), and quenching (photo O) are operations that heat and cool metal parts to provide a desired material property, such as material strength. Water, oil, and brine are common solutions used to cool hot metal parts. Steam, smoke, metal scale, and mist are all by-products of these operations.

A filtration system suitable to handle solids or metal scale, as well as mist and smoke, is required. Steam is a concern in heat treating, and it is necessary to cool the process air to ensure all liquids have condensed from a vapor to a liquid state. See Chapter 1D, *Handling Hot Airflow Applications* of this manual for details on cooling process air.

When collecting the mist from a brine solution, special precautions must be made to the mist collector to minimize the risk of salt corrosion.

N) Annealing steel tubes

O) Oil quench of steel springs

Part Washers

Types of Mist	Water (droplets, vapor, steam)	Rust Inhibitor
Typical Size	Up to 10 microns	1 to 5 microns

Part washers are used to remove the oils, greases, and lubricants used in the manufacturing of the parts prior to assembly or storage. Parts washers can be:

- Batch style: A tray or bucket is immersed in a wash tank and soaked.
- Conveyor style (photo P): Parts sit on a conveyor moving through washing, rinsing, drying, and sometimes surface treatment operations before exiting the other end.

These operations generate steam, water vapor, and water mist.

Part washers generate a large quantity of water vapor and steam. Water vapor cannot be filtered with mist collectors as the vapor will pass through the different medias and filters available. What must be done is to cool the exhaust stream below 104°F prior to it reaching the mist collector. This will cause most of the water vapor to condense to a liquid, which can then be captured by the mist collector.

If you do not sufficiently cool the exhaust air prior to the mist collector, the vapor will condense in the plant air after the filtration system, giving the appearance that the mist collector is not working. See Chapter 1D, *Handling Hot Airflow Applications* in of this guide for how to cool the hot air.

P) Typical conveyor style parts washer with cooling stack

Some part washer operations apply a rust inhibitor at the end of the washer. If this is true in your case, a filter media that has a depth-loading characteristic is needed; otherwise, the rust inhibitor will surface-load on the filter, dry on the filter fibers, and reduce filter life.

Electrical Discharge Machine (EDM) Operations

Typical Types of Mist	Smoke	Fume
Typical Size	0.07 to 1 micron	0.5 to 2 micron

EDM operations remove metal through a burning process that generates an electric arc between an electrode and the part. This process is commonly performed under a pool of dielectric oil used to flush metal debris away from the electrode and part.

EDMs generate a very fine smoke and fume that can be seen rising out of the pool of dielectric oil. These applications are typically light-loading in a mist collector, but offer a challenge in that the emissions are mostly submicron smoke and metal fume.

Q) A Chamilles Robofil EDM machine

Lube Oil Reservoirs

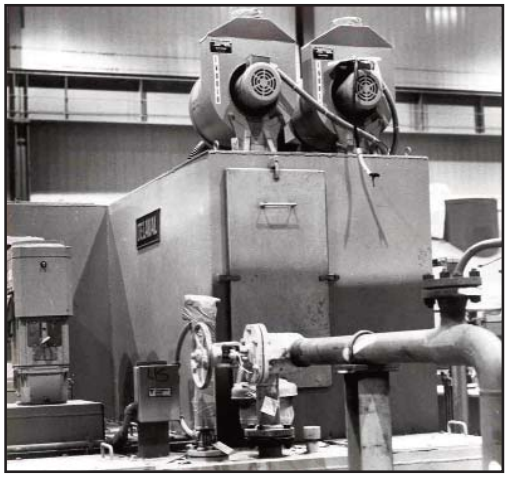
Typical Types of Mist	Oily Smoke	Oil Mist
Typical Size	0.07 to 1 micron	0.5 to 2 microns

Lube oil reservoir applications involve pulling a slight negative pressure on the oil reservoir of generator sets, pumps, and other large engine applications to prevent oil vapor and mist from escaping into the surrounding air. As oil circulates through the lubrication system, it is heated, compressed, and returned to the oil reservoir, where fine mist and vapor are present. In smaller engines, a breather vent may be used, but in larger applications, a mist collection system is needed that is capable of both pulling a negative pressure on the reservoir and providing high efficiency mist filtration.

These applications produce fairly clean mist, if the oil in the lubrication system is periodically changed, much like changing oil on a car when it gets dirty and loses its ability to properly lubricate. As the generator sets and pumps are critical to the facilities operation, routine maintenance of the oil is common.

A common solution to reservoir applications has been the centrifugal mist collector, with or without a final filter. Newer, higher RPM machines generate more heat, resulting in smoke – and a final filter is needed on the mist collection system.

Lube oil reservoir applications can also be hot and, therefore, may require cooling of the process air so that oil mist, not oil vapor, goes to the mist collector. [Oil vapor will pass through and may condense in the cooler air around the machinery making it look like oil mist is penetrating through the system. See Chapter 1D, *Handling Hot Airflow Applications*.]



R) Two Centrifugal Mist Collectors mounted on a Transamerica Delaval Feed Water System

Plastic and Rubber Applications

Typical Types of Mist	Oily Smoke
Typical Sizes	0.07 to 3 micron

Plastic molding, extruding, and melting, along with rubber curing operations are common applications generating an oily smoke. Although commonly thought of as a particulate smoke, it is actually a thermally-generated mist consisting of plasticizers and oils. These applications generate a light-to-medium amount of oily smoke, depending upon the amount of plasticizer and oils in the materials.

One concern of plastic molding and extruding applications revolves around the forms and dies. If they are burned clean, an oily smoke with some solids will be generated, requiring a filtration system that can handle both mist and fine solids.

In some instances, plasticizer is valued and reclaimed for later use in the manufacturing of plastics. If so, an electrostatic precipitator may be preferred, as there is no filter material in such a system to adsorb and retain collected liquid. An electrostatic precipitator will also handle the solids generated from burning clean the forms and dies. In applications where plastic vapors have odors that must be controlled as well, using a high loft media style collector with optional carbon adsorption module is recommended.

1B. Types of Lubricants and Coolants

Lubricants and coolants used in metalworking processes do just that: lubricate and/or cool. Coolant or lubricant choice depends on the type of cutting being done, the materials being machined, machine tool manufacturer's recommendations, coolant manufacturer's recommendations, history of the facility using one fluid or another, trial and error, cost, and a host of other factors.

There are several important factors in collecting mist from water-soluble coolants vs. straight oil lubricants.

Water-Soluble (Water-Soluble, Semi-Synthetic, Synthetic) Coolants

Water-soluble coolants fall into 3 categories:

1. An oil solution that contains emulsifiers to mix (emulsify) the oil in water.
2. Synthetic coolants that are man-made chemicals and are typically soluble in water.
3. Semi-synthetics that are partially oil with emulsifiers and partially man-made synthetic chemicals that provide the benefits of both the emulsified oil and synthetic coolants.

These materials are called **coolants** as they are better at cooling than they are lubricating. Water, in fact, has a good capacity to dissipate heat, and it is also inexpensive to replace as water evaporates. The synthetic components that coolant manufacturers have developed have an even better capacity to dissipate heat. Since the late 1990's, the amount of synthetic and semi-synthetic coolant being used in manufacturing has increased significantly as the price of oil has gone up and manufacturing costs of synthetic coolants has come down.

The primary lubricating component of these coolants is the petroleum oil. On a continuous scale, as the coolants range from water-soluble to semi-synthetic to synthetic, the amount of petroleum oil in the material is reduced to almost none. As the amount of petroleum oil is reduced, the capacity for the coolant to lubricate also decreases.

What makes these types of coolants challenging to handle in a mist collection systems is that they typically contain some amount of paraffin wax – up to 10% is common. This is a concern because the water evaporates during mist collection and a wax residue is left behind. The wax coats the filters and significantly reduces their effective life.

Evaporation typically occurs under one of two conditions:

1. Machine tool is turned off for long periods, but the mist collector remains on. Pulling air across a wet filter will evaporate the water and saturate the air. (The same thing will occur if you have a glass of water and set it in your office for a week. See how much water you lost during the week.) A fan pulling air across the filter just accelerates the evaporation process.
2. The process is hot and too little coolant is used. The water evaporates before it gets to the filter. At this point, the "mist" collector is mostly a "wax" collector.

The good news is that the wax collected in the filters can be controlled:

- Wax can be re-liquefied by washing/soaking the filters in warm/hot water.
- Use a spray nozzle and warm water to periodically spray the filters. The warm water will liquefy the wax and drain much of it off the filters. As water needs to be added to the sump to replenish the water lost during machining, adding water at the mist collector with the mist collector drains running to the coolant sump typically will not have any adverse affects.
- Use a machine tool interlock that turns off the mist collector when the machining center is not in use or after it has been sitting idle for a given amount of time. Interlocking to the main access door so the mist collector turns off after one minute of the main access door being open and turns back on when the main access door closes, is a great solution and can maximize the filter life of any gravity draining mist collector.

- If using centrifugal mist collectors, which can handle high volumes of coolant, the best control method for the paraffin wax is to use a warm water flushing cycle, then spin down the rotating drum for 3 to 5 minutes after the machine tool is shut down. This allows the collected coolant to be centrifugally pushed out of the filters and only a minimal amount of wax residue may remain.
  Tip: If your rotating drums goes out of balance and causes excessive maintenance in a centrifugal collector, it's probably a wax build-up problem in the primary filter. Flush the filters with warm water.

What makes water-soluble applications simpler is that between the emulsifiers and the molecular forces in water molecules, water molecules tend to be rather large – greater than 1 micron in size. Mist particles greater than 1 micron are easier to filter out of the airstream and easier to drain than submicron mist particles. This is why when handling most water-soluble mist applications, the primary filter efficiency of most mist collectors is sufficient. Only in extreme conditions is a final filter or polishing filter, such as a HEPA filter, needed.

Straight Oil

Straight oil is just that, straight oil. Most straight oil mist is over 95% petroleum oil and may contain a few additives such as dyes, odorants, and rust inhibitors. Petroleum oil is a great lubricant. In the same way your car engine uses oil to lubricate the pistons in the engine, oil is used in metal machining to lubricate the cutting tools, reduce friction, and produce a high quality part.

What makes oil applications challenging to the mist collector is that oil is **not** a great coolant. In fact, it has the lowest cooling capacity of any of the liquids used. Since it does not have a good cooling capacity, oils commonly burn and evaporate in applications involving hard metals and/or high speed tooling, creating what looks like "smoke."

Experience has shown that what we see as smoke is mostly thermally generated mist. When oil applications become too hot, oil evaporates. As it condenses, oil particles smaller than 0.1 micron form. As these particles come in contact with other condensed oil particles, submicron mist smaller than 1 micron are formed. Tests conducted by Donaldson Company, Inc. have demonstrated that the mass mean particle size of thermally-generated mist is typically about 0.7 micron.

Besides thermally-generated mist, a percentage of the oil is burned, either completely or non-completely. The portion that is not completely burned is known as unburnt hydrocarbon or soot. Unburnt hydrocarbons are often solids left behind due to incomplete combustion of the oil and generally have a mass mean particle size of 0.3 micron. This represents a very small amount of the total collected mist and smoke and typically won't significantly reduce filter life.

In handling straight oil applications, you want to separate them into smoky or not smoky. Non-smoky applications are the simplest of all mist applications. Most mist collectors will handle straight oil mist well without any significant problems.

Smoky applications are more challenging, and the following points are recommended:

- **Cool the process:** Smoke is caused by heat, and to ensure that all the vapor generated is condensed to a liquid, the temperature of the air prior to the mist collector should be less than 105°F. It's best to have a temperature below 105°F in the ducting of these applications at least 15 to 20 feet before the collector. This ensures you are collecting mist and the vapor is not condensing after the mist collector, making it look like mist is going straight through the filter.
- **Slow the process:** Having duct velocities below 2500 fpm (feet per minute) will also provide the maximum amount of residence time for the smoke to condense into a liquid in the ducting prior to the mist collector. If you don't have at least 15 feet of ducting between the mist collector and machine tool, run your pick-up off the machine tool 5 to 10 feet in the air, elbow the ducting downward and into the mist collector. If the air temperature inside the machine tool or at the process is hotter than 105°F, add a "Y" fitting and damper to draw in cooler plant air. This will allow the reduction of air temperature at the mist collector.

Smoky applications typically require a mist collector with a final filter. Typical final filters are either HEPA or 95% DOP (Dioctyl Phthalate).

- A HEPA filter is 99.97% efficient at 0.3 microns.
- A 95% DOP filter is 95% efficient at 0.3 microns.

For the past several years, a shift in the choice of a final filter has occurred: 95% DOP filters are becoming more common than HEPA filters for handling smoke. The industry has learned that 95% DOP filters are acceptable in most applications as a final filter. With a mass mean particle size of 0.7 microns for smoke (thermally generated mist), and with a primary filter efficiencies at least 70% efficient at 0.7 microns, total system efficiencies greater than 99% at 0.7 micron are common when using 95% DOP final filters. This is more than efficient enough to meet many federal, state, and local regulations, and even satisfies some of the toughest company indoor air quality and union requirements.

In addition to the final filter, it is a good idea to use higher efficiency prefilters on straight oil applications to remove more mist before it reaches the primary filter. Heavy density mesh filters achieve fairly high efficiencies without requiring larger fans to overcome high differential static pressure drops. These higher efficiency prefilters can be retrofitted into an existing mist collector, prolonging the filter life of the primary filter.

Properties of Coolants and Lubricants

The table below summarizes properties that are important to know for mist collection and other properties that help in understanding why each coolant or lubricant is used.

PRIMARY PROPERTIES

	Straight Oil	Water Soluble	Semi-Synthetic	Synthetic
Lubricity	Excellent	Good	Good	Poor to Good
Cooling	Poor	OK	Good	Excellent
Rust Control	Good	Poor	Good	Good
Sump Life	Good	Short	Average	Excellent

SECONDARY PROPERTIES

	Straight Oil	Water Soluble	Semi-Synthetic	Synthetic
Clean	Average	Dirty	Average	Excellent
Stable	Yes	Poor (Mixture)	Foam	Can Foam
Smoke	Yes	Maybe	Maybe	Not Often
Disposal	OK - Burn	OK	Harder	Difficult
Economics	Good	Lowest Cost	Good	Expensive

OTHER PROPERTIES

	Straight Oil	Water Soluble	Semi-Synthetic	Synthetic
Dilution	N/A	1:5-40 (water)	1:10-40 (water)	1:10-40 (water)
Petroleum Oil	~100%	30% - 85%	5% - 30%	0%
Paraffin Wax	No	Yes	Maybe	Maybe

S) Properties of Coolants and Lubricants

1C. The Purpose of a Mist Collector

It is imperative to understand what the primary purpose of a mist collector is, so that your expectations are in line with what the mist collector can do. In most manufacturing plants, the objective is cleaner plant air, specifically:

- to prevent mist from becoming airborne,
- to prevent workers from breathing in mist laden air, and
- to eliminate or prevent a haze in the plant air.

Mist collection experts agree that these goals can be best achieved by “containing” the mist generated in the machine tool enclosure and only capturing the lightest and smallest mist particles generated inside that enclosure that otherwise would “drift out” of the machine tool enclosure. If this is done well, the finest and lightest mist particles that cause indoor air pollution are filtered out of the air by the mist collector and most of the coolant or oil remains in the machining center to perform its job of cooling or lubricating.

When mist collection is **not** done well, the following may occur:

1. Mist escapes through the machine tool access doors, chip conveyors, and other openings in the machine tool.

2. Too much mist is pulled into the mist collector, limiting proper cooling and lubrication.
3. The mist collector is collecting so much mist that it cannot filter it out fast enough, requiring frequent filter changes.

1D. Determining Airflow

There are several methods for determining how much airflow you need for any mist collector application. All of the methods will not be discussed in this manual; rather only the most commonly used methods will be examined.

Open Area Method for Enclosed Machines

This method is used for machine tools with mostly complete enclosures around the machine tool. The goal of this method is to “contain” the mist in the machine enclosure and prevent it from getting into the ambient facilities air.

To size the airflow requirement, look at the areas on the machining centers that are open. Are some always open, such as chip conveyors? Are some areas open only occasionally, such as primary access doors used for removing parts, changing tools, etc.?

First, look at the machine tool and assess how much open area there is in square feet. Some common open areas are:

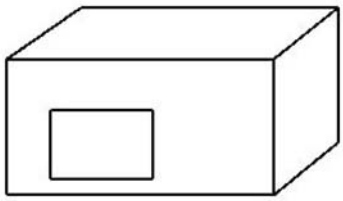
- Chip conveyor.
- Sealing around the primary access door to machine enclosure.
- For machines with external tool changers, openings around the wall between the machine enclosure and tool changer.
- Openings on the top of the enclosure of larger vertical milling centers.

Add up the square footage of these “always open” areas and multiply that by 100 feet per minute to find the first part of the total airflow. This will ensure that during operation of the machine tool, mist does not escape through these openings.

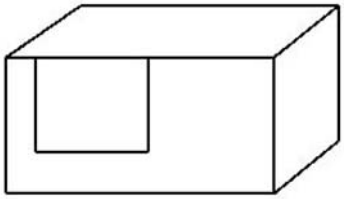
Always Open Airflow = (sq ft always opening) x (100 fpm) (Eq. 1)

Next, account for when the machining process is stopped and the primary access doors are open. The 3 images below illustrate the type of doors that are common on machining centers: (T) front vertical door: inside the cabinet there is a lip or wall above, below and to each side of the door; (U) a front vertical door that extends up to the roof of the machining center; (V) and a front door that extends vertically and recesses inward across the roof of the machine.

For styles (T) and (U) [vertical door with lip and vertical door without lip], measure the square footage of the door and multiply by 25 or 50 feet per minute as shown in the images above.



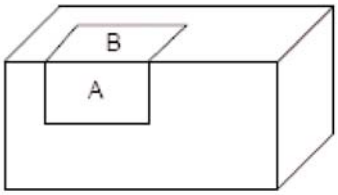
T) Vertical Door w/Lip (sq ft x 25 to 50 fpm)



U) Vertical Door w/o Lip (sq ft x 50 fpm)

Door Airflow = (sq ft door opening) x (door velocity in fpm) (Eq. 2)

For style (V) [vertical door that recesses into the cabinet], measure the square footage of the vertical section of the door (shown as section “A”), measure the square footage of the recessed part of the door (shown as section “B”), add them together, and multiply by 75 feet per minute.



V) Vertical Door w/Roof (sq ft x 75 fpm)

Door Airflow = [(sq ft door opening A) + (sq ft door opening B)] x (75 fpm) (Eq. 3)

Next add the airflows for the always open areas and the airflow for the main access doors together. This gives you the total airflow required.

Total Airflow = (Always Open Airflow) + (Door Airflow) (Eq. 4)

Air Exchange Method for Enclosed Machines

This method uses the volume of the machine enclosure and assumes a complete replacement of the air volume every few seconds. This method is best used for:

- Applications where visible clarity of the machining process is required.
- Large machines with internal volumes greater than 1000 cubic feet.

The air exchange method is as simple as measuring the “internal” volume of the machining center (Width x Depth x Height).

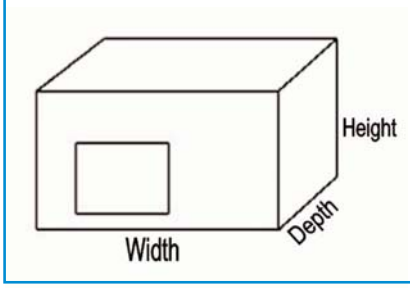
- For mist containment, multiply the volume by 4 air changes per minute (an air exchange every 15 seconds).
- For visible clarity inside the machine enclosure, multiply by 6 to 10 air changes per minute (an air exchange every 6 to 10 seconds).

Total Airflow = (Width x Depth x Height) x (Exchange Rate) (Eq. 5)

See table below for air exchange guidelines.

Air Exchange Method Exchange Rates

Purpose	Exchange Rate (# per minute)	Frequency of Exchange
Mist Containment	**4**	15 seconds
Visible Clarity – water soluble	**6 to 8**	10 to 7.5 seconds
Visible Clarity – straight oil	**8 to 10**	7.5 to 6 seconds



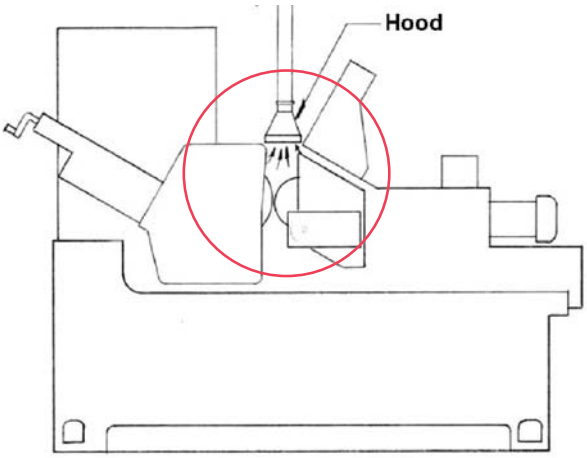
W) Air Exchange Rates

Machines without Good Enclosures

When you have a machine that is not well enclosed and requires mist collection, custom hooding is typically required. Since there is no enclosure, mist containment is no longer the goal; instead, capturing the small and medium sized mist particles near the point of generation is the goal. (The larger mist particles are too big and heavy to be picked up by most hoods and do not become airborne.)

Examine the following in determining how to capture the mist.

Is the mist being generated and thrown in one direction? On centerless grinders (photo X), Blanchard grinders (photo Y), surface grinders, and large lathes on some milling centers, you can see that almost all of the mist generated is thrown in one direction by the machine tool or part turning. In this case, a hood designed and located in the mist throw zone is ideal. This can be seen in the picture of a centerless grinder (photo X). A hood is placed above the grinding wheel where much of the mist from this process is thrown.



X) Hood above grinding wheel captures most of the mist generated

Another example of an open machine is a Blanchard Grinder. On 60-inch Blanchards and smaller, the mist generated by the large grinding wheel is thrown directly against the left wall of the machine and drifts up the wall. On larger Blanchards, hoods on both the left wall and rear wall are required. Although it may seem that such grinders pose difficulty for mist collection, a simple single hood mounted off the left guard as long as the Blanchard is deep will be sufficient to capture up to 95% of all mist.

Y) 30-inch Blanchard with hood and mist collector

A large canopy hood covering the top of the Blanchard is not required, although some installations may require a partial top guard to increase the capture efficiency of the hood. These top guards can be a simple flat plate. To ensure they can be moved out of the way when top access is required, add a hinge and simple pulley/winch system. A large canopy hood may be frequently moved and may not be put back correctly or at all, defeating the purpose of the hood and mist collector in the first place.

Do you have a large surface to cover with a hood? If so, a large canopy-style hood may be the best choice. It can cover the perimeter of the area where mist is generated, and curtains or other materials can be dropped from one or more sides to create a partial enclosure.
The negative with canopy hoods is that they are large and require a lot of airflow. An example of a canopy-style hood is shown in photo Z on a Model 940 Prince Die Caster. Note the custom canopy hood is on the front side of the filtration systems that covers the entire area between the die platens and the side walls of the machine. As access is required to change the dies, the hood and collector are designed to roll out of the way to allow unobstructed maintenance.

Z) Canopy-style hood on die cast mist collector, on casters, to roll out of the way for maintenance

There's not one right hood solution for all machines not enclosed or only partially enclosed – the key is to examine how the mist and contaminants travel, then use a hood that appropriately captures them. Airflow is driven by hood design and is not covered in this guide. Hood designs and details can be found in Industrial Ventilation – A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, Inc. This manual is updated about every 3 to 4 years and is one of the primary resources used in the mist filtration industry.

Handling Hot Airflow Applications

In airstreams hotter than 104°F, a portion of the mist is typically in vapor form. The problem is that mist collectors are not designed to filter vapors, (which is a gas, not a liquid or particulate) and they go through the collector without being stopped. When the vapor hits the cooler plant air, it condenses and becomes visible as fog. While it is possible to use an adsorbent such as activated carbon or a thermal oxidizer to handle the vapor, both of these solutions are costly and not practical.

The best way of addressing vapor is to reduce the temperature of the air going to the mist collector to below 104°F. At temperatures below 104°F, most of vapor will condense and you can then filter it as a liquid via the mist collector.

Note that the maximum operating temperature of TEFC motors used in mist collectors is also 104°F.

To calculate the cooling air required, the following equations apply:

$$T_{mix}(M_1C_1 + M_2C_2) = M_1C_1T_1 + M_2C_2T_2 \quad \text{(Eq. 6)}$$

$$M = \left(Q\ x\ \delta \frac{(460+70)}{(460+T)}\right) \quad \text{(Eq. 7)}$$

Where:

M = Mass flow rate of air (lbs/min)
M_1 = Mass flow rate of process air (lbs/min)
M_2 = Mass flow rate of cooler mixing air (lbs/min)
Q = Volumetric flow rate (ACFM)
δ = Density of air at air temperature (lbs/ft^3)
T_{mix} = Temperature of mixed airstream (°F)
T_1 = Temperature of process air (°F)
T_2 = Temperature of cooler mixing air air (°F)
C_1 = Specific heat of process air (BTU/lb°F)
C_2 = Specific heat of cooler mixing air (BTU/lb°F)

Between the temperatures of 50°F and 250°F, which is the range of almost all mist collector applications, the specific heat of air varies by less than 1%. To simplify equation 6, assume $C_1 = C_2$. Solving equation 6 for mass flow rate M_2 and substituting that value into equation 7 and solving for the volumetric flow rate Q_2, the following simplified equation applies.

$$Q_2 = \left(\frac{Q_1(T_1 - T_{mix})(460+T_2)}{(460+T_1)(T_{mix}-T_2)}\right) \quad \text{(Eq. 8)}$$

Q_1 = Original process airflow in CFM
Q_2 = Cool mixing airflow required to reach T_{mix} in CFM
T_1 = Temperature of original process airflow (°F)
T_{mix} = 104°F or other mixed air temperature
T_2 = Temperature of cool mixing air (°F)

Lastly, to calculate total airflow required for sizing ducting and the mist collector, add the original airflow and the cooling airflow together:

$$Q_{Total} = Q_1 + Q_2 \quad \text{(Eq. 9)}$$

Locate the mix point at least 15 feet before the mist collector to mix in cooler air, cool the vapor, and have the vapor condense prior to the mist collector. As most hot mist applications have fine mist, duct velocities should be kept below 2500 feet per minute to allow the maximum amount of time for vapor to condense. If you mix the air too

close to the mist collector and/or have an air velocity that is too fast, the mist will not have enough time to condense and visible emissions out the exhaust of the mist collector should be expected.

To bring in mixing air, use a “Y” fitting or 45 degree branch fitting at least 15 feet from the mist collector, with one branch for your process air and the other branch for the cooler air used to reduce the process air temperature. Place a damper on the cooling air inlet line to regulate how much cool air is brought into the process, so you can ensure enough airflow is pulled from the mist source. The air velocities for both branches should be calculated and designed to be similar, to reduce the amount of static pressure required at the mixing point. If you don’t have 15 feet of room between the application and the mist collector, use a couple of elbows and 15 feet of ducting constructed in a “C” or “S” pattern to ensure proper cooling of the process air and mist.

Cooling air with air is quite inefficient, but remains the most common method used. A better solution is to cool the air with water, oil, coolant, or other material compatible with the type of mist being collected.

- Use the same “Y” fitting or 45 degree branch inlet at least 15 feet from the mist collector inlet.
- Solve equation 6 for M_2 where M_2 is the mass flow rate of the liquid sprayed, T_2 is the initial temperature of the liquid sprayed, C_1 and C_2 are the specific heat of air and specific heat of liquid spray.
- Use equation 7 to solve for M_1 (mass flow rate of air) and insert that value in equation 6.

The location of the spray nozzle, the particle size of the mist sprayed, and how the cooling fluid mixes are all critical to the success of using a fluid to cool the airflow. A typical application requires using 5 to 10 times more liquid than you calculate, as much of the mist will drop out of the airstream and not provide the desired cooling. Note that installing a system designed for up to 20 times more liquid than you calculated is appropriate if the 15 feet of ducting prior to the mist collector has more than one elbow to it. This is because much of the mist sprayed is going to impact the elbows and ducting walls, and drop out of the airflow before fully cooling the air.

1E. Selecting a Mist Collector Based on Calculated Airflow

When selecting your new mist collector, keep in mind that the airflow calculated is the airflow required to prevent the mist from escaping the machine enclosure during normal operation. Be cautious, as the stated airflow of most mist collectors is determined with clean filters, not dirty filters.

For example, if you calculate a requirement of 800 CFM and you have the option of choosing an 800 CFM mist collector or 1200 CFM mist collector, the 1200 CFM mist collector is the better choice. The 800 CFM mist collector will probably work for the first few weeks/months, but once the filters begin to load, the mist collector will no longer have enough airflow to contain the mist inside the machining center.

If you require a final filter (95% DOP or HEPA) to capture smoke, don't forget that it will also load up and reduce the total airflow of the mist collector over the life of the filter. A larger motor and fan may be required or you may need the next larger size mist collector to provide proper airflow throughout the designed life of the filters.

If you oversize the mist collector, you will probably never know that it was oversized as it will work well and provide long filter life. If the mist collector is undersized, you will encounter short filter life, have insufficient airflow to capture or contain the mist generated, and need frequent maintenance.

1F. Location of Mist Generated

When planning mist collection systems, be sure you understand the location of each machine generating mist and any plans to move those machines in the future. In a job shop, its common for machines to be moved monthly, whereas at a facility that always makes the same part on the same machine and has done so for 20 years already, it's probably safe to assume that machining centers are not frequently moved and will not be moved in the future.

With the advent of LEAN initiatives, there may be more tendency to move equipment around to create work cells. If you do not know, contact the facilities manager, facilities operation manager, plant engineer, or other personnel responsible for plant operations.

Frequently Moved Machining Centers

For facilities that move machines around the plant floor, you want mist collectors that can move with the machines quickly and easily. A mist collector mounted directly to each machining center has obvious advantages. As the machine is moved, the mist collector can travel with it, minimizing the reconnection time.

Ducted mist collectors, on the other hand, may be complicated to reconnect in a new location, or require redesign of the ducting after situating your machines.

Infrequently Moved Machining Centers

In facilities that don't move machinery around much, there are many options.

- Install individual mist collectors on each machining center.
- Have a mist collector for each machining cell or for similar nearby machining operations.
- Install a central system that filters the mist from dozens of machines.

There is no one solution right for all facilities. When you understand the advantages and disadvantages of each type of system, the one that works best with the operation of your facility can be selected. Each type of system is described in detail in Chapter 2.

1G. Combining Mists

When multiple machines require mist collection, questions arise regarding whether a large central system or smaller individual mist collectors are best. (See Chapter 2, Types of Collector Installations, for explanations of the differences between individual and central systems.) What's important to consider at this stage is whether you have the option to combine the mists together.

If the coolant and/or oils used are identical for each machine, then combining the airflows from multiple machines is a viable option to consider. There will typically be no cross contamination and the drain from the mist collector can go to the nearest machining center or to a central coolant sump.

If the coolant and/or oils used are different from machine to machine, then combining them may not be a good option. Here are some things to consider:

1. Are there any incompatibilities between the two or more coolants and/or oils that you are mixing together? Contact the supplier of those liquids and discuss with them any concerns.
2. What comes out of the drain line is going to be a mixture of whatever oils and coolants were collected by the mist collector, and will require proper disposal.
3. Are there any concerns if collected liquids run down the inside of the ducting and a small amount runs into a machine that uses a different coolant or lubricant? This may cross contaminate the system and increase the tramp oil percentage in that machine or

coolant sump. Discuss possible consequences with your coolant or lubricant supplier. A duct layout that minimizes the chance of cross contamination of collected oils and lubricants inside a machining center will be necessary.

4. Look into disposal concerns. In some instances, waste oil is burned to produce steam or electricity. Water in the oil reduces the ability of the waste oil to burn and may not be accepted. Synthetic fluids are the most difficult to dispose of as the man-made compounds in these fluids are designed not to decompose and typically require special handling requirements. Contact your local or state government environmental department for the proper disposal procedures.

Generally, the additional cost of handling mixed oil and coolants does not offset any benefit realized by combining them. Most of the time, it works out better to install separate mist collectors to handle each coolant or lubricant used.

2. Types of Collector Installations

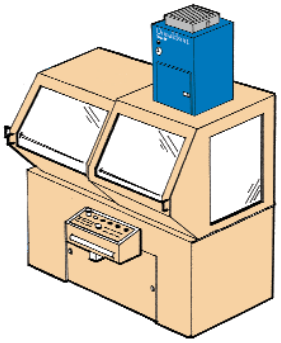
There are several good ways to design and install a mist collection system:

- A machine-mounted mist collector.
- A single mist collector ducted to 1 machine (single ducted).
- A single mist collector for a machining center cell – typically 3 to 4 machining centers (cellular system).
- A central mist collector for up to 20 machining centers (central system).
- Ambient filtration.

A discussion of each follows.

2A. Machine-Mounted Systems

A machine-mounted mist collector is the most popular and in many cases the most practical solution for mist collection. The mist collector is mounted on top of a machining center. It may be mounted such that the bottom of the mist collector is open and connected to the machining center or a short piece of flex hose or ducting may be used to connect a bottom inlet collar to the machining center.



AA) Mist collector mounts on top of machining center

Advantages:

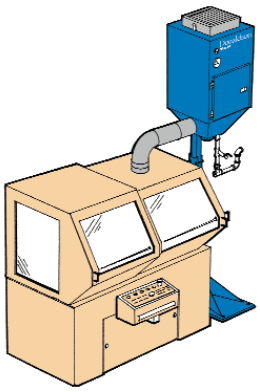
- Flexibility to move machining center easily when manufacturing operations change.
- Power up the collector only when machining center is on. (Recommend machine tool interlock with each machine for maximum energy savings and longest filter life.)
- Oil/coolant is returned to machining center.
- No floor space required.
- Simple maintenance.
- Only one machine is without mist collection during any significant mist collector maintenance.

Disadvantages:
- Each machine requires a motor starter.
- On collectors with a bottom inlet, the drain is typically not designed for 24 hour per day operations.
- Low ceilings, overhead cranes, electrical conduits, etc. may interfere.
- Multiple machine require multiple collectors.
- High total energy investment.

2B. Ducted Single Machining Center Systems

A single mist collector for a single machine where the mist collector is mounted on the floor, hung from the ceiling, or mounted to a beam is the second most common mist collector installation. It's typically used:
- When machine-mounting is not an option due to the size or weight of the mist collector.
- Where top access to the machining center is required.
- Where tolerances are so critical that the user cannot risk the motor vibration affecting the quality of the part.

These systems typically are mounted no more than 10 feet away from the machining center and have minimal ducting.



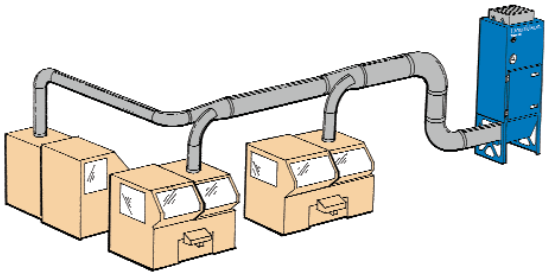
AB) Mist collector is connected by ducting to a single machining center

Advantages:
- Flexibility to move machining center easily when manufacturing operations change.
- Turning on the collector only when machining center is on. (Recommend machine tool interlock with each machine for maximum energy savings and longest filter life.)
- Simple maintenance.
- Only one machine without mist collection during any significant mist collector maintenance.

Disadvantages:
- Each machine requires a motor starter.
- Ducting must be selected and installed properly to minimize chance of leaks.
- Multiple machine require multiple collectors.
- High total energy investment.

2C. Ducted Cellular Systems

A single mist collector for a machining cell typically consists of 3 or 4 machining centers. With LEAN manufacturing practices, it is becoming more common to see machining cells, instead of machines just set down in a row. The parts manufactured in a machining cell may move between machines or the same part is manufactured in each machine, and each machine uses the same oil or coolant. Each machining cell is the responsibility of one person. In these instances, installing one mist collector for the machining cell may be more practical than individual mist collectors.



AC) A single mist collector supports several machining centers

Advantages
- Mist collector only operates when machining cell is operating. (Recommend machine tool interlock for maximum energy savings and longest filter life.)
- Energy usage is minimized by using fewer collectors, so fewer fans.
- Maintenance can be performed on mist collector when machining cell is not in operation.
- Maintenance only needs to be performed on one mist collector, not three or four, reducing costs of filters, maintenance time, and disposal costs.
- Collected mist can be easily returned to the coolant filtration system of one machine or the cellular coolant filtration system.
- When the machining cell is modified or no longer necessary, the mist collector can be moved and reused elsewhere.

Disadvantages:
- Ducting must be selected and installed properly to minimize chance of leaks.
- Balancing the airflow between all machines so each machine has enough airflow requires expertise.

2D. Ducted Central Mist Systems

A single mist collector ducted to multiple machines, typically no more than 20 machining centers. These large systems were popular in the 1980's and 1990's, but are no longer common today.

Advantages

- Lowest cost mist collector solution (1 collector for many machines).
- Single fan and single motor starter makes installation of the mist collector quicker.
- Maintenance staff only has to schedule filter changes on one unit.

Disadvantages:

- Fan is either on or off. For facilities that don't run all machines at once, excess energy usage is required.
- Requires large amount of floor space.
- Installation cost may be higher due to more ducting and larger duct diameters.
- Ducting must be selected and installed properly to minimize chance of leaks.
- Duct diameter for main run is larger and can require extra floor space.
- Larger duct runs may require additional static pressure to operate well, which may minimize the energy benefit of a central system.
- If using more than 1 coolant/oil, the collected mist cannot be reused, resulting in higher disposal costs.
- When mist collector maintenance is required or the mist collector is down, all or a large portion of the plant's mist collection will be down.
- Balancing the airflow between all machines so each machine has enough airflow requires expertise.

2E. Ambient Mist Filtration Systems

An ambient mist filtration system is designed to remove mist from the general plant air without being directly connected to the source generating the mist. Ambient systems are infrequently used as a primary mist filtration system, but are used in cases where source capture cannot be done well or not at all. Ambient collection is occasionally used as a polishing system to provide exceptional air quality to a facility.

Advantages:

- Used when there are several machines that have no enclosures or when 100% mist containment and capture can not be achieved.
- Used after source capture units are installed on all machines, to add a final degree of air cleanliness for the cleanest plant air possible.

Disadvantages:

- Ambient systems have a maximum system efficiency of 70% (typically 50%), which may not be efficient enough to meet local, state, federal, and/or union requirements.
- Ambient systems require that specific airflow patterns be managed for the entire plant – from ambient mist filtration systems, HVAC, personal fans, and any other air moving device in the facility. See pictures on the following pages. If the airflow patterns don't work together or if the facility opens doors and windows to bring in fresh air, system efficiencies typically fall to less than 50%.
- For mist to be captured by the ambient filtration system, mist must rise, get into the airflow pattern created, and then be removed from the plant air. This means that workers are still exposed to a high concentration of mist at the source of generation.
- Airflow patterns from ambient units can stain when mist is entrained in the discharge air and pushed towards corners and walls.

Should you consider installing an ambient mist collection system, here are the 5 steps toward a properly designed system that maximizes the capabilities.

$$Total\ Air\ Volume\ of\ Room = Length\ x\ Width\ x\ Height \qquad \text{(Eq. 10)}$$

1. What is the volume of the room that you want to filter? Measure the height, width, and length of the room to calculate the volume of air to be filtered

2. Is the volume of mist in the air light or heavy?

Condition of Mist	Minutes per Air Exchange
Light	20 minutes
Medium	15 minutes
Heavy	10 minutes

AD) Ambient Air Exchange Table

3. Calculate the airflow required for the ambient system dividing the volume of air to be filtered by the minutes per air change.

$$Total\ CFM = \frac{Total\ Air\ Volume\ of\ Room}{Minutes\ per\ Air\ Change} \qquad \text{(Eq. 11)}$$

Example: A shop area 200 feet by 100 feet by 20 feet, and the amount of airborne mist is a medium loading. Calculate the amount of airflow required.

$$Total\ CFM = \frac{(200\ ft\ x\ 100\ ft\ x\ 20\ ft)}{15\ Minutes\ per\ Air\ Change} = 26{,}667\ CFM$$

4. Determine the type of mist collector that you are using and the nominal airflow for that unit. The manufacturers of ambient air filtration systems will be able to provide you with this information. To determine how many mist collectors will be required, divide the total airflow from equation 11 by the nominal airflow of the mist collectors selected.

$$\#\ Mist\ Collectors = \frac{Total\ CFM}{CFM\ \ Mist\ Collector} \qquad \text{(Eq. 12)}$$

Example: It's common for a Media/Vee-Bag style mist collector to operate at 3000 CFM per collector.

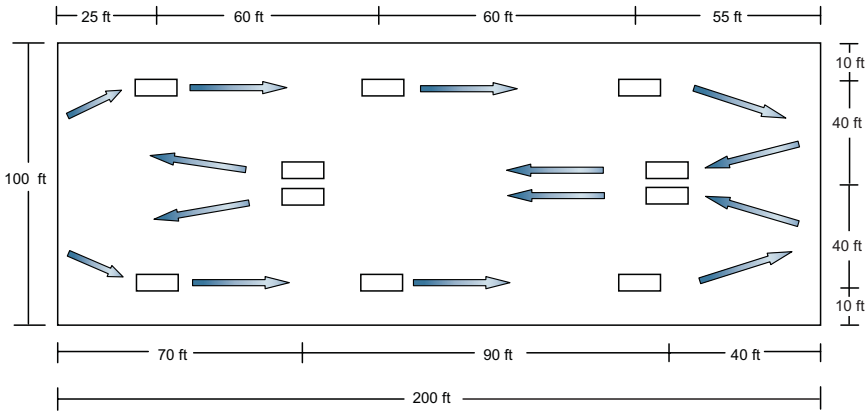
$$\#\ Mist\ Collectors = \frac{26{,}667\ CFM}{3000\ CFM} = 8.9\ Mist\ Collectors$$

Since you can't install and operate part of a mist collector, let's consider 9 mist collectors, each operating at 3000 CFM being required to properly filter the mist in the air.

5. The last item is to layout how the collectors are going to fit into the room such that there is a good airflow pattern developed to capture the mist generated. To provide maximum capture efficiency, place the mist collectors such that an oval airflow pattern is developed by pushing air from the exhaust of one unit to the inlet of another. In creating the oval airflow pattern, there are some basic rules of placement:

- Distance from the exhaust of one unit to the inlet of the next unit should be no less than 50 feet, no greater than 100 feet.
- The side-to-side distance between units no greater than 50 feet
- Never place the exhaust of a mist collector closer than 20 feet from any corner.
- The typical distance between the side of the unit to the wall is 10 to 20 feet.

Let's complete the example:



AE) Layout of Ambient Filtration System for 200 ft x 100 ft x 20 ft facility

You will notice that although we calculated 9 mist collectors required at 3000 CFM each, when it came to locating the mist collectors, 10 were required to complete the airflow pattern. In this example, a figure 8 airflow pattern was developed. If the manufacturer of the ambient systems offers 6000 CFM mist collectors, the 4 mist collectors in the middle of the figure 8 could be combined together and two 6000 CFM collectors could be substituted.

Lastly, the units that blow air directly towards the wall should use louvers to turn the exhaust so air is "bounced" off the walls towards the inlet of the next collector, as illustrated on the right and left sides of the previous diagram.

3. Installing the Mist Collector

Before selecting which type of mist collector is right for your needs, consider some other factors that may affect the type of system you install and the type of technology that you purchase.

3A. Locating the Mist Collector – Indoors vs. Outdoors

Although most mist collectors are installed indoors, from time to time, questions do come up about locating mist collectors outdoors. Here are the concerns regarding **outdoor installations**:

1. Are you located in an area where temperatures below 32°F will occur, either occasionally or frequently, either during the day or at night?
   - If you are collecting water-soluble coolants, at temperatures below 32°F, water will freeze. Although the air temperature exhausted through the mist collector may be warmer, drain lines typically operate at ambient temperatures and may freeze. Also consider times when the system is off. Ice in a mist collector will prevent proper draining and may blind-off filters.
   - If you are collecting straight oil or other non-water-soluble liquids, be aware of the fluid viscosity. Although oil will not freeze at 32°F, oil does thicken as the weather gets colder and draining may be inhibited, both from the filters and through the drain.
2. Is the facility located in or near a residential area?
   - If you are collecting water-soluble coolants, exhausting water vapor or humid air into colder outdoor air can cause water vapor to condense resulting in a water cloud being developed. This will look like the filtration system isn't working. In residential neighborhoods, it is common for someone driving by to log a complaint about visible emissions to the local or state environmental agency, resulting in a visit and possible investigation.
3. Mist collectors are not typically designed for outdoor installation. Although they can perform well, attention needs to be placed on all gasketed seams, electrical connections, pressure taps, etc. to ensure that rain and other weather conditions do not affect the performance of the mist collector. A roof and/or partial enclosure around the mist collector is recommended to minimize weather related failures to the mist collector. If this isn't possible, a weather cover on the exhaust of the mist collector should be installed. This will turn the vertical exhaust of a mist collector downward to minimize the chance of windblown rain and weather from affecting the internals of the mist collector. See photo AF, a centrifugal mist collector on a lube oil reservoir with an exhaust/weatherhood.

AF) Example of a weatherhood over the exhaust of the centrifugal mist collector to avoid intake of rain, debris, etc.

3B. Hooding Designs

Although most mist collectors are mounted directly or ducted to a machine enclosure, about 10% of mist applications require special hood design. These are usually:

- Machine tools that are over 20 years old.
- Custom machine tools that handle very large parts and cannot be well enclosed.
- Machines where top access is critical for loading parts and tools
- Other applications that now require air filtration due to indoor air quality regulations on applications other than metal cutting and forming.

First Resource: When designing custom hoods, the first resource to use is the Industrial Ventilation – A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, Inc. You'll find dozens of hood designs and recommended airflow calculations depending upon the size of the hood.

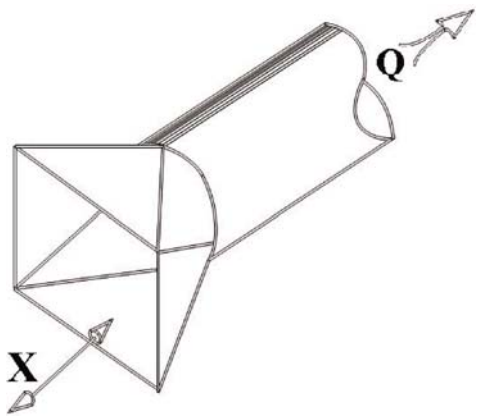
Hood Size*:* To determine the size of the hood, which is not always clear, first ask yourself how is the mist being generated? Is mist rising due to a hot process? Is the mist thrown in one general direction from the machine tool or coolant spray nozzle? Is it being scattered in every direction? Don't look at the mist above or near the process when investigating this; instead, look directly at the generation source and track what the mist does. In most cases, you will find the majority of mist travels in one direction, making it easier to capture. The capture hood should be as large as it needs to be to capture the mist generated at the source and should be located as close as possible to the generation source.

Once you have a hood sized, you then need to calculate how much airflow is needed to capture the mist. The next chart (from the Industrial Ventilation – A Manual of Recommended Practice) details the typical air capture velocities for the hood.

Recommended Capture Velocities for Mist Collection Hoods*

Released At/Into	Application Examples	Capture Velocity (ft/min)
Low velocity/moderately still air	Batch part washers, die casting, thermal rise applications	100-200
Active generation	Low speed lathes, cold headers, stamping	200-500
High initial velocity	Most metal cutting, grinding	500-2000

AG) Recommended Capture Velocities for Mist Collection Hoods



AH) Capture hood for point source collection

To determine the amount of airflow required for the hood, apply equation 13:

$$Q = V\left(10\,X^2 + A\right) \qquad \text{(Eq. 13)}$$

Where:
Q = Required Airflow (cu. ft/min)
V = Capture Velocity (ft/min)
X = Distance from source (ft)
A = Face area of Hood (sq ft)

The closer the hood is to the source of mist and the smaller the hood, the lower the amount of airflow required to remove the mist and the smaller the mist collector.

* From American Conference of Governmental Industrial Hygienists (ACGIH®), Industrial Ventilation: A Manual of Recommended Practice, 22nd Edition. Copyright 1995. Reprinted with permission.

3C. Machining Center Pick-Up Point Location

The most common method of picking up mist is to connect the mist collector to a machining center enclosure. Many machine tool manufacturers provide a knockout plate or cut out specifically designed for mist collector connection. Although provided, the locations specified by the machine tool designer are not always the best location, especially on older machines.

When selecting where to connect the mist collector to the enclosed machining center, remember that the purpose of mist collection is to:

- Contain the mist inside the machining center by pulling a negative pressure on the machine enclosure. This prevents mist from leaking out the doors, around seals, and escaping through other open areas in the machine tool cabinet.
- Filter the smallest and lightest amount of mist pulled into the mist collector.

This is accomplished through cross ventilation of the enclosed space. This means any open area, whether always open such as a chip conveyor or sometimes open such as a door, will allow air into the machine tool and will sweep the inside of the enclosure free of mist.

Consider that a machine tool is much like a mountain cave and you have been given the job to provide fresh air to the cave. You need to remove the air at the back of the cave and replace it with fresh mountain air. To sweep the cave free of that old stagnant air, what would you do? As they do in cave mining of minerals, cut a vent hole at the back of the cave. By pulling air up and out of that vent hole with a fan, fresh mountain air will enter through the cave entrance and provide fresh air to the cave.

Locate the following on the machine tool:

- Chip conveyor
- Main access door
- Tool changer door
- Machine tool drive motor and any openings in the cabinet around it (common on vertical machining centers)
- Other areas where plant air can enter the machine tool (through the bottom, around door seals, etc.)

Select a location on the machine tool cabinet that is as far away from all of these openings as possible. You will typically want your pick-up point high on the walls of the machine enclosure or on the top to prevent excess mist and chips from being picked up. The most common locations for the mist collector pick-up are:

- Along the back wall of the cabinet as high up as possible.
- On the top of the cabinet, as close as possible to the rear left or right corner.

Pick-Up Point Do's & Don'ts

- **Don't** install a mist collector directly above the main access door or tool changer door. Mist in the corners of the machine will not be picked up and once these large doors are open, mist may drift out of the machine enclosure.
- **Don't** install the mist collector where mist is directly thrown. If mist comes off the machine tool and impacts the rear right corner of the machine, install the mist collector to pull from the rear left corner of the machine, minimizing the mist load to the mist collector. If you must install in an area that has a lot of mist thrown at the pick-up point, install deflectors between the mist source and pick-up point to knock down as much of the larger mist as possible.
- **Do** size your pick-up point so that the inlet velocity is less than 2000 feet per minute.
- **Do** cut a small slot (1" x 6-10") or two in the machine tool enclosure if it is too-well sealed to produce the necessary cross ventilation air pattern.

3D. Ducting Types

The types of ducting most common in mist collection include metal spiral, metal flanged, clamp together, PVC, and flex hose. The advantages and disadvantages of each are discussed below.

Metal spiral is the most commonly used ducting in mist collection. It is:

- Relatively inexpensive.
- All ducting contractors have experience with it.
- Lengths of 20 feet and even longer are available, minimizing the number of joints.
- Available in almost any diameter needed.

AI) Outdoor installation of a Donaldson® Torit® Dryflo® DMC-D2 mist collector using spiral ducting

Metal flanged is only moderately used in mist collection because it carries high cost both in purchase price and in installation cost. The advantage is that each flange is caulked to prevent leaks and bolted together. For mist collection systems where any leak will be a problem, this flanged ducting is one of your best choices.

AJ) Typical flanged pipe

Clamp together type ducting is popular because it is easy to work with.

- With duct sections 5 feet long, one person can install it.
- Cost is between metal spiral and metal flanged.
- For applications that operate 24 hours a day, any leaking is going to be minimal.
- For facilities that move their equipment around frequently, clamp together ducting can be easily disassembled and upon relocation of equipment, clamped back together.

Disadvantages: if this ducting is not installed correctly, leaks can develop at any clamp point.

AK) Clamp together ducting (Donaldson Torit Easy Duct™) used from the mist collector, with a short piece of flex hose to connect to the application

PVC and CPVC are not commonly used in mist collection, although they are seen from time to time. PVC can look nice when it is first installed, but it can carry a static charge if not properly grounded, attracting any dust in the air. When handling mists that are flammable/explosive, using materials that are known to build-up static charge are not a good choice.

PVC is considered piping, not ducting. If you compare a 6-inch PVC pipe and a 6 inch spiral duct, you will notice that the diameters are not the same. Since PVC is not usually used, collars to mount to a machine enclosure and even to the mist collector are difficult to find or need to be made special.

AL) Example of PVC pipe connecting a Donaldson Torit Dryflo mist collector to a machining center

Flex hose is used just about everywhere in mist collection. It may be used to connect a machining center to a mist collector or to connect to overhead ducting in a cellular or central system. In applications where hoods need to be moved, flex hose is commonly used. Flex hose is typically used with centrifugal mist collectors for ease of maintenance and because these systems are typically less than 10 feet away.

Disadvantage: Flex hose does present a problem if it is not properly hung. A pool of liquid can develop and cause it to sag, eventually plugging up the hose and cutting off the airflow. Always run flex hose vertically, not horizontally.

AM) Good installation of Flex Hose

AN) Poor installation of Flex Hose (starting to sag)

Types of Ducting Used in Mist Collection
A = Distinct Advantage S = Some Advantage X = Disadvantage

	Metal Spiral	Clamp Together	Metal Flanged	PVC (CPVC)	Flex Hose
Cost (purchase & install)	A	S	X	S (X)	S
Ease of Installation	S	A	A	S	X
Ease of Disassembly	S	A	A	X	A
Ease of System Modification	S	A	A	X	A
Leak Resistant	S	S	A	A	S
Available Sizes	A	A	A	X	S

AO) Types of ducting used in mist collection

3E. Ducting Do's and Don'ts

Although selecting and installing the proper ducting can be done easily, here are some points that will ensure the ducting system selected is optimally installed for collection of mist:

- Always slope ducting toward the source of mist, toward the mist collector, or both if necessary. Mist will impact the ducting walls and will settle out of the airstream.
- Flex hose lengths should never be longer than 10 feet. Use solid ducting as far as possible and run only the last few feet with flex hose. Flex hose requires more pressure drop due to internal resistance caused by the metal helix surrounding the hose.
- Flex hose should be well supported and never installed horizontally. Liquid will build up on horizontally laid flex hose and, as liquid quantities build up, the flex hose will sag, blinding off the airflow.
- All ducting should be installed per local, state, and federal regulations. Proper duct hangers should be used, and if you are installing systems where the ducting could become 100% filled with liquid (i.e. fire suppression system installed using water), ensure that the ducting is installed to withstand the weight.
- When using clamp together ducting, install the clamps such that the clamp end is upward. This minimizes leaks.
- When using slide gate dampers, install the dampers so the damper is serviced from the top side of the duct. Slide gate dampers that slide horizontally or downward will be a source of leaks.
- Whenever drilling a hole in the ducting for taking airflow measurements, temperature measurements, static pressure readings, or other purposes, locate the holes on the side or top of horizontal ducting to minimize the chance for leaks. Only drill holes the size you need. Covering any hole with duct tape will not only prevent air from being pulled into the hole, it will also make it easier to locate the hole in the future.
- The duct conveying velocity for mist collection is important. Here is a simple chart detailing recommended duct conveying velocities for mist collection.

Recommended Mist Collection Duct Conveying Velocities	
Mostly mist (most mist collection systems)	2000 to 3000 feet per minute
Mist with fine dust (i.e. surface grinding)	3500 to 4000 feet per minute
Mist with large dust, small chips	4000 to 4500 feet per minute

AP) Recommended mist collection duct conveying velocities

- Duct conveying velocities should be maintained throughout the duct system. Use the highest conveying velocity required for any source of mist, and design the entire duct system to operate at that duct velocity.
- *A note of caution*: the mist collector is designed to filter mist, not handle large amounts of dust and chips. Use deflectors to prevent dust and chips from entering the ducting or move the hood location to where dust and chips will not be picked up.
- For additional ducting recommendations, see Industrial Ventilation – A Manual of Recommended Practice, American Conference of Governmental Industrial Hygienists, Inc.

3F. Electrical Controls

Every mist collector requires a motor starter. Whether a simple switch or a magnetic starter, a device for turning the unit on and off is required. You will need to purchase or supply the appropriate motor starter as required by local, state, and federal regulations.

When installing a mist collector, consider how it will operate, who turns it on, who turns it off, and who will maintain it.

Consider installing the electrical controls for the mist collector through the use of a machine tool interlock. If the machine tool is shut down an hour for maintenance or shut down over the weekend, why chance leaving the mist collector running – costing dollars in electricity. It is all too common for an operator to leave at the end of a shift and forget to turn off the mist collector. Often, the ambient noise in a facility is louder than the mist collector, so employees cannot easily determine if the mist collector is running or not.

The Benefits of Using Machine Tool Interlocks

Most mist collectors will increase their usable filter life through the use of machine tool interlocks. Each time a mist collector is shut down, collected mist drains and flushes the filters.

- When handling water-soluble coolants, turn the airflow off when no mist is being collected to allow the paraffin wax in the water-soluble coolants to flow out of the filter. If, instead, it dries into the filter material, filter life will decrease and maintenance time and costs will increase.

If using a centrifugal mist collector, it's a good practice to run it for 5 minutes (once mist is no longer being collected) to centrifugally flush the collected mist out of the filters.

- This is especially important with water-soluble mists: paraffin wax is left behind and, as the remaining water evaporates from the filters, it will solidify in the filter media, causing a weight balance issue. Over time this leads to increased maintenance in changing filters and/or balancing the filter drum.
- A machine tool interlock with a timer to turn off the centrifugal mist collector after 5 minutes is recommended.

3G. Drains

A properly designed drain system is critical to the successful operation of a mist collector. Drains allow collected mist to empty out of the system while the system is running. This is done by creating a liquid barrier between the mist collector and the ambient plant air that prevents air from flowing up or down the drain. If the drain system is improperly designed and/or installed, you will see reduced filter life and increased maintenance costs.

The common types of drains are P-traps, drain hose, and drain collection container (drain bottle). P-traps and drain hose loops must be filled with coolant or oil before initial operation for these drains to operate correctly.

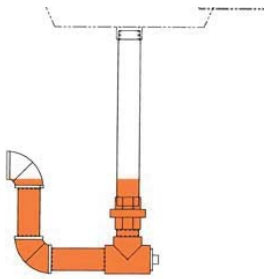
P-Trap

The P-trap is a very common and simple device to ensuring a liquid barrier exists between the mist collector and ambient air. Much like a bathroom sink drain P-trap that prevents sewer odors and gases from entering your home, a P-trap on a mist collector ensures that mist flows out of the drain and ambient air doesn't flow up the drain into the mist collector.

Here is How a P-Trap Works:

When the mist collector is off:

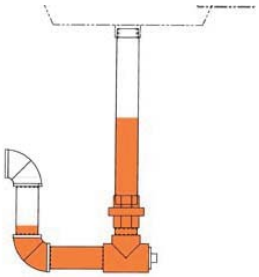
- No suction.
- Oil level on both sides of the P-trap is the same.



AQ) P-Trap with mist collector fan off.

When the mist collector is immediately turned on:

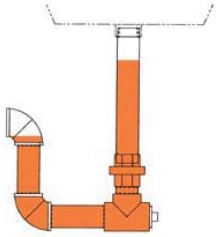
- Oil is pulled upward on the long leg towards the collection point.
- The difference in oil levels on each side represents the static pressure (in inches oil or inches coolant) that the fan has available at the drain point of the mist collector.



AR) P-Trap on mist collector that is just turned on.

When the mist collector P-Trap reaches steady state:

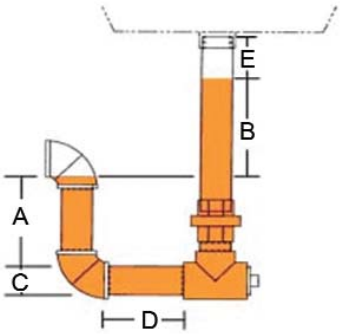
- The height difference between both sides represents the static pressure (in inches oil or inches coolant) that the fan has available at the drain point of the mist collector.
- The height above the oil represents a safety factor that prevents oil from being stored in the inlet plenum.
- If oil is stored in the inlet plenum, it will probably re-entrain in your airflow, which will increase mist loading rates and reduce filter life.



AS) P-Trap at steady state.

Equations for designing a P-Trap

A = 1/2 the maximum static pressure (in inches) available at the drain locations + 1 inch
B = The maximum static pressure (in inches) available at the drain location
C = Outer diameter of pipe
D = Minimum of 3 inch (longer for dirtier coolants)
E = 1 inch



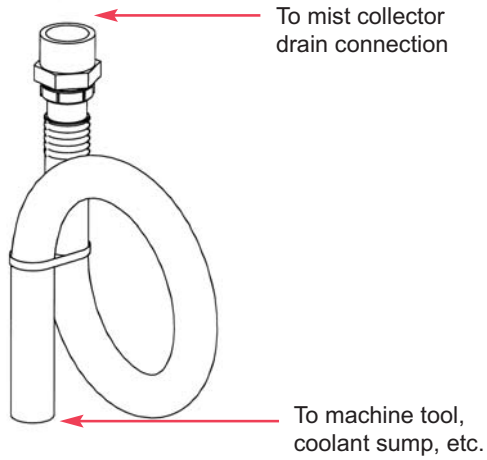
AT) P-Trap design

- Clearance under the P-trap will be required for installation and maintenance.
- These design parameters work for liquid specific gravities of 0.9 to 1.1. For specific gravities lower than 0.9 or greater than 1.1, contact the manufacturer of the mist collector or contact Donaldson Torit Applications Engineer for assistance (800-365-1331).
- 1 to 2inch diameter pipe is typically used for the P-trap.

Drain Hose with Loop

A drain hose, from 1 to 2 inches in diameter is another commonly used drain. The drain hose can be installed in two ways: loop or submerged.

A looped drain hose is installed by looping the drain hose into a 12 to 16 inch vertical loop and securing the loop using a zip-tie or other binding device. By filling the drain loop with coolant, a liquid barrier is developed that will prevent air from being pulled up the drain hose and ensure proper drainage of collected mist.



AU) Drain Hose w/Loop

Drain hoses that are installed with the drain loop should have the bottom of the drain above the liquid level that it drains into. If the bottom of the hose is submerged in liquid, you create a double trap condition that can prevent mist from properly draining.

For installations where static pressures of the fan exceed 10 inches H_2O, hose loops greater than 12-16 inches will be required.

Drain Hose without Loop

A drain hose without a loop is used when:

- The drain of the mist collector is under positive pressure (air flows out of the drain with collected mist), or
- The end of the hose is submerged in liquid (used in place of a drain loop).

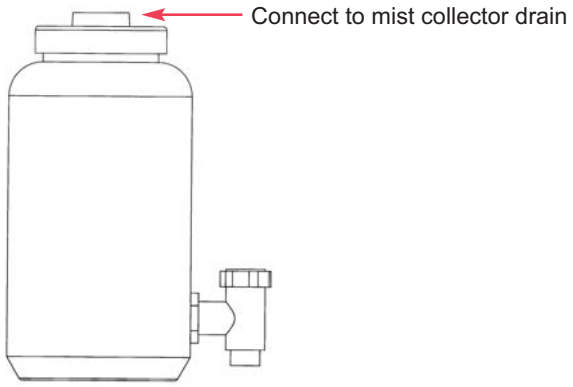
Drain hoses without loops are most commonly installed on centrifugal mist collectors as these drains are positively pressured and “blow” mist out of the drain. This type of drain should be installed so the drain hose runs downhill (positively pressured drains typically do not have enough pressure to push mist uphill).

When the drain hose is under positive pressure, never submerge the drain hose in liquid, as it will either back up with collected mist or bubble air through the collected mist and may generate airborne mist.

If you use a submerged drain hose system, it replaces a drain hose with loop or a P-trap. The drain hose should be installed such that when the mist collector is running, oil or coolant will be pulled up the drain line as high as the static pressure of the fan is capable of pulling, typically no more than 3 to 6 inches. It is recommended to submerge a drain line at least 6 inches, so that it never operates without enough liquid above the end of the hose. Should the hose become unsubmerged, the drain will not function properly and reduced filter life may result.

Drain Collection Container

A drain collection container or drain bottle is commonly used in applications where there is very little liquid expected to drain. Low amperage EDM machines and other light oily smoke applications are typically where these are used. The drain bottle creates a vapor lock and allows mist to flow into the bottle and displace the air. Simply screw a short connection piece between the drain bottle and the mist collector drain. When the drain bottle needs to be emptied, it's recommended to turn the mist collector off first.



AV) Drain Bottle

3H. Gaskets and Caulking

Gaskets & caulking are used in mounting the mist collector to a machine tool, between sections of ducting, and where sections of the collector itself are joined together. Using the proper gaskets and caulking is critical in preventing leaks.

While various **gasket** materials are available, NBR or Buna-N gasket material has been proven to be compatible with most oil and coolant mists used today.

- Note the adhesive used to secure the gasket onto the mist collector. Depending upon the adherence surface, such as a painted surface (enamel or powder paint) or unpainted surface (aluminum or galvanized steel), different gasket adhesives may be required. Check with your supplier of gaskets and adhesives for compatibility.

Caulk is another critical item that must be compatible with the mist you are collecting and compatible with the surface being adhered to.

- For enamel painted surfaces and non-painted surfaces, an RTV adhesive caulk will typically be sufficient.
- When working with powder painted surfaces, a synthetic rubber body seam sealer, similar to those used for automotive repairs, has shown great success.

When applying caulk, apply it to the surface in a continual bead. If you must stop and restart applying caulk, overlap where you stopped so there is no gap in which collected oil could make its way past the caulk. If there is a gap, it will show up as a leak.

4. Selecting the Right Mist Filter Media & Collector Configuration

Despite the different configurations of mist collectors available, it's the filter media that makes the mist collector perform the way it does. The packaging of the media in the filter and the design of the mist collector are important, but without media that is efficient enough, or without media that drains well enough, the mist collector will not meet your performance expectations.

4A. Filter Media Technology

Although most mist collector manufacturers only offer one media option for each mist collector, there are some important points to note regarding the different types available and how they are used in the filters elements. Mist collector media is made up of polyester fibers, glass fibers, or both.

Polyester fibers are the largest fibers used in mist collection. Filter materials made from polyester typically have these characteristics:

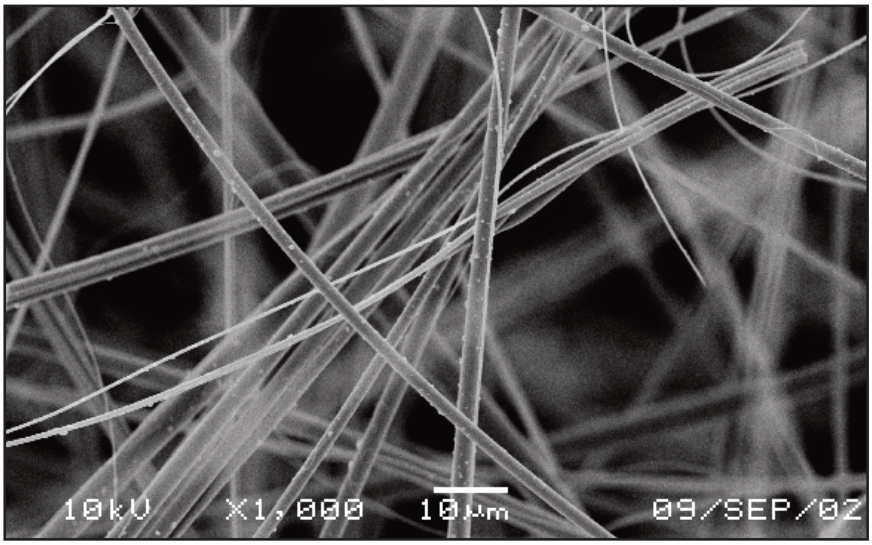
- Low efficiency.
- High storage capacity for solids.
- Relatively low cost.

The most common polyester filter you'll see installed is the outer wrap of a Donaldson® Torit® Dryflo® cartridge. It coalesces the heaviest mist droplets and quickly drains.

Glass fibers are the smallest fibers used in mist collection. To achieve high efficiency, fine glass fibers are used in filter materials. Glass is found in almost all mist collector filters, as it is what provides efficiency sufficient to remove some of the finest mist particles. The most common glass-based filter installed today is the vee-bag or multi-pocket filter used by most mist collection manufacturers. Glass fibers are bonded to a scrim material and sewn into bags.

Filters that are made up of all glass, although they have the highest efficiency, tend to have shorter filter life – the higher the efficiency of the filter, the more difficult it is for mist to drain. If you don't properly size and select the collector, filter life of weeks has been known to happen with glass-based media. Although glass-based filters can have high efficiencies, they have difficulty retaining their high efficiency because the glass fibers are typically not bonded to each other. Over time, the glass fibers get wet and start to sag, developing large holes in the media. Efficiency degradation up to 25% can occur from the time they are installed to the point where it is time to change them.

See photo AW, an image from the scanning electron microscope (SEM) of an all glass fiber media. You can see that nothing bonds the fibers together, and in the middle of the image the fibers have clumped together. Can you see how these fibers will move around as they get wet?



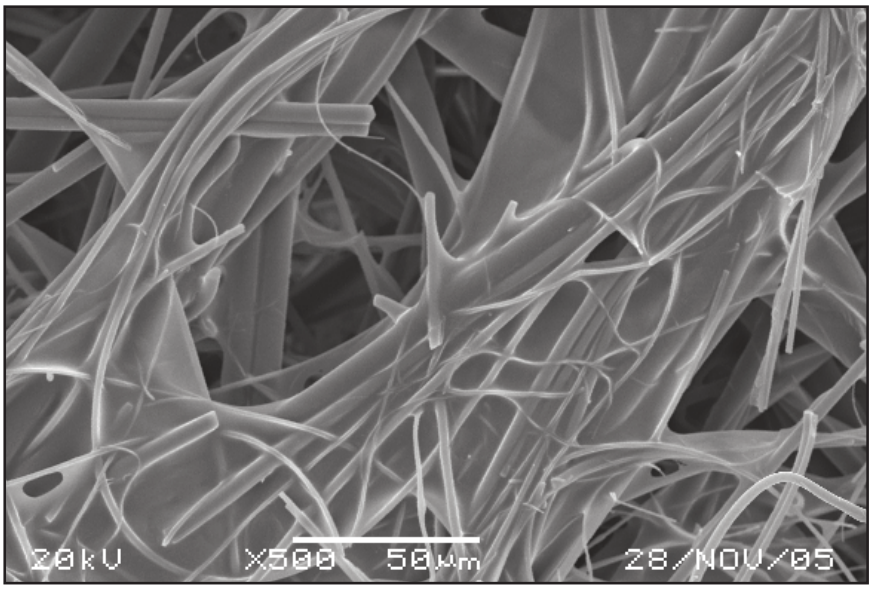
AW) SEM image of all glass filter media magnified 1000 times

The best performing mist collector filters use a combination of polyester and glass. As mentioned, polyester fibers are large and drain well, whereas glass fibers are small and provide high efficiency. Combined, they yield a filter with the benefits of both types of fibers – high efficiency and good drainage.

Polyester and glass have been combined since the late 1980's and were released to the mist filtration market in the 1990's in the Donaldson® Torit® Dryflo® product. Since then, other manufacturers have started offering similar filters.

The polyester and glass fibers are made into a paper-like material using a resin to bind the two types of fibers together. We know today that resins block a significant portion of the small glass fibers, reducing the potential efficiency and making mist drainage more difficult.

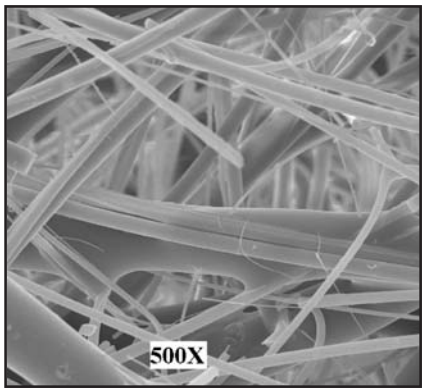
The SEM picture below (AX) of Donaldson Dryflo media clearly shows how the resin binds the fibers together and how it blocks airflow from passing through the smaller glass fibers.



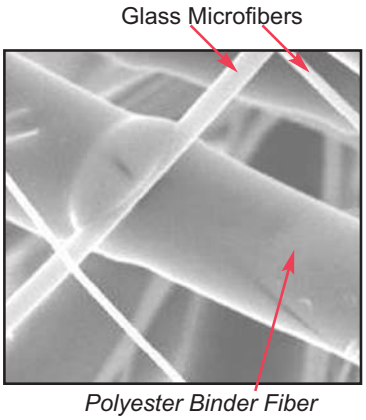
AX) SEM image of polyester/glass filter media at 500X shows resin "webbing" between fibers

In 2006, a new mist filtration media was released under the Donaldson brand name Synteq™ XP (patent pending). It's a combination of polyester and glass fibers that uses a special polyester fiber to bond the glass to the polyester without the need for resin or other binding agents.

In SEM (AY), you can see an example of Synteq XP magnified 500X and a zoomed-in image of how the small glass fiber is melted into the surface of the polyester fiber in SEM (AZ). This allows the small glass fibers to provide high efficiency while providing clear drain pathways for collected mist by way of the polyester fibers.



AY) Donaldson Torit Synteq XP filter media for liquid, magnified 500X



AZ) Donaldson Torit Synteq XP filter media – high zoom

Below is a comparison chart of different types of filter media and the mist collectors where they are commonly used. Besides efficiency and filter life, how the filter handles solids and chemical compatibility are important factors to consider.

Filter Media Comparisons

Media Type	Type of Mist Collector	Media Efficiency	Chemical Compatibility	Solids Handling	Filter Life
Lofted Glass	Vee-Bag Media Collector	Medium High	High	High	Medium
Lofted Glass Fibers (Matted)	Panel Filter	High	High	Medium	High
Polyester Fiber	Cartridge Prefilter	Low	Medium	High	Medium
Polyester Felts	Centrifugal	Medium	Medium	Low	Low
Polyester & Glass (Resin)	Old Cartridge	Medium	Medium	Low	Medium
Synteq™ XP Polyester & Glass (No Resin)	New Cartridge	High	Medium	Medium	High

BA) Filter media comparisons

4B. HEPA / 95% DOP Filter Media Technology

A HEPA filter or 95% DOP filter is used as a final filter in mist collection to:

- Provide high efficiency to meet local, state, federal, corporate, or union indoor air standards.
- Act as a back-up filter in the case the primary filter fails and mist bypasses through or around the primary filter.
- To filter smoke and fumes generated by the mist collection application.

On mist collectors, the use of a final filter may be optional or may be integrated into the design of the system.

What do HEPA and 95% DOP mean?

- A HEPA (High Efficiency Particulate Air) filter is 99.97% efficient at 0.3 microns.
- A 95% DOP filter is 95% efficient at 0.3 microns.

Each of these filters is tested using a dust called Dioctyl Phthalate (DOP). DOP is a dust made for filter tests; it is manufactured to have an average particle size of 0.3 microns. Counting and comparing the number of DOP particles upstream and downstream of these final filters allows an efficiency calculation.

Dust at 0.3 microns is used for testing because it is the most difficult particle size to filter out of the air. With thermally-generated mist, as well as solid smoke and fume particles less than 1 micron particle size, it is important to know that one of these two final filters may be efficient enough to remove the pollutant.

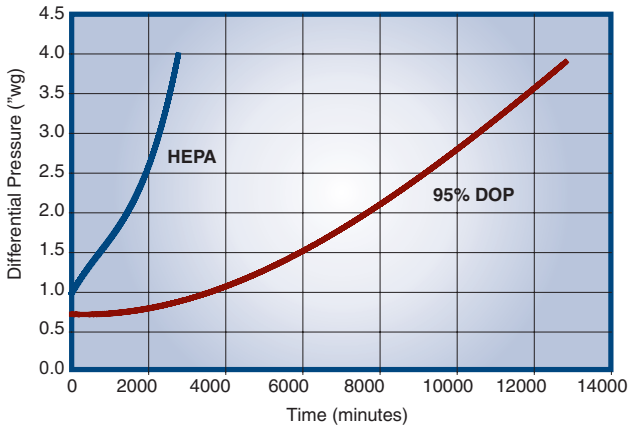
Experience has shown that a 95% DOP final filter may be sufficient as a final filter for most mist applications that need a final filter. Oily smoke has an average particle size of 0.7 microns and oil mist is the next largest particle size, typically 0.8 micron and larger. A 95% DOP filter starts at 95% efficiency at 0.3 microns, and becomes more efficient as you increase the particle size: a 95% DOP filter may be 98% to 99% efficient at 0.7 microns.

Combined with the efficiency of the prefilter and primary filter, mist collector systems using a 95% DOP filter may achieve 99.5% total removal efficiency or higher on most mist applications.

At this system efficiency, exhaust air out of a mist collector is expected to be below 1.0 mg/m^3, which is below the OSHA standard for oil mist, as well as below most union and corporate standards.

Since the early 2000's, the use of 95% DOP filters has become more popular. They provide high mist collector system efficiencies, cost about the same as a HEPA filter, and can achieve 3 to 5 times the life. The chart below shows the life comparison of the standard 95% DOP and HEPA filters manufactured by Donaldson® Torit®.

In a head-to-head test using submicron mist generators to simulate oily smoke and the finest oil mist, a 95% DOP filter outlasted a HEPA filter by 3 to 5 times. Not every application will see 5 times the life by switching from a HEPA to 95% DOP filter, but experience has shown that most applications can see over 3 times longer final filter life.



BB) HEPA vs 95% DOP

The primary reason for the longer filter life is that the 95% DOP filter media developed by Donaldson Company, Inc. was specifically designed to retain oily smoke while providing the longest life.

Lastly, 95% DOP filters are typically the same price or slightly cheaper than HEPA filters. These same filters are used in dust collection – but unlike mist collection, dust collection requires higher efficiency when handling certain potential carcinogenic dusts that can be smaller than 1 micron. For that reason, HEPA filters are more valuable in dust collection and provide mist collector customers an opportunity to purchase 95% DOP longer lasting filters at a reduced cost.

4C. Mist Collector Technology

Before selecting one type of mist collector over another, understand the functional aspects of each type of mist collector, as well as advantages and disadvantages when applied to different applications.

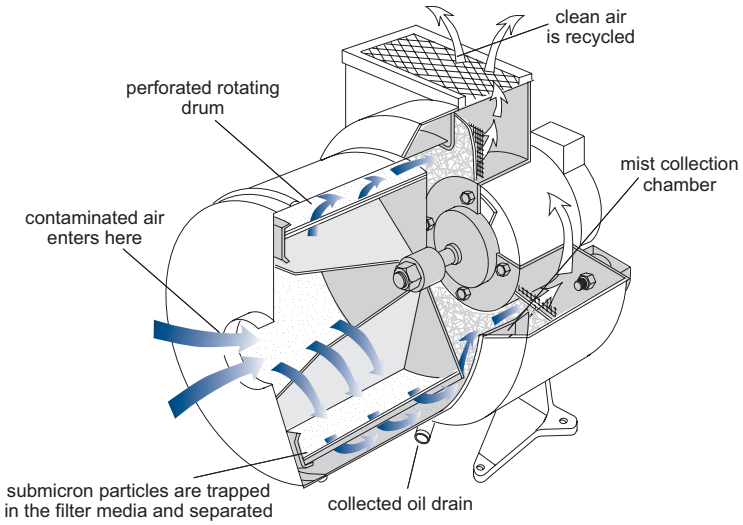
Centrifugal Mist Collector

The centrifugal mist collector is one of the oldest technologies used today for filtering mist. A derivative of the lube oil mist filtration systems developed for engine rooms of diesel submarines, the centrifugal mist collector is proven technology.

The centrifugal mist collector operates much like a clothes dryer:

- Mist-laden air enters through the inlet and directly into a rotating drum.
- The rotating drum, which also acts as a fan, has a filter inside that coalesces mist into large droplets.
- Centrifugal force pushes the large mist droplets out of the filter and towards the drain.

These systems usually have the option of a final filter for thermally generated mist and/or vapors: 95% DOP, HEPA, or activated carbon.



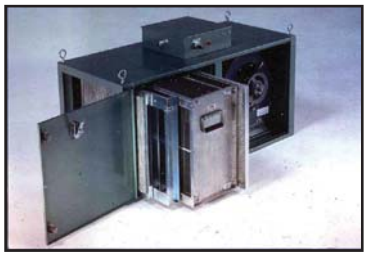
BC) Typical airflow path in a centrifugal mist collector

Advantages:
- Typically highly efficient on water-soluble and straight oil mist applications.
- Handles highest volumes of mist.
- Inexpensive filters.
- Small, easily machine mounted.

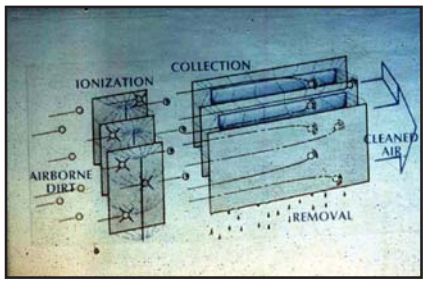
Disadvantages:
- Not recommended for applications where dust, grit, and swarf are collected as the rotating drum can experience balance problems, requiring a high degree of maintenance.
- Airflows under 1000 CFM only.
- Frequent filter maintenance.

Electrostatic Precipitators

The electrostatic precipitator operates in this manner:
- Mist-laden air is drawn through an ionizer that gives the particles either a positive or negative charge. (Picture BD)
- The charged particles then get captured by a collection cell that utilizes alternating positively and negatively charged plates to push/pull the charged particles onto a plate. The plates then drain the collected mist out of the system.



BD) Electrostatic precipitator, open to show the stages



BE) Electrostatic Technology Breakdown

Advantages:
- There are no filters to service or replace.
- Airflow doesn't decrease with use, as there are no filters to build up static pressure or plug up.
- Energy usage is relatively low.
- High efficiency when new and fully cleaned.

Disadvantages:
- Efficiency of an electrostatic precipitator steadily decreases from the time it's turned on to the time it is cleaned.
- Maintenance can be frequent after the first year of use. Maintenance on just the collection cell is not sufficient to maintain high efficiency.
- There are no gauges available to indicate when maintenance is required. Maintenance is typically done when mist is seen exiting the exhaust of the mist collector.

- If a collection cell charged plate ever becomes damaged, even with the slightest dent, an electric arc can occur, reducing efficiency.
- Maintenance staff may not be comfortable performing maintenance on a system that operates on 10,000 volts or more.
- Not recommended for water-soluble coolants because water can evaporate as air passes over the collected mist on the collection cell, leaving behind a layer of paraffin wax, which reduces the efficiency and increases maintenance.
- Not recommended for applications where metal dust, chips, and swarf will be collected, as arcing can occur between the collection cell plates.
- Designed only for light-to-medium mist quantities. Can be designed to handle somewhat heavier mist through the use of a second set of ionizer and collection cell (called double pass) or by adding prefilters to the system.

Mist Collectors with Panel Filters

A panel filter mist collector employs rectangular filters, typically 24 x 24 x 12 inches, and requires 2 or 3 filters of this size to provide a high efficiency system. These systems typically integrate a final filter, such as a 95% DOP or HEPA filter.

Advantages:
- High efficiency for the life of the filter.
- Long filter life.
- Designed for 24-hour-per-day operation.

Disadvantages:
- Multiple panel filters are expensive to replace.
- Doesn't handle solids well.
- May provide higher efficiency than required for the application, costing a higher initial cost.
- Filters can be heavy and may require more than one person to replace or require lift equipment.

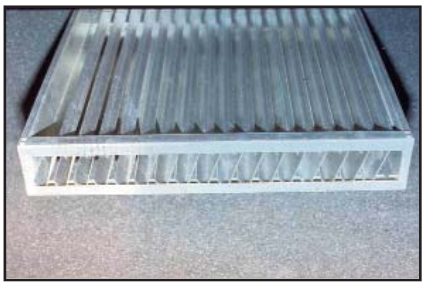
BF) Custom panel filter unit with optional prefilter and high static fan

Media/Vee-Bag Mist Collector

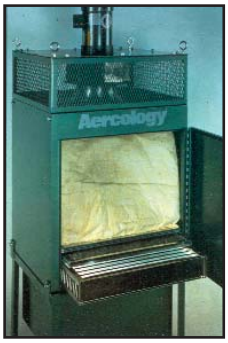
A vee-bag or media style unit utilizes a high-loft glass material sewn into bags or placed into small panel filters. These systems come with one or two prefilters – typically chevron-style impinger and a metal mesh prefilter. The metal mesh filter also acts as an air straightener before the primary filter.

Vee-bag technology has been around since the 1970's and is still widely used today. When properly sized and selected, vee-bags have high efficiency and long life. Of all mist collectors, these systems are the least forgiving when you increase the airflow above their design point. These systems have a reputation for short filter life or mist by-pass when they have been modified for more airflow than they were originally designed to handle.

BG) Vee-bag with loops to support bag



BH) Chevron-style impinger, used as a prefilter



BI) Internal view of vee-bag style mist collector

Advantages:

- Are the most versatile mist collectors, capable of handling mist applications with dust, grit, and swarf.
- Are typically designed in a modular format so that final filters, carbon adsorption filters, and additional prefilters can be added to handle just about any mist application, either first fit or retrofit.
- Low cost – you only need to purchase the filter modules that best fit your application.
- Can retrofit additional modules as the application changes.

Disadvantages:

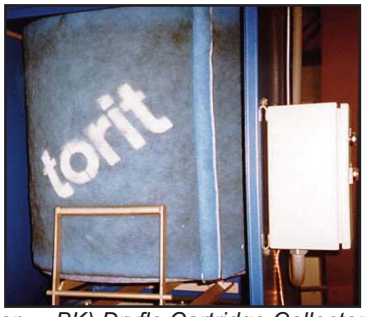
- Must de-rate airflow for 24-hour-per-day operation.
- Easily fails when pushed beyond designed airflow.

Cartridge Mist Collector

Cartridge style mist collectors have been around since the 1990's. These systems use a pleated filter media, rolled to form a round or oblong cartridge.

- The cartridges can hold plenty of filter media in a fairly small space, allowing the typical footprint of cartridge systems to be the smallest available.
- The media available is the older polyester/glass with resin bonding (Donaldson® Torit® Dryflo®) or the latest Synteq™ XP media (Donaldson Torit WSO). Synteq XP uses a polyester/glass combination, but without resin to provide the highest efficiency and longest lasting filters on the market.

BJ) Dryflo Cartridge Collector



BK) Dryflo Cartridge Collector

BL) WSO Cartridge Collectors

BM) Oblong WSO Filter Cartridge

Advantages:

- Highest efficiency
- Long filter life
- Smallest footprint
- Simple maintenance
- Application flexibility – multiple prefilters and primary filter choices, optional final filter

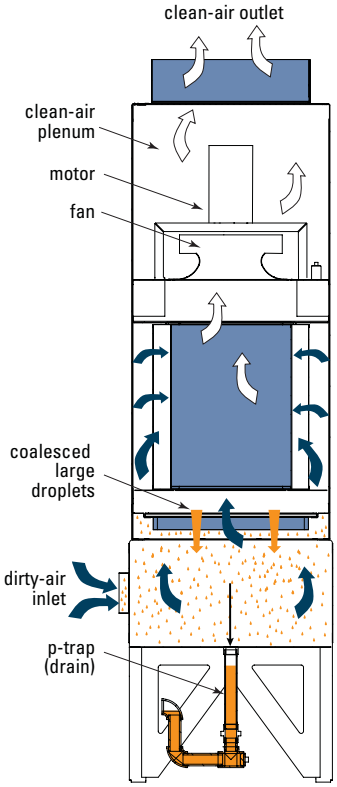
Disadvantages:

- Not for heavy dust or dirty mist applications
- Polyester fibers may not be suited for plasticizer mist applications

5. System Operation

Most mist collectors operate similarly, with the exception of the centrifugal mist collector. In all others, air enters at the bottom or in the inlet plenum, passes through one or more prefilters, through the primary filter (electrostatic precipitator: ionizer/collection cell), through a fan, and out the exhaust. A final filter such as a HEPA or 95% DOP may be included before or after the fan. The detailed diagram below is showing this airflow pattern through the Donaldson Torit WSO mist collector.

The installation and operation manual from the manufacturer of the mist collector will detail specific system operations for your mist collector.



BN) Internal view of vee-bag style mist collector

5A. Start-Up Procedures

After installing the mist collector and before turning it on, there are several steps that should be followed to ensure that it is ready for service. After the ducting has been installed, the motor starter and electrical controls have been installed and tested, and collector mounted securely, follow these steps:

1) Turn the system on and off. Check the rotation of the fan to ensure it is turning in the proper direction. If it turns backwards, significant reduction in airflow and static pressure will occur. (Have a certified electrician switch two of the three – 3 phase leads in the control box and recheck fan rotation.)
2) Check the drain system. Ensure that a drain system was connected. If using a P-Trap or drain hose loop, ensure these are completely filled with the oil or coolant being collecting with this mist collector. This will ensure that collected mist properly drains from the mist collector while operating.
3) Check all filters to ensure they are properly installed. If retention systems are used to secure filters in place, ensure the retention systems are in their upright and locked position.
   a. In assembling of the mist collector, especially larger systems, it's common to remove the prefilters and sometimes primary filter to make it easier to erect the system. HEPA or 95% DOP filters are sometimes omitted from the system during shipping to ensure these filters are not damaged.
4) Turn the system on and check that the pressure gauges are reading properly. If they read 0 or less, the gauge tubes may have been installed backwards and should be switched on the back of the gauge.
5) If you have a manometer and pitot tube, anemometer or other devices that measure airflow and static pressure, check the airflow and static pressure at the inlet of the mist collector to ensure the expected air volume and static pressure are available. There may be an obstruction in the ducting, filters not properly installed, or the fan may be running backwards. Make necessary corrections.

This completes the start-up procedures for most mist collectors. Check the installation and operation manual from the manufacturer for additional start-up procedures.

During the first few weeks of a newly installed mist collection, it is wise to monitor the filter pressure drop and airflow. If the pressure drop increases faster than expected or the airflow has significantly decreased, there is an obstruction in the system; filters are receiving a lot of dust, dirt, grit and swarf; or the system is not draining properly, causing mist to be re-entrained back onto the filter. Examine the filter, drain system, and ducting for signs of improper operation.

5B. Balancing the Airflow

When connecting a mist collector to two or more mist applications, it is important that the airflow be balanced so there is sufficient airflow for each mist application. Having too much airflow at one application can cause excess mist to be pulled in; whereas, too little airflow at another application might result in mist not being captured and polluting the air. There are two commonly-used methods for balancing airflow:

- Using **blast gates** or **dampers** to add resistance to one leg of a system such that the other leg has sufficient airflow.
- **Balance by design**, where static pressure is balanced in the system such that no blast gate or dampers are required. In mist collection, where dampers can leak if not properly installed, balance by design is recommended.

Proper procedures for balance by design and installing blast gates are found in Industrial Ventilation – A Manual of Recommended Practice, Chapter 5, American Conference of Governmental Industrial Hygienists, Inc.

6. Troubleshooting Common Problems

When you receive a new mist collector from the manufacturer, it will have an installation/operation manual that includes a basic trouble-shooting section at the end of the manual. Below are troubleshooting questions and answers that supplement the manuals you received with your mist collector.

Q: My filters require changing 2 to 3 times per year, where they use to be changed about yearly. Why?

- Are you using the original manufacturer's replacement filters or superior quality filters, or are you purchasing filters from a low cost, knock-off distributor claiming to supply filters of the same quality as the original manufacturer? If you purchase filters for 1/2 the price and get 1/3 to 1/2 the life, is it really a savings? Purchase filters from the original manufacturer and see if your filter life returns to original.

- Has your facility changed its operations from operating one shift per day to operating two? Operating twice as many hours per week will cause changing filters over twice as often. If you require less frequent filter changes, it will be necessary to install additional filtration systems, splitting the airflow between the existing and new systems.

- Has your facility changed to operating three shifts per day? Most gravity draining mist collectors are not designed for operating three shifts per day (continuous duty) unless they were originally designed and installed with that in mind. Mist collectors often need to have their airflow de-rated 33% to 50% of maximum design to provide acceptable filter life on continous operations. Contact the manufacturer of the mist collector to discuss continuous-duty requirements.

- Have you changed your process from using water-soluble coolant to straight oil? Straight oil, if delivered at pressures over 800 psi, used on very hot applications, or used on machines with high velocity through spindle nozzles, creates smaller mist particles than water-solubles. Smaller mist particles take longer to coalesce into large enough droplets that can drain, which will keep more mist on the filters longer, causing higher pressure drops. Smaller mist particles can also pass through the primary filter media and cause shorter life to the final filter, such as a HEPA.

De-rating the airflow down to 75% of the current airflow on the collector is recommended, if your primary filter requires replacing sooner than before. If your HEPA filter is plugging, try switching to 95% DOP final filters. For most mist applications, the 95% DOP will provide similar air quality and last 3 to 5 times longer. See Chapter 4, *HEPA/95% DOP Filter Media Technology*.

- Have you changed your process from using straight oil, synthetic, or semi-synthetic to a water-soluble coolant? Water soluble coolants and some semi-synthetic coolants contain up to 20% paraffin wax. As water evaporates out of the coolant, it leaves behind the paraffin wax that builds up on the filter media fibers, causing shorter life. This is most common in applications:
    a. Running less than 20 hours per day.
    b. Where the amount of mist collected varies constantly.
    c. Where the mist collector can run for more than one hour without any liquid mist collected.

  A warm water spray can re-liquefy the paraffin wax in some instances. Warm water spray is most helpful in restoring the primary filter of a centrifugal mist collector back to new. Another recommendation is to consider a machine tool interlock that turns the mist collector off when no mist needs to be collected.

- Are you machining different metal and metal alloys today that you were not previously doing or not previously doing much of? Harder metal alloys can create more heat, causing finer mist particles and smoke. This will cause primary filters to become more saturated with mist as smaller particles take more time to coalesce into larger droplets that can drain. Using a machine tool interlock to maximize “off time” of the collector to promote draining will improve primary filter life. If you have sufficient airflow, de-rating your collector to 75% of its current airflow will also increase the primary filter life. If your HEPA filter is plugging, try switching to 95% DOP final filters. For most mist applications, the 95% DOP will provide similar air quality and last 3 to 5 times longer. (See Chapter 4, *HEPA/95% DOP Filter Media Technology*)

- If you’re using straight oil, have you recently increased the coolant pressure? Higher coolant pressures, especially with straight oils, cause smaller and finer mist particles to be formed. This will cause primary filters to become more saturated with mist as smaller particles take more time to coalesce into larger droplets that can drain. Using a machine tool interlock to maximize “off time” of the collector to promote draining will improve primary filter life. If you have sufficient

airflow, de-rating your collector to 75% of its current airflow will also increase the primary filter life. If your HEPA filter is plugging, try switching to 95% DOP final filters. For most mist applications, the 95% DOP will provide similar air quality and last 3 to 5 times longer. (See Chapter 4, HEPA/95% DOP Filter Media Technology)

Q: I was expecting significantly longer filter life, but from first install, filter life has been extremely short.

- Is your mist collector machine mounted without ducting? Most machine-mountable mist collectors have a small diameter inlet connected to the machining center. This small diameter inlet may also be the same hole that collected mist drains through. If you calculate or measure the air velocity through that inlet. Any mist collected on the filter is unable to drain through an upward velocity of 5000 feet per minute. Solution: Add a hopper with legs or inlet option that separates the air inlet and drain. (See Chapter 3, *Drains*, for type of drain options available and how to install.) The short life caused by poor drainage is typically due to operating 24 hours per day without sufficient time to drain. A machine tool interlock installed between the machine tool and mist collector can significantly increase the filter life as it will provide more draining time.

- Was your system designed with machine tool connection velocities over 3000 feet per minute? Mist collection, when done on a fairly well-enclosed machine, is about mist containment – not sucking like a vacuum trying to capture every bit of large mist spray. A capture velocity below 2000 feet per minute at the machine tool will minimize the amount of mist captured, while still providing the same level of mist containment. Having less mist drawn into the ducting means there is less mist that the mist collector has to handle, which results in longer filter life. Solution: Increase the size of the pick-up point on your machine tool to provide a lower velocity inlet and modify your ducting as appropriate. The capture velocity of your hood at 2000 feet per minute or below should also be maintained for at least the first 5 feet of the ducting.

- Was your system designed with duct velocities greater than 3000 feet per minute? Once mist is captured in the ducting, you can either:
    a. Transport it at high velocity (ensuring that almost all of it will be airborne when it arrives at the mist collector).
    b. Slow the air velocity (so that a majority of the larger mist particles will settle out of the air and drain down the ducting). This can be done by increasing the size of your ducting such that the air velocity in the ducting is

between 2000 and 3000 feet per minute, averaging 2500 feet per minute throughout the entire system. Not only will less mist be airborne when it gets to the mist collector, but increasing the diameter of your ducting will decrease the amount of static pressure required to move the air and mist from the machine tool to the mist collector, allowing you additional static pressure for filter loading. Don't forget to slope the ducting a few degrees to allow any mist that drops out to run towards the machine tool or back to the machine enclosure. (See Chapter 3, *Ducting Do's & Don'ts* for recommended conveying velocities.)

- Is the spray generated by the machine tool being sprayed directly into the mist collector inlet? Or are there chips being thrown directly into the mist collector inlet? A mist collector is designed to contain the mist generated in the machine tool enclosure and only capture the smallest mist particles that would otherwise become airborne in the plant air when the machine tool is operating and when the primary access doors are opened just after machining. Solutions:
    a. Add a deflector to the pick-up point inlet to reduce the amount of spray and chips that can get directly pulled into the mist collector inlet. If there is not sufficient room, look for another location to install the mist collector inlet such that the spray and chips generated will not be pulled into the mist collector. (See Chapter 3 for *Hooding Designs and Pick-up Points.*)
    b. Contact the manufacturer and ask about higher efficiency prefilters that can remove more mist than your current prefilters remove.

- Are you using a water-soluble coolant? Water-soluble coolants and some semi-synthetic coolants contain up to 20% paraffin wax. As water evaporates out of the coolant, it leaves behind the paraffin wax that builds up on the filter media fibers, causing shorter life. This is most common in applications
    a. Running less than 20 hours per day.
    b. Where the amount of mist collected varies constantly.
    c. Where the mist collector can run for more than 1 hour without any liquid mist collected.

  A warm water spray can re-liquefy the paraffin wax in some instances. Warm water spray is most helpful in restoring the primary filter of a centrifugal mist collector back to new. Another recommendation is to consider a machine tool interlock that turns the mist collector off when no mist needs to be collected.

Q: Mist is passing directly through the filters, creating a visible emission at the discharge and/or creating a stain on the wall.

- Is your process generating a lot of heat, vaporizing the oil or water used in the process? Mist collectors cannot stop oil vapor or steam until it condenses to a liquid. For example, a parts washer with a hot drying cycle might see water vapor condense after the mist collector, when the heated moist air of the parts washer hits the cooler plant air and cools. **Solution:** Cool the airstream to below 104°F at least 15 feet before the inlet of the mist collector by drawing in cooler plant air through a "Y" or "Tee" fitting. See Chapter 1, *Handling Hot Airflow Applications,* for guidance on calculating how much airflow is necessary to cool hot process air.

- Was your mist collector designed to handle the airflow and duty cycle which you are currently operating at? If your process operating schedule has increased to 3 shifts per day or if the mist collector is not being shut off when not in use, the filters can become over saturated. Once they reach 100% saturation, any additional mist collected pushes mist through the filter and causes a visible emission. This is most commonly seen in vee-bag style units that are unforgiving when not designed properly. Even with filter static pressure drops reading less than 1-inch H_2O, saturation can be reached and visible emissions occur.

- Is your application generating smoke, but your mist collection does not have a final filter installed on it? Contact the manufacturer for recommendations on installing a 95% DOP or HEPA filter on your mist collector to handle smoke.

- Staining on a wall is not necessarily caused by the mist collector letting mist through the filters. Any fan that blows air will push ambient plant air around, and if the ambient air is not clean due to other sources of mist, smoke or dust in the plant, it will impact a wall or surface and may leave a visible stain after several months of operation.

7. Glossary

acfm – Actual cubic feet of air flowing past a fixed location in 1 minute.

ACGIH – American Conference of Governmental Industrial Hygienists.

Aercology, Inc. – A company purchased in 1997 by Donaldson Company, Inc. and integrated under the company's Donaldson® Torit® brand of industrial collectors.

Air, Standard (Conditions) – Dry air at 70°F and 29.92 in Hg barometer pressure; air density is 0.075 lb/ft^3 and specific heat is 0.24 BTU/lb-ft.

Air-to-Media Ratio – Refers to filtration velocity and is also called air-to-cloth ratio.

Ambient Air – The surrounding air of an environment, commonly referring to the air one would breathe. Also an Aercology ambient filtration system for light-to-moderate commercial or industrial applications.

Ambient Air Collection – Capture of contaminant-laden air from the general environment instead of at the point of contaminant generation through the use of closed loop, recirculating air patterns.

Ambient Air Collection Systems – Systems designed to capture contaminant-laden air from the general, ambient environment. Efficient systems are designed to create closed loop, recirculating air patterns for optimum contaminant capture. Also known as a free hanging or unducted systems.

Anemometer – Instrument used to measure the velocity of air.

ANSI – American National Standards Institute.

°C – Degree Celsius in the metric or SI system of units.

Carbon Filter – A filter used for collection of gas or vapor phase contaminants. Carbon filters can be in the form of filter media impregnated with carbon or as refillable trays or housings holding granular carbon. There are numerous types of carbon and impregnated carbons for specific contaminants with high quality, virgin, coconut shell carbon best suited for most general applications.

CFM – Cubic Feet per Minute.

Chevron Impinger – A filter assembly consisting of a series of metal plates fastened at an angle to the airstream. The plates have chevrons or inverted V's bent in the front and rear edge of the plate. The front chevron increases air velocity to increase impaction on the inner plate surface. If fluids are liquid, air velocity pushes collected liquids along plate wall into the V of the rear chevron where they drain from the filter.

CNC – Computer numeric controlled. It defines how a machine tool is programmed; it does not define the type of machine nor a specific brand.

Collection Cell – A series of alternately charged ground and positive plates assembled into a housing as a collection filter in an Electrostatic Precipitator system. Particles charged by the ionizer in the EP system collect on the ground or positively charged collection plates where they are removed by cleaning.

CPZ – A mixture of carbon, potassium permanganate (with or without activated alumina) and zeolite used for complex gas/vapor applications.

Cubic Foot – Unit of volume measuring 1 foot long by 1 foot wide by 1 foot high, or its equivalents.

δ – Density factor of air at different conditions, δ being 1 at standard conditions. The ratio of actual air density to density of standard air. The product of the density factor and the density of standard air (0.075 lbs/ft^3)will give the actual air density in pounds per cubic foot; d x 0.075 = actual density of air, lbs/ft^3.

Delta P (ΔP) – Pressure drop across a collector or media; i.e., the difference in initial and final pressures. (See also Pressure, Differential.)

Density – Ratio of the mass of a substance to the volume of the specimen.

Depth Loading – The collection of contaminant throughout the entire thickness of the filter media rather than on the surface.

Derate – To lower the rated capability of an electrical or mechanical apparatus. For example, derate the air-to-media ratio (or filtration velocity) for an application with high loading or requiring filter drainage. Donaldson Torit Modular MediaFilter™ systems are often derated to promote filter drainage on continuous operation mist collection systems.

Dielectric Oil – An oil that is a nonconductor of electricity used in EDM applications to flush debris away from the electrode.

DOP – Dioctyl Phthalate. A liquid used to test the efficiency of final filters at 0.3 microns, such as HEPA and 95% DOP filters.

DOP Efficiency Test – A filter efficiency test using dioctyl phthalate mist consisting of particles 0.3 microns in diameter as the test aerosol. The concentration of particles (by count) measured upstream and downstream of the filter determines the efficiency. This method is generally used to rate very high efficiency or "absolute" filters because of the small particle size of the contaminant and the very high efficiencies usually demanded (99+ percent).

Double Pass – Running two identical filters or filter modules in series to promote high collection efficiency or increased contaminant capacity.

Duct – Enclosed tube or passage for constraining air or gas flow within the enclosure until it is delivered to a desired destination, such as a collector or fan, or exhausted to atmosphere.

Ducted System – Typically a collection system utilizing ductwork or piping to convey clean or contaminant laden air to or from the unit.

EDM – Electrical Discharge Machine.

Efficiency – Filter efficiency measures how much contaminant the filter removes and is typically expressed as a percent of incoming dust removed.

Emulsify – Combining two liquids together that normally do not mix, such as oil and water. Requires an emulsifying agent (or emulsifier) to mix the two materials.

Entrainment – The phenomena of dirt being drawn into a moving airstream. Used in ambient systems to remove contaminants from the general air.

EPA – Environmental Protection Agency

°F – Degree Fahrenheit.

ft/min – Feet per minute, a measure of velocity.

ft^2 – Square feet, a measure of area.

ft^3/min – Cubic Feet of air flowing past a fixed location in 1 minute (cfm).

Filtration – The mechanical action of separating matter out of suspension, using a filter medium such as a cartridge filter or bag filter.

Filtration Velocity – Filtration velocity, or velocity of the airstream when it enters or passes through the filter media, often referred to as the air-to-cloth (A/C) or air-to-media ratio (AMR).

FPM – Feet per Minute.

HEPA – Acronym for high efficiency particulate air filter. To earn the HEPA rating a filter must have a minimum particle removal efficiency of 99.97% for all particles of 0.3 micron diameter.

HVAC – Heating, Ventilation and Air Conditioning.

Impinger – Set of louvers that cause air to flow in a tortuous path causing large liquid droplets and particulate to be removed from the air.

Inch of Water, in W.G.– Unit of pressure equal to the pressure exerted by a column of liquid water 1 inch high at a standard temperature.

Inlet Plenum – An air chamber, or add-on box, that serves as the air entry point, velocity reduction and air distribution system into the filtration system. Collars for ducting or piping are attached to the inlet plenum.

Ionizer – The component that charges particulate in Electrostatic Precipitator systems.

Junction Box – A box where wires and connections from electrical devices, typically motors, are located for easy accessibility by a field electrician. The junction box may be mounted on the collector and not act as a motor starter. However, a motor starter may easily be wired to a junction box.

Manometer – Instrument for measuring air or gas pressure. It is essentially a U-tube partially filled with a liquid and so constructed that the amount of displacement of the liquid indicates the pressure exerted on the sensing end of the manometer tube.

Mechanically Generated – Contaminants generated by mechanical movements such as coolant mist from rotating chucks, spindles, and heads. Mechanically generated contaminants tend to be larger than those thermally generated.

mg/m^3 – Milligram per Cubic Meter.

Micron – A measurement of size equal to the length of one millionth of a meter, or 1/1000000 meters. This length is also referred to as a micrometer, symbolized by µm.

Odor – A strong, distinctive smell. Odors can be airborne particulates or from gas/vapors.

OSHA – Occupational Safety and Health Administration.

Pitot Tube – A device that can be used to measure the velocity pressure in a duct and its corresponding volumetric airflow.

Pressure, Differential – Pressure drop across a collector or media, i.e. the difference in static pressure between the upstream and downstream sides of a collector due to the resistance of the filters.

Pressure, Static (SP) – Pressure exerted in all directions by a fluid at rest. For a fluid in motion it is exerted in a direction normal or perpendicular to the direction of flow. It is usually expressed in inches water gauge, and it can be positive or negative.

Racetrack Air Pattern – An arrangement of free hanging (or ambient) collectors in which the clean air from one unit blows into the dirty air inlet of another unit throughout a facility to create a circular, recirculating or racetrack air pattern. The air pattern entrains airborne contaminants and pushes them into the inlets of downstream units for removal.

scfm – Standard Cubic Feet per Minute. Standard conditions of temperature (68°F) and pressure (1 atmosphere).

Source Capture – The capture of contaminants at the point of generation prior to escaping into the workplace environment. This can be done with local exhaust systems or engineered air pollution control systems.

sp. gr. – Specific Gravity.

Static Pressure – The amount of pressure it takes to push/pull air through a filter, ducting, or mist collection system. Typically measured in inch H_2O, mm H_2O or pascals.

Swarf – Metal dust and debris from metal cutting operations.

Thermally Generated – Contaminants generated by thermal or heat. generating processes such as ultra-fine mist and smoke. Thermally generated contaminants tend to be smaller than those mechanically generated.

Vapor – Gaseous form of substances. They can be changed to a solid or liquid state by an increase in pressure or decrease in temperature.

Vee-Bag – A filter element with “v” shaped pockets. Also known as a pocket filter, typically with fiberglass media, available in various grades of efficiency.

List of Charts, Illustrations, & Tables

List of Charts, Illustrations, & Tables (continued)

List of Equations

Enclosed Machine Airflow Sizing

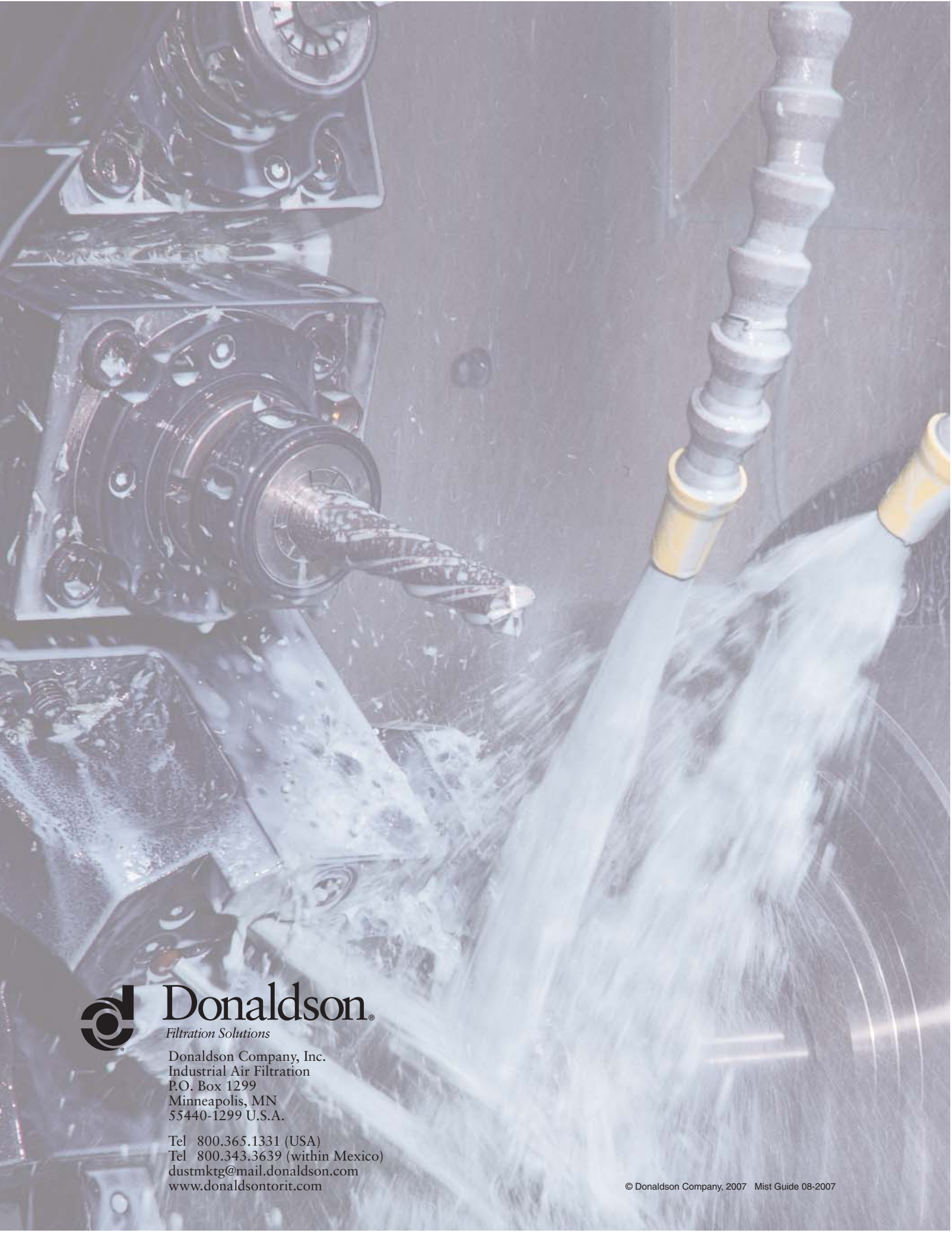
Handling Hot Airflow

Ambient Air Filtration

Ducted Hood

About Donaldson Company, Inc.
Donaldson is a leading worldwide provider of filtration systems and replacement parts. We are a technology-driven company committed to satisfying Customers' needs for filtration solutions through innovative research and development. We serve customers in the industrial manufacturing and diesel engine markets providing in-plant air cleaning, compressed air and gas purification, power generation filtration, disk drive filtration, and air, lube, and fuel filters for off-road equipment and on-road trucks. 11,500 employees contribute to the company's success at over 35 manufacturing locations around the world. Donaldson is a member of the S&P MidCap 400 Index and Donaldson shares are traded on the NYSE under the symbol DCI. Additional company information is available at www.donaldson.com. Donaldson Torit, the Donaldson division that designs & manufactures dust, fume and mist collectors, has been providing solutions to industrial mist applications for over 40 years and has sold over 75,000 mist collectors during that time. Looked to for innovative solutions by its customers, Donaldson Torit is the market leader in media development, filter performance, and delivering quality products to our customers worldwide. See products at www.donaldsontorit.com.

##



Donaldson®

Filtration Solutions

Donaldson Company, Inc.
Industrial Air Filtration
P.O. Box 1299
Minneapolis, MN
55440-1299 U.S.A.

Tel 800.365.1331 (USA)
Tel 800.343.3639 (within Mexico)
dustmktg@mail.donaldson.com
www.donaldsontorit.com