RoboVent
A Nederman Company

Complete Guide to Weld Fume Extraction

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Weld fume mitigation is essential for both robotic welding and manual welding. In this paper, we provide weld fume control strategies, including fume collection and air filtration options to protect welders from hazardous substances in weld fumes. The emphasis is on removing fumes from the breathing zone for welders and others working in the vicinity of welding operations. In addition, control strategies must be designed to ensure compliance with all relevant regulations, including worker health and safety regulations for indoor air quality and worker exposure and environmental regulations for air exhaust. The following represents current best practices and recommended strategies for weld fume removal.

What are weld fumes?

Weld fumes are a complex mix of oxidized and unoxidized metals, silicates, fluorides, welding gases and other materials, including solid particulate, vapors and gases[1]. Most of the solid particles that make up weld fumes are in the sub-micron range[2], which creates challenges for weld fume collection and filtration. For **MIG (GMAW), stick (TMAW) and flux-cored welding**, the majority of weld fume comes from the welding consumable (the welding wire or rod). But even **laser welding** and **resistance welding** can produce significant fume from base metals and coatings, especially if metals are galvanized, painted or contaminated with lubricants. The exact makeup depends on the welding process and materials used, but may include:

- Metals and metal oxides from base metals and consumables, including iron, aluminum, zinc, manganese, hexavalent chromium (hex chrome), nickel, beryllium, molybdenum, vanadium, cobalt and copper
- Silicates and fluorides
- Toxic metals such as cadmium, lead and chromates from paints and coatings or zinc oxide from galvanized metals
- Volatile organic compounds (VOCs) from paints, solvents and metalworking fluids (MWFs)
- Traces of shielding gases such as carbon dioxide, argon or helium

What Are the Health Risks of Weld Fumes?

Weld fumes are associated with many different kinds of health risks when inhaled[3]. Because particulates in weld fume are very small, they can be breathed deeply into the lungs, where they can cause lung damage or travel through the bloodstream and cause damage to other organs. Many of the substances found in welding smoke, such as hexavalent chromium, are considered to be carcinogenic. Other health risks include **manganism** (from manganese exposure) and other neurological disorders, kidney damage, chronic lung diseases, metal fume fever, and irritation to the eyes, throat, nasal passages and bronchial passages.

[1] Karlsen, J. T., Farrants, G., Torgrimsen, T., & Reith, A. (1992). Chemical composition and morphology of welding fume particles and grinding dusts. *American Industrial Hygiene Association Journal, 53*(5), 290-297.

[2] Brand, P., Lenz, K., Reisgen, U., & Kraus, T. (2013). Number size distribution of fine and ultrafine fume particles from various welding processes. *Annals of occupational hygiene*, 57(3), 305-313.

[3] OSHA (2013) Fact Sheet: Controlling Hazardous Fume and Gases During Welding, DSG FS-3647

What Are the Exposure Limits for Weld Fumes?

The Occupational Safety and Health Administration (OSHA) has set a Permissible Exposure Limit (PEL) for total weld fume concentration of 5 mg/m3 when welding mild steel, iron or aluminum. It also has set (usually much lower) exposure limits for individual compounds and elements commonly found in weld fumes, such as manganese, hexavalent chromium, nickel, lead and zinc. Employers are responsible for ensuring that worker exposure does not exceed the exposure limit over a shift. OSHA PELs carry the weight of law in the United States and can be enforced; exceeding these limits may expose employers to fines and sanctions. Employers should also be aware of recommended exposure limits set by industry organizations as best practices; these may be lower than the OSHA-regulated exposure limit.

- **OSHA:** OSHA exposure limits are known as permissible exposure limits (PEL), which are based on a time-weighted average (TWA) of exposure across an 8-hour work shift. PELs may be expressed in parts per million (ppm) or in mg/m3, depending on the material. For some materials, OSHA may also set a ceiling limit (C), which represents the maximum level an individual may be exposed to at any one time. Highly toxic materials may also have a lower Action Limit (AL); exposure above the action limit may trigger additional mitigation activities, such as medical surveillance. A complete list of OSHA PELs can be found at **www.osha.gov**, reference OSHA1910.1000. OSHA standards are set based on both health impacts and the technical feasibility of reaching the PEL. OSHA sets separate standards for the Construction and Maritime industries; all other employers will fall under the General Industry regulations.
- **ACGIH:** The American Congress of Governmental Industrial Hygienists sets recommended threshold limit values (TLVs) based on an 8-hour TWA. ACGIH has also set ceiling limit recommendations for some contaminants. ACGIH TLVs and ceiling limits do not carry the force of law but are considered to be best practices in industrial hygiene. These guidelines are set based on scientific research on health impacts of exposures without consideration of technical feasibility; they are often more stringent than the OSHA PEL.
- **NIOSH:** The National Institute of Occupational Safety and Health sets recommended exposure limits (RELs) for welding fumes, total particulates and individual weld fume constituents. They have also set ceiling limit recommendations for some contaminants. NIOSH RELs are not directly enforceable but are often used as guidelines by OSHA and other regulatory bodies when setting standards. NIOSH guidelines can be found in their "Pocket Guide to Chemical Hazards."

While only OSHA PELs are enforceable by law at a national level, organizations may wish to aim for the often more stringent guidelines provided by ACGIH or NIOSH in setting their internal standard as a way to "future-proof" their weld fume ventilation and air filtration systems. Organizations should also be aware that standards set by their state or local jurisdiction may be stricter than those set by OSHA; where national and state or local standards differ, the more stringent limit applies. It is always advisable to check for the most updated OSHA, state or local regulations when designing a weld fume mitigation strategy.

It is important to understand the composition of your weld fume when setting exposure levels. Weld fume composition will vary depending on the base metal, consumables, and any coatings or lubricants found on the base metal. For example, welding stainless steel produces dangerous hexavalent chromium compounds (chromium VI) not typically found when welding other materials. Welding fumes from galvanized metals, on the other hand, contain zinc oxides and, often, lead. For this reason, it is not sufficient to set an exposure limit for "weld fume" in general without understanding the constituents of the fume and their relative levels of toxicity. If you are not sure of the chemical composition of your weld fume, laboratory testing may be advised.

Table 1: Exposure Limits for Selected Weld Fume Components, General Industry

	OSHA PEL	NIOSH REL	ACGIH TWA
Chromium VI	0.005 mg/m3	0.0002 mg/m3	0.0002 mg/m3
Manganese Fume	5 mg/m3	1 mg/m3	0.02 mg/m3
Cobalt	0.1 mg/m3	0.05 mg/m3	0.02 mg/m3
Lead	0.05 mg/m3	0.05 mg/m3	0.05 mg/m3
Nickel	1 mg/m3	0.015 mg/m3	0.02 mg/m3
Cadmium	0.005 mg/m3	0.002 mg/m3	0.002 mg/m3
Aluminum dust (respirable fraction)	5 mg/m3	5 mg/m3	1 mg/m3
Titanium dioxide (total dust)	15 mg/m3	1.4 mg/m3 (fine) or 0.3 mg/m3 (ultrafine)	10 mg/m3

From OSHA.gov Permissible Exposure Limits – Annotated Table Z-1, January 2022. Check for updated national and local regulations and NIOSH and ACGIH guidelines when creating your facility plan.

Welding Fume Control

General Principles

Weld fume can be controlled through exhaust ventilation or air filtration. Regardless of the method used, the goal is the same: to reduce the concentration of weld fumes within the breathing zone below the exposure limit set by the facility. This is done by removing contaminated air and replacing it with clean, fresh air.

- In an exhaust system, contaminated air is simply vented to the outdoors. A makeup air system is generally required to bring clean, fresh air into the facility and maintain adequate pressures.
- In an air filtration system, air is captured and filtered to remove contaminants before returning the air to the facility or exhausting it to the outside. A collection system equipped with a filtration method (e.g., a dust collector) is used to clean the air.

For either exhaust ventilation or air filtration, air may be collected using source capture methods or through general (ambient) capture.

- In a source capture system, air is collected close to the point where contaminants are generated. Some applications can be enclosed under a hood to contain weld fumes and enable efficient fume capture. For manual welding, welders may utilize a fume arm, backdraft table or a weld torch with built-in fume extraction at the tip (fume gun).
- In a general or ambient system, air is cleaned or ventilated for the entire facility. Typically, this is achieved by removing large volumes of air and replacing it with clean air. This is also known as dilution ventilation.

Best Practice

Generally speaking, a source capture system using air filtration is the preferred method for collecting weld fume. A source capture system keeps weld fume out of the breathing zone and prevents it from contaminating the rest of the facility. Filtration systems are preferred over exhaust systems because they prevent contaminants from polluting the environment and keep warmed or cooled air inside the facility, reducing energy waste. We'll take a closer look at the alternatives in the following pages.

Exhaust Ventilation

An exhaust ventilation system uses fans to pull air out of the facility. Exhaust ventilation systems can be either general (ambient) or local (source capture).

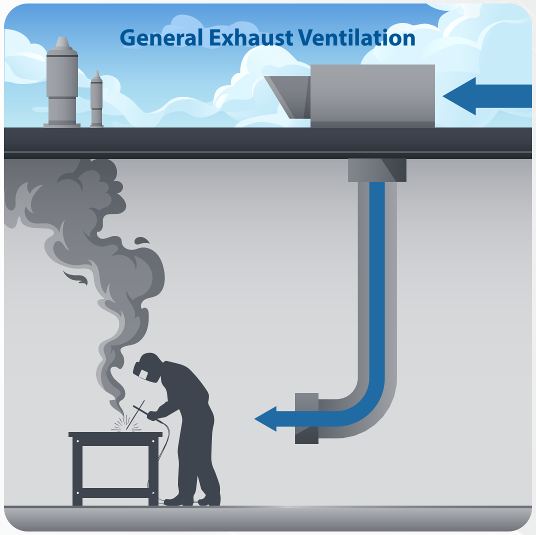
- **General exhaust ventilation:** General exhaust ventilation is used to turn over air for the whole facility or a large zone. Exhaust ventilation uses fans to pull contaminated air out of the building. To maintain pressure, there must also be a source of fresh makeup air coming into the facility. This can be accomplished by simply opening windows or ventilation shafts or by installing a makeup air system, which uses fans to mechanically pull fresh outdoor air into the building. Exhaust fans are usually placed in the ceiling or high in the walls to pull contaminated air up and out of the building, while the makeup air system may be positioned to push air in at a lower level. This creates a rising airflow pattern in the facility that continually pulls dirty air up and away from the breathing zone and maintains a supply of fresh air where people are working.
- **Local exhaust ventilation:** Local exhaust ventilation is used to capture and remove emissions from point emission sources. Like general exhaust ventilation, it simply exhausts air to the outside. Source capture may be achieved by any of the methods described below, including hoods, backdraft tables or fume arms. However, these source capture methods are much more commonly used with air filtration.

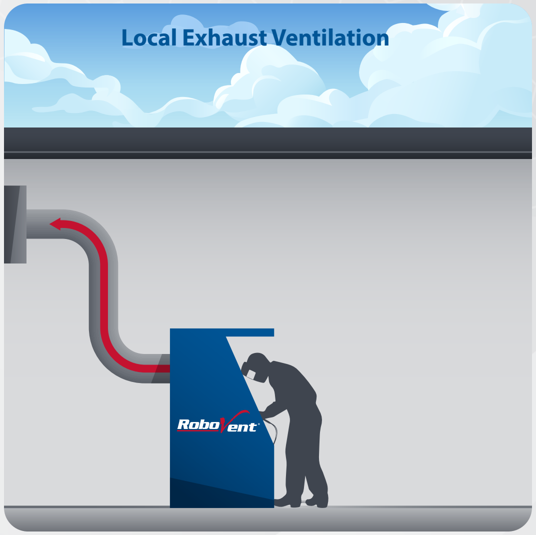
An exhaust system works on the dilution principle; rather than cleaning the air, it is simply designed to dilute concentrations of contaminants below the PEL by mixing in plenty of fresh air (at least 2,000 CFM of air for each welder). A general exhaust ventilation system may be appropriate in spaces where:

- overall emissions are low;
- emissions are evenly distributed throughout the space and cannot be easily contained; and/or
- workers are not working in the immediate vicinity of the emission source.

Natural ventilation (e.g., windows, doors, passive venting) is usually not adequate for welding operations. OSHA regulations allow the use of natural ventilation only if:

- welding is not done in a confined area;
- the welding area has at least 10,000 cubic feet of air per welder (roughly 22′ x 22′ x 22′);
- the ceiling height is not lower than 16 feet; and
- cross ventilation is not blocked by equipment, partitions or structural barriers.





Exhaust ventilation has some significant downsides, however.

- Exhausting weld fume to the outdoors may put the facility out of compliance with environmental regulations, especially if fume concentration levels are high.
- An ambient exhaust system will not keep weld fumes out of the breathing zone; welders may still be exposed to levels higher than the PEL near welding processes even if indoor air quality for the facility as a whole is within regulatory guidelines.
- Exhaust ventilation systems use more energy than air filtration systems, especially if indoor air must be heated or cooled. Exhausting conditioned air to the outdoors and bringing in unconditioned outdoor air drives up energy costs and puts added strain on HVAC systems.

Air Filtration Method

Where possible, it is recommended that facilities use air filtration to clean contaminated air. Cleaned air may be returned to the facility (if certain conditions are met) or vented to the outdoors. An air filtration system for welding and other industrial contaminants usually uses a dust collector or wet collection system to filter contaminated air; the HVAC system alone is not adequate to provide filtration for weld fumes and other manufacturing emissions. An air filtration system may be used for either general (ambient) or local (source capture) air filtration.

OSHA has several criteria for recirculating filtered air within a facility[4], which include:

- An air cleaning/filtration system must be used to provide continuous and reliable collection of contaminants.
- The system must use filtration suitable to the type and volume of contaminants and remove as much of the contaminant as technically feasible.
- Return air must bring contaminant levels down below PELs for all toxic materials.
- The system must have fail-safes to ensure that air is not recirculated if the equipment is malfunctioning.
- Employees must be properly trained in the use of air filtration equipment.

A dust collector captures and filters contaminated air. The dust collector can be ducted to a hood or other source capture system. The type shown here is a cartridge-style dust collector. *[Source: RoboVent]*

Air Filtration Systems

Weld fume is most commonly captured using either an industrial dust collector (dry filtration) or a wet filtration system (wet scrubber). There are several types of dust collectors, including baghouse, cyclone and cartridge-style. Wet collectors may also be used; these are typically used when the dust is combustible. Cartridge-style dust collectors are by far the most commonly used type for welding and fabrication.

[4] OSHA (OSHA Technical Manual Section III: Chapter 3)

Source Capture

A source capture system collects contaminants from close to the source where they are produced. This may be accomplished via the use of hoods or enclosures that contain fume-producing processes or localized capture methods (such as fume arms) that pull weld fumes in as they are produced to prevent propagation through the facility. Source capture is considered to be a best practice for weld fume collection and is preferred wherever possible. A source capture system consists of the following basic elements: a capture hood, duct system, fan (blower) and exhaust ductwork. In a filtration source capture system, the hood is ducted to a dust collector that captures and filters the air to remove contaminants.

Source Capture Methods:

Robotic Welding

For robotic welding, the entire process can be contained under a large hood or enclosure. Weld fumes are contained within the hood and exhausted or collected by a dust collector or wet filtration system. The hood should be designed to contain the particulate within the cell and not allow it to escape into the facility. No employees should be working inside the hood.

The hood for robotic welding should be designed to minimize the amount of air that must be moved. It should also prevent fugitive fume from escaping the enclosure. If the robotic process cannot be fully contained under an enclosure, an overhead capture hood that collects rising fumes may be used. Hood design is an important element of the overall efficiency and effectiveness of the system.

The hood is ducted to a dust collection system that captures and filters particulate. The dust collector must maintain capture velocities that prevent fume from building up inside or under the hood.

In some cases, the robotic welder may be equipped with a tip extraction hood that collects a majority of weld fume as it is created at the weld seam. This can be a useful alternative if the welder cannot be easily enclosed under a hood or if overhead cranes or other equipment are required. The amount of fume collected by this method may vary depending on the welding process and the way the robot moves. In some cases, it may be desirable to combine a tip extraction system with an ambient system to collect fugitive fume.

Best practice

Collect weld fumes close to the source and minimize the amount of air that needs to be moved to reduce energy costs and keep fumes away from the welder's breathing zone.

Source Capture Methods:

Manual Welding

Source capture for manual welding must pull weld fume away from the breathing zone of the welder. For this reason, the large hoods and enclosures used for robotic welders are not appropriate for manual welding. There are several source capture options for manual welding.

Backdraft tables/booths: A backdraft (or sidedraft) table or booth uses an intake plenum that is positioned to pull weld fume back and away from the welder's face. The plenum may be combined with a work surface or booth for an all-in-one workstation and weld fume collection system. Backdraft tables are a good choice for smaller weldments that fit on the work surface. Unlike fume arms, they do not require any repositioning. Backdraft tables may be ducted to a separate dust collector or may integrate filtration right into the unit.

Note: *Downdraft tables, which pull air down rather than up, are not generally recommended for weld fume; because weld fume rises, downdraft tables may miss a portion of fume that rises beyond the reach of the extraction system before it can be collected.*

Fume extraction guns/torches: A fume gun (or extraction torch) combines fume collection with the welding torch itself. A fume gun has a small hood integrated into the tip of the weld torch, which is attached via a hose to a dust collection system. The best fume guns may capture between 90-95% of weld fume at the source; however, actual capture rates will depend in part on the technique used by the welder and the position of the torch. Hood position and airflow velocity for the capture system must be carefully calibrated to ensure efficient capture without disrupting the shielding gases. A fume gun can be a good option for large weldments or enclosed areas where other methods of source capture are impractical. Used correctly, it ensures efficient fume capture with little or no effort on the part of the welder and little or no impact on weld seam quality or welder comfort. Fume guns are only used with MIG welding.

Hi-Vac Extraction: Fume guns, fume arms and individual welding stations may be ducted to a hi-vac extraction unit for dust collection and filtration.

Fume arms: Fume arms are mobile arms with a small hood on the end that is positioned over the weld seam. It is important to ensure that the fume arm is always correctly positioned to pull weld fume as it is created; this may require the welder to reposition the arm several times if working on a larger piece. Fume arms are a practical and flexible source capture option that can be used with either smaller tabletop pieces or larger weldments.

Considerations in Source Capture System Design

When designing a source capture system, there are several considerations to keep in mind.

Capture method: Make sure the capture method is appropriate for the type of welding (e.g., manual vs. robotic) and will keep weld fumes away from the welder's face and areas where people are working.

Filtration system: In most cases, a source capture solution is ducted to a filtration system (e.g., a cartridge dust collector or wet collector) to filter the air and collect particulates for proper disposal. This may be a single dust collector for each individual node (e.g., a robotic weld cell, fume arm, backdraft table, etc.) or a centralized system that collects fume from multiple nodes. Small portable dust collectors may be used with individual fume guns or fume arms, and some systems combine the hood and dust collection system in one unit (e.g., a backdraft table or fume arm with integrated dust collection). Filter media should be chosen to capture the small particulate in weld fume; typically, this will require filters rated at MERV 15 or above (see below, Filtration).

Hood design: Using a smaller enclosure or collecting fume closer to the generation source/weld seam will minimize the volume of air that must be moved for efficient capture, which will reduce energy requirements and costs for fume collection. When using source capture methods such as fume arms, the distance between the fume source and the capture hood should be no more than one times the duct diameter.

Air velocity: Air velocity must be calibrated to ensure efficient capture of fume without disrupting the shielding gases. Air velocity will depend on the rate of capture you are aiming to obtain. Typically, the velocity at the weld source needs to be around 150 FPM; this is the velocity needed to influence the direction of the weld fume and prevent fume from escaping. Higher velocities waste air and risk disrupting the shielding gases and causing porosity in the weld. There is a balance between capture rate and weld quality which is important to maintain when using source capture. For hoods and enclosures, the velocity at all of the openings should be equivalent to the capture velocity of the particulate.

Fugitive fume: If the hood or enclosure does not fully capture all weld fume, a secondary ambient air filtration or general ventilation system may be needed to remove the remaining fume. Fugitive weld fume commonly results from improper positioning of a fume arm, the use of smoking/cooling bins for cooling parts, or fumes rising from hot weld seams after a fume arm or fume gun has been repositioned.

Ambient Air Filtration Method

Ambient air filtration may be used as a stand-alone weld fume solution where source capture is not possible or as part of a hybrid solution that includes both source capture and general/ambient filtration. Ambient air filtration eliminates the need for ductwork, enclosures or source capture hoods. It also minimizes interference with the shielding gases while welding. However, like general exhaust ventilation, ambient air filtration does not prevent weld fumes from entering the breathing zone and may not adequately protect welders from weld fume exposure. In addition, it requires turnover of large volumes of air, which can be very energy intensive. For these reasons, source capture is advised where possible.

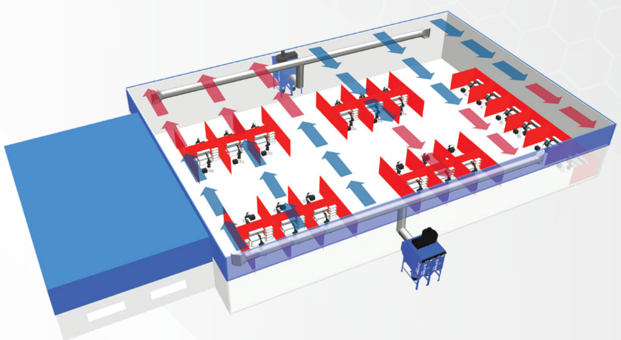
Ambient Configurations

Ambient air filtration systems are designed to create airflow patterns in the building that continually move contaminated air toward the collection system and filtered air back into the breathing zone. There are several common configurations for an ambient system.

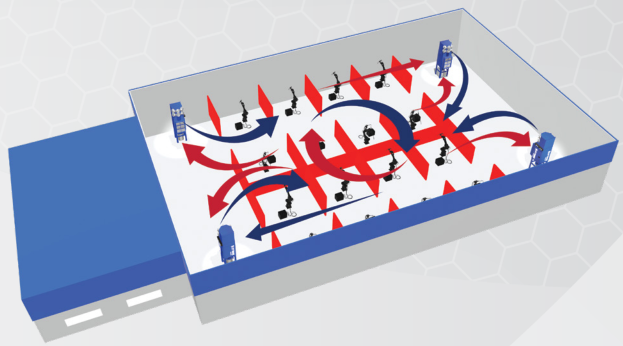
Considerations in Ambient System Design

- **Air changes:** An ambient air filtration system turns over all of the air in the room or facility on a regular basis. There must be enough air changes per hour to remove contaminants as they are being generated and prevent buildup to undesired levels. Depending on the volume and type of contaminants present, this may require a minimum of 10 to 25 or more air changes per hour to maintain desired indoor air quality and meet regulatory requirements.

- **Filtration:** Filtration in the general air cleaning method must be chosen to capture the sub-micron particulate present in weld fumes as well as any noxious gases and vapors present. See below for filter media recommendations. **See page 12 for filter media recommendations.**



Push-pull configuration: This configuration uses a series of parallel ducts to move air in a linear pattern near the ceiling. This pattern can also be achieved with a series of ductless dust collectors mounted near the ceiling or on sidewalls. Welding fumes naturally rise as they are generated, allowing them to be captured by ceiling-mounted ducts or collectors.



Circular configuration: This method uses a series of floor-mounted dust collectors with directional intake and exhaust plenums that are positioned to create a circular airflow pattern.

Overhead capture: A large stationary capture hood can be placed directly over the welding operation to capture fumes as they rise.

Filtration Types to Filtration Methods

The filtration system must be equipped with filters capable of removing the very small particulate created by thermal processes such as welding. Particle size distribution for welding depends on the welding process, but particles are largely in the 60-200 nm (0.06 – 0.2 micron) range, though they can cluster together into complex chains or structures in the 5-10 micron range[5]. Weld fume particulate may also be mixed with larger particles from co-existing processes such as cutting or grinding and environmental contaminants such as dust, pollen and mold spores. For most applications, it is recommended that the filtration system be capable of removing 85% or more of the smallest particulate; when working with highly toxic materials such as hexavalent chromium (produced when welding stainless steel), a capture rate of 95% or greater may be advisable. Always check with your local regulations to ensure that the filtration system reduces contaminant levels below the required PEL; air quality testing may be advised after the system is in place to ensure that the filtration system is adequate for the level and type of fume produced.

Filter Ratings

A majority of dry particulate filters are rated using the MERV (Minimum Efficiency Reporting Value) rating system, which assigns values of 1 – 16. The filter's MERV rating tells you how efficiently it captures particulate within different size bands (3 – 10 microns, 1 – 3 microns and 0.3 – 1.0 microns). The higher the MERV rating, the more efficiently the filter captures smaller particulate.

Above MERV 16, filters are classified as High-Efficiency Particulate Air (HEPA) filters. HEPA filtration may be advised when welding stainless steel or materials with coatings that produce highly dangerous contaminants.

Filter Rating	0.3 – 1.0 microns	1.0 – 3.0 microns	3 – 10 microns
MERV 13	Less than 75%	90% or better	90% or better
MERV 15	85-94%	95% or better	90% or better
MERV 16	95% or better	95% or better	90% or better
HEPA	99.97% or better	99% or better	99% or better

Best practice

For weld fume, we recommend a rating of at least MERV 15 for general weld fume and a rating of MERV 16 or higher when welding stainless steel.

These filters are not rated to capture liquids or gas-phase contaminants. A molecular filter, such as activated carbon, will be needed if capture of gas-phase contaminants is required.

ANSI/ASHRAE Standard 52.2 provides testing requirements for air filters, which are used to determine the MERV rating. Results of independent testing should always be obtained to ensure that filters meet system requirements.

[5] Brand, P., Lenz, K., Reisgen, U., & Kraus, T. (2013). Number size distribution of fine and ultrafine fume particles from various welding processes. *Annals of occupational hygiene*, 57(3), 305-313.

Filtration Types

Mechanical Filters

Both MERV and HEPA filters remove dry particulate using mechanical filtration. Particles are captured by the fine fibers of the filter media through a combination of direct impact/interception, electrostatic attraction/sieving and diffusion. Both cartridge dust collectors and baghouse dust collectors utilize mechanical filtration. Filters for cartridge-style dust collection systems come in a variety of ratings, typically starting at MERV 11 all the way up to MERV 16.

For welding, it is recommended to choose filters with a higher MERV rating (MERV 15 or above). For a progressive filtration solution, the dust collector may be fitted with a pre-filter at the intake and HEPA or activated carbon after-filters.

Most HVAC filters also rely on mechanical filtration (though some may be impregnated with activated carbon or use electrostatic filtration). In general, it is not recommended that companies rely on the HVAC system for weld fume removal. If the primary dust collection system is able to reduce weld fume contamination below acceptable levels, no special consideration may be needed for HVAC filter selection. If the HVAC system is required to collect fugitive fume left by the primary dust collection system, HVAC filters should also be MERV 15 or higher.

Best practice

Cartridge dust collectors are an optimal choice for most welding operations due to their range of filter media options (including high-efficiency filters), smaller size per CFM, and energy efficiency.

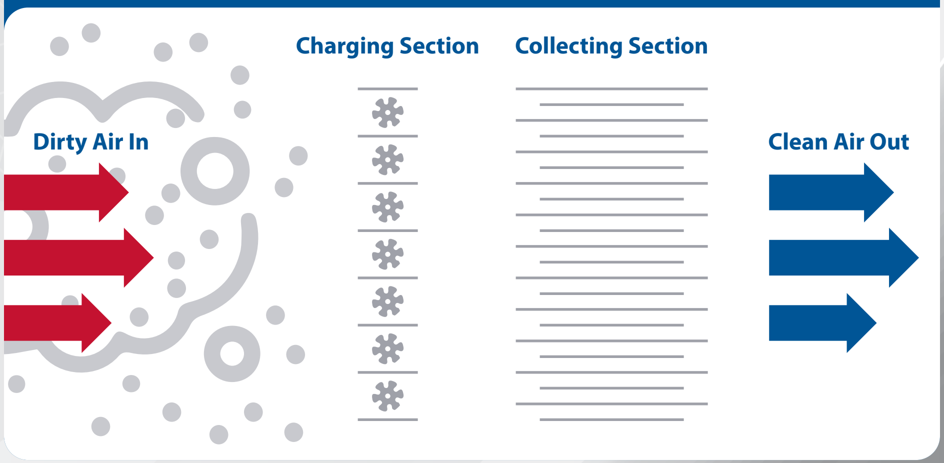
Water Scrubbing

In some cases, wet collection systems may be advised. Wet dust collectors ("scrubbers") use water droplets to filter dust. Air is drawn in through a blower system and passes through a fine mist of water droplets. Particulates are captured when they come into contact with the water droplets, which are then collected in a settling tank to separate out the solids from the liquid water. These systems may be recommended when working with highly combustible materials such as aluminum or titanium.

Electrostatic Precipitator

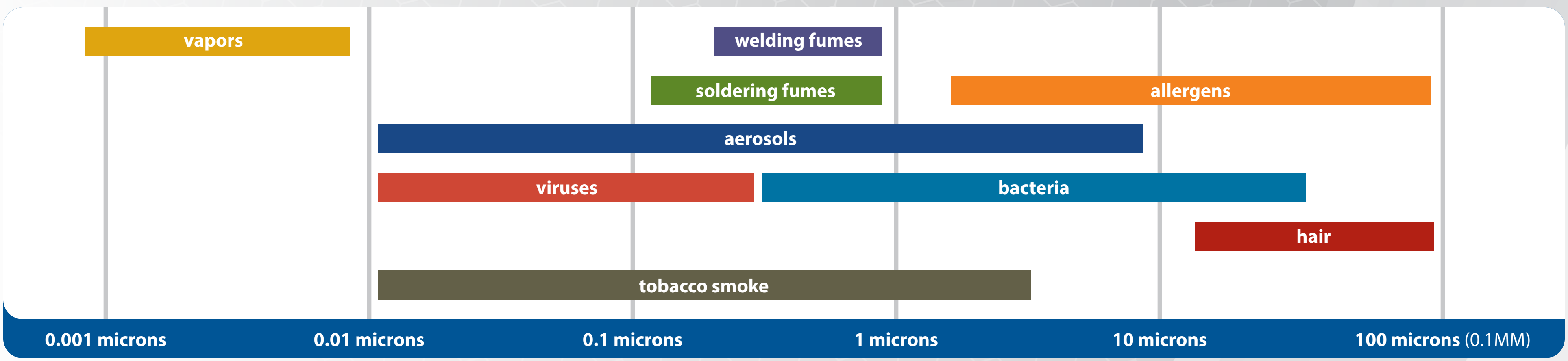
Electrostatic precipitators are not typically used for weld fume collection due to the large volume of fume created during welding. They are more commonly used for collection of cigarette smoke or diesel exhaust. These devices use ionization to create charged air within the collector, which imparts a charge to incoming particles. As particles move between plates with opposite charges, they are attracted to the plates and pulled out of the airstream. Filtration efficiency depends on several factors, including air velocity, collector plate spacing, the cleanliness of the plates, and the magnitude of ionization. They require a high level of maintenance to keep collector plates clean, which makes them less than ideal for weld fume collection. A double-pass system with two sections of collector plates may be needed for complete particle capture.

Typical Two-Stage Electrostatic Precipitator



Molecular Filtration

Molecular filtration is used to capture gas-phase and vaporous contaminants that may be present in weld fumes, such as VOCs or shielding gases. Molecular filtration may or may not be required as part of the weld fume collection strategy; typically, this will only be used if high levels of noxious gases or vapors are present along with the dry particulate in the weld fume. The most common type of molecular filtration used for welding and metalworking is activated carbon. Activated carbon works by adsorption, in which molecules are attracted to the surface of the material and held by chemical or physical bonding. Activated carbon and other adsorptive materials have thousands of "micropores" to maximize the available surface area for adsorption. Specialized materials may be used to remove specific molecular contaminants.

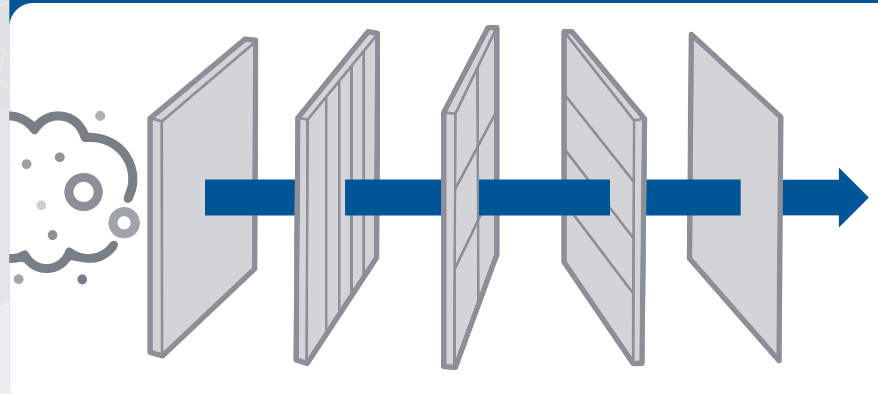


Progressive Filtration

In a progressive filtration system, multiple filters are used, each having a higher efficiency rating than the previous. This allows larger particles to be removed by lower-priced filters, extending filter life for filters with higher efficiencies. Progressive filtration may be desirable when weld fume is mixed with coarser dust from other processes, such as metal grinding. For example, a MERV 6 filter may be used as a first-stage disposable filter to remove the larger particles, followed by a MERV 15 filter to remove fine contaminants. When welding materials containing chromium, nickel, or other highly toxic and regulated substances, a HEPA filter may be recommended for final filtration. If gas-phase or vaporous contaminants are present, a molecular filter such as activated carbon may also be used. Progressive filtration may also be achieved by using a cyclone dust collector for first-stage filtration before passing air into a cartridge dust collector. A typical filter stack for progressive filtration may be:

- Washable metal mesh spark arrestor and/or centrifugal spark arrestor
- Cartridge, pocket or cell-style dry filters
- Molecular filter (e.g., activated carbon)
- HEPA after filter

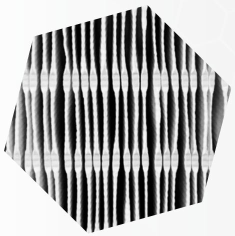
Progressive Filtration



Considerations for Filter Media Selection and Configuration

When choosing filters for weld fume collection, there are several considerations.

Pressure drop: There is a tradeoff between filter efficiency and energy requirements for the dust collection system. Higher efficiency filters require more energy to push air through; this is experienced as pressure drop across the filters. High-efficiency filters will also become loaded more quickly, resulting in higher pressure drop and higher energy use. Only choose higher levels of filtration (e.g., HEPA) if required for the application.



Available filter media area: Cartridge filter design comes into play in determining how much filter media is available to trap weld fumes. Cartridge filters are typically pleated, which allows more filter area to be backed into the cartridge. Filter pleat design can impact how much of the media is actually available and how easily dust can be pulsed off the filter.

Media types and coatings: Cartridge-style dust collectors may offer a range of different filter media types. For weld fume, a cellulose/polyester blend or microfiber media may be used. While not strictly required for dry weld fume, filter coatings (e.g., PTFE or nanofiber) can help to shed dust from the cartridge more efficiently. This reduces filter loading and extends filter life. Coatings may also be recommended if collecting oily particulate, such as weld fume mixed with vaporized metalworking fluids.

Filtration efficiency: When designing the air filtration system, choose the filter that reduces weld fume to acceptable levels and meets PEL requirements. In most cases for weld fume, that will mean a MERV 15 filter or higher.

Operation and Maintenance of Air Filtration Systems

An air filtration system must be properly installed and maintained to ensure that expected results are achieved. This includes:

- System commissioning and validation
- Appropriate filter selection and installation
- Regular filter changes
- Maintenance of the collection system

Operation and maintenance requirements will depend on the type, make and model of the filtration system; always follow the recommendations provided by your owner's manual for your equipment. The recommendations below are only a general overview.

System Integrity and Validation

System integrity is essential to ensure that the dust collection system is performing as expected. No matter what type of air filtration system you are using, proper setup, commissioning and system validation will be required. This includes:

- Proper design of the system, including sizing and placement of the collectors, hood and ductwork design for source capture solutions, and analysis of airflow patterns for ambient systems
- Setup of the filtration device(s) (e.g., dust collector or wet scrubber) according to manufacturer's specifications
- Calibration of the system (airflow velocities, etc.) to meet capture rate requirements
- Validation and testing to ensure that expected capture rates have been met and resulting air quality meets requirements

Dust Collector Installation, Operation and Maintenance

An air filtration system must be properly installed and maintained to ensure that expected results are achieved. This includes:

- System commissioning and validation
- Appropriate filter selection and installation
- Regular filter changes
- Maintenance of the collection system

Operation and maintenance requirements will depend on the type, make and model of the filtration system; always follow the recommendations provided by your owner's manual for your equipment. The recommendations below are only a general overview.

System Set-up and Validation

Proper setup, commissioning, and system validation will be required for any dust collection system. This includes:

- Proper design of the system, including sizing and placement of the collectors, hood and ductwork design for source capture solutions, and analysis of airflow patterns for ambient systems.
- Installation of filters according to manufacturer's specifications.
- Calibration of the system (airflow velocities, etc.) to meet capture rate requirements.
- Validation and testing to ensure that expected capture rates have been met and resulting air quality meets requirements.

Installation of Filters

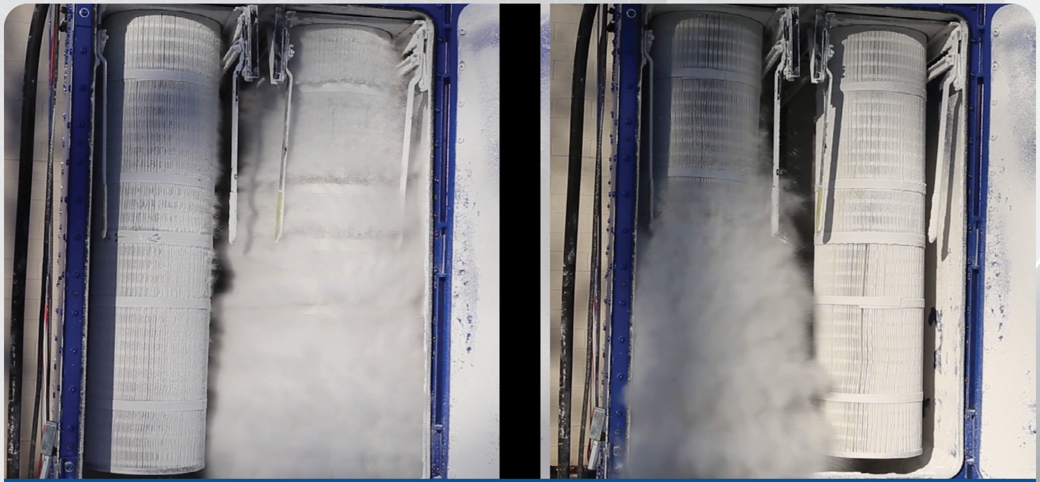
Always follow the manufacturer's instructions for your dust collector when installing or replacing filters, and use filters that are designed to the specification of the manufacturer. Using improperly fitting filters or improper installation of filters may result in leaks of contaminants past the filter cabinet, which may put the facility out of compliance.

Spark Control

If welding takes place near the system intake or ductwork, it is advisable to have a method of spark arrestance to prevent a stray spark from igniting the filters. A spark arrestance system may consist of a metal mesh screen, a series of baffles, or a device that extinguishes sparks using centrifugal force to prevent live sparks from reaching the filter chamber. They may be installed inline with the ductwork or at the intake for the dust collection system. Other types of spark detection and suppression systems utilize sprinklers or small bursts of moisture to combat sparks.

Screen-type spark trap

Centrifugal spark arrestor



With Pulse Nozzle | Without Pulse Nozzle

Filter-Pulsing Systems

Some dust collectors are equipped with a filter-pulsing system to extend the life of the filters. The pulsing system uses a jet of air at regular intervals to pulse excess dust off the filters and into the collection bin. A filter pulsing system can significantly increase filter life and reduce maintenance requirements. A coated filter may enable more efficient pulsing.

Safety Systems

The dust collector should be equipped with safety systems to ensure continued safe operation and protection from dust collector fires and explosions. The specific requirements are determined by OSHA regulations and standards set by the National Fire Protection Association (NFPA). When collecting combustible dust, the dust collector must conform to system design standards outlined in NFPA 652, NFPA 68 and NFPA 69. **(Read more: Are Weld Fumes Combustible?)** The exact requirements will depend on the characteristics of your weld fume and the specific hazards in your facility, but may include some or all of the following.

Deflagration system:
If your dust is combustible, the dust collector may need to be equipped with explosion vents and a deflagration system in accordance with NFPA 68 and 69.

Particulate monitor:
The dust collector should be equipped with a particulate monitor to detect leaks past the filter chamber. An auto-stop function should shut down the system if a leak is detected.

Fire/smoke detector:
The dust collector should have a fire/smoke detector that will sound an alarm if a fire is detected in the filter chamber. For maximum safety, the detection system may also be connected to a damper system that shuts off airflow and/or a fire suppression system.

Fire suppression system: The fire suppression system may consist of a water sprinkler system, a carbon dioxide (CO_2) system, or a clean-agent gas fire suppression system.

Dust Collector Maintenance

Preventive maintenance is essential to ensure proper continued working of the dust collection system. Maintenance activities and schedules will depend on the type of dust collector you have and the volume of fume you are collecting. For a cartridge-style dust collector, standard maintenance activities include:

- **Drum/bin emptying:** In a cartridge collector, collected dry particulate falls off the filters and into a tray or bin for collection. When the tray or bin becomes full, it must be safely emptied and dust must be disposed of in accordance with local regulations.
- **Cartridge filter changes:** Filters should be changed on a schedule recommended by the manufacturer or when pressure drop across the filter chamber raises by a certain level (specific to your dust collector), indicating that filters have become loaded.
- **Spark arrestor cleaning:** Mesh-style spark arrestors must be cleaned frequently to avoid buildup of soot from weld fume. Centrifugal spark arrestors should also be cleaned and inspected periodically to remove dust collected in the dust trap or any buildup on the interior walls.
- **Filter pulsing system:** Check the pulsing system on a regular basis to ensure that it is operational and the compressed air valves have not become clogged.
- **Ductwork:** Ductwork should be inspected and cleaned on a regular basis to prevent buildup of potentially flammable particulate inside the ductwork.
- **General inspection and repair:** Regular PM should include inspection of all parts (fans, belts, motor, etc.) to ensure proper operation, and worn or damaged parts should be replaced.

Watch RoboVent's Preventitive Maintenace video

Filter and Collected Dust Disposal

Check with local, state, and federal regulations for guidelines on disposing of loaded filter media and collected dust from welding operations, especially if the dust contains toxic byproducts of welding such as chromium, lead or manganese. Safety precautions should be taken by employees when handling dirty filters or emptying dust bins.

- Care should be taken to avoid creating dust clouds when emptying bins for disposal. A vacuum system should be used to clean up any spilled dust.
- Employees should be provided with personal protection equipment (PPE), including gloves, protective eyewear and N95 masks to avoid breathing in or directly touching dust during filter changes and bin emptying.

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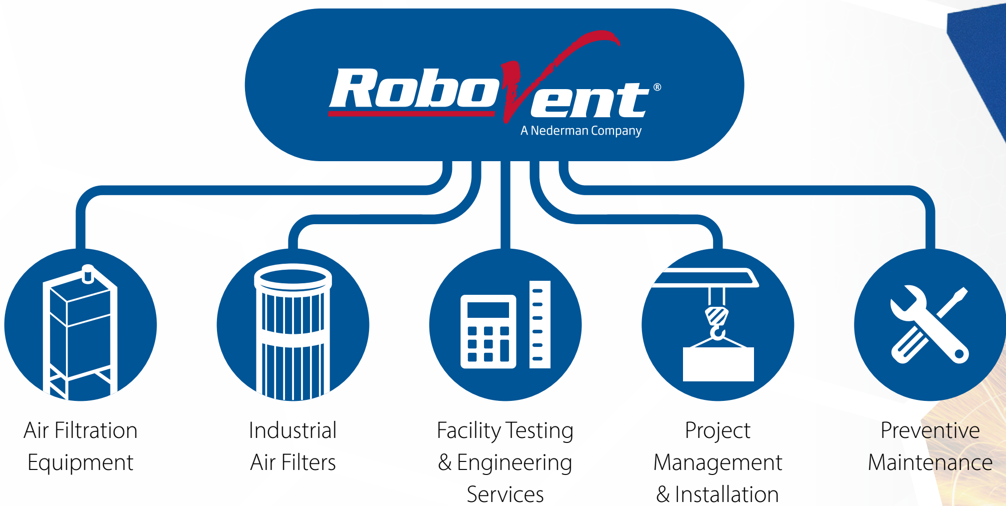

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