A publication of the Fabricators & Manufacturers Association, Intl.®

Fume management in heavy fab operations

Proper reconnaissance, planning, and equipment investment can help a heavy fabrication shop manage dust and fumes.

Figure 1
Maintaining a clean work environment in a shop that specializes in heavy fabrications can be difficult because of the sheer size of some of the projects. But with proper testing of the indoor atmosphere, planning, and understanding what needs to be accomplished to keep employees safe and meet regulatory requirements, a shop can create a fume management system that meets its goals. Photos and graphics courtesy of Camfil APC.

Metalworking facilities engaging in large-scale fabrication must be diligent in controlling hazardous dust and fumes that contain harmful metal particulate from processes such as welding, thermal cutting, sanding, and polishing. To maintain a clean work environment (see **Figure 1**), fumes must be captured, contained, and removed from the air, and the clean air returned indoors or, in some cases, exhausted outdoors.

A well-designed and maintained dust and fume collection system will properly filter fumes and other hazardous contaminants generated during heavy fabrication. These systems prevent respiratory problems and keep facilities in compliance with current air quality requirements. Air filtration also helps to keep controls and other computerized systems free from damaging dust and fumes. In facilities where air can be filtered and recycled, it can minimize the need for costly makeup air.

Any heavy fabrication facility looking to create a fume management program should follow the seven following steps before investing in fume management equipment.

1 Order a Dust Hazard Analysis

Performing a dust hazard analysis is the best way to evaluate your facility's risk of employee exposure. Get to know your dust by completing dust explosivity testing, having an industrial hygienist or environmental engineering assessment performed, and conducting a dust analysis to identify all characteristics of the dusts you generate.

The Occupational Safety and Health Administration's (OSHA's) General Duty Clause, Section 5(a)(1), stipulates that an employer is responsible for identifying and abating hazards in the work place. OSHA is an excellent resource and provides guidelines on hazard identification and assessment.

2 Explore Explosiveness and Flammability Testing

National Fire Protection Association (NFPA) standards 652, 654, and 484 require a combustible dust hazard analysis (DHA) to assess risk and determine the necessary fire and explosion protection. OSHA requires employers to have records identifying the dust generated in fabricating activities. Facilities producing combustible dust during their processes must complete a DHA by the fall of 2020 and demonstrate reasonable progress toward completion of the DHA in each of the years approaching the deadline.

The first step in a hazard analysis is determining whether your dust is explosive. The results found in your dust explosivity testing should include the Kst and Pmax, which indicate the amount of pressure an explosion can generate and how fast it can travel, respectively. NFPA classifies dusts according to explosibility in terms of their Kst values and by type (organic or metal) (see **Figure 2**).

Kst is the normalized maximum rate of explosion pressure rise, measured in bar m/s. A bar is a metric unit of pressure that is slightly less than the average atmospheric pressure on earth at sea level. Your dust collection equipment supplier needs the Kst and Pmax values at a minimum to correctly size explosion venting or suppression systems.

3 Conduct an Industrial Hygiene Assessment of Employee Exposures

To identify and control harmful exposures to dust and fumes, you need to conduct an industrial hygiene assessment. It's important that your assessment includes, but not be limited to, the following OSHA permissible exposure limit (PEL) items: iron oxide, lead oxide, manganese, nickel, chromium, respirable dust, and total particulate.

Ask your dust collection equipment supplier to recommend an industrial hygienist or environmental engineering company experienced in identifying dust and fumes specific to heavy fabrication facilities.

Combustible Dust Classifications

Dust Explosion Class	Kst	Characteristic
St 0	0	Not explosible
St 1	<200	Weak to Moderately Explosible
St 3	200-300	Strongly Explosible
St 4	>300	Very Strongly Explosible

Figure 2
The National Fire Protection Association organizes combustible dust classifications from "not explosible" to "very strong explosible."

4 Prioritize Dust by Hazard and Quantity

In addition to conducting explosibility testing and industrial hygiene assessment, it is important to analyze other dust characteristics to determine the best dust collection system and filters for your heavy fabrication operation. Key dust properties include particle size, dust shape, gravity, moisture level, and abrasiveness. Understanding these components lend to the optimal design of dust-control equipment.

Dust collection equipment suppliers often can conduct this type of dust testing and work with you to specify the best system for your application. Dust sample bench testing is an excellent tool to better understand the physical properties of your dust, which forms the basis for equipment selection. To create a complete picture of your operation, the testing laboratory should ask for detailed application data. OSHA maintains a list that identifies hazardous chemicals commonly associated with welding, cutting, and brazing operations, with links to more specific information on sampling and analysis.

5 Create Facility Air-quality Goals

Part of your management program should include creating air-quality goals based on guidelines found in Industrial Ventilation: A Manual of Recommended Practice for Design from the Association Advancing Occupational and Environmental Health (also known as ACGIH, the American Conference of Governmental Industrial Hygienists) and OSHA regulations regarding the PEL for various metals, particularly where workers are at risk for long-term health effects.

Review the results from your industrial hygiene assessment, OSHA guidelines, explosive dust testing, and dust analysis. Prioritize based on your dust hazard, making efforts to source-capture the high-hazard and high-dust producers when possible. As you explore solutions to capture each dust, evaluate these methods in order: source capture (fume arms, bench hoods, and hoods), enclosures, overhead hood, and—when these are not practical—ambient ventilation.

If you are recirculating the cleaned air, you'll need to keep below OSHA PELs for contaminants. If you are exhausting the air outdoors, you are subject to the Environmental Protection Agency (EPA) National Emission Standard for Hazardous Air Pollutants (NESHAP) Rule 6x. Within this standard are materials that contain 1 percent by weight manganese or 0.1 percent by weight cadmium, chromium, lead, or nickel. If you opt to exhaust the air outdoors, you must perform an EPA Method 22 Fugitive Emission test per NESHAP Rule 6x. The test is conducted using a visual determination of fugitive emissions from exhaust sources and performed by a trained observer.

Addressing employee concerns by listening, observing, and questioning your workers is an important part of an assessment. They can let you know if current engineering controls are effectively managing dust and fumes at the facility and suggest areas for improvement in processes and equipment.

6 Isolate High-hazard and High-quantity Dust/Fume Sources

The best way to reduce workers' exposure to hazardous dusts and fumes is to install a dust collection system with high-efficiency primary cartridge-style filters and secondary safety monitoring filters. It is preferable to capture fumes and dust at their source to prevent them from expanding throughout the plant. This is accomplished by incorporating extraction arms, hoods, or enclosures into the process application. Source capture is extremely effective.

Once high-hazard and high-quantity dust and fume sources are identified, they should be isolated from the rest of the facility and contained in a specific area. These areas can be designed to be kept under negative pressure. The extracted air is either drawn directly into a local collector or ducted to a dust collector located remotely. Often the filtered air can be safely returned into the facility to create an airflow pattern to improve the contaminant control.

7 Consult with Fellow Manufacturers and Authorities

Networking with peer manufacturers in your industry is another way to discover processes, equipment, and vendors to help you manage dust and fumes. Also consult with professional associations and certification groups. Ask your authority having jurisdiction, such as Factory Mutual or local fire marshals, for their safety guidelines.

When selecting an air pollution control supplier, look for one that is experienced in heavy metal fabrication applications; is knowledgeable about OSHA, NFPA, and EPA requirements; and has the technical resources to develop an engineered solution. The supplier also should offer a full range of equipment to give unbiased advice on the right type of system for your facility.

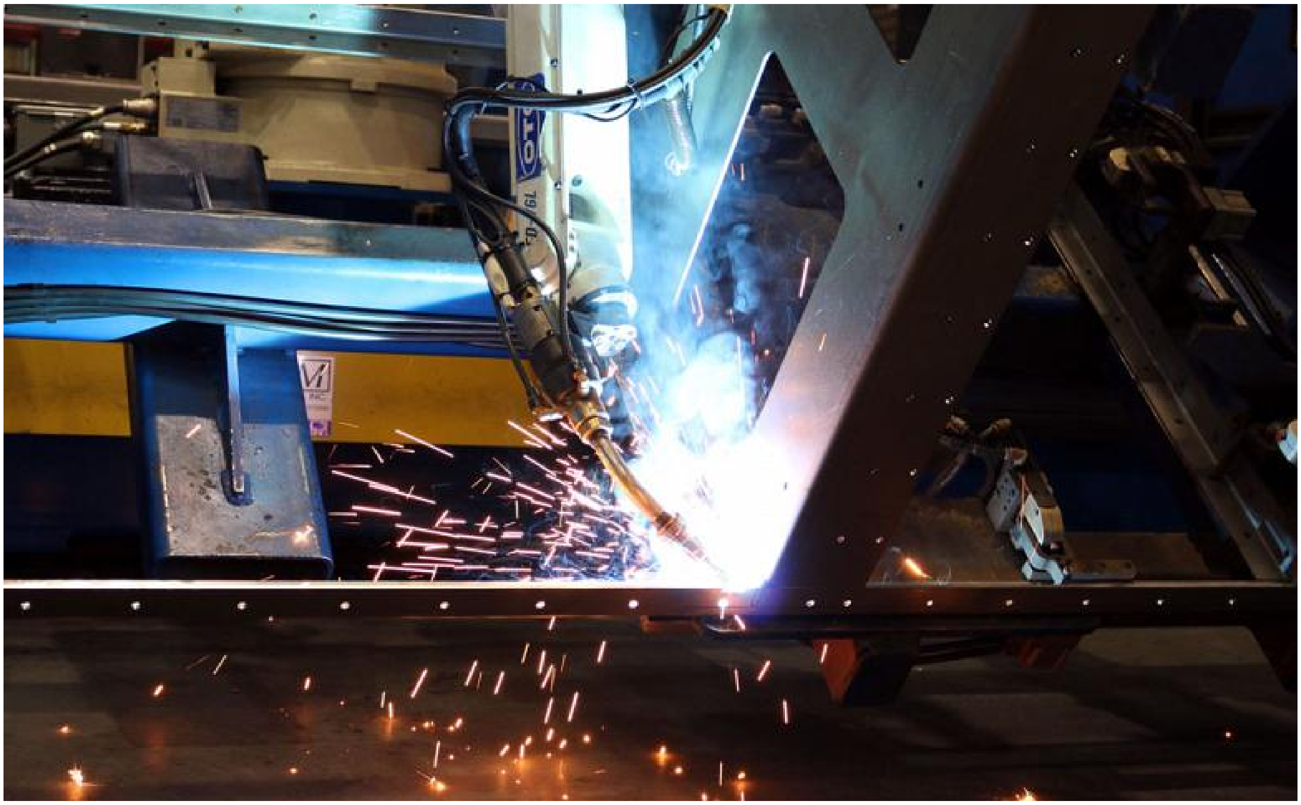

Figure 3
Because of the speed of robotic welding systems, automated welding cells generate a lot of fumes. The best way to contain those fumes is with a full enclosure of the welding activity.

If your facility works with metals that are subject to restrictive OSHA particle counts or has set standards that exceed current OSHA PEL, you can expect to pay more for your dust and fume management solution. That's because you'll need to use a highly engineered system, with high-efficiency cartridge filters and high-efficiency particulate air (HEPA) secondary filters for the best control for respirable particulates.

The Different Ways to Manage Dust and Fumes

A dust collector designed specifically for your metalworking operation is an accepted and proven engineering control that can filter hazardous airborne contaminants. There are three general types of cartridge dust and fume collection systems:

Source-capture systems are popular for applications involving small parts and fixture welding. They typically use flexible source capture arms, slotted fume hoods, or smaller slotted hoods with side shields on a workbench operation.

Enclosures and canopy hoods often are used if the footprint area is a medium size, such as 12 by 20 feet or less. Curtains or hard walls may be added to the sides of a hood to create a booth or enclosure, as long as they don't interfere with workspace. In the case of robotic weld cells and hard automation, a full enclosure over and around the application often can be used (see **Figure 3**).

Ambient systems that filter all the air in the shop using a central system or multiple smaller collectors often are favored for larger work areas involved in multiple operations. The dust and fume collector also might require a bank of HEPA safety monitoring filters (also called secondary or after-filters) for added filtration and backup protection, particularly where air is returned indoors downstream of the collector.

It’s important to note that although ambient systems help control hazardous dust, they do not remove fumes from the breathing zone. As a result, personal protection equipment might still be required. However, an ambient system will allow workers to use fans to direct fumes away from the breathing zone.

Plasma, laser, and robotic cutting generates sparks, smoke, and fumes. Proper ventilation is required to prevent inhalation of airborne particles, particularly the tiniest particles that can settle deep into lung tissues. Dust collectors capture particles at the source. Dust, fumes, and smoke are pulled down through the table and removed through the ductwork, where they are filtered through the dust collector. The sparks and molten metal settle in the area below the table and accumulate in the spark arrester before to the dust collector.

Particle properties, airflow, and loading rates differ widely in these applications. Power, type, and quantity of cutting heads; material being cut; the use of an automated material handling system; table size; and cell size all play a role in determining airflow and collector size. Because of this, a fabricator should work with a supplier that has expertise in metal cutting to size a cost-saving and space-appropriate filtration system that is reliable, durable, and easy to maintain.

When designing a safe, productive welding area, consider both current and future needs, especially if you foresee future growth. That way, when the time comes to expand your operation, you can do so cost-effectively and efficiently. Removing fumes when floor space is at a premium requires intelligent design, understanding, and coordination to meet the facility’s needs.

When possible, a shop should separate weld areas from the rest of the plant. If you can create a walled off or curtained area with permanent openings to your general facility, the task of dust and fume isolation becomes much easier. Consider this a large enclosure in which you filter dust and fumes then recirculate clean air and maintain a negative pressure. Now your dust and fumes are contained and the effect on adjacent areas has been minimized.

Figure 4
A weld shop with a recirculating cleaned air system not only keeps the indoor work environment clear of fumes, but also eliminates the need to replace the air that might otherwise be vented outside.

Keep in Mind Flexibility and Operating Cost Savings

When creating a dust and fume collection system, be sure to design in flexibility and look for measures that provide operating and energy cost savings. For example, system zoning within the factory means that your collection system can be operated where it is needed while other areas can be turned down or shut off.

Incorporating variable-speed drives for fans on dust collectors saves energy because fans aren't running at full speed. For example, a dust collector with a variable-speed drive that is governed by the static pressure of the system produces a steady airflow. With this feature, the system only runs the motor speed as needed to maintain the static pressure setpoint, automatically reacting to filter loading or movable applications such as a long plasma table. Having this feature increases reliability, extends filter life, reduces maintenance, and creates energy savings.

It is recommended to use a secondary safety filter when recirculating into your facility. A simple method of achieving this is to incorporate integrated safety monitoring filters. These can incorporate multiple styles of filters, including HEPA, when needed to obtain OSHA PEL levels.

Recirculating the filtered air is an intelligent way to save energy and maximize return on investment when using a dust collection system. By recirculating heated or air-conditioned air through the plant instead of venting it outdoors, the cost to replace that air is eliminated (see **Figure 4**). Facilities in all regions of the U.S. report five- to six-figure annual energy savings, with the greatest savings seen in northern climates that experience longer, colder winters. In addition, you can eliminate the complex EPA paperwork and monitoring procedures involved when fumes are exhausted outdoors.

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