

Fume Collection Solutions for Hexavalent Chromium Exposure

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With a new lower OSHA limit for workers exposed to hexavalent chromium, providing a clean air working environment is more important than ever.

Hexavalent Chromium (CrVI) compounds are used as corrosion inhibitors and present an occupational hazard to workers that weld, cut or grind chromium-containing metals such as stainless steel. Particles of hexavalent chromium can be in mists, dust or fumes. Mists can come from using molten metal. Dusts can come from grinding or cutting. Fumes can be generated during torch cutting and welding operations.

Exposure to hexavalent chromium fumes poses a health risk to humans. To address these risks, OSHA lowered the permissible exposure limit to a concentration

level of 5 micrograms per cubic meter. Achieving compliance involves implementing the proper air filtration and dust collection solutions. The goal of this white paper is to provide information that will directly help in providing healthy, clean air for welders and supporting personnel.

HEALTH RISKS OF HEXAVALENT CHROMIUM

The most significant health risks are through inhalation and skin contact. These risks include lung cancer, nasal septum ulcerations and perforations, skin ulcerations, and allergic and irritant contact dermatitis.

Welding or torch cutting converts small metal particles into metal vapor. When the vapor cools and condenses back into particles it

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forms visible or invisible fumes. Welding smoke is an example of visible fumes. But even if the fumes are invisible, particles can still be present.

Generally, particles in weld fumes are submicron in size with average diameters from 0.3 to 0.7 microns. Lung retention is minimal with particles in this size range. However, thermal effects can cause agglomeration of the particles into particle chains and clusters that exceed one micron. These can be deposited in the human respiratory tract.

UNDERSTANDING THE NEW OSHA REGULATION

OSHA's 2006 regulation for employee exposure to hexavalent chromium significantly reduced the permissible exposure limit (PEL) from 52 to 5 micrograms. The regulation (Volume 71, Number 39, 10099-10385) also includes provisions relating to preferred methods for controlling exposure, respiratory protection, protective work clothing and equipment, hygiene, medical surveillance, hazard communication and record keeping.

This rule applies to all manufacturing processes where hexavalent chromium is present. Industries most likely to be affected by the regulation include:

- Electroplating – hard chrome electroplating

- Thermal spraying
- Welding – all types could be affected, but the highest concentration is in stainless steel welding
- Steel mills – rolling mills and forging operations
- Metal cutting – all types including laser, plasma and oxyacetylene

Complete information and a copy of the regulation (Volume 71, Number 39, 10099-10385) are available at the OSHA web site: www.osha.gov/SLTC/hexavalentchromium/index.html.

Pertinent quotes from the regulation include:

“OSHA concludes that engineering controls, such as local exhaust ventilation, process control, and process modification or substitution, can be used to control exposures in most operations.” (Vol. 71, No. 39, 10334)

“OSHA has determined that the primary controls most likely to be effective in reducing employee exposure to Cr(VI) are local exhaust ventilation and improvement of general dilution ventilation. ... This includes installing duct work, a type of hood, and/or a collection system.” (Vol. 71, No. 39, 10262)

“Welding: The welding operations OSHA expects to trigger requirements under the Cr(VI) rule are those performed on stainless steel,



UAS' SFC Series downward flow cartridge collectors combined with either a hooding or ducting source capture system are the ideal solution for collection of hexavalent chromium fumes.

as well as those performed on high-chrome-content carbon steel and those performed on carbon steel in confined and enclosed spaces. ... OSHA has determined that engineering and work practice controls are available to permit the vast majority (over 95%) of welding operations on carbon steel in enclosed and confined spaces to comply with a PEL of 5 µg/m³. ... The two most common welding processes, shielded metal arc welding and gas metal arc welding, ... may require the installation or improvement of local exhaust ventilation ... OSHA recognizes that the supplemental use of respirators may still be necessary in some situations.” (Vol.71, No.39, 10262-10263)

With the new lower OSHA limits for worker exposure to hexavalent chromium, providing a clean

air working environment is more important than ever. Hence, knowing how to calculate the amount of weld fumes and, in turn, how to capture those fumes is critical.

CALCULATING WELD FUME GENERATION

The first step in deciding how to control hexavalent chromium is knowing how much weld fume is released into the air. The amount of weld fumes generated determines the type and size of equipment needed to adequately collect the contaminated air, filter it and re-circulate it into the facility.

The amount of weld fumes generated will vary depending on the welding process used and the metal being welded. The weight of fumes generated is a percentage of the weight of deposited metal. This percentage can be based on the length of weld electrode used. Table 1 lists the typical ratios by welding process and metal type.

Table 1 – Weld Fume Ratios

Welding Process	Metal Type	Range Weight of Fumes/ Weight of Deposited Metal
FCAW	Carbon Steel Stainless Steel	0.9-2.4%
SMAW	Carbon Steel	1.1-5.4%
SMAW	Stainless High Alloy	0.3-1.4%
GMAW	Carbon Steel	0.3-0.9%
GMAW	Stainless Steel	0.6-7%
GMAW	Copper, Aluminum	0.5-1.6%

If continuously gas metal arc (GMA) welding on stainless steel at the rate of 10 pounds per hour, the maximum rate of weld fume produced would be 10 pounds x 0.07 (0.7%), or 0.7 pounds per hour.

CONTROLLING HEXAVALENT CHROMIUM WITH AIR FILTRATION DEVICES

So what is the best way to capture the hexavalent chromium weld fumes present in workplace air?

There are normally three different ways of maintaining air quality:

- Dilution ventilation
- Ambient air collection using dilution air and a dust or fume collection device
- Source capture using a dust or fume collection device

Choosing the right solution depends on the type and quantity of contaminant generated.

Dilution ventilation involves providing enough dilution (replacement) air into the enclosed space to completely replace the workplace air. This is not an adequate solution for controlling hexavalent chromium, however. First, while dilution air helps control exposure, it doesn't protect an individual worker's breathing zone. Air must still pass that worker's breathing zone as it is being exhausted from the facility.

Secondly, the amount of dilution air required to maintain the permissible exposure limit would be too high to be feasible. For example, a 30,000-cubic foot enclosed welding space with three welders continuously welding would require enough dilution air to completely replace the workplace air 25.8 times per hour. That equates to approximately 12,900 cubic feet of air pulled in and exhausted out of the facility. All of that air must be heated or cooled and the cost would be largely wasted.

Ambient air collection is also based on a room air change schedule but includes a dust or fume collection device mounted to the ceiling or wall. This is also not an adequate solution for collecting hexavalent chromium fumes. The reason neither of these methods will help meet the permissible exposure limit is because neither protects the worker's breathing zone. If air contaminated with more than the permissible concentration of

hexavalent chromium must pass through the worker's breathing zone before being collected, it poses a health risk.

The best way to achieve target room contamination levels is to use a source capture fume collection device. Specifically, a device with a close capture hood will collect the fumes at the point of generation. The fumes are drawn into the hood and pulled away from the worker's breathing zone. The closer the hood is to the point of generation, the lower air volume is required to draw in the contaminated air. However, getting too close to the welding operation may affect the heat and weld quality.

There are, however, many factors that could render a source capture system impractical. These include the following where ...

- Work is done on large parts and the worker has no fixed operating position.
- Workers are unable to use hooded systems. Some source capture systems may require physical positioning by the worker. If it is unlikely the worker will perform that positioning, the system is rendered ineffective.
- There are a large number of small weld smoke producers in a confined area.

- Places in which overhead cranes and process obstructions make ducting installation impossible. Unducted systems, properly designed, can keep the fume collection units out of the craneways and still achieve effective results.

If source capture of weld fumes is not an option and ambient air collection is required when welding on stainless steel, the welder will be required to wear personal respiratory protection at all times.

Once the fumes are captured, they are usually pulled into an air filtration device. This can be either an electrostatic precipitator (ESP) or a cartridge collector. When dealing with hexavalent chromium, a cartridge collector is the only viable option.

CHOOSING THE RIGHT FUME COLLECTION DEVICE

While electrostatic precipitators (ESP) are ideally suited for collection of weld smoke they are not recommended for control of hexavalent chromium. ESPs cannot match the overall efficiency of a cartridge collector source capture system, especially if the air is returned into the work space. In fact, it would take several ESP collectors lined up in a row to equal the same efficiency as one cartridge collector.

A good MERV 15 cartridge filter with nanofiber technology is more than adequate to meet the 5 microgram/m³ OSHA standard. These filters are 99.999 percent efficient. When using the previous example of GMAW welding on stainless steel at the rate of 10 pounds per hour, the maximum rate of weld fume produced would be 0.7 pounds per hour. With a 350 cubic feet per minute cartridge collector using nanofiber filters, all but 0.533 micrograms per cubic meter of hexavalent chromium would be captured. This is approximately 10 times better than the OSHA requirement. If the air is returned into the facility, the exhaust should go through a monitored HEPA afterfilter. This is used in case something happens to the main cartridge filters.

Robotic welding areas also need air quality attention. They should be enclosed as much as possible and maintain either an adequate air change schedule or an in-draft through every crack or opening. Contaminated air should be filtered through a cartridge collector. Strip curtains should be used to prevent weld fumes from migrating into other areas of the facility. If a person has to enter the enclosure occasionally, it is recommended to suspend welding activity for a few minutes and purge the enclosure before entering.

IMPORTANT DESIGN AND OPERATION CONSIDERATIONS

For source capture systems, hood design and placement are critical to the overall performance of the collection system. The hood design should take into consideration the various types and configurations of hoods, operator or process interference and the characteristics of the contaminant generation process itself. The first step to designing a source capture system is to determine the most effective type of hood design and the actual placement of the hood relative to the point of contaminant generation. Consult a ventilation specialist to design hooding and ducting that will meet collection requirements without interfering with the production process.

Another critical factor in the operation of fume collection equipment is the type of filter media used. Cartridge collectors use pleated paper, paper-polyester blend or polyester cartridge filters. The filters are cleaned on-line during the collection process. Newer filters that feature nanofiber technology offer high filtration efficiency and are capable of trapping 99.99 percent or more of sub-micronic materials and virtually 100 percent of larger particles.

Today's filter media are often marketed based on their Minimal Efficiency Reporting Value (MERV).

The higher the MERV rating (1 to 20), the better the filter is at removing particulates, especially very small particulates, from the air. While the MERV rating is the most accurate efficiency measurement available, do not select a filter on MERV rating only. The filter may be designed to achieve a high MERV rating, but at the cost of other important factors like pressure drop, cleanability, compressed air usage and filter life. These are all important determinants of a filter's total performance and life cycle cost.

Unfortunately, no industry standards exist to measure all these factors together and how they relate to each other. The best way to determine filter performance for your application is to consult an expert, test the filters in your equipment and ask for referrals from others in your industry.

If source capture cartridge collectors are currently used to control weld fumes, consult with a ventilation engineer to determine if they are adequate to meet the new OSHA standard. The ventilation engineer can evaluate proper source capture hood design, ducting and fan size and recommend any modifications needed to make the increase the equipment's efficiency.

SUMMARY

The source capture system combined with a cartridge collector is the only viable way to deal with stainless weld fumes. Even then, and if the air is to be returned into the workplace, a monitored safety HEPA after-filter should be used.

As ESPs are lower in overall efficiency than cartridge filter collectors, they would not be ideally suited for stainless weld fumes, especially if the air is to be returned to the workspace.

If ambient air collection is required when welding on stainless steel, the welder will be required to wear personal respiratory protection at all times.

Every stainless welding situation has special requirements as to the welding process in use, the amount of weld fumes generated and the welding location. To determine the best solution for your application, consult a specialist. United Air Specialists' application engineers are available to provide guidance. Contact UAS at sales@uasinc.com or visit www.uasinc.com to locate a representative near you.

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