Hexavalent Chromium: What You Need to Know

Hexavalent chromium has become a hot environmental topic in the thermal spray community and among welders. New OSHA regulations are forcing everyone to take a close look at their processes and implement changes to them or install engineering controls to help reduce exposure.

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Hexavalent Chromium is the Most Toxic Form of Chromium

Hexavalent chromium can be a problem in welding and thermal spray operations, and most manufacturers are discovering they need to install engineering controls to help reduce worker exposure. This paper addresses some questions regarding the new OSHA regulations, including:

- What is hexavalent chromium?
- What are the new OSHA regulations?
- What applications can hexavalent chromium come from?
- How can a worker be exposed?
- What does hexavalent chromium do to the body?
- What are employers and employees required to do if hexavalent chromium is in the facility?

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What is Hexavalent Chromium?

Chromium shows up in predominantly three forms. **1) Trivalent Chromium**, which occurs naturally as chrome ore and is also an essential nutrient for proper metabolism; **2) Metallic or Elemental Chromium**, typically found in aerospace alloys; and **3) Hexavalent Chromium**, typically from industrial processes like welding and thermal spray.

Hexavalent Chromium is the most toxic form of chromium.

Reading through articles and publications, you will see hexavalent chromium identified in different ways, including: Hex Chrome, Chrome VI, CrVI and Cr 6+.

New OSHA Permissible Exposure Levels

The Occupational Safety & Health Administration (OSHA) has defined two levels of exposure for hexavalent chromium. The new Permissible Exposure Level (PEL) for hexavalent chromium is 5 µg/m^3 in an 8-hr shift. **This PEL of 5 µg/m^3 was reduced from 52 ug/m^3. A factor of 10.**

The second level is called the Action Level at 2.5 µg/m^3. This is where employers are required to take specific actions, and failure to take these actions may result in penalties.

Where Does Hexavalent Chromium Come From?

Some of the industrial processes that can produce hexavalent chromium include:

- Coatings (spray primers/paints)
  - coatings containing *chromates:* dyes, paints, inks and plastics
  - Chrome plating
  - Blending/sanding coatings containing chromium
- Welding of alloys containing chromium
  - Stainless steel and Nickel Alloy
- Thermal Spraying, including plasma, electric arc and combustion (including HVOF)
  - Metallic chromium in the feedstock may be converted to the hexavalent form.
  - Hexavalent chromium may be present in a feedstock containing any form of chromium.
- Smelting of Ferro-Chromium Ore
- Portland cement impurities
- Dip-tanks
  - Anodizing and Plating lines
- Leather tanning - Ammonium Dichromate

Important Clarification Points:
In your facility, you may be producing a dust, fume or mist that contains hexavalent chromium. It is important to realize hexavalent chromium has its own threshold limit value (TLV) that may be lower than other components present as airborne contaminants.

Remember that hexavalent chromium is usually only a percentage of the dust, fume or mist generated, and other processes will produce fume containing small amounts of hexavalent chromium. Be advised it is entirely possible to exceed the TLV for hexavalent chromium while staying under the TLV for other fumes given off.

Typical particle sizes produced of the material containing hexavalent chromium differ by process and application.

Type of Fume	Size Range of Fume Particles
Wet paints with chromates	0.7 - 34 microns
Chrome plating	0.75 - 6.4 microns
Welding	0.05 – 2.0 microns*
Thermal Spraying	0.05 – 2.0 microns*

* 80% of total fume is in this very small size range.

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How Do Workers Become Exposed?

If your company has a process that could be producing hexavalent chromium, workers can be exposed through many sources.

- You can **inhale** it through your nose and mouth from processes producing dusts, fumes and mists.
- If a medium containing hexavalent chromium lands on your skin, it can be **absorbed** through the skin.
- **Ingestion** (swallowing). If a worker fails to use proper personal hygiene, the exposed area of clothing or skin can land on food, tobacco and cosmetics and be ingested.

How Does Hexavalent Chromium Affect the Body?

Once in the body, hexavalent chromium typically targets certain organs. Respiratory tract (inhalation damage to mucous membranes), perforation of septum (tissue between the nostrils of nose), lungs, eyes, skin, liver and kidneys are some examples.

A worker exposed to hexavalent chromium may experience symptoms such as sinus irritation, nosebleeds, ulcers (stomach and nose), skin rash, chest tightness, wheezing and shortness of breath.

Employer Requirements

If a company has determined that it could potentially be producing hexavalent chromium, it is required to do the following:

- implement air sampling,
- medical monitoring and provide employee notification of monitoring results,
- implement engineering controls,
- adopt respiratory protection program,
- demarcation of work areas containing hexavalent chromium,
- execute an employee training program,
- provide availability of OSHA regulations and company policy to employees.

The frequency of air sampling a company must do depends on what level of hexavalent chromium was discovered in the facility. If the area tested above the PEL of 5.0 µg/m^3, testing has to be done every three months. If the area is above the Action Level of 2.5 µg/m^3 but below the PEL, then a company is only required to do air sampling every six months. If the area is below the action level, the company is required to take an initial baseline and then it is left up to the facility hygienists to decide on a sampling frequency. Sampling yearly is a typical strategy in this case.

Medical monitoring of all employees is required in facilities that test above the Action Level of 2.5 µg/m^3. The standard on hexavalent chromium requires medical surveillance but leaves the selection of the specific tests to the physician or other licensed health care professional (PLHCP.) This may be an on-site company nurse or the employee may need to go to his own health care provider for tests.

Some of the things that a company could do include:

- Review of health and work history
- Physical exam
- Report of the outcome of the exam

Once an exam is completed, a written summary should be provided to the employee within two weeks and kept on file at the company by the industrial hygienist.

When Hexavalent Chromium is above PEL

On processes producing hexavalent chromium above the PEL of 5 µg/m^3, engineering controls must be implemented. **Engineering controls** must be in place and running by May 31, 2010. Until then, **respiratory protection** is mandatory until engineering controls are implemented. **Please note that *rotation of employees to different jobs to achieve compliance is NOT permitted by OSHA.***

Welding and thermal spraying are two of the industrial processes which can produce significant hexavalent chromium emissions. The amount of actual hexavalent chromium in the fume may be impacted by:

- Method of welding or thermal spraying
- Electrode type or gun (welding only)
- Base metal material and composition (welding only)
- Powder or wire composition
- Voltage (higher voltages speed production but increase fume rates)
- Electrical current
- Arc length (welding only)
- Shielding gas (welding only)
- Rate of welding or thermal spraying
- Welding Angle (welding only)

When estimating how much hexavalent chromium fume is produced from a process, remember that:

- As melting rate increases, fume generation rate increases
- As the power increases, fume generation rate increases

The amount of hexavalent chromium in fume can be estimated using the following formula:

E = W x PC x EF x CF

- E = Specific metal emitted [lbs/year]
- W = Total weight of electrode used [lbs/yr]
- PC = Percent composition of specific metal [%]
- EF = Emission Factor per ton of electrode [lbs/ton]
- CF = Conversion factor [1 ton or 2000 lbs]

The new state-of-the-art spray booths at Falmer Thermal Spray (Salem, MA) are ducted outside the building into a (1) Donaldson® Torit® cyclone pre-cleaner, (2) then into Downflo® Oval (DFO) dust collector with Ultra-Web® filters, and (3) finally through a HEPA filter at the outlet on the roof. The system filters hexavalent chromium and other thermal spray particulate from the daily operations.

Emission factors are expressed in a number of different ways:

- % of particulate per pound of electrode
- mg of particulates per pound (lb) of electrode
- Pound of pollutant per pound of electrode consumed

You can find emission factors from many sources* including:

- www.epa.gov
  - www.epa.gov/ttn/chief/ap42/ch12/index.html
  - Compilation of Air Pollutant Emission Factors AP-42
  - For arc welding Section 12.19
- California Air Resources Board
  www.arb.ca.gov/toxics/welding/welding.htm
- National Shipbuilding Research Program
  www.ewi.org/uploads/document_library/white_papers/NSRP%20ASE%20Project.pdf

* Please note that websites are often updated and links are amended, so if these links are broken, begin at the home page and search key word hexavalent chromium

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You can also estimate emission factors by taking the fume generation rate and multiplying by the chrome content, then multiplying the result by the hexavalent chromium ratio:

- FGR x fume composition x % chrome as Cr6+
- (lb fume/lb electrode) x (lb Cr/lb fume) x (Cr 6+/cr in fume)

Note EF has no units = [%] x [%] x [%]

OSHA expects exposure to be reduced as far as reasonably practicable.

For work area and **demarcation** of areas that may contain hexavalent chromium, companies are expected to do at least the following:

- Areas with airborne exposure above the PEL must be demarcated with appropriate signage to limit unauthorized entrance.
- Locations surrounding processes using hexavalent chromium must be free of surface contamination. Of the four ways to clean up surface contamination (sweeping, blowing with compressed air, wet mopping, and vacuuming), wet mopping and HEPA vacuuming are the only ways that are effective and acceptable. Compressed air can only be used under very specific conditions if vacuuming is not feasible; consult the OSHA website for those conditions.

Companies are expected to make the regulations available for any employee to see. If you would like to research on your own, here are two of many places to go for more information:

- 29 CFR 1910.1026, Hexavalent Chromium can be found on the OSHA website*: www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=13096
- OSHA Fact Sheet* on hex chrome: www.osha.gov/OshDoc/data_General_Facts/hexavalent_chromium.pdf

* Please note that OSHA often updates and amends links, so if these links are broken, begin at www.osha.gov and search key word hexavalent chromium

Employee Requirements

Employees have responsibilities, too — to protect themselves. They are required to use proper personal protective equipment, good housekeeping skills, engineering controls once implemented, and good personal hygiene techniques. Good personal hygiene includes not using tobacco, not applying cosmetics, not eating anything, not placing fingers in mouth or nose, and washing hands/face prior to doing any of the above activity, before taking a break or at the end of their shift.

Engineering Control Includes Good Dust & Fume Collection Systems

A well-designed ventilation system, including a properly operated dust collector, can be a factor in reducing general hexavalent chromium exposure levels in a facility.

As shown in the chart on page 2, sizes of the fume particles that carry hexavalent chromium vary from 5/100 of a micron to 34 microns, and most are in the very small range (sub-micron to 2 microns). It is therefore necessary to use filter media in the fume collection system that can capture a full range of sizes, from sub-micron to large particulate. High efficiency filters are recommended, such as Ultra-Web® nanofiber cartridge filters from Donaldson® Torit®.

Each filter should have at least 1.5 inches of water gauge pressure drop across it to optimize performance.

A well-designed ventilation system will have sufficient capture velocities at the various hoods to help control any emissions containing hexavalent chromium. The ACGIH Industrial Ventilation Manual offers several examples, including:

- VS-90-01 through 03 for Welding
- VS-90-20 for Robotic Welding
- VS-90-30 for Metal Spraying
- VS-90-10 for Torch Cutting
- Laser tables 250 fpm for zone (not covered)

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