Hexavalent Chromium: What You Need to Know

Hexavalent chromium has become a hot 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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Controlling 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?

Hexavalent 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 other level is called the Action Level (AL) 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 & plastics
  - Chrome plating
  - Blending/sanding coatings containing chromium
- Welding of alloys containing chromium
  - Stainless steel & 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
- Maintenance on processes containing hexavalent chromium
  - Machine turnarounds/cleanouts
  - Filter changes on dust collectors
  - Waste material handling
- 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.)

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. So be advised: it is entirely possible to exceed the TLV for hexavalent chromium while staying under the TLV for the non-hexavalent chromium components of the fume.

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 w/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 be potentially producing hexavalent chromium, OSHA requires the following:

- implement air sampling,
- monitor medical status of employees and notify employees of monitoring results,
- implement engineering controls,
- adopt respiratory protection program,
- demarcate 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 (AL) 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 AL of 2.5 µg/m3. 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 can produce significant hexavalent chromium emissions with the amount of actual hexavalent chromium in the fume 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 [lb/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. The system controls hexavalent chromium and other 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:

- % of particulate per pound of electrode
  - 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

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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, OSHA expects companies 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 4 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=13216
- OSHA Fact Sheet* on hex chrome: www.osha.gov/OshDoc/data_General_Facts/hexavalent_chromium.pdf

* Please note that OSHA often changes 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

The collection system you use for dust or fume control is a key factor in achieving effective control of hexavalent chromium.

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 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 filters from Donaldson® Torit®. Each filter should have at least 1.5 inches of water gauge pressure drop across the filters and the capture velocities at the hoods should be as recommended in ACGIH Industrial Ventilation Manual. Here are some examples:

- 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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Combined with powerful Donaldson Torit Downflo® Oval dust collectors, Easy-Trunk® or Porta-Trunk® fume collectors, your filtration solution can achieve effective engineering control of the dusts and fumes containing hexavalent chromium.

Ambient fume collection (sometimes termed general ventilation) is NOT recommended, as it typically only cleans 70% of the air at any given time. Ambient collection is simply not powerful enough to take care of hexavalent chromium-carrying fumes. Capture hoods located as close to the source of generation as possible, and ducted into a well-built dust/fume collector, will ensure better confinement of the particles.

Your Donaldson Torit sales representative can help in determining which engineering controls will be most effective for you. He can speak to the application variables associated with the processes in your plant, help calculate the airflow required, and help estimate how much fume is being generated. While Donaldson Torit engineers are NOT experts on hexavalent chromium, they are experts in air filtration solutions for your processes.

References

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2. Speaker, Bart van de Velde, Rockwell Automation, Presentation at Donaldson International Technical Conference, Nov 2007, Leuven, Belgium.

3. Buffalo Forge Co. Fan Engineering, Eighth edition, 1983

4. Air Movement and Controls Association, Inc. AMCA Publication 201-90, Fans and Systems.

5. Duct cost, Brian McAlpine, Nordfab Co., Inc.

6. American Conference of Industrial Hygienists (ACGIH)Industrial Ventilation: A Manual of Recommended Practice for Design, Cincinnati, Ohio: Kemper Woods Center, 2007 26th edition.

Summary

In summary, hexavalent chromium is a regulated, toxic material that must be dealt with by implementing proper precautions, including:

(a) Engineering controls where required
(b) Respiratory protection if needed
(c) Good housekeeping practices
(d) Proper personal protective equipment
(e) Good personal hygiene practices.

Helpful Links:
www.donaldson.com/en/industrialair/regulations
www.donaldson.com/en/industrialair/fume
www.UltraWebisAlwaysBetter.com

Glossary of Terms

µg/m³	Micro grams per cubic meter of air
ACGIH	American Conference of Industrial Hygienists
AL	Action Level
Chrome VI	Abbreviation for hexavalent chromium
Cr 6+	Abbreviation for hexavalent chromium
CrVI	Abbreviation for hexavalent chromium
E = W x PC x EF x CF	Formula for estimating the amount of hexavalent chromium in fume. See page 4.
FGR	Fume generation rate
Hex Chrome	Abbreviation for hexavalent chromium
HVOF	High Velocity Oxy-Fuel
OSHA	Occupational Safety & Health Administration of the United States Government
PEL	Permissible Exposure Level
TLV	Threshold Limit Value
PLHCP	Physician or Licensed Health Care Professional

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