Industry Guide 45

A Guide to Hexavalent Chromium Cr(VI) for Industry

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This guide is the third in a series of industry guides focused on the Health Hazards Special Emphasis Program. It is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.

The information in this guide was revised in 2013.

To obtain additional copies of this guide, or if you have questions about North Carolina occupational safety and health standards or rules, please contact:

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Additional sources of information are listed on the inside back cover of this guide.

The projected cost of the NCDOL OSH program for federal fiscal year 2012–2013 is $18,073,694. Federal funding provides approximately 30.5 percent ($5,501,500) of this total.

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Foreword

Chromium in its hexavalent form has been used in industry for decades for metal plating to produce shiny, chrome-plated metal. Not only does it impart a shiny appearance, but it also protects the underlying metal from rust and corrosion.

Today we know that those desirable properties can come with a potential health threat to workers who use or are exposed to hexavalent chromium, Cr(VI). We know now that inhaling Cr(VI) can lead to lung cancer in exposed workers. To protect workers from exposure to hexavalent chromium, employers are required to limit employee exposure to this substance.

A Guide to Hexavalent Chromium Cr(VI) for Industry examines the workplace requirements for safely working around hexavalent chromium. The seriousness of the threat that airborne hexavalent chromium poses to workers' health is also examined.

In North Carolina, the N.C. Department of Labor (NCDOL) enforces the federal Occupational Safety and Health Act through a state plan approved by the U.S. Department of Labor. NCDOL offers many educational programs to the public and produces publications to help inform people about their rights and responsibilities regarding occupational safety and health.

When reading this guide, please remember the mission of the N.C. Department of Labor is greater than just regulatory enforcement. An equally important goal is to help citizens find ways to create safe workplaces. Everyone profits when managers and employees work together for safety. This guide, like the other educational materials produced by the NCDOL, can help.

Cherie Berry
Commissioner of Labor

Note

This guide is intended to provide a generic overview of the standard-related topic and is not intended to alter or determine compliance responsibilities.

Generally speaking, Part 1910 standards apply to general industry, Part 1926 standards apply to the construction industry, and Part 1915 standards apply to shipyards. However, in instances where there are gaps in coverage, standards may apply across boundaries.

This guide discusses the "Hexavalent Chromium Standards." Provisions that are not applicable to all industry settings are identified within the text of this guide. **It is intended to be consistent with all existing OSHA standards; therefore, if an area is considered by the reader to be inconsistent with a standard, then the OSHA standard should be followed.**

1

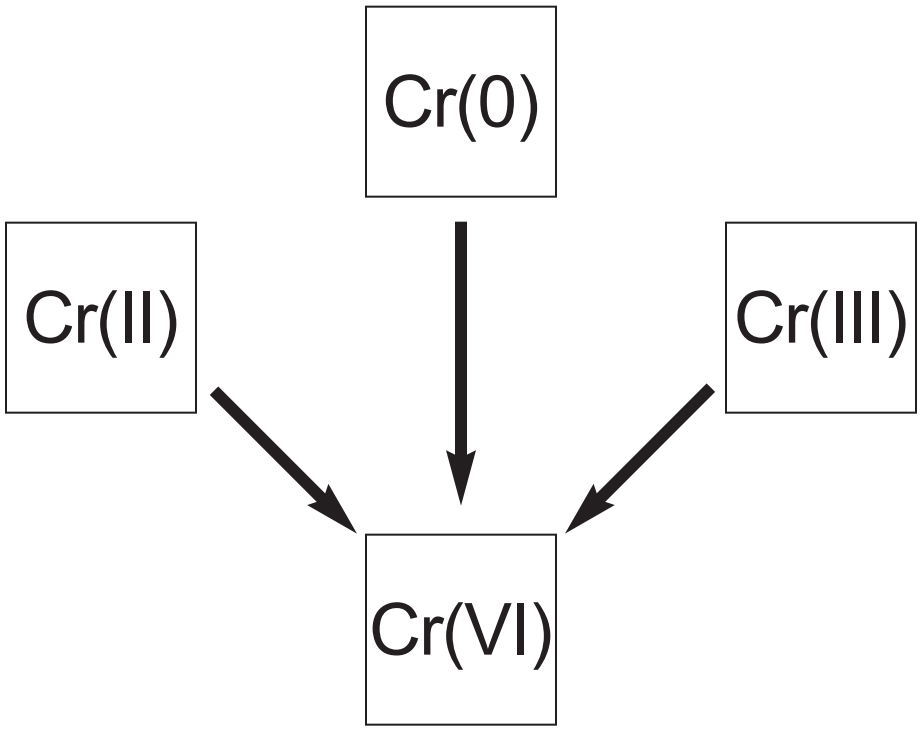
What Is Hexavalent Chromium?

Background

Hexavalent chromium, Cr(VI), is one of the oxidation states of the element chromium and is the toxic form that poses a health risk to workers exposed to it. Chromium is the 21st most abundant element, the sixth most abundant of the transition metals, and is mined as the principal ore chromite (chrome iron ore), $FeCr_2O_4$. Chromium has oxidation states ranging from −2 to +6, of which the divalent (+2, chromous), trivalent (+3, chromic) and hexavalent (+6) are the most important. Trivalent chromium, Cr(III), which is the most stable form of chromium, is found in trace amounts in the human body and is believed to be necessary for sugar metabolism. Elemental chromium, Cr(0), does not occur naturally but can be prepared by heating the ore in the presence of aluminum or silicon.

Figure 1

Oxidation Paths to Cr(VI)



Where Can Hexavalent Chromium Be Found?

Hexavalent chromium compounds have varied uses in industry and are often used for their anti-corrosive properties in metal coatings, protective paints, dyes and pigments. Hexavalent chromium can also be formed when performing "hot work" such as welding on stainless steel, melting chromium metal or heating refractory bricks in kilns. In these situations, the chromium is not originally in the hexavalent state but at sufficiently high temperatures undergoes oxidation (i.e., loses electrons) to yield the hexavalent form.

Stainless steel is defined in metallurgy as a ferrous alloy with a minimum of 10 percent chromium content. High oxidation resistance in air at ambient temperature is normally achieved with additions of a minimum of 13 percent chromium (by weight), and up to 26 percent chromium (by weight) is used for harsh environments. The chromium achieves corrosion resistance by forming a *passivation layer* of chromium(III) oxide (Cr_2O_3) when exposed to oxygen. The layer is too

thin to be visible so the metal always appears shiny. It is, however, impervious to water and air, protecting the surface of the metal beneath. Also, when the surface is scratched, this layer quickly reforms. Materials scientists refer to this phenomenon as *passivation.*

Hexavalent chromium is also present in some pesticides, in particular chromated copper arsenate (CCA), which has been used as a wood preservative. The U.S. Environmental Protection Agency (EPA) banned the use of CCA products to pressure treat wood that is intended for most residential settings effective Jan. 1, 2004, due to concerns over arsenic poisoning.

Some other Cr(VI)-containing compounds and their uses are listed in Table 1.

Table 1

Some Cr(VI)-Containing Compounds and Their Uses

Chemical Name and Formula	Synonyms	Uses
Chromium trioxide *CrO3*	Chromic acid, chromic trioxide, chromium oxide, chromium (VI) oxide, chromia	Chromium plating, aluminum anodizing and chemical intermediate for chromate copper arsenate wood preservatives. Also ceramic glazes, colored glass, metal cleaning, inks and paints.
Lead chromate *PbCrO4*	C.I. Pigment Yellow 34, crocoites, lead chromium oxide, plumbous chromate	Decorating china, pigment in industrial paints, rubber and plastics, pigment in oil paints and watercolors, and printing fabrics.
Sodium dichromate *Na2Cr2O7*	Disodium salt, chromium sodium oxide, dichromic acid, disodium dichromate, sodium bichromate, sodium dichromate	Inks; oxidizing agent in manufacture of dyes and other synthetic organic chemicals; electric batteries; manufacture of chromic acid, other chromates and chrome pigments; corrosion inhibiting paints; component of wood preservatives; and colorant for glass.
Zinc chromate *ZnCrO4*	Zinc salt, chromium zinc oxide, zinc chromium oxide, zinc tetraoxychromate	Priming paints for metals, varnishes and pigments in aerospace paints.

What Are the Health Effects of Exposure to Chromium (VI)?

Workplace exposure to Cr(VI) may cause the following health effects:

- Lung cancer in workers who breathe airborne Cr(VI);
- Irritation or damage to the nose, throat and lungs (respiratory tract) if Cr(VI) is inhaled; and
- Irritation or damage to the eyes and skin if contacted with Cr(VI).

Airborne Cr(VI) can be inhaled as a dust, fume or mist by workers producing chromate pigments, dyes and powders (such as chromic acid and chromium catalysts); working near chrome electroplating; performing hot work and welding on stainless steel, high chrome alloys and chrome-coated metals; and applying and removing chromate-containing paints and other surface coatings. Skin exposure to Cr(VI) can occur while handling solutions, coatings and cements containing Cr(VI). Table 2 contains a listing of some industries where workers might be exposed to Cr(VI).

Table 2

Some Industries Where Occupational Exposure to Cr(VI) May Occur

Aircraft painters	Laboratory workers
Battery manufacturers	Metal cleaners
Boiler scalers	Metal workers
Candle manufacturers	Painters
Cement workers*	Pottery glazers
Chemical workers	Refractory brink manufacturers
Chromate workers	Steel workers
Chromium platers	Textile workers
Crayon manufacturers	Wood preservative workers

*The concentration of Cr(VI) in portland cement is considered too low to pose a significant health risk and is, therefore, excluded from the scope of the chromium (VI) standards. However, workers are still at significant risk for skin irritation and dermatitis.

The sections of this document that follow discuss the provisions of the chromium (VI) standards. Employee exposure to chromium (VI) is regulated by separate standards for the general industry (1910.1026), construction (1926.1126) and shipyard (1915.1026) sectors. The requirements of these standards are identical with the exception of the provisions for regulated areas, hygiene areas and practices, and housekeeping.

2

Exposure Monitoring and Control

Permissible Exposure Limit

Employers must ensure that no employee is exposed to an airborne concentration of hexavalent chromium in excess of five micrograms per cubic meter of air (5 $\mu g/m^3$) as an 8-hour time-weighted average (TWA). This determination must be made without regard to the use of personal protective equipment, such as respiratory protection. This means that employers cannot apply the level of protection that the respirator can provide to determine whether an employee is overexposed to hexavalent chromium present in the air.

The hexavalent chromium standards also set an action level, which is equal to one-half the permissible exposure limit (PEL), or 2.5 $\mu g/m^3$ as an 8-hour TWA. Exposure of employees at or above the action level triggers certain other requirements of the hexavalent chromium standard even though employees are not exposed above the PEL.

Exposure Assessments and Monitoring

Employers who have a workplace or work operations covered by the standard must determine the 8-hour TWA exposure for each employee exposed to chromium (VI). In so doing, employers must assess all work operations for their potential to generate airborne hexavalent chromium particulates, including welding fumes and mists from chrome plating operations. To achieve this, however, the standard provides two options: the *scheduled monitoring option* and the *performance-oriented option*.

Scheduled Monitoring Option

Initial Monitoring

The scheduled monitoring option is the type of exposure monitoring that has been a traditional requirement in OSHA's substance-specific standards. Using this type of exposure monitoring, employers must perform initial monitoring to determine the 8-hour TWA exposure for each employee using a sufficient number of samples collected in the employee breathing zone of each employee that fully characterizes their full shift exposure to chromium (VI). This must be done for each job classification on every shift where employees may be exposed.

Does this mean employers must do initial monitoring for every employee? No, employers are only required to conduct monitoring of selected employees that is representative of other employees in the same job classification working in the same area as the employees monitored.

Periodic Monitoring

Under the scheduled monitoring option, the results of initial monitoring are used to determine whether additional exposure monitoring is necessary and, if so, how often. If *initial monitoring* shows that employee exposure is below the action level, then monitoring may be discontinued for the employees that this monitoring represents. If initial monitoring reveals that the represented employees are exposed at or above the action level but not above the PEL, monitoring must be repeated every six months. If initial monitoring shows employee exposure is above the PEL, monitoring must be repeated every three months.

If the results of *periodic monitoring* show that employee exposure to chromium (VI) is below the action level and this is confirmed by another sample taken at least seven days later, the employer can discontinue monitoring for those employees represented by this monitoring. The scheduled monitoring option is summarized in Table 3 below.

Table 3

Monitoring Frequency for Scheduled Monitoring

Exposure Scenario	Required Monitoring Activity
Below the action level (< 2.5 µg/m^3)	No periodic monitoring is required for workers represented by this monitoring
At or above the action level but at or below the PEL (2.5 µg/m^3 to 5 µg/m^3)	Monitor every six months
Above the PEL (> 5 µg/m^3)	Monitor every three months

Additional Monitoring

Additional monitoring is required when a change in the production process, raw materials, equipment, personnel, work practices or control methods may result in new or additional exposures to hexavalent chromium or when the employer believes new or additional exposures may have occurred. This can occur when there are alterations in the production process, raw materials, equipment, personnel, work practices or control methods used in the workplace. The following examples demonstrate circumstances where additional monitoring would be required.

Example 1. An employer had conducted initial monitoring of a chrome-plating operation when fume suppressants were used. However, the employer decided to discontinue the use of fume suppressants. Additional monitoring would be necessary to determine worker exposure to Cr(VI) under the modified conditions.

Example 2. A welder working at a metal fabricator was initially monitored in an open, outdoor location while welding on a stainless steel part. The fabrication of the final product now requires work in an enclosed location to weld the part in place. Even though the task and materials may remain constant, the changed environment would be expected to result in exposure to higher levels of Cr(VI).

Performance-Oriented Option

The performance-oriented option permits the employer to determine the 8-hour TWA exposure for each employee using a combination of air monitoring data, historical monitoring data or objective data sufficient to accurately determine current worker exposure to Cr(VI). This option gives employers flexibility in assessing the Cr(VI) exposures of their personnel. If an employer elects to use this option, the exposure determination must be made prior to the time that the work operation commences and must provide the same degree of assurance that worker exposures have been correctly characterized as that provided by the scheduled monitoring option. As with the scheduled monitoring option, the employer is expected to reevaluate worker exposures when there is any change in the production process, raw materials, equipment, personnel work practices or control methods that may result in new or additional exposures to Cr(VI). However, employers using this option do not have to follow a fixed schedule for performing reevaluations.

Regulated Areas

The hexavalent chromium standard for general industry, 29 CFR 1910.1026, requires the employer to establish a regulated area wherever a worker's exposure to airborne concentrations of Cr(VI) is, or can be reasonably expected to be, above the PEL. The Cr(VI) standards for construction and shipyards do not include this requirement due to the practical difficulties expected in establishing regulated areas for operations in these sectors.

Employers are required to distinguish the regulated area from the rest of the workplace in a manner that adequately establishes and alerts workers to the boundaries of the regulated area. The standard does not specify how employers must identify the regulated area. Warning signs, gates, ropes, barricades, lines, textured flooring or other methods may be appropriate. Whatever method is selected must effectively warn workers who are not authorized not to enter the area. Authorized personnel are those employees whose job duties require them to be in the area and may include maintenance personnel, managers and quality control engineers. In addition, designated worker representatives may enter the regulated area to observe exposure monitoring. All people who enter the regulated area must use proper protective equipment, including respirators when appropriate.

Control Measures

Whenever exposures exceed the PEL, employers must use engineering and work practice controls to reduce and maintain Cr(VI) exposures to or below the PEL. When feasible engineering and work practices controls have been used to reduce airborne exposures to Cr(VI) to the lowest levels achievable but levels are still above the PEL, employers must supplement them with the use of respirators that complies with the Respiratory Protection Standard, 29 CFR 1910.134.

Engineering controls include substitution (using a less toxic material or process that results in lower exposures), isolation (enclosing the source of exposure), and ventilation (such as local exhaust ventilation near the source of the exposure).

Work practice controls involve making adjustments in the way a task is performed. Workers must know the best practices when performing a task so that they minimize their exposure and maximize the effectiveness of the control. For example, welders should be trained to position the object being welded between themselves and the local exhaust ventilation. This example shows how work practice controls can complement engineering controls in providing worker protection.

Employers may not rotate workers to different jobs as a means of achieving compliance with the PEL. Hexavalent chromium is specifically regulated in its own standard because it has been determined to be a human carcinogen (cancer-causing substance). Because carcinogens have no threshold level below which no health effects (e.g., lung cancer) will be observed, the use of job rotation to reduce individual employee exposures exposes more workers to Cr(VI). This prohibition is found in other OSHA carcinogen substance-specific standards (e.g., asbestos, 1,3-butadiene, cadmium, ethylene oxide, methylenedianiline and methylene chloride).

A few exceptions are provided to the general requirement to use engineering and work practice controls to reduce employee Cr(VI) exposure below the PEL. In the aerospace industry, when workers are painting aircraft or large aircraft parts (e.g., interior or exterior of whole aircraft, aircraft wings or tail sections, or comparably sized aircraft parts), engineering and work practice controls must only reduce employee exposure to Cr(VI) to or below 25 $\mu g/m^3$.

Otherwise, if an employer can demonstrate that a particular process or task does not result in employee exposure to Cr(VI) above the PEL for 30 or more days in any 12 consecutive months, the employer is allowed to use any combination of controls, including respirators alone, to achieve the PEL. Historical data, objective data or exposure monitoring data may be used for this purpose.

Common Welding Practices

As previously stated, one significant source of airborne exposure to Cr(VI) can arise from welding on stainless steel and other metal-chromium alloys. Because different types of welding processes have different fume generation rates, the risk for exposure of welders to welding fumes and gases will, in part, be affected by the type of welding performed.

Shielded metal arc welding (SMAW), also referred to as "stick welding," is commonly used for welding on mild steel, low alloy steel and stainless steel. In SMAW, the electrode is held by hand and the electric arc flows between the electrode and the base metal. The electrode, which is consumed in the process, is covered with a flux material that provides a shielding gas for the weld to minimize impurities. In addition, SMAW is generally considered to have little potential for generating ozone, nitric oxide and nitrogen dioxide gases.

Gas metal arc welding (GMAW) or metal inert gas (MIG) welding is used on most types of metal and is faster than SMAW. In GMAW, an electric arc flows between the base metal and the consumable solid-core electrode, which is continuously fed from a spool. Because the electrode has no core and is not covered in flux material, an inert gas is supplied externally to exclude impurities. In spite of requiring a higher electrical current than SMAW, GMAW produces less fumes since the electrode has no fluxing agents. However, GMAW produces significant levels of ozone, nitrogen oxide and nitrogen dioxide gases as a result of the intense electric current involved.

Fluxed core arc welding (FCAW) is commonly used for mild steel, low alloy steel and stainless steel welding. In this welding process, a consumable electrode that has a central core containing fluxing agents is continuously fed from a spool during welding and an external inert gas may also be provided. This, in conjunction with the high electrical current used, results in a substantial amount of welding fume generated although there is little generation of ozone, nitric oxide and nitrogen dioxide gases.

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, uses a nonconsumable tungsten electrode. Filler metal is fed manually and the shielding gas is supplied externally. High electrical currents are used, resulting in significant levels of ozone, nitric oxide and nitrogen dioxide gases, but very little fume.

Submerged arc welding (SAW) is used to weld thick plates of mild steel and low alloy steels. In this welding process, the electric arc flows between the base metal and a consumable wire electrode. Unlike the other welding processes, there is no visible arc because the arc is submerged under flux material which, in turn, keeps fume levels low. This process also produces little ozone, nitric oxide and nitrogen dioxide gases. Due to the type of flux material used, the major airborne hazard is fluoride compounds.

Welding Fume Generation

When attempting to determine the most likely components to be present in the welding fume, employers should consult the safety data sheets and manufacturer's technical data sheet for the consumable electrode or wire. The majority of the fumes generated are derived from the filler metal and the flux coating or core of consumable electrodes. In general, the base metal contributes only a minor amount to the total plume since the base metal weld pool is cooler than the electrode tip. However, the base metal can be a significant factor of the fume exposure if the metal or surface residue contains a highly toxic substance, such as chromate-containing coatings and lead-based paint.

Other factors affect the amount of welding fume generated and the rate at which it is generated. Fume generation increases with an increase in electrical current and arc voltage. The diameter of the electrode also affects the fume generation rate, with a small diameter electrode creating fume at a higher rate than a larger diameter electrode.

In gas shielding arc welding, the choice of shielding gas can directly affect fume generation. The use of 100 percent carbon dioxide gas causes greater fume generation than when argon gas is used.

Besides the obvious affect of the speed of welding on fume generation, the type of current can also have a direct impact on fume generation. Utilizing a pulsing current during welding generates fewer fumes than using a steady current welding process.

Although FCAW generally produces welding fume at a greater rate on mild steel as compared with SMAW, the Cr(VI) levels in the fume are greater for SMAW than for FCAW. This may be due, in part, to the stabilizing effect that alkali metals, such as sodium and potassium, have on Cr(VI). These alkali metals are often found in SMAW electrode coatings and may also be present in FCAW flux.

Cr(VI) Exposure Factors During Welding

Besides the type of welding process used, other factors should be considered when evaluating potential exposure to Cr(VI). The first of these is the chromium content of the base metal as well as the flux ingredients in the consumable electrode. Obviously, the greater the chromium content of the base metal, the greater the potential for Cr(VI) in the fume. Ingredients in the flux may also have a stabilizing effect on Cr(VI) resulting in higher Cr(VI) concentrations.

The presence of chromates in coatings and paints that are applied to the base metal to resist corrosion will add to Cr(VI) concentrations during welding. Prior to performing repair work on painted structures, be sure to analyze samples of the coating for the presence of Cr(VI) and any other toxic metals (e.g., lead) that may be present. Where these metals are found to be present, the coating should be removed from areas where welding will occur using methods that will minimize any airborne exposure.

Another factor that has a significant impact on Cr(VI) exposure is the position of the work piece relative to the welder. Welding in a down-flat position, i.e., where the work piece is positioned below the waist, has the highest potential for exposure to Cr(VI) due to the path of travel of the smoke plume. Welding in a horizontal position also has a high potential for Cr(VI) exposure due to the welding fume path of travel. The least potential for exposure is associated with welding in a vertical position where the welder's breathing zone is typically below the path of travel of the plume.

Other factors to consider in evaluating Cr(VI) exposure potential during welding are associated with ventilation. Obviously, the use of local exhaust ventilation (LEV) when welding is preferred over general or dilution ventilation since it captures the welding fume at the source and removes it from the welder.

In addition, the type of work environment can have a direct effect on Cr(VI) exposure. Where welding must be done inside buildings or in an enclosed space and LEV is not used or is not feasible, there is an greater potential for exposure not only to the welder but to others working inside the building or enclosed space due to the accumulation of fumes.

Finally, the types and amount of other activities in the area that can increase Cr(VI) exposure must be considered. For example, plasma cutting inside enclosed spaces during welding can increase exposure levels, especially if the area is poorly ventilated.

Respiratory Protection

Employers are required to provide respirators to employees when engineering and work practice controls are not sufficient to maintain employee exposure to Cr(VI) at or below the PEL. Respirators are required:

- During work operations where engineering and work practice controls are not feasible (e.g., maintenance and repair activities);
- Emergencies (i.e., an occurrence that results, or is likely to result, in uncontrolled release of Cr(VI) that is not an incidental release that can be controlled by employees in the immediate area or by maintenance personnel);
- Where employees are exposed above the PEL for less than 30 days in any 12 consecutive months and the employer has opted not to implement engineering and work practice controls to achieve the PEL;
- Periods necessary to install or implement feasible engineering and work practice controls; or
- Operations where all feasible engineering and work practice controls have been implemented but are not sufficient to reduce exposures to or below the PEL.

Where respirator use is required or necessary, the employer must establish a respiratory protection program that meets the requirements of the Respiratory Protection Standard, 29 CFR 1910.134 and provides the employee with a respirator having an appropriate assigned protection factor. The N.C. Department of Labor has prepared a publication (*Industry Guide #44: A Guide to Respiratory Protection*) to assist employers in understanding and meeting the requirements of this standard. In addition, a sample respiratory protection program can be accessed by going to http://www.nclabor.com/osha/consult/sample_programs.htm.

Protective Work Clothing and Other Equipment

Because hexavalent chromium produces health effects due to contact with the eyes or skin, the employer must also provide appropriate protective clothing and equipment whenever contact with Cr(VI) poses or is likely to pose a hazard to workers. Some examples of protective clothing and equipment that may be necessary include, but are not limited to, gloves, aprons, coveralls, foot coverings and goggles. Employers must provide and maintain the clothing and equipment at no cost to the worker. Ordinary street clothing and uniforms or other accessories that do not protect workers from Cr(VI) hazards are not considered protective clothing or equipment under the standard.

The employer must ensure that workers and others who handle protective clothing and equipment take the following precautions:

- Workers must remove protective clothing and equipment that have become contaminated with Cr(VI) either at the end of their work shift or when they complete their tasks involving Cr(VI) exposure, whichever comes first.
- No worker can be permitted to remove contaminated protective clothing or equipment from the workplace, except those workers who job is to launder, clean, maintain or dispose of the clothing or equipment.
- Contaminated protective clothing or equipment that is removed for laundering, cleaning, maintenance or disposal must be stored and transported in sealed, impermeable bags or other closed, impermeable containers.
- Bags or containers of contaminated protective clothing or equipment that are removed from change rooms for laundering, cleaning, maintenance or disposal must be labeled in accordance with the Hazard Communication Standard, 29 CFR 1910.1200.
- Protective clothing and equipment must be cleaned, laundered, repaired and replaced as necessary to ensure that the effectiveness of the clothing and equipment is maintained.
- Any person who launders or cleans protective clothing or equipment contaminated with Cr(VI) must be informed by the employer of the potentially harmful effective of Cr(VI) exposure and that the clothing and equipment should be laundered or cleaned in a manner that minimizes skin or eye contact with Cr(VI) and prevents exposure to Cr(VI) in excess of the PEL.

Removal of Cr(VI) from protective clothing and equipment by blowing, shaking or any other means that disperses Cr(VI) into the air or onto a worker's body is prohibited.

Hygiene Areas and Practices

The Cr(VI) standards include requirements for change rooms, washing facilities, and eating and drinking areas when protective clothing and equipment are required to minimize exposure to Cr(VI). These requirements are:

Change rooms are required only when workers must change out of street clothes to use protective clothing and equipment. Change rooms required by the Cr(VI) standards for general industry and shipyards must conform to the requirements of 29 CFR 1910.141, whereas those specified in the Cr(VI) standard for construction must conform to the requirements of 29 CFR 1926.51. In addition, they must be effective in preventing Cr(VI) contamination of street clothes, and be equipped with separate storage facilities for protective clothing and equipment and for street clothes. This is intended to limit exposures after the work shift ends and avoid conveying Cr(VI) contamination to the workers' cars and homes.

Washing facilities must be provided and must be readily accessible and capable of removing Cr(VI) from the skin. Washing facilities must comply with the sanitation requirements in 29 CFR 1910.141 (for general industry), 29 CFR 1926.51 (for construction) and 29 CFR 1915.97 (for shipyards). The employer must ensure that affected workers use these facilities when necessary. This includes making sure that workers who have skin contact with Cr(VI) wash their hands and faces at the end of the work shift and prior to eating, drinking, smoking, chewing tobacco or gum, applying cosmetics, or using the toilet.

Eating and drinking areas and surfaces must conform with 29 CFR 1910.141 (for general industry), 29 CFR 1926.51 (for construction) and 29 CFR 1915.97 (for shipyards) and be maintained as free as practicable of Cr(VI) whenever employers allow workers to consume food or beverages at a worksite where Cr(VI) is present. Employers are also required to ensure that workers do not enter eating and drinking areas wearing protective clothing or equipment unless the protective clothing or equipment is properly cleaned beforehand. Employers may use any method for removing surface Cr(VI) contamination from clothing and equipment that does not disperse the dust into the air or onto the worker's body. For example, a worker wearing coveralls for protection against Cr(VI) could do a thorough HEPA vacuuming of the coveralls prior to entering the lunchroom. **Reminder: Do NOT blow dust off protective clothing and equipment!**

Housekeeping

The Cr(VI) standard for general industry also includes housekeeping measures. Similar requirements were not included in the construction and shipyard standards due to expected difficulties in complying with these requirements in those industry sectors. Proper housekeeping focuses on sources of exposure to Cr(VI) that engineering controls are not designed to address such as surface contamination, which can lead to skin contact. Therefore, employers are responsible to ensure that all environmental work surfaces are kept as free as practicable of accumulations of Cr(VI)-containing materials. Accordingly, any spills and releases of Cr(VI)-containing materials in the workplace must be promptly cleaned up and disposed in accordance with environmental regulations for hazardous waste disposal.

Worker Training and Communication

Employers must inform workers about the hazards associated with exposure to Cr(VI) and understand the necessary measures they can take to protect themselves. Through a comprehensive hazard communication program, as required by the Hazard Communication Standard (29 CFR 1910.1200), employers must provide employees with the information and training regarding labels and safety data sheets (SDSs).

In addition, the Cr(VI) standards require employers to provide sufficient information and training to ensure that employees can demonstrate knowledge of:

- The requirements of the Cr(VI) standard; and
- The medical surveillance program required by the standard, including recognition of the signs and symptoms of adverse health effects that may result from Cr(VI) exposure.

A copy of the Cr(VI) standard must be available to affected workers at no cost.

3

Medical Surveillance

Medical surveillance serves several purposes when considering worker exposure to Cr(VI). It allows physicians or other healthcare professionals to determine if an individual can be exposed to Cr(VI) at their workplace without experiencing adverse health effects. It permits appropriate intervention to be taken when Cr(VI)-related adverse health effects are identified in an individual. Finally, it determines an employee's fitness to use personal protective equipment, in particular, respirators.

Employers must provide a medical surveillance program for all employees:

- Exposed or may be exposed to Cr(VI) at concentrations at or above the action level (as an 8-hour TWA) for 30 or more days per year; or
- Experiencing signs and symptoms of adverse health effects associated with Cr(VI) exposures; or
- Exposed in an emergency situation (i.e., any occurrence resulting in a uncontrolled release of Cr(VI) that is not an incidental release that can be controlled by workers in the immediate area or by maintenance personnel).

What are some signs and symptoms of adverse health effects that are associated with exposure to Cr(VI)? These include blistering lesions, redness or itchiness of exposed skin, shortness of breath or wheezing that worsens at work, nosebleeds, and a whistling sound while inhaling or exhaling.

A licensed physician must perform or supervise all medical examinations and procedures, provided at no cost to employees and at a reasonable time and place. If employees must travel away from the worksite, the employer must pay them for the time spent undergoing medical examinations, including travel time.

Frequency of Medical Examinations

Employers must make medical examinations and consultations available to employees:

- Prior to employee assignment to an area where negative-pressure respirators are worn,
- Within 30 working days after assignment to a job involving exposure to Cr(VI) at any level;
- At least annually thereafter;
- Within 30 days after a physician or licensed healthcare professional (PLHCP) issues a written medical opinion that recommends additional examination(s);
- Whenever a worker shows signs or symptoms of adverse health effects associated with exposure to Cr(VI);
- Within 30 days following exposure during an emergency involving an uncontrolled release of Cr(VI);
- At the termination of employment unless the last examination provided was less than six months prior to the date of termination.

If the employee was examined within the past 12 months and that examination meets the criteria of the standard, another medical examination is not required.

Content of Medical Examination

Medical examinations must include the following:

- A medical and work history that focuses on:
  - Past, present and anticipated future exposure to Cr(VI);
  - History of respiratory system dysfunction;
  - Any history of asthma, dermatitis, skin ulceration or nasal septum perforation; and
  - Smoking status and history.

- A physical examination focusing on the skin and respiratory tract; and
- Any other examinations or tests suggested by the examining physician.

Employers must provide the following information to the examining physician:

- A copy of the applicable Cr(VI) standard and its appendixes;
- A description of the affected employee's former, current and anticipated duties relating to Cr(VI) exposure;
- The employee's representative current exposure level and anticipated Cr(VI) exposure levels;
- A description of any personal protective equipment and respiratory equipment used, including when and for how long this equipment has been worn; and
- Information from previous medical examinations not otherwise available, currently within control of the employer.

It is the employer's responsibility to obtain the physician's written opinion within 30 days of the examination. The physician's written opinion must contain:

- The PLHCP's opinion regarding whether the worker has any detected medical condition(s) that would place the worker at increased risk of material impairment to health from future exposure to Cr(VI);
- Any recommended limitations on the employee's exposure to Cr(VI) or the use of any personal protective equipment, such as respirators; and
- A statement that the employee has been provided an explanation of the results of the medical examination and has been informed of any medical conditions resulting from exposure to Cr(VI) that require further evaluation or treatment, and any special provisions for the use of protective clothing or equipment.

The physician must not reveal any specific findings or diagnoses in the written opinion that are unrelated to workplace exposure to Cr(VI). The employer must provide a copy of the physician's written opinion to the affected employee within two weeks after receiving it.

4

Recordkeeping

Why do employers need to maintain records regarding occupational exposure to hexavalent chromium? Accurate records can verify employer compliance with the Cr(VI) standard and can assist in diagnosing and identifying workplace-related illnesses. Therefore, employers are required to maintain records of worker Cr(VI) exposures (including air monitoring data, historical monitoring data and objective data) and medical surveillance records.

Air Monitoring Data

Employers must keep records of all employee exposure monitoring used to comply with the standard for 30 years. The record must indicate:

- The date of measurement for each sample taken;
- The operation involving exposure to Cr(VI) that was monitored;
- Sampling and analytical methods used and evidence of their accuracy;
- The number, duration and results of samples taken;
- The type of protective devices used (e.g., type of respirators worn); and
- The name, Social Security number and job classification of all workers represented by the monitoring and specifying which employees were actually monitored.

Historical Monitoring Data

When an employer relies on historical monitoring data to determine worker exposure to Cr(VI), an accurate record of the historical monitoring data must be maintained. The record must show:

- The data was collected using methods that meet the accuracy requirements of the standard;
- That the processes and work practices, characteristics of the Cr(VI)-containing material, and environmental conditions at the time the data was obtained were essentially the same as those of the job for which current exposure is being determined; and
- Any other relevant data regarding operations, materials, processes, or work exposures.

Objective Data Records

Where employers use objective data to demonstrate compliance with the Cr(VI) standard, they must keep an accurate record for as long as it is relied upon. The record must include:

- The Cr(VI)-containing material in question;
- The source of the objective data;
- The testing protocol, test results and analysis of the material for release of Cr(VI);
- A description of the process, operation or activity and how the data support the determination; and
- Other data relevant to operations, materials, processes or employee exposures.

Employers must make exposure records available when requested by affected employees, former employees, their designated representatives, and the commissioner of labor or her designee.

Medical Surveillance Records

Employers must keep all medical surveillance records for the duration of the employee's employment plus 30 years, including:

- The employee's name and Social Security number;
- The employee's medical examination results, including the medical history, questionnaires, responses, test results and physician's recommendations;
- The written opinions of the PLHCP;
- Any employee medical complaints related to Cr(VI) exposure; and
- A copy of the information provided to the examining PLHCP (i.e., a description of the worker's duties as they relate to occupational Cr(VI) exposure; worker's Cr(VI) exposure levels; a description of PPE used by the worker; and information from previous employment-related medical examinations).

Employee medical surveillance records must be available to the subject employee, anyone having specific written consent of that employee, and the commissioner of labor or her designee.

Glossary

The following terms are used in this document but are not elsewhere defined:

Action level (AL): A concentration for a specific substance, calculated as an 8-hour time-weighted average, that triggers certain required activities such as exposure monitoring and medical surveillance. Typically the AL is one-half that of the PEL for that substance. The AL for Cr(VI) is 2.5 micrograms per cubic meter (2.5 $\mu g/m^3$).

Assigned protection factor (APF): The workplace level of respiratory protection that a respirator or class of respirators is expected to provide to employees when the employer implements a continuing, effective respiratory protection program as specified by the respiratory protection standard.

Exposure or occupational exposure: Exposure to airborne chromium (VI) that would occur if the employee were not using a respirator.

Historical monitoring data: Data from chromium (VI) monitoring conducted prior to May 30, 2006, obtained during work operations conducted under workplace conditions closely resembling the processes, types of material, control methods, work practices and environmental conditions in the employer's current operations.

Objective data: Information that demonstrates the expected worker exposure to Cr(VI) associated with a particular product or material or a specific process, operation or activity. Information that can serve as objective data includes, but is not limited to, air monitoring data from an industry-wide survey; data collected by a trade association from its members; or calculations based on the composition or chemical and physical properties of a material. The data must reflect workplace conditions closely resembling the processes, types of material, control methods, work practices and environmental conditions in the employer's current operations.

Oxidation: Any reaction in which electrons are transferred.

Permissible exposure limit (PEL): An exposure limit that is published and enforced by OSHA as a legal standard. The hexavalent chromium standard has an 8-hour time-weighted average (TWA) permissible exposure limit of 5 micrograms per cubic meter of air (5 $\mu g/m^3$).

Respirator: Any device designed to provide the wearer with respiratory protection against inhalation of a hazardous atmosphere. Respirators used in addition to engineering and work practice controls to protect employees from overexposure to Cr(VI) must be NIOSH certified.

Time weighted average (TWA): The average exposure level determined from samples, taken for different time periods, throughout a workday. The TWA is determined by multiplying each sample by the time the sample was taken, adding these results and dividing this sum by the total sampling time. Where the TWA is compared to an 8-hour PEL (or AL), the sum is divided by eight hours or 480 minutes, depending on the units of time used.

References

1. National Toxicology Program, National Institutes of Environmental Health Sciences. *Report on Carcinogens,* 11th Edition.
2. Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention. *Toxicological Profile for Chromium,* Draft for Public Comment. September 2008. http://www.atsdr.cdc.gov/.
3. Spear, Jerome. *Hexavalent Chromium Exposure Factors From Welding Operations.* J.E. Spear Consulting, LP. 2009. http://www.jespear.com/articles/weldingchrom-1.pdf.
4. Occupational Safety and Health Administration (OSHA). *Hexavalent Chromium.* OSHA Publication 3373-10. 2009. Available: http://www.osha.gov/Publications/OSHA-3373-hexavalent-chromium.pdf.
5. U.S. Department of Labor, OSHA, *Federal Register.* Volume 71, Pages 10099–10385. Occupational Exposure to Hexavalent Chromium: Final Rule, February 28, 2006. Available: http://www.osha.gov/FedReg_osha_pdf/FED20060228.pdf.

Additional Resources

Standards

Hexavalent Chromium Standard, 29 CFR 1910.1026 (General Industry)
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=13096

Hexavalent Chromium Standard, 29 CFR 1915.1026 (Shipyards)
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=13116

Hexavalent Chromium Standard, 29 CFR 1926.1126 (Construction)
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=13117

Respiratory Protection Standard, 29 CFR 1910.134
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=12716)

Respiratory Protection Standard - Appendix A (Fit Test Procedures)
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9780)

Hazard Communication Standard, 29 CFR 1910.1200
http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099

Sample Programs

Hazard Communication
http://www.nclabor.com/osha/consult/sample_programs.htm

Operating Documents

Inspection Procedures for the Chromium (VI) Standards – CPL 02-02-074
http://www.osha.gov/OshDoc/Directive_pdf/CPL_02-02-074.pdf

Special Emphasis Program for Exposure to Health Hazards – OPN 135E
http://www.nclabor.com/osha/compliance/publicopn/opn135e.pdf

Hexavalent Chromium Interpretations, General Industry (Federal OSHA)
http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=INTERPRETATIONS&p_toc_level=3&p_keyvalue=1910.1026&p_status=CURRENT

Hexavalent Chromium Interpretations, Construction (Federal OSHA)
http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=INTERPRETATIONS&p_toc_level=3&p_keyvalue=1926.1126&p_status=CURRENT

Hexavalent Chromium Interpretations, Shipyards (Federal OSHA)
http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=INTERPRETATIONS&p_toc_level=3&p_keyvalue=1915.1026&p_status=CURRENT

Publications

Small Entity Compliance Guide for Hexavalent Chromium Standards (Federal OSHA)
http://www.osha.gov/Publications/OSHA_small_entity_comp.pdf

Other Agency Information

NIOSH Respiratory Protection Subject Index Page
http://www.cdc.gov/niosh/topics/respirators/

OSH Publications

We provide a variety of OSH publications. These include general industry and construction regulations, industry guides that cover different OSH topics, quick cards, fact sheets and brochures that cover a wide variety of serious safety and health workplace hazards. Workplace labor law posters are available free of charge. To obtain publications, call toll free at 1-800-NC-LABOR (1-800-625-2267) or direct at 919-807-2875. You may view the list of publications and also download many of them at **www.nclabor.com/pubs.htm.**

Occupational Safety and Health (OSH)
Sources of Information

You may call 1-800-NC-LABOR (1-800-625-2267) to reach any division of the N.C. Department of Labor; or visit the NCDOL home page on the World Wide Web: http://www.nclabor.com.

Occupational Safety and Health Division

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Local Telephone: 919-807-2900 Fax: 919-807-2856

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 3rd Floor)

For information concerning education, training, interpretations of occupational safety and health standards, and OSH recognition programs contact:

Education, Training and Technical Assistance Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2875 Fax: 919-807-2876

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 4th Floor)

For information concerning occupational safety and health consultative services contact:

Consultative Services Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2899 Fax: 919-807-2902

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 3rd Floor)

For information concerning migrant housing inspections and other related activities contact:

Agricultural Safety and Health Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2923 Fax: 919-807-2924

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 2nd Floor)

For information concerning occupational safety and health compliance contact:

Safety and Health Compliance District Offices

Raleigh District Office (3801 Lake Boone Trail, Suite 300, Raleigh, NC 27607)
Telephone: 919-779-8570 Fax: 919-420-7966

Asheville District Office (204 Charlotte Highway, Suite B, Asheville, NC 28803-8681)
Telephone: 828-299-8232 Fax: 828-299-8266

Charlotte District Office (901 Blairhill Road, Suite 200, Charlotte, NC 28217-1578)
Telephone: 704-665-4341 Fax: 704-665-4342

Winston-Salem District Office (4964 University Parkway, Suite 202, Winston-Salem, NC 27106-2800)
Telephone: 336-776-4420 Fax: 336-767-3989

Wilmington District Office (1200 N. 23rd St., Suite 205, Wilmington, NC 28405-1824)
Telephone: 910-251-2678 Fax: 910-251-2654

*****To make an OSH Complaint,* OSH Complaint Desk:** 919-807-2796***

For statistical information concerning program activities contact:

Planning, Statistics and Information Management Bureau

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2950 Fax: 919-807-2951

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 2nd Floor)

For information about books, periodicals, vertical files, videos, films, audio/slide sets and computer databases contact:

N.C. Department of Labor Library

Mailing Address:
1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-807-2850 Fax: 919-807-2849

Physical Location:
111 Hillsborough St.
(Old Revenue Building, 5th Floor)

N.C. Department of Labor (Other than OSH)

1101 Mail Service Center
Raleigh, NC 27699-1101
Telephone: 919-733-7166 Fax: 919-733-6197