



HEXAVALENT CHROMIUM IN DRINKING WATER

A REVIEW OF REGULATIONS AND TESTING PROCEDURES





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Hexavalent chromium (also known as chromium-6) is a family of chemical compounds used in a variety of materials, including paints, dyes and inks, as well as in industrial applications, such as electroplating and welding. As the most toxic form of chromium, chromium-6 has been linked to lung cancer and other respiratory diseases and illnesses, primarily due to prolonged exposure. Even simple direct skin contact with the chemical can lead to skin irritation, including rashes, ulcers and permanent scarring.

Exposure to chromium-6 in the U.S. workplace is actively regulated by the U.S. Occupational Safety and Health Administration (OSHA). In addition, 25 states, the Virgin Islands and Puerto Rico have adopted their own standards, regulations and enforcement mechanisms to protect workers against exposure to chromium-6. In most cases, state regulations mirror federal workplace exposure regulations, although some local jurisdictions may have tighter regulations or more strict enforcement.

Despite documented risks associated with exposure to chromium-6 in the workplace, the presence of chromium-6 in drinking water remains unregulated under the current provisions of the federal Safe Water Drinking Act. But that situation may change as a result of recent research showing elevated levels of chromium-6 in the drinking water supplies of 31 different cities across the United States. The U.S. Environmental Protection Agency (EPA) could move to establish federal limits for chromium-6 in drinking water as early as 2012, following the completion of its own chromium-6 risk assessment.

This UL white paper provides background on chromium and chromium exposure, specifically, human exposure to chromium-6 in drinking water, and discusses the results of recent studies showing levels of chromium-6 in drinking water greater than California's initial public health goal of 0.06 µg/L (parts per billion or ppb). The paper reviews current government regulation and oversight of chromium-6, testing procedures and protocols for assessing chromium-6 levels in water, and the minimum laboratory capabilities required for accurate chromium-6 testing. The white paper concludes with recommendations for public water system operators addressing future chromium-6 regulations and testing requirements.





Chromium and Chromium Exposure

Chromium is a tasteless, odorless chemical compound that occurs naturally in the environment in rocks, soil and plants, and in volcanic dust and gases. It is present in several different forms, including chromium-0 (metal form), chromium-3 (trivalent form) and chromium-6 (hexavalent form). Some forms of chromium are actually beneficial to humans; for example, chromium-3 is recognized as an essential human nutrient and is found in common foods as well as vitamins and other nutritional supplements.¹

Chromium-6 is most widely found as a component of coloring pigment used in paints, dyes, inks and plastics, and is often added as an anticorrosive agent to paints, primers and other surface coatings. Chromium-6 is also found in chromic acid, used in the electroplating of metal parts to provide a protective or decorative coating. In industrial applications, chromium-6 is typically produced as a result of welding on stainless steel, or the melting of chromium metal, when extremely high temperatures convert chromium to a hexavalent state.

Human exposure to chromium-6 is typically the result of inhaling fumes from products containing chromium-6 or produced by industrial processes; contact through inhalation typically involves the nose, throat and lungs. Exposure can also

occur as a result of products containing chromium-6 coming in contact with the skin, or chromic acid or chromate dusts coming in contact with eyes. Human exposure to chromium-6 can also result from the ingestion of drinking water, which potentially facilitates the transfer of the chemical throughout the body.

The health effects related to exposure to chromium-6 depend in part on the type, amount and duration of exposure. According to OSHA, in cases where direct contact is the likely route of exposure, adverse health effects can include minor skin irritations, dermatitis, rashes and skin ulcers. Exposure from inhalation can range from irritation of the nose and throat, and asthma and asthma-related symptoms, including wheezing and coughing, to more serious health issues, including lung cancer.²

Health effects related to exposure to ingested chromium-6 are presently the subject of active investigation by the EPA and other government agencies as well as private researchers. In its draft “Toxicological Review of Hexavalent Chromium” released in September 2010 for public comment, the EPA states that there is “evidence of an association between oral exposure to hexavalent chromium and stomach cancer in humans.” Further, the report notes that “available evidence indicates that chromium interacts with DNA, resulting in DNA damage and mutagenesis.”³

A final version of the EPA’s assessment is expected to be released in late 2011.

Perhaps the most widely known case involving human exposure to drinking water containing chromium-6 was the subject of a civil suit brought against Pacific Gas and Electric (PG&E) by attorney Edward Masry and his associate Erin Brockovich in the mid-1990s. In that case, a PG&E facility in Hinkley, Calif., was found to have discharged wastewater containing high concentrations of chromium-6 into unlined ponds, which then percolated into the local groundwater. The lawsuit, settled in 1996 for a record \$333 million, claimed that residents of Hinkley experienced significantly higher rates of cancer as a result of their consumption of drinking water with elevated levels of chromium-6.

Regulatory Oversight of Chromium-6 in Drinking Water

Although the PG&E case generated significant public interest, levels of chromium-6 in drinking water have remained unregulated at the federal level. The federal Safe Drinking Water Act (SDWA), originally published in 1974 and amended as recently as January 2011, currently identifies maximum concentration levels in drinking water for more than 100 different chemicals. While concentrations of total chromium are limited to 100 µg/L (ppb), the Act does not specifically set concentration



limits for chromium-6. Further, the EPA does not require local water systems to test drinking water supplies for chromium-6 concentrations.

At the state level, California has been the most active to date in efforts to establish limits for chromium-6 in drinking water and in monitoring concentration levels in local water supplies. The California Department of Public Health (CDPH, formerly the Department of Health Services) classified chromium-6 as an “unregulated chemical requiring monitoring” in 1999, and began receiving samples from local water authorities in January 2001.

Separately, the state’s Office of Environmental Health Hazard Assessment (OEHHA) began efforts to establish a public health goal for chromium-6, proposing a goal of 0.06 µg/L (ppb) in September 2009. The proposed public health goal was revised downward to 0.02 µg/L (ppb) in July 2011⁴, paving the way for the California CDPH to proceed with efforts to establish a primary drinking water standard setting a maximum contaminant level for chromium-6.

The level of interest in increased federal regulation of chromium-6 in drinking water rose dramatically in late 2010, when the non-profit Environmental

Working Group (EWG) released findings from a study evaluating chromium-6 levels in public drinking water supplies in 35 selected cities across the United States. According to a report issued by the EWG, water samples from 31 of 35 cities evidenced detectible levels of chromium-6, with samples from 25 cities exhibiting levels of chromium-6 higher than 0.06 µg/L (ppb). The average chromium concentration for all cities included in the study was 0.18 µg/L (ppb); one city in the study, Norman, Okla., had chromium-6 concentration levels of 12.90 µg/L (ppb).⁵

The release of the EWG study on chromium-6 levels in drinking water prompted the EPA to publish recommendations in January 2011 regarding the monitoring of chromium-6 levels in drinking water by state and local drinking water authorities.⁶ The EPA’s guidance includes recommendations on the frequency and process for collecting water samples for testing. It also provides detailed information on preferred laboratory testing methods for accurately assessing chromium-6 concentrations.

The EPA also pledged to release the final version of its “Toxicological Review of Hexavalent Chromium” in 2011, and to determine if additional standards and testing requirements are appropriate.

In a meeting in December 2010 with a group of U.S. senators inquiring about the EPA’s response to the EWG study, EPA Administrator Lisa Jackson noted that, based on the current draft risk assessment, the EPA would likely revise drinking water regulations to account for the more recent scientific findings.⁷

At least some lawmakers are likely to keep pressure on the EPA to follow through on its commitment to strengthening chromium-6 drinking water standards. In January 2011, U.S. senators Barbara Boxer and Dianne Feinstein introduced legislation that would set a one year deadline for the EPA to establish an enforceable limit for chromium-6 in drinking water. Further legislative and regulatory developments are expected throughout 2011.

Finally, the EPA has proposed changes to its Unregulated Contaminant Monitoring Regulation 3 (UCMR 3) requiring the monitoring of contaminants using EPA and/or consensus analytical methods. As published in the Federal Register in March 2011,⁸ proposed changes would include chromium-6 among the list of contaminants under UCMR 3 subject to assessment monitoring by public water systems. No decision about the proposed UCMR 3 changes was available at the time this white paper was being prepared.

Applicable Monitoring Guidelines and Testing Methods and Protocols

As previously noted, the EPA issued recommendations in January 2011 for public water systems regarding enhanced monitoring measures for chromium-6 in drinking water. While the agency evaluates what additional monitoring and testing measures should be implemented, this guidance represents the best framework currently available for the assessment of chromium-6 content by public water systems.

The EPA's guidance includes recommendations in the following areas:

- Preferred sampling locations
- Sampling frequency
- Laboratory assessment methods

Preferred Sampling Locations

To ensure the most accurate sampling results, the EPA recommends collecting samples from the following locations:

Intake/well locations — Samples should be collected at the intake or well location so that untreated water can be evaluated. Systems with multiple intakes, wells or other entry points should collect samples from representative entry points to a distribution system, so that data can be used to identify corresponding water sources with concentrations of chromium-6.

Entry points to the distribution system — Samples should also be collected at the points at which treated water enters a distribution system. Again, systems with multiple entry points should collect samples from representative entry points.

The number of entry points sampled will likely depend on the number of treatment facilities, as well as the historical levels of chromium concentrations in treated water.

Distribution system — Finally, samples should be collected at various locations within the distribution system, with special attention to those locations considered to represent the “maximum residence time.” The number of sample locations within a distribution system will depend on the number of entry points, proximity of entry points to each other and overall size of the distribution system.

Sampling Frequency

The EPA recommends that public water

systems that rely on surface water sources, such as lakes and streams, collect samples for assessment at least once every three months. This frequency is necessary to capture variations in the levels of chromium-6 that may occur in source waters. Public water systems that rely on ground water sources should be sampled once every six months. To the extent practical, water samples should be collected from all specified locations on the same day.

Laboratory Assessment Methods

The EPA currently recommends the use of a modified version of EPA Method 218.6, “Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater and Industrial Wastewater Effluents by Ion



Chromatography,”⁹ for analyzing drinking water samples for chromium-6 content. The modified method¹⁰ includes a lower effluent rate, longer reaction coil and larger injection volume, which combine to significantly increase the sensitivity of an assessment. As such, the modified method allows for the detection of chromium-6 concentrations as low as 0.02 µg/L (ppb), consistent with California’s proposed public health goal, and for reporting concentrations as low as 0.06 µg/L (ppb).

Recommendations for Selecting a Testing Laboratory

While the increased federal regulation of chromium-6 appears likely, there are presently no requirements specifically limiting chromium-6 content in drinking water. Further, California is the only jurisdiction in the United States that

currently requires the monitoring of drinking water for chromium-6. Due to the absence of regulations regarding chromium-6, most laboratories serving the drinking water analytical market do not include this contaminant in their scope of services, making it difficult for public water systems to identify testing laboratories that are both equipped and technically qualified to assess drinking water samples to emerging concentration limits.

While there are a number of laboratories that possess the instrumentation required to conduct chromium-6 analysis consistent with the modified requirements of EPA Method 218.6, many of these laboratories are routinely testing for higher, i.e., less sensitive, concentrations of chromium-6 in wastewater, and therefore may not have

the knowledge or experience to test to the level of sensitivity required for drinking water assessment.

As such, public water systems should exercise care when selecting a testing laboratory to perform testing for chromium-6 in drinking water, and conduct the necessary due diligence to ensure that their selected laboratory possesses the requisite equipment and technical expertise. Testing laboratories certified by an accrediting authority to conduct testing to an approved ion chromatography method (such as EPA Method 300.0, SM 41108, or ASTM D4327) and which have expertise in drinking water testing should be given priority over other laboratories. Taking these steps can help ensure accurate testing results and minimize wasted time and expense.



Summary

Public concerns about the presence of chromium-6 in drinking water are bringing increased attention from regulators, elected officials and public water system operators. As a result, new federal and state regulations restricting chromium-6 concentrations in drinking water can be expected in the near future, and mandatory testing of drinking water for chromium-6 levels may not be far behind. A competent and qualified testing laboratory can provide important guidance in establishing an effective chromium-6 monitoring program, and help address the anticipated challenges of meeting regulations in the future.

UL can assist public water system operators in monitoring low-level concentrations of chromium-6 in drinking water, and has the capabilities to test for chromium-6 concentrations as low as 0.02 µg/L under EPA Method 218.6, and for total chromium concentrations as low as 0.1 µg/L under EPA Method 200.8. For more information about the “Hexavalent Chromium: A Review of Regulations and Testing Procedures” white paper and UL’s capabilities in chromium-6 monitoring and testing, please contact Nathan Trowbridge, customer experience manager, at Nathan.R.Trowbridge@ul.com

¹ Agency for Toxic Substances & Disease Registry web site. Center for Disease Control. Web. 13 Jun. 2011. <http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=17>

² Health Effects of Hexavalent Chromium. OSHA, Jul. 2006. Web. 13 Jun. 2011 http://www.osha.gov/OshDoc/data_General_Facts/hexavalent_chromium.pdf

³ Toxicological Review of Hexavalent Chromium. U.S. Environmental Protection Agency, External Review Draft, Sep. 2010. Web. 13 Jun. 2011. http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=221433

⁴ Public Health Goals for Chemicals in Drinking Water: Hexavalent Chromium (Cr VI). California Environmental Protection Agency, Office of Environmental Health Hazard Assessment, Jul. 2011. Web. 23 Aug. 2011. <http://oehha.ca.gov/water/phg/pdf/Cr6PHGo72911.pdf>

⁵ Chromium-6 in U.S. Tap Water. Report of the Environmental Working Group, 2010. Web. 13 Jun. 2011. http://static.ewg.org/reports/2010/chrome6/chrome6_report_2.pdf

⁶ EPA’s recommendations for enhanced monitoring for Hexavalent Chromium (Chromium-6) in Drinking Water. U.S. Environmental Protection Agency (EPA). Web. 13 Jun. 2011. <http://water.epa.gov/drink/info/chromium/guidance.cfm>

⁷ Statement from EPA Administrator Jackson on her meeting with 10 U.S. Senators on Chromium-6. Environmental Protection Agency, 22 Dec 2010. Web. 13 Jun. 2011. http://www.epa.gov/agingepa/press/epanews/2010/2010_1222_1.htm

⁸ Revisions to the Unregulated Contaminant Monitoring Regulation (UCMR 3) for Public Water Systems. Federal Register, 3 Mar. 2011. Web. 13 Jun. 2011 <http://www.federalregister.gov/articles/2011/03/03/2011-4641/revisions-to-the-unregulated-contaminant-monitoring-regulation-ucmr-3-for-public-water-systems>

⁹ Method 218.6: Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography, Revision 3.3. EPA Office of Research and Development and Office of Science and Technology, 1994. Web. 13 Jun. 2011 https://www.nemi.gov/apex/?p=237:38:1709276447323432:::P38_METHOD_ID:9508

¹⁰ Determination of Hexavalent Chromium in Drinking Water Using Ion Chromatography. Application Update 144. Dionex Corporation. 13 Jun. 2011 http://www.dionex.com/en-us/webdocs/4242-AU144_LPN1495.pdf

Note that an equivalent ion chromatographic system comprised of comparable hardware from any manufacturer can generate an acceptable level of performance, and meet the quality control requirements of EPA Method 208.6