Toxics Use Reduction Institute

SUMMARY OF POLICY ANALYSIS

***Recommendation to separate hexavalent chromium compounds from the Chromium Compounds category (MassDEP Category 1012)* and**
Recommendation to designate hexavalent chromium compounds as a Higher Hazard Substance

The Toxics Use Reduction Institute recommends that hexavalent chromium compounds be separated from the larger Chromium Compounds category, and that hexavalent chromium compounds be designated as a Higher Hazard Substance. This Policy Analysis presents the factors the Institute has taken into account in developing this recommendation.

1. State of the Science

The Chromium Compounds category **(MassDEP category 1012)**, which exists under both the federal Toxics Release Inventory (TRI) and under TURA, includes all forms of chromium, except zero valence chromium metal. This policy analysis discusses chromium compounds only. It does not discuss, or recommend any changes related to, zero valence chromium metal.

The hazards of hexavalent chromium compounds are significantly different from those of non-hexavalent chromium compounds. Hexavalent chromium compounds are confirmed human carcinogens, mutagens and developmental toxicants and have high acute toxicity. Non-hexavalent chromium compounds do not pose the same level of concern with regard to either chronic or acute toxicity.

2. Number of facilities affected

Separating hexavalent chromium compounds from the Chromium Compounds category would not bring in any new filers, although it is estimated that one existing filer could be required to file two Form S reports (one for hexavalent and one for other chromium compounds) rather than a single Form S report for all Chromium Compounds.

The TURA program estimates that the 1,000 pound reporting threshold that would apply to a higher hazard substance would result in approximately 20 facilities being required to begin reporting use of hexavalent chromium compounds. These facilities are expected to be found primarily in industry sectors related to production of colorants, resins, plastics and plating/surface finishing. Other industry sectors are expected to be minimally affected.

3. Opportunities for New Filers

Alternatives are available for many uses of hexavalent chromium. In many cases, the alternatives are technically straightforward, produce equally good final products, and are financially feasible. Barriers and challenges include customer specifications (especially specifications related to color), and the need for additional training or worker skills. Alternatives to hexavalent chromium processes may require greater process control, operator skill and maintenance than hexavalent chromium processes. Industry representatives emphasize the importance of education and training up and down the supply chain, because customer specifications frequently determine facilities' choices of process and materials.

In addition to facilities that could be expected to meet the 1,000 lb/year threshold, a significant number of small facilities are likely to be using smaller amounts of hexavalent chromium on an occasional basis. There may be opportunities for outreach and technical assistance to these facilities to help them identify options for reducing or eliminating hexavalent chromium use.

4. Regulatory context

Both hexavalent and non-hexavalent chromium compounds are subject to a variety of regulations at the state, federal, and international levels. Some statutes regulate both the general category of “total chromium compounds” and the more specific category of “hexavalent chromium compounds.” Hexavalent chromium compounds are subject to more regulations than other chromium compounds, due to their serious adverse effects on human health and the environment. For example, California regulates hexavalent chromium compounds as carcinogens and male and female developmental toxicants under Proposition 65, and is working to develop a drinking water standard for hexavalent chromium. US EPA is currently examining the possibility of regulating hexavalent chromium separately from other chromium compounds in setting drinking water standards. In Europe, use of hexavalent chromium compounds is prohibited for many uses, including uses in packaging, vehicles and electronics, except where exemptions are provided.

5. Implications for the TURA program

Separating hexavalent chromium compounds from the chromium compound category and making hexavalent chromium compounds a higher hazard substance would have several implications for the TURA program.

Implications for TURA program agency staff and services:

- Implications include greater information on use of hexavalent chromium compounds in Massachusetts; increased opportunities to work with facilities to make the best possible choices in selecting alternatives to hexavalent chromium; and enhanced opportunities to protect health and the environment by working with smaller hexavalent chromium users. Attention brought to hexavalent chromium by the European Union’s RoHS directive has created a potentially important window of opportunity for these efforts.
- The program agencies, particularly TURI and OTA, provide a number of services on an on-going basis. It is appropriate to add new content to these activities over time; thus, program services related to hexavalent chromium would enhance, not detract from, existing program activities.

Implications for administrative and regulatory guidance:

- The TURA program will need to create an internal identification number for hexavalent chromium compounds for reporting purposes, and will need to provide clear guidance to facilities on how to determine whether their chromium use is hexavalent.
- Requiring separate reporting of hexavalent chromium compounds would make TURA requirements different from TRI requirements for this substance. However, it would also place Massachusetts in the mainstream of newer state and federal regulatory initiatives related to chromium compounds.

Implications for TURA filer fees: There would be some additional cost to companies that would begin reporting hexavalent chromium compounds based on the lower reporting thresholds.

Toxics Use Reduction Institute

POLICY ANALYSIS

Recommendation to separate Hexavalent Chromium Compounds from the Chromium Compounds category(MassDEP category 1012),
and
Recommendation to designate Hexavalent Chromium Compounds as a Higher Hazard Substance

The TURA Science Advisory Board (SAB) has recommended separating hexavalent chromium compounds from the larger Chromium Compounds category, due to the higher toxicity of hexavalent chromium. The SAB previously placed hexavalent chromium on their guidance list of More Hazardous Substances and has recommended designating hexavalent chromium compounds as a Higher Hazard Substance under TURA.

If the hexavalent chromium compounds are separated from the larger chromium compounds category, facilities using either hexavalent chromium compounds or lower-valence chromium compounds will be subject to TURA requirements if they meet the threshold relevant to the type of compound they are using. Facilities using both hexavalent and non-hexavalent chromium compounds will be subject to TURA requirements for both types of compounds. However, some facilities that previously met the threshold for all chromium compounds combined may no longer meet that threshold, since quantities used will be totaled separately. For facilities that do not know the valence state of their chromium compounds, the TURA program will provide guidance indicating that they should assume it is hexavalent until they are able to determine that it is not.

If hexavalent chromium compounds are designated as a Higher Hazard Substance, the reporting threshold would be lowered to 1,000 lbs/year for facilities using these substances in TURA-covered sectors with ten or more employees. New facilities entering the program under the lower reporting threshold would be required to file annual toxics use reports, pay annual toxics use fees, and develop a toxics use reduction plan every two years. In addition, the TURA program would prioritize hexavalent chromium compounds in allocating program resources, providing targeted assistance to companies in reducing or eliminating use of this chemical.

This policy analysis begins by summarizing the scientific information considered by the Science Advisory Board. It then presents available information on companies that are likely to enter the program as a result of the lower reporting threshold; analyzes opportunities and challenges that are likely to face new filers as they enter the program; and discusses the implications of this policy measure for the TURA program. Based on this analysis, the Toxics Use Reduction Institute recommends that hexavalent chromium compounds be separated from the larger chromium compounds category, and that hexavalent chromium compounds be designated as a Higher Hazard Substance.

Note: This policy analysis discusses chromium compounds only. It does not discuss, or recommend any changes related to, zero valence chromium metal.

1. State of the Science

Overview of terminology

The Chromium Compounds category (MassDEP category 1012), which exists under both the federal Toxics Release Inventory (TRI) and under TURA, includes all forms of chromium, except zero valence chromium metal.[*] Chromium exhibits a wide range of possible oxidation states (or "valence states") ranging from chromium(-II) to chromium(VI).

- *Trivalent chromium.* Chromium compounds are stable in the trivalent state (+3) and occur in nature in ores, such as ferrochromite.
- *Hexavalent chromium.* The hexavalent (VI or +6)) form is the second most stable state. Hexavalent chromium rarely occurs naturally; it is usually produced from industrial activity.
- *Other valence states of chromium.* Elemental chromium (chromium(0)) does not occur naturally,[1] , and is separately reportable in aerosol form under TURA. Of the other oxidation states, +2 is somewhat common and +1, +4 and +5 are rare.[2] Oxidation states -2 and -1 also exist, although rarely.

This policy analysis discusses chromium compounds only. It does not discuss, or recommend any changes related to, zero valence chromium metal.

SAB actions and recommendations

When the SAB originally categorized the chemical list in 1999, it placed hexavalent chromium compounds on the 'More Hazardous' list and trivalent chromium compounds on the 'Less Hazardous' list. The SAB did this for informational purposes, to help provide guidance to companies, even though these substances did not exist as separately reportable categories under TURA.

In 2010, the SAB revisited the chromium compounds category in more depth with more recent information. In light of this information, the SAB voted to keep hexavalent chromium on its 'More Hazardous' list, and recommended that the Council designate hexavalent chromium compounds as a Higher Hazard Substance. The Higher Hazard Substance recommendation was based primarily on the carcinogenicity data for hexavalent chromium compounds.

The SAB also voted to move trivalent chromium compounds from its 'Less Hazardous' list to its 'Uncategorized' list, due to the fact that these can transform into hexavalent chromium compounds under certain circumstances. The SAB also took into consideration the fact that non-hexavalent chromium compounds are recognized as asthmagens by the Association of Occupational and Environmental Clinics (AOEC).

[*] Zero valence chromium metal (CAS 7440-47-3) is reportable only as an aerosol under TURA. If a facility exceeds the 25,000 lb threshold for chromium metal aerosol and for chromium compounds, they have the option of reporting their total use of both under the chromium compounds category.

Acute Health Effects of Chromium Compounds (including information on hexavalent and non-hexavalent compounds)

- Hexavalent chromium compound exposure via inhalation has been documented to cause several short-term and intermediate effects including, but not limited to, respiratory irritation, epistaxis (nosebleed), asthma, sensitization, and dermatitis. Health effects can vary based on the solubility of the compounds. The Agency for Toxic Substances and Disease Registry (ATSDR) published a detailed draft report on the toxicity of the various forms of chromium in 2008; this report is a useful source of additional details on these and other health effects.[3]
- The Science Advisory Board considered LD50s for a sample hexavalent and a sample trivalent chromium compound (chromium trioxide and chromic oxide, respectively). These data are shown in Appendix A.
- The LD50 for trivalent chromium compounds is approximately 10 times that of hexavalent chromium compounds, indicating that trivalent chromium compounds have much lower acute toxicity.[4]

Chronic Health Effects of Chromium Compounds[5] (including hexavalent and non-hexavalent compounds)

- The International Agency for Research on Cancer (IARC) classifies hexavalent chromium compounds in Group 1 (carcinogenic to humans). In contrast, trivalent chromium compounds are Group 3 (not classifiable with regard to carcinogenicity to humans).
- Long-term inhalation of hexavalent chromium is known to cause lung cancer.[6] It also can result in damage to the nasal mucous membrane, perforation of the nasal septum, and asthma. If inhaled through the mouth, it can cause periodontitis and gingivitis.
- Impacts of chronic hexavalent chromium skin exposure include dermatitis, hypersensitivity reactions, eczema, and kidney or liver damage. The characteristic lesions resulting from hexavalent chromium exposure are referred to as "chrome holes" or "chrome ulcers." Chronic eye exposure can result in conjunctivitis.[7]
- Hexavalent chromium is a mutagen, a developmental toxicant, and a renal toxicant.[8] [9] [10]
- Both hexavalent chromium compounds and non-hexavalent chromium compounds are recognized by AOEC as asthmagens.[11]

Conversions between hexavalent chromium compounds and trivalent chromium compounds

Trivalent chromium is the most likely species to exist in the environment. It is relatively insoluble in water, and has low reactivity and low mobility in soils. Under certain conditions, hexavalent chromium will convert (be reduced) to trivalent chromium in the natural environment. Conversion from hexavalent chromium to trivalent chromium would be most likely to occur in the presence of iron (in air, water or soil) or organic matter.

Hexavalent chromium is highly water soluble. It is possible for chromium (III) to be oxidized to hexavalent chromium in air or water in the presence of manganese oxide. The hexavalent state is also favored under oxidizing conditions (e.g., shallow aquifers), alkaline conditions, and in situations where there is manganese or low iron[12] (for example, in the naturally occurring conditions in the southwest US). Conversion of trivalent chromium to hexavalent chromium is a slow process – in lab conditions 2-17% will convert over a period of several months[13].

The potential for trivalent chromium to convert into hexavalent chromium factored into the SAB's decision to move non-hexavalent chromium compounds to its 'Uncategorized' category (rather than Less Hazardous Chemicals category).

In some instances, the distinction between the hazard of trivalent and hexavalent chromium is blurred by the purity of the source material (both for testing and for use) and the changing oxidation states due to biological and chemical activity.

Uncertainty

In general, the effects of hexavalent chromium and trivalent chromium are well understood. Thus, uncertainty does not play a significant role in our policy analysis for these substances. The uncertainty around speciation of chromium states in the environment did play a role in the SAB's decision to move non-hexavalent chromium compounds from its "less hazardous chemicals" category to its "uncategorized" list (i.e. to raise the level of concern about non-hexavalent chromium compounds).

2. Number of facilities affected

Chromium compounds, including both hexavalent and other valence states of chromium, are used in a range of industrial processes and consumer products. Chromium can provide manufactured products with hardness, shininess, durability, color, corrosion resistance, heat resistance, and decay resistance. For example:

- Decorative chrome plating produces a durable surface coating on items such as school furniture. Decorative chrome plating can be achieved using either hexavalent or trivalent chromium forms.
- Jet turbine engine parts rely on hard chrome plating to resist corrosion, high temperatures, and wear. Hard chrome plating is generally achieved using hexavalent forms of chromium.
- Chromium-based pigments are valued for their vivid colors and resistance to weathering; they are commonly used in traffic paints for those reasons.
- Anti-corrosion coatings containing chromium compounds are widely used, particularly in marine applications, where their resistance to salt spray and their "self-healing" properties are important.
- The biocidal properties of chromium compounds are key to their use in wood preservatives.[14]

The major application of chromium is in the production of alloys, primarily stainless steel; historically, this has amounted to 50-60% of total chromium use.[15] Wood preservation, metal processing, leather tanning, and pigments have historically been the main uses of chromium compounds.[16]

Uses of Chromium Compounds in Massachusetts Manufacturing

Based on recent filings under the Massachusetts Toxics Use Reduction Act (TURA), the companies reporting Chromium Compounds in the greatest quantity in Massachusetts are involved in the production and use of pigments, metal finishing, electroplating, the manufacture of abrasives, and manufacture of asphalt roofing shingle granules. Chromium compounds are also generated as a by-product of electricity generation.

Historically, Chromium Compounds have been reported to the TURA program by the following sectors (current sectors in bold):

Table 1.Sectors that have reported use of chromium compounds under TURA	
2262	Finishing plants, manmade
2269	Finishing plants, nec
2295	Coated fabrics, not rubberized
2299	Textile goods, nec
2491	Wood preserving
2531	Public building & related furniture
2621	Paper mills
2816	Inorganic pigments
2819	**Industrial inorganic chemicals, nec**
2851	Paints and allied products
2865	Cyclic crudes and intermediates
2869	**Industrial organic chemicals, nec**
2899	Chemical preparations, nec
3069	Fabricated rubber products, nec
3081	Unsupported plastics film and sheet
3087	**Custom compound purchased resins**
3111	Leather tanning and finishing
3291	**Abrasive products**
3295	**Minerals, ground or treated**
3297	Nonclay refractories
3316	Cold finishing of steel shapes
3324	Steel investment foundries
3325	Steel foundries, nec
3341	Secondary nonferrous metals
3357	Nonferrous wire drawing and insulating
3411	Metal cans
3425	Saw blades and handsaws
3471	Plating and polishing
3479	Metal coating and allied services
3554	Paper industries machinery
3678	Electric connectors
3695	Magnetic and optical recording media
3714	Motor vehicle parts and accessories
3822	Environmental controls
3841	Surgical and medical instruments
3861	Photographic equipment and supplies
4911	**Electric services**

As of 2008, only eight companies filed for chromium compounds. Given the significant reduction over time in the number of facilities filing for chromium compounds, the program examined the trends in more detail to determine whether facilities had gone out of business, or whether facilities had continued to operate but had stopped using chromium at reportable levels.

As shown Table 2 below, of the 52 facilities that have ever reported chromium compounds use, all but ten are still in business, indicating that the trend is not primarily explained by companies closing. The ten facilities that have gone out of business or moved manufacturing out of Massachusetts include three leather tanning facilities, two audio/film manufacturers, four plastics or wire coating facilities, and one wood treatment facility. In addition, of the 52 facilities that have ever reported chromium compounds, 26 did not file in 1990.

One of the reasons that facilities ceased reporting is a result of the 2006 amendments to TURA. Prior to the amendments, a facility that met the 10,000 (otherwise used) or 25,000 (manufactured or processed) pound threshold for reporting any one chemical was then subject to a 10,000 pound threshold for all manufactured or processed chemicals used at the facility, rather than the 25,000 pound threshold that would have applied otherwise. After the change, meeting the relevant threshold requirements for one chemical did not lead to any change in reporting requirements for other chemicals. Five facilities, including two utilities, appear to have stopped reporting on chromium compounds use as a result of this change.

In summary, some sectors have moved out of chromium compound use entirely, while others continue to be significant users of chromium compounds. Metal finishing, metal products and pigments continue to be important sectors using chromium compounds; electricity generation is also significant because it is the principal source of reported on-site releases of chromium compounds, as noted above. Wood preservation, on the other hand, has moved away from chromium compound use entirely, responding to regulatory drivers.

Table 2 . Chromium Compounds[1]**:**

Massachusetts Use by Use Categories (1990 and 2008)

Use Category[2]	**Facility Name**	**Use (pounds)**		**Maximum Use [year]**
		1990	**2008**	
Electricity Generation[3]	Dominion Energy Brayton PT	-[4]	126,137	
	Dominion Energy Salem Harbor	-	-	23,254 [2005]
	Mt Tom	-	-	18,200 [2005]
	Somerset Power	-	-	14,400 [2002]
	subtotal	-	*126,137*	
Leather Tanning	Bond Leather Co	-	-	531,188 [1994]
	Carr Leather	81,815	-	
	Salem Suede Inc	-	-	258,600 [1995][5]
	subtotal	*81,815*	-	
Metal Finishing	Facilities that Plate or Treat with Chromium			
	Columbia Manufacturing [6]	20,000	-	
	Duralectra Inc	628	-	
	Independent Plating	-	-	13,700 [1998]
	Micron Medical Prod	-	-	64,734 [2004]
	Plating Technology	-	-	21,329 [2000]
	Tech Etch Inc	-	-	12,572 [2000]
	Westfield Electroplating Co	16,400	-	
	Manufacturers of Metal Finishing Chemistries			
	Heatbath Corp [7]	11,730	-	
	Luster On Products I	239,496	87,686	
	subtotal	*288,254*	*87,686*	
Metal Products	Allegheny Rodney Strip Division	30,360 [8]	-	
	Engineered Materials	-	-	1,392,396 [2002]
	Saint Gobain Abrasives	-	61,414	
	Texas Instruments	4,100	-	
	Wollaston Alloys Inc[9]	44,569	31,013	
	subtotal	*79,029*	*92,427*	
Organic Chemicals	ISP Freetown Fine Chemicals	-	-	25,706 [2000]
	subtotal	-	-	
Photograhy and Audio Film	BASF Corporation	769,637	-	
	Polaroid Corporation	43,602	-	
	subtotal	*813,239*	-	

Pigments	Resins and Coatings			
	Alphagary	-	-	54,540 [2000]
	American Insulated Wire Corp	630,000	-	
	Certainteed Granule Plant / Bird Inc Roofing	26,040	35,369	
	Clariant Corp	55,000	6,801	
	DN Lukens	-	21,515	
	Franklin Paint	-	-	145,593 [2005]
	General Cable	96,147	-	
	Gitto Global	-	-	12,343 [1997]
	Globe Rubber Works	-	-	39,450 [1997]
	Haartz Corp	24,524	-	
	Hudson Color Concentrates	-	85,987	
	Indusol	44,100	-	
	Madison Cable Corp	-	-	61,789 [1993]
	Pliant Corp	-	-	19,554 [2002]
	Polymer Concentrates	-	-	11,633 [2001]
	Spectra Polymer Inc	47,305	-	
	Surface Coatings Inc	22,450	-	
	Teknor Apex Co	249,127	71,945	
	Vernon Plastics	18,838	-	
	Laminated Paper			
	PWA Rollan Decor Inc	19,650	-	
	subtotal	*1,233,181*	*221,617*	
Textile Dyes	Duro Finishing Corp	-	-	90,315 [1996]
	Malden Mills	-	-	192,837 [1992]
	Zeneca Inc	62,000	-	
	subtotal	*62,000*	-	
Wood Preservatives	Bestway of New England	-	-	174,420 [2001]
	North American Woodpreserving	93,423	-	
	Northeast Treaters Inc	429,496	-	
	Universal Forest Products [10]	148,171	-	
	subtotal	*671,090*	-	
Distribution	Univar	-	-	2,631,637 [1991]
	Total	**3,228,608**	**527,867**	

General notes about this table:

- Some facilities in the early years of the program confused chromium with chromium compounds. For the purposes of the present analysis, the TURA program has corrected these errors to the extent possible. Specifically, where a facility reported chromium and the TURA program believes the facility should have reported chromium compounds, that change has been made in this table, and is explained in the individual footnotes. Similarly, some facilities reported chromium compounds in place of chromium; these have been corrected as well. Note, however, that the main TURA data file has not been changed, so figures presented here may not be identical to TURA data found online.
- This table excludes facilities which stopped reporting when chromium alloys (>50 microns) were delisted in 1995. Some facilities reporting in 3 or fewer intermediate years only are also not shown.

Notes on individual entries in the table:

[1] Includes the following reported TURA chemicals: chromium compounds, chromic acid and sodium bichromate; [2] Use Categories were assigned based on the Institute's examination of TURA data and in some cases may not represent the actual use; [3] The 1990 data do not include the use and output of electricity generation companies, which were not required to report until 1991;[4] "-" indicates that the facility either is not using the chemical or has dropped below the reportable threshold;[5] Maximum year reported as chromium [6] 1990 use reported as chromic acid [7] 1990 use reported as chromium [8] 1990 reporting was as chromium. Chromium Compounds amount assumed based on later years chromium compounds use; [9] Wollaston Alloys reported use declined from millions of pounds to thousands of pounds in 1995 due to the metal alloys exemption. Because it is unknown how much of their 1990 use was non-alloy, an amount equal to the 1999 reported use has been included for 1990. [10] 1990 use reported as chromium. Source: Massachusetts Toxics Use Reduction Act data for 2008.

Facilities likely to be affected by separating hexavalent chromium from the Chromium Compounds category

Separating hexavalent chromium compounds from the Chromium Compounds category, without a higher hazard designation, would not bring in any new filers, although some facilities could be required to file two Form S reports (one for hexavalent and one for other chromium compounds) rather than their current one Form S report. The TURA program estimates that only one existing TURA filer would be required to file two Form S reports in this way (and this filer has already reached its maximum fee, so its payments would not actually increase); others are likely to use predominantly one species, or not to use a large enough quantity of two different species to be required to file two reports.

Facilities likely to be affected by a Higher Hazard designation for hexavalent chromium compounds

Based on input from TURA program personnel and industry experts we have developed the following estimates of expected numbers of new filers:

SIC Code	**Sector**	**Number expected to report**
3087 and 2816	Custom compound purchased resins and inorganic pigments	1-5
3089	Plastics products, not elsewhere classified	1-5
3471	Plating and Polishing/surface finishing	10-35

In the resins, pigments and plastics sectors, we have estimated that a small number of the many Massachusetts companies in that industry use hexavalent chromium compounds in colorants over the 1,000 pound threshold, resulting in the potential for 1-5 new filers. In addition, a number of plating and surface finishing companies may use hexavalent chromium compounds above 1,000 lbs/year. Other estimates in the table above are based on the use of chromium in niche applications in the relevant industries.

As shown in the table above, the industry sectors in which new filers are most likely to be found are SIC 3089 (Plastic Products), SIC 3087 (Custom Compounded & Plastic Resins), and SIC 3471 (Plating and Polishing). Other SIC codes are expected to be minimally affected. An industry expert estimated that a total of about 35 facilities would be likely to be using more than 1,000 pounds per year of hexavalent chromium compounds. The representative did not provide estimates on the likely number of employees at these facilities. The representative noted that a large number of additional facilities are likely to have the capacity to use hexavalent chromium compounds on an as-needed basis, but would be using smaller amounts of the substance (one hundred to several hundred pounds per year).

Because some users may have fewer than ten FTEs, the TURA program expects that a total of approximately 20 of these facilities would begin filing under TURA as a result of a higher hazard designation for hexavalent chromium.

3. Opportunities for New Filers

a. Trends among past and current filers

The use of Chromium Compounds among TURA filers has decreased over the life of the program. In 1990, twenty three companies reported use of a total of 3,436,614 pounds of chromium compounds. By 2008, just eight companies were reporting use of 497,366 pounds of chromium compounds. Firms reported on-site releases of 4,578 pounds of chromium compounds in 1990; this dropped to 569 pounds in 2008, with nearly 90% of that amount coming from a single filer -- a power plant.

One sector that formerly was a major user of chromium compounds in Massachusetts is wood preservation. In 2003 there were three companies in that sector that filed under TURA, using a combined 514,846 pounds of chromium compounds. Following the phase-out of chromated copper arsenic (CCA) wood treatment that began in that year, all three companies switched to alternative products (copper azole and alkaline copper quaternary preservatives.) The companies are still doing business in Massachusetts, but no longer file for chromium compounds under TURA.

Another major user of chromium compounds (in traffic paints and related products,) phased-in non-chromium pigments beginning in 2005. That company, which reported use of over 145,000 pounds of chromium compounds in 2005, no longer meets the reporting threshold for chromium compounds (either due to having dropped below the threshold, or due to no longer using chromium compounds at all).

Table 3. Massachusetts Chromium Compounds Data: Used and Released in 1990 and 2008

Data – MA TURA	Year		Change in pounds	% Change
	1990	2008		
Chromium Compounds used (pounds)	3,228,608	527,867	-2,700,741	-84%
Chromium Compounds released (pounds)	4,196	572	-3,624	-86%

Notes:
*In the early years of the program, some facilities reported individual chromium compounds such as chromic acid separately, in error. All individual chromium compounds have been added into the chromium compounds category for the purposes of this table.
* In the early years of the program several facilities confused chromium reporting with chromium compound reporting. For these facilities, TURI has assigned whichever substance seems most appropriate for the particular facility. For this reason, the numbers presented here are not identical to those found in the online TURA data. See Table 2 for the details of how these figures were calculated for individual facilities.
*In some cases, facilities used both chromium and chromium compounds and then were able to take the alloy exemption in 1995 for chromium. For those facilities a chromium compound amount was estimated for consistency.
*In 2006, 5 facilities appear to have stopped reporting due to the elimination in the 2006 Amendments of the "automatic" 10,000 lb threshold.

Some changes in the data have occurred due to changes in reporting requirements. In particular, there are three major reporting issues that could affect the chromium numbers:

- Sometimes, particularly in the earlier years of the program, facilities confused their reporting of chromium with their reporting of chromium compounds. However, these errors account for only a small percentage of chromium compound use reported in 1990.

- Facilities are no longer required to report on chromium metal in alloy form. However, this does not significantly affect the chromium compounds numbers.
- As discussed in Section 2 above, due to the 2006 amendments, facilities reporting between 10,000 and 25,000 pounds of chromium compounds manufactured or processed are no longer required to report.

Because the hexavalent and non-hexavalent forms of chromium have been reported as a single category, the TURA program does not know how many existing TURA filers use hexavalent chromium specifically, or what trends may have occurred in substitution between hexavalent and other forms of chromium compounds.

b. Availability of alternatives

The principal applications of hexavalent chromium that continue to be relevant for potential filers within Massachusetts are electroplating; surface treatment; etching; and paints and pigments. In this section, we review information on alternatives to hexavalent chromium for these uses. Opportunities and challenges are summarized in Table 4, at the end of this section.

Many alternatives are available for hexavalent chromium processes. There are some challenges, however. In particular:

- Hexavalent chromium processes tend to be more forgiving, requiring less process control, operator skill and maintenance than processes that use non-hexavalent chromium.
- Many Massachusetts companies produce components for the military, aerospace and electronics industry; the specifications of those users affect the alternatives that are considered. In particular, customer requirements for specific colors often limit facilities' choices. Thus, education and training of customers is just as important as training within facilities as a means to facilitate adoption of safer alternatives.

i. Electroplating

Decorative Electroplating[17]

For decorative chromium electroplating applications, switching from a hexavalent to a trivalent chromium form is technically straightforward. Comparison testing has shown that the trivalent plating process has many advantages over the hexavalent process, and the finished product performs similarly.[18] One important advantage is that the trivalent chromium process is more efficient; less offgassing occurs and thus less aerosol is produced. Trivalent chromium processes also tend to be more energy efficient. Some Massachusetts metal finishing companies have phased out the hexavalent process; however, most continue to offer a choice of processes to their customers.

According to industry representatives, one of the barriers to switching from hexavalent chromium processes to alternative processes is concern about differences in color (which is frequently an aspect of changing process chemistries). For example, facilities that produce replacement parts (e.g. for faucets or other household equipment) may have concerns about creating replacement parts that are of a slightly different color from existing equipment.

In some cases, there may be additional technical considerations. For example, according to an industry representative, an ancillary benefit of using hexavalent chromium for plating furniture (such as chairs used in schools) is that it serves to passivate the inside of the furniture, enhancing durability and rust resistance. Facilities shifting to safer alternatives may, thus, need to find alternative approaches for ensuring durability.

In summary, there are technically feasible alternatives for most or all decorative plating applications, but customer education may be a necessary component in many cases.

Hard (functional) chromium electroplating

Replacing hexavalent chromium in hard/functional chromium electroplating applications may be more difficult. Companies often point to military specifications as dictating the use of hexavalent chromium. Some military specifications have been revised to eliminate the need for hexavalent chromium, but many continue to require it. In some cases, this is based primarily on a preference for specific colors that can only be achieved through a hexavalent process.

The US Department of Defense (DoD) issued a policy memo in 2009 that directed its research agencies to increase their efforts to find and publicize alternatives to hexavalent chromium. DoD's ASETSDefense Initiative is charged with being the "primary source of information on environmentally preferable alternatives [to hexavalent chromium] that maintain performance and are cost-effective."[19]

Significant research and development investments have been made by DoD and others to find and test alternatives to hard chrome. Options include thermal sprays (high velocity oxy-fuel and plasma sprays); nickel-free electroplates and composites; weld facing methods and micro-arc welding; heat treatments and plasma nitriding; laser modification, alloying and coating; electrodeposited nanocrystalline cobalt-phosphorus coating; explosive bonding; physical vapor deposition/magnetron sputtering; chemical vapor deposition; and nickel/tungsten/boron electroplating

Industry representatives note that electroless nickel can, in some cases, have performance superior to that of hexavalent chromium, while in other cases it is less preferable, depending on the specific application.

Industry representatives emphasize the importance of educating customers so that they will specify alternatives to hexavalent chromium when appropriate.

ii. Surface treatment

Passivation

Chromic acid is also used for passivation of stainless steel. According to an industry representative, much of this work is done by very small facilities, including machining shops. These facilities are unlikely to meet the 1,000 lb/year threshold. The industry representative estimated that about 5,000 pounds of hexavalent chromium are being used, statewide, in processes of this kind.

An alternative for this application is the use of citric acid for passivation of stainless steel. The industry representative noted that citric acid can be used for all stainless steel alloys. The principal barrier is that customer specifications may not allow for this alternative.

Hexavalent use at small shops may be particularly inefficient. If baths are not carefully maintained, they will need to be replaced more often. Although this use of hexavalent chromium is below even the threshold for a higher hazard substance, it may be an area of opportunity for technical assistance to help these small facilities reduce their use and waste.

Again, this is an instance in which the TURA program can potentially play a key role by convening actors up and down the supply chain to facilitate adoption of safer alternatives through revision of customer specifications.

Aluminum and zinc conversion coatings

Chromating processes for aluminum and zinc conversion coatings account for the most significant on-going use of hexavalent chromium in Massachusetts. Conversion coatings inhibit corrosion on metal parts, and are important in military, nautical and aerospace applications. In Massachusetts, aluminum is currently in wide use, in particular for electronic uses within military equipment.

Traditionally, hexavalent chromate conversion coatings were widely used. These have been largely replaced by trivalent chromium conversion coatings, such as the Trivalent Chromium Pretreatment (TCP) of aluminum, developed and patented by the US Naval Air System Command and now called for in many military specifications.

According to an industry representative, conversion coating processes can generally be switched to a non-hexavalent process at little or no additional cost. In particular, they noted that there are many success stories in switching processes for conversion coatings on zinc.

In general, shifting away from hexavalent chromium in these applications can save money, and from a technical perspective the change is relatively simple, because drop-in replacements are frequently available.

As for other processes, a technical barrier to making the change is that the non-hexavalent solutions are less forgiving, with a tighter operating window and more careful bath maintenance required.

The other barrier to replacing hexavalent chromium with safer alternatives is color. Some colors produced through hexavalent processes can also be produced through non-hexavalent processes. However, military specifications, in particular, frequently specify color shades that can only be achieved with hexavalent chromium processes. In addition, even where the same color can be achieved through hexavalent and non-hexavalent processes, some of the color options in non-hexavalent processes may be achieved through use of dyes that could raise other health and environmental concerns. Industry representatives emphasize that education and training of customers is key. Small changes in color requirements in military specifications, in particular, could significantly ease the transition to safer alternatives.

Industry representatives estimate that a small shop carrying out zinc and aluminum conversion coatings would use 500 to 1,000 lbs of hexavalent chromium annually, and that a medium sized facility would exceed the 1,000 lb/year threshold.

In summary, a significant number of Massachusetts facilities are likely to be using chromating processes for aluminum and zinc conversion coatings, and feasible alternatives are available for many of these uses. Customer specifications, again, are likely to be the most significant barrier to change.

Case study: Replacing chromate conversion coatings with a chromium-free alternative

Vicor Corporation adopted alternatives to a number of its existing processes in order to ensure compliance with the European Union's Restriction on Hazardous Substances (RoHS). One such effort was Vicor's work to replace hexavalent chromium compounds in conversion coatings on aluminum products. Prior to RoHS, Vicor finished most aluminum products with clear chromate conversion coatings containing hexavalent chromium. Although trivalent chromium was an option under RoHS, Vicor decided to move to a completely chromium-free process in anticipation of possible future customer requirements for chromium-free products.

Vicor selected a non-chromate conversion coating and educated its suppliers upstream about the transition. One key difference with the non-chromate conversion coating was that a difference in the appearance of the final product: whereas the chromate process had produced a sanded appearance, the alternative produced a tumbled appearance. Vicor ensured, however, that performance was equal to or better than the original product.

Source: Richard A. Paulauskas, "Vicor's RoHS Initiative," report to the Toxics Use Reduction Institute, May 2006. Available at http://www.turi.org/for_industry/alternatives_research/industry_matching_grants/fy06_demonstration_sites/vicor_rohs_compliance.

Anodizing

Another important application of chromic acid (a hexavalent form) is anodizing. This process is highly desirable for protecting critical items with complex geometries that have lap joints, crevices, recesses or blind holes that can entrap electrolytes.

Sulfuric acid anodizing is an alternative to the chromium process in this application, and in fact is more widely used than chromium; however, in some critical applications the properties of the chromium process continue to be preferable. For complex geometries, if sulfuric acid becomes entrapped, it can cause corrosion during the product's service life; chromic acid will not. This accounts for the continued use of chromic acid anodizing for protective coatings in the aircraft and defense related industry.[20]

iii. Etching (chromic acid etchant for plating on plastics)

Hexavalent chromium in the form of chromic acid is used for plating a metal surface onto plastic products. This process is used by only a small number of facilities, but is significant because the process requires a relatively high concentration of hexavalent chromium in the solution. An industry representative estimated that only two facilities in Massachusetts use this process.

In this process, chromic acid is used to etch microscopic holes and irregularities onto a previously smooth plastic surface. This etching makes it possible to plate metal onto the surface, allowing the metal to adhere to the surface irregularities. One Massachusetts facility uses this process in a mirroring process, adding a layer of silver onto etched plastic.

One alternative to this approach is plasma etching. Plasma etching presents some limitations in the types of plastics for which it can be used, and is better for some applications than for others. For example, it works well for plating small parts. For large objects, there may be additional considerations, such as the need to hold the object in a fixed position during plating; this may require new equipment and/or worker training.

iv. Paints and pigments, colorants and dyes

A variety of alternatives are available for chromium in pigments. Some alternatives also pose significant health and environmental hazards, while others are superior from a health and environmental perspective. Pigments containing hexavalent chromium are used both for coloring plastics, and in paints. In paints, hexavalent chromium not only serves as a pigment, but also provides corrosion protection.

Alternatives include inorganic pigments based on acid solutions of synthetic oxonitrides[21]; iron oxide pigments[22]; bismuth vanadate pigments[23]; organic/inorganic pigment blends using titanium dioxide, mixed metal oxide titanites, and/or iron oxide; rutile tin zinc compounds; and others.[24]

As early as the beginning of the 1990s, many firms found that they were able to replace chromium in the majority of pigments in which it had been used previously. Increasingly, manufacturers are shifting away from, or eliminating completely, the use and production of heavy-metal-based colorants.[25]

Table 4. Alternatives to Hexavalent Chromium Compounds: Opportunities & Challenges

Process	Application	Alternatives	Opportunities	Challenges
Electroplating	Decorative electroplating	Trivalent chromium (among others)	Greater efficiency; equivalent performance.	Customer color specifications. Loss of ancillary anti-corrosion function. Alternatives require more training & operating control.
	Hard (functional) electroplating	Specialized alternatives available in some applications. Examples include electroless nickel.	Superior performance & reduced labor costs in some cases.	Customer performance & color specifications. Inferior performance in some cases.
Surface treatment	Passivation of stainless steel	Citric acid	Feasible in many applications.	Customer specifications.
	Aluminum & zinc conversion coatings (chromating)	Several options, including trivalent chromium pretreatment (TCP)	Minimal cost to convert; can produce cost savings.	Alternatives have tighter operating window, require greater bath maintenance. Customer specifications for color.
	Anodizing	Sulfuric acid	Feasible in many applications.	Can become entrapped and cause corrosion.
Etching	Plating on plastics	Plasma etching	Feasible in many applications.	Depending on the object to be etched, may require new equipment.
Paints, pigments, colorants and dyes	Pigments in plastics and paints. Anticorrosion function in paints.	Organic and inorganic alternatives for pigments	Feasible in many applications.	EH&S concerns about some alternative pigments. Loss of ancillary corrosion protection.

4. Regulatory context

Regulations vary in the way they categorize hexavalent versus other chromium compounds. Some regulations make clear distinctions between the two. Other regulations treat them as a single category. In the case of drinking water standards, US EPA is currently examining the possibility of regulating hexavalent chromium separately from other chromium compounds, responding to concerns about widespread hexavalent chromium contamination in drinking water.

Due to their serious adverse effects on human health, hexavalent chromium and its compounds are subject to multiple regulations at the state, federal, and international levels.

Federal regulations

EPCRA	• Chromium Compounds are reportable under TRI. Under the TRI definition, the Chromium Compounds category "includes any unique chemical substance that contains chromium as part of that chemical's infrastructure." • Chromium Compounds are also included on EPCRA's List of Extremely Hazardous Substances, and thus are subject to Tier II reporting requirements in MA.
CAA	• Chromium is designated as a Hazardous Air Pollutant.[26]
CERCLA	• Hexavalent Chromium (identified with the CAS number 18540-29-9), as well as a number of individual hexavalent chromium compounds, appear on CERCLA's Priority List of Hazardous Substances.[27] Hexavalent chromium is ranked #18 on the list.
RCRA	• "There are some 23 waste or process waste streams that are specifically named (40 CFR 261.31 and 40 CFR 261.32) as hazardous under RCRA because of potential total or hexavalent chromium content. In addition any material that contains chromium that will leach 5 mg/L total chromium under the Toxicity Characteristic Leaching Procedure (40 CFR 191) is considered a characteristic RCRA hazardous waste."[28]
Occupational exposures	• American Conference of Governmental Industrial Hygienists (ACGIH) TLV-TWA lists hexavalent chromium as a confirmed human carcinogen, with a TLV-TWA of 0.05 mg(Cr)/m3.[29] • "The NIOSH REL (10-hour TWA) is 0.001 mg Cr(VI)/m^3 for all hexavalent chromium [Cr(VI)] compounds. NIOSH considers all hexavalent chromium compounds (including chromic acid, tert-butyl chromate, zinc chromate, and chromyl chloride) to be potential occupational carcinogens."[30] • The NIOSH REL (8-hour TWA) is 0.5 mg Cr/m^3 for chromium metal and chromium (II) and chromium (III) compounds.[31] • The OSHA PEL is 0.005 mg CrO_3/m^3 (8-hour TWA) for chromic acid and chromates (including tert-butyl chromate with a "skin" designation and zinc chromate); 0.5 mg Cr/m^3 (8-hour TWA) for chromium(II) and chromium(III) compounds; and 1 mg Cr/m^3 (8-hour TWA) for chromium metal and insoluble salts."[32]
SDWA	• The maximum contaminant level (MCL) for total chromium,

	set in 1991, is 0.1 mg/L or 100 ppb.[33] However, EPA is currently examining the possibility of setting a separate MCL for hexavalent chromium, and is encouraging water systems to monitor hexavalent chromium levels separately from other chromium compounds.[34]
CWA	• Chromium is listed as a toxic pollutant (Section 307A) and effluent limitation guidelines have been set for hexavalent chromium (Section 304B).[35]
FDA	• "The Food and Drug Administration (FDA) limits the amount of chromium in bottled water to 0.1 mg/L."[36]

Massachusetts Regulations

Massachusetts: Occupational	• Subject to Right-to-Know requirements[37]
Massachusetts: Environmental & Public Health	• Ambient air guidelines for hexavalent chromium:[38] o Threshold Effects Exposure Limit (TEL) 0.003 µg/m^3 (24-hour average) o Allowable Ambient Limit (AAL) at 0.0001 µg/m^3 (annual average) • Drinking water standard for Chromium (total) (acceptable daily intake over a lifetime exposure) is 0.1 mg/L (identical to the MCL at the federal level, under SDWA).[39] • Chromium is also regulated under the Massachusetts Hazardous Waste regulations.[40]
Massachusetts DEP	• The Massachusetts Contingency Plan differentiates a 50-fold difference in the clean-up standard for hexavalent and trivalent chromium.[41]

Other state regulations of interest:

- Chromium (hexavalent compounds) are regulated as carcinogens and as male and female developmental toxicants (Revised December 19, 2008), under California's Safe Drinking Water and Toxics Enforcement Act of 1986 (Proposition 65).[42]
- In the absence of a federal drinking water for hexavalent chromium specifically, California is working to develop such a standard. California EPA's Office of Environmental Health Hazard Assessment (OEHHA) has proposed a Public Health Goal (PHG) for hexavalent chromium in drinking water of 0.02 parts per billion. If adopted, this PHG could later serve as the basis for development of a mandatory drinking water standard in California.[43]
- Maine's law on Toxic Chemicals in Children's Products includes hexavalent chromium, as well as a number of specific chromium compounds, on its List of Chemicals of High Concern.[44]
- Nineteen states, including Maine, New Hampshire, Vermont, Connecticut and Rhode Island, have Toxics In Packaging laws that limit the total concentration in packaging of 4 heavy metals (lead, mercury, cadmium and hexavalent chromium) to 100 ppm.[45]

International

- *Occupational exposure limits.* Many countries have occupational exposure limits for hexavalent chromium. Some are the same as the OSHA standard, while some are less protective. Sweden also has a Short Term Exposure Limit, in addition to its Time Weighted Average limit.[46]
- *European regulations.*

- The Dangerous Substances Directive (76/769/EEC) regulates chromium in several different applications. For example, cement and cement-containing preparations may not be used or placed on the market, if they contain, when hydrated, more than 0.0002% soluble chromium VI of the total dry weight of the cement. Some exceptions are made where exposure is not expected.[47]
- Hexavalent chromium is one of the six chemicals regulated under the Restriction on Hazardous Substances (RoHS), which applies to electrical and electronic equipment.[48] Under RoHS one exception listed for the substance is "Hexavalent chromium as an anticorrosion agent of the carbon steel cooling system in absorption refrigerators up to 0.75% by weight in the cooling solution."[49]
- Ten chromium substances or substance categories are listed on the European Chemicals Agency's Candidate List of Substances of Very High Concern (SVHC) for Authorization list.[50] They are: Chromium trioxide (VI) 1333-82-0, Sodium dichromate, dihydrate (VI) 7789-12-0 and Sodium dichromate (VI) 10588-01-9, Potassium dichromate (VI) 7778-50-9, Ammonium dichromate (VI) 7789-09-5, Sodium chromate (VI) 7775-11-3, Potassium chromate (VI) 7789-00-6, Lead sulfochromate yellow (VI) 1344-37-2, Lead chromate (VI) 7758-97-6, Lead chromate molybdate sulfate red (VI) 12656-85-8, Acids generated from chromium trioxide and their oligomers: Chromic acid 7738-94-5, Dichromic acid 13530-68-2 and oligomers of chromic acid and dichromic acid.
- The End-of-Life Vehicles (ELV) Directive 2003/53/EC prohibits the use of hexavalent chromium in vehicle materials and components, except where specific exemptions are provided.[51]
- The Toy Safety Directive (2009/48/EC) sets limits for both hexavalent and trivalent chromium in accessible parts of toys.[52]
- The Packaging and Packaging Waste Directive (94/62/EC) stipulates that the sum total concentration of heavy metals (lead, cadmium, mercury and hexavalent chromium) in packaging shall not exceed 100 ppm.[53]

- *China:*
  - Hexavalent Chromium is also regulated under China's Regulation of Hazardous Substances in Electrical and Electronic Equipment, commonly known as China RoHS.[54]

5. Implications for the TURA program

Separating hexavalent chromium compounds from the chromium compound category and making hexavalent chromium compounds a higher hazard substance will change the threshold to 1,000 for hexavalent chromium compounds while leaving the typical TURA thresholds of 10,000 or 25,000 pounds in place for non-hexavalent chromium compounds.[†] This policy action would have several implications for the TURA program.

Implications for TURA program agency staff and services

- *Information.* Designating hexavalent chromium compounds as a higher hazard substance will help the program to determine the extent to which hexavalent chromium compounds are still being used in the Commonwealth. This information, in turn, can help to inform program activities to help users identify alternatives and toxics use reduction opportunities.

[†] The 25,000 pound threshold applies to facilities that "manufacture or process" a chemical, while the 10,000 pound threshold applies to those that "otherwise use" a chemical.

- *Alternatives assessment.* In working with facilities to reduce their use of toxic chemicals, a key goal is to help facilities make the best possible choices in selecting alternatives, avoiding options that could be equally or more hazardous. The TURA program has significant expertise in alternatives assessment, and has multiple resources to offer facilities as they assess alternatives to higher hazard substances. Separating hexavalent chromium compounds from the larger chromium compounds category, and designating hexavalent chromium as a higher hazard substance, would significantly increase the ability of the TURA program to carry out this function effectively. Among other factors, it would ensure that facilities using hexavalent chromium compounds that are not currently subject to TURA program requirements would come into contact with the TURA program, increasing these facilities' likelihood of taking advantage of the program's education, training, and technical asssistance on the alternatives.
- *Staff time and TURA program resources.* The program agencies, particularly TURI and OTA, provide a number of services on an on-going basis, focusing on different chemicals and industries that are current priorities for us or for MA companies. For example, TURI regularly provides chemical- and process-specific training sessions for TUR Planners; produces chemical-specific fact sheets; conducts alternatives assessments; convenes industry supply chain groups; provides peer mentoring opportunities; and sponsors demonstration sites. All of these work areas can be focused on whatever issues are most important in a given year. Furthermore, to ensure that there continues to be value added from these activities, new content is important. For these reasons among others, it is appropriate for the TURA program to continue to designate new higher hazard substances over time, even when the program agencies are experiencing some resource constraints.
- *Public health and environmental benefits.* Conversations with industry representatives have made it clear that a significant portion of continuing use of hexavalent chromium use is likely to be occurring below the thresholds that currently apply for chromium compounds. Furthermore, according to industry representatives, users of small quantities may use hexavalent chromium less efficiently per unit of product. If the TURA program is to continue achieving and documenting meaningful toxics use reduction, it is important to continue to extend the reach of the program to these smaller users who can potentially make greatest use of the technical assistance and other services the program has to offer.
- *Timing and windows of opportunity.* Industry representatives on the TURA Advisory Committee pointed out that now is an important window of opportunity to work with companies on reducing or eliminating their use of hexavalent chromium, because the need to comply with the European Union's RoHS directive has already drawn many facilities' attention to this chemical.

Implications for administrative and regulatory guidance

- *Internal identification number.* The TURA program will need to create an internal identification number for hexavalent chromium compounds for reporting purposes. This will be necessary because CAS numbers exist for individual hexavalent chromium compounds but there is no CAS number for all such compounds as a group.
- *Reporting guidance.* In addition, as part of the compliance assistance offered with the lower reporting threshold, it will be important to conduct outreach to ensure that facilities are distinguishing accurately between hexavalent chromium compounds and non-hexavalent chromium compounds for reporting purposes. The program will need to provide clear guidance to facilities regarding how to determine whether their chromium use is hexavalent, and how to determine whether their chromium changes valence state within the production unit. Facilities should already be identifying each time the chromium forms a new compound, as this constitutes "manufactured" chemical use under TRI reporting rules, so the additional effort will be identifying what the valence state is of the chromium in the compound.

- *Relationship to federal and other state requirements.*
  - Requiring separate reporting of hexavalent chromium compounds will make TURA requirements different from TRI requirements for this substance. This difference will make it particularly important to provide clear reporting guidance.
  - Requiring separate reporting of hexavalent chromium compounds will place Massachusetts in the mainstream of newer regulatory initiatives related to chromium compounds, including California's initiative to regulate hexavalent chromium in drinking water separately from total chromium compounds; EPA's initiative to re-examine its approach to regulating chromium compounds in drinking water; and a variety of European regulations that regulate hexavalent chromium separately from other chromium compounds.

Implications for TURA filer fees

- There would be some additional cost to companies that would begin reporting hexavalent chromium compounds based on the lower reporting thresholds. Most of the new filers would likely be facilities with fewer than 50 employees. The base fee for this size facility is $1,850. Some filers would not be new to the program and already pay a base fee, but would potentially pay an additional per-chemical fee of $1,100.
- Assuming that the lower reporting threshold brings in 20 facilities that are not already reporting under TURA, the additional cost in fees to filers (and revenue to the program) could be $59,000 (20 small companies reporting hexavalent chromium compounds only). If some of the facilities that begin filing for hexavalent chromium compounds under the lower reporting threshold are already TURA filers, there would be less cost to these filers since they already pay a base fee.
- It is also possible that separating hexavalent chromium compounds from the larger category of chromium compounds could lead some facilities to no longer be subject to TURA program requirements. This would be the case if a facility had previously met the 10,000 or 25,000 pound threshold due to using a combination of hexavalent and non-hexavalent compounds, but did not meet the threshold for either hexavalent (1,000 pounds under the HHS designation) or non-hexavalent (10,000 or 25,000 pounds under regular TURA reporting thresholds) compounds on their own. This scenario is unlikely, but possible. Similarly, it is possible that a facility currently reporting chromium compounds and using both trivalent and hexavalent forms, would be required to report each separately and pay an additional per chemical fee.

6. Summary

Separating hexavalent chromium compounds from the larger Chromium Compounds category will make it possible for the TURA program to identify Massachusetts facilities that are using these compounds, and to provide clear information to facilities on the hazards associated with hexavalent chromium compounds in particular. Designating hexavalent chromium compounds as a Higher Hazard Substance will further enhance the TURA program's ability to identify and work with these facilities, and to ensure that Massachusetts facilities remain in the forefront of the effort to switch to safer substitutes.

Appendix A: Key Data Points the SAB considered for Chromium Compounds

Hexavalent Chromium Compounds: Data for Chromium Trioxide, CAS# 1333-82-0.

International Agency for Research on Cancer (IARC)	Group 1 (carcinogenic to humans)
Developmental Toxicity	Listed on Proposition 65 as developmental toxicant
Reproductive Toxicity	Listed on Proposition 65 as male and female reproductive toxicant
Mutagenicity	21 Studies indicate mutagenic effects in RTECS
LD50	Oral rat 80 mg/kg
ACGIH Threshold Limit Value (time weighted average)*	0.05 mg/m^3
Bioconcentration factor	n/a

Non-hexavalent Chromium Compounds: Data for Chromic Oxide, CAS #1308-38-9

International Agency for Research on Cancer (IARC)	Group 3; 1 positive study in the Chemical Carcinogenesis Research Information System[55]
Developmental Toxicity	Not in RTECS
Reproductive Toxicity	Not in RTECS
Mutagenicity	5 positive studies available in RTECS[56]
LD50	Oral mammal 621 mg/kg
ACGIH Threshold Limit Value (time weighted average)*	0.05 mg/m^3
Bioconcentration factor	n/a

Appendix B: Glossary of Regulatory Terms

ACGIH	American Conference of Governmental Industrial Hygienists
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CWA	Clean Water Act
EPCRA	Emergency Planning and Community Right to Know Act
FDA	Food and Drug Administration
LC50	Lethal Concentration (lethal to 50% of test animals in specified time period)
LD50	Lethal Dose (lethal to 50% of test animals in specified time period)
MCL	Maximum Contaminant Level
NIOSH	National Institutes of Occupational Safety and Health
OSHA	Occupational Safety and Health Administration
RCRA	Resource Conservation and Recovery Act
RTECS	Registry of Toxic Effects of Chemical Substances
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
Tier II	Chemical inventory reporting requirements for facilities subject to EPCRA
TRI	Toxic Release Inventory
TWA-PEL	Time-weighted average - Permissible Exposure Limit
TWA-REL	Time-weighted average – Recommended Exposure Limit
TWA-TLV	Time-weighted average - Threshold Limit Value

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[33] US EPA Basic Information about Chromium in Drinking Water: http://water.epa.gov/drink/contaminants/basicinformation/chromium.cfm#one

[34] US EPA, "EPA's Recommendations for Enhanced Monitoring for Hexavalent Chromium (Chromium-6) in Drinking Water," updated January 28, 2011, available at http://water.epa.gov/drink/info/chromium/guidance.cfm, viewed April 2011.

[35] Www.expub.com; ListEXPERT

[36] http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/BottledWaterCarbonatedSoftDrinks/ucm077148.htm

[37] Massachusetts Division of Occupational Safety, Massachusetts "Right-to-Know" Law (MGL 111F), Workplace Regulation (454 CMR 21.00), www.mass.gov/dos/rtk/index.htm (Click on Occupational Safety and Health Programs, then Masachusetts Workplace Safety and Health Program, then Right to Know.)

[38] Massachusetts Department of Environmental Protection, Revised Air Guidelines, www.mass.gov/dep/air/aallist.pdf

[39] Massachusetts Department of Environmental Protection, "Standards and Guidelines for Contaminants in Massachusetts Drinking Waters" (Spring 2007), available at http://www.mass.gov/dep/water/dwstand.pdf

[40] Massachusetts Hazardous Waste regulations, 310 CMR 30.125, Maximum Concentration of Contaminants for Toxicity Characteristic, http://www.mass.gov/dep/service/regulations/310cmr30.pdf.

[41] Massachusetts Contingency Plan Reportable Concentrations in Groundwater and Soil http://www.mass.gov/dep/cleanup/laws/rcs_899.htm

[42] California Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65), http://oehha.ca.gov/prop65/prop65_list/newlist.html

[43] California EPA Office of Environmental Health Hazard Assessment, "Announcement of Second Public Comment Period Draft Technical Support Document on Proposed Public Health Goal for Hexavalent Chromium in Drinking Water," December 31, 2010, available at http://oehha.ca.gov/water/phg/chrom123110.html.

[44] Maine Chemicals of High Concern List http://www.maine.gov/dep/oc/safechem/highconcern/

[45] Toxics in Packaging Clearinghouse, accessed at: www.toxicsinpackaging.org/

[46] Occupational Exposure limits are available for hexavalent Chromium in the following countries: Australia: TWA 0.05 mg(Cr)/m3; Austria: TRK 0.05 mg(Cr)/m3, TRK 0.1 mg(Cr)/m3 (welding fumes), and TRK 0.1 mg(Cr)/m3 (production); Belgium: TWA 0.01 mg(Cr)/m3; Denmark: TWA 0.005 mg(Cr)/m3; Japan: Certain chromium VI compounds are listed as having an OEL of 0.01mg/m3; while others are listed as having an OEL of 0.05mg/m3; New Zealand: Chromium (VI) compounds, as Cr (water soluble) have an OEL of 0.5mg/m3 TWA. Other certain water soluble compounds that are indicated as confirmed carcinogens have the same limit. Sweden: TWA 0.005 mg(Cr)/m3; STEL 0.015 mg(Cr)/m3, Carcinogen, Sen, June 2005; Switzerland: MAK-W 0.05 mg(Cr)/m3, Carcinogen, December 2006. UK: 0.05mg/m3 8-hr TWA reference period, Carcinogen, Sen. Source: www.expub.com; ListEXPERT.

[47] Council Directive on the Approximation of the Laws, Regulations and Administrative Provisions of the Member States Relating to Restrictions on the Marketing and Use of Certain Dangerous Substances and Preparations (76/769/EEC). Available at http://ec.europa.eu/enterprise/sectors/chemicals/documents/reach/archives/market-restrictions/

[48] Restriction on Hazardous Substances, legislation available at http://ec.europa.eu/environment/waste/weee/legis_en.htm

[49] DIRECTIVE 2002/95/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment accessed online at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2002L0095:20100925:EN:PDF

[50] European Chemicals Agency (ECHA) Candidate List of Substances of Very High Concern for authorization http://echa.europa.eu/chem_data/authorisation_process/candidate_list_table_en.asp

[51] European End of Life Vehicle Directive Accessed at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0053:EN:HTML

[52] "The specific limit values laid down in Directive 88/378/EEC for certain substances should also be updated to take account of the development of scientific knowledge. Limit values for arsenic, cadmium, chromium VI, lead, mercury and organic tin, which are particularly toxic, and which should therefore not be intentionally used in those parts of toys that are accessible to children, should be set at levels that are half of those considered safe according to the criteria of the relevant Scientific Committee, in order to ensure that only traces that are compatible with good manufacturing practice will be present. Specific migration limits are given under the Directive 88/378/EEC for both hexavalent and trivalent chromium: as follows, "In dry, brittle, powder-like or pliable toy material, Chromium (III) = 37.5 mg/kg, Chromium (VI) = 0.02 mg/kg; in liquid or sticky toy material, Chromium (III) = 9.4 mg/kg, Chromium (VI) = 0.0005 mg/kg; and in scraped-off toy materials, Chromium (III) = 460 mg/kg, Chromium (VI) = 0.2 mg/kg."Directive 2009/48/EC on the safety of toys accessed at: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:170:0001:0037:EN:PDF

[53] European Union Directive 94/62/EC on packaging and packaging waste, article 11, accessed at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:1994L0062:20090420:EN:PDF.

[54] For detailed information, see http://www.chinarohs.com/.

[55] Www.expub.com; CCRIS Reference: ELIAS,Z, POIROT,O, SCHNEIDER,O, DANIERE,MC, TERZETTI,F, GUEDENET,JC AND CAVELIER,C; CELLULAR UPTAKE, CYTOTOXIC AND MUTAGENIC EFFECTS OF INSOLUBLE CHROMIC OXIDE IN V79 CHINESE HAMSTER CELLS; MUTAT. RES. 169(3):159-170, 1986

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